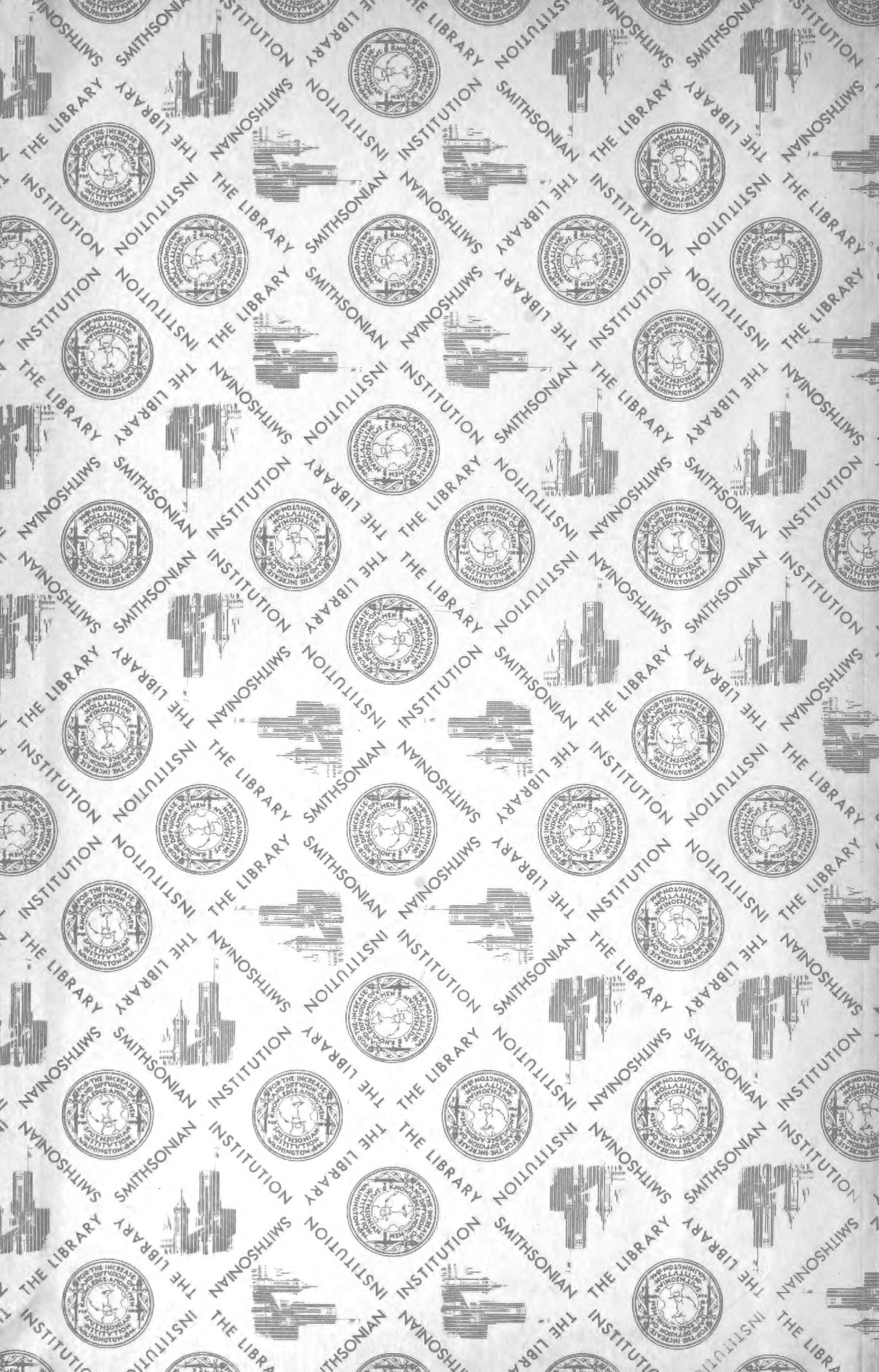
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ANNALS
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Volume XIV MARCH, 1921 Number 1

THE IMPUDICA GROUP OF THE DIPTEROUS GENUS TIPULA LINNAEUS.

By W. G. DIETZ, M. D.

A sharply defined, natural group of the genus Tipula Linnaeus, characterized as follows: Hypopygium of the male—the genital chamber widely open above, (Pl. I, Figs. 1, 2, 3, 4, 5, 6, 6a). The ninth tergite relatively short, the ninth sternite much prolonged beyond the former. The ninth tergite deeply incised in the middle (except madina), the sides emarginate, the lateral portion more or less distinctly incurved beneath, (Pl. I, Fig. 6c). The incurved margin generally ends in a sharp spine, (Pl. I, Fig. 6c), visible in some species (impudica, dimidiata, Pl. I, Figs. 6b, 8) from above. From the lateral inflexed margin extends a thin shelf or lamina, which bears in the middle a process, compressed and sharply pointed, (except *pyramis pellucida*, where it is broader and obtuse), the upper margin of which fits into the median incision of the tergite, (Pl. I, Figs. 6b, 6c, 8, 9). This process I designate as the subtergal process. Ninth sternite ample, more or less deeply emarginate. Pleurites ample, subtruncate or more or less cone-shaped. Pleural suture present, abbreviated (Pl. I, Fig. 1a). The outer apical appendages are small and inconspicuous, narrowly lanceolate, curved cephalad, the apices abut into or lie beneath the lateral emargination of the ninth tergite, Pl. I, Figs. 1, 2, 3, 4, 5, 6, 6a). The inner apical appendages more conspicuous, the posterior portion laminate and subcautinous with the lower apical appendages; the anterior portion is elevated and consists of two more or less distinct, narrow perpendicular blades (Pl. I, Fig. 1a), which are strongly chitinized and the anterior end of the inner blade overlaps the anterior end of the outer. The lower apical appendages are conspicuous and present the principal aspect of the genital chamber. As stated above, they appear to be sub-continuous with the inner apical appendages and both arise from the inner surface of the ninth pleurites; laminate in form, the basal portion broadly horizontal, the apical part more or less convoluted, generally emarginate within and without, (Pl. I, Figs. 1, 2, 3, 4, 5, 6, 10), having somewhat the shape of a ploughshare. In a few species (*diversa*, *lyrifera*, Pl. I, Figs. 1 and 2), they are narrowly lanceolate and extend conspicuously beyond the ninth sternite.

The eighth sternite is narrowed posteriorly, subtruncate, or emarginate apically and bears a brush of stiff hairs. In two species (*pyramis*, *pellucida*, Pl. I, Figs. 7 and 7a) the apical margin bears a median process, from its upper surface, near the base, projects a long, slender, curved appendage (Pl. I, Fig. 7).

Ovipositor elongated; valves slender, the upper pair slightly curved upwards.

The following characters are common to all the species here enumerated and will not be repeated in the description of new species. Rostrum of moderate length and thickness; nasus short, obtuse (except *mitrata*). Palpi robust, the last joint at most as long as the three preceding joints together. Frontal callosity small. Antennae of moderate length, flagellar joints approximately unicolorous, fuscous, except the basal joint, which is more or less concolorous with the scapal joints; the basal enlargement, bearing the usual whirl of setae, is usually more blackish than the rest of the segment, the setae scarcely as long as the respective segment. Thoracic dorsum with four darker lines or stripes, generally narrow (broad, *pyramis*, *pellucida*), the inner pair of these lines apparently limit the normal median vitta, are wider and curved outwardly in front, becoming attenuated and approximating each other posteriorly; the lateral stripes are scarcely more than one half the length of the thorax, the anterior end being at same distance from the pseudosutural foveae, and are margined with a paler line (except *pyramis*, *pellucida*); the outer edge of the inner lines bears a row of generally very short hairs. Wings approximately unicolorous, antestigmal spot distinct, extending at least into cell 1st M^2; except *dimidiata*, stem of cell M^1 scarcely more than one-third the length of the cell. The setigerous punctures (Trans. Am. Ent. Soc., XLIV, p. 107), are especially marked on veins R, Cu, Cu^1 and A^2. Halters pale, knob dark fuscous.

The species are of medium to fairly large size, except *dimidiata*, which is a small fly. As far as known to me, they are all inhabitants of the Pacific slope.

KEY TO THE SPECIES.

1. Eighth sternite of male with a median process; subtergal process short, obtuse and not compressed laterally.................................... 2
Eighth sternite without such a process. The subtergal process long, compressed, pointed.................................... 3
2. Process of eighth sternite elongate, pointed................*pyramis* Doane
The process shorter, rounded................................*pellucida* Doane
3. Lower apical appendages of hypopygium long, lanceolate, conspicuously extending beyond the ninth sternite.................................... 4
This appendage is broader, ploughshare-shaped; not conspicuously prolonged.................................... 5
4. Canthi of the median incision of the ninth tergite very acute (Pl. I, Fig. 1), *diversa* spec. n.
Canthi obtuse, (Pl. I, Fig. 2).............................*lyrifera* spec. n.
5. The ninth tergite produced in the middle, (Pl. I, Fig. 3)........*madina* sp. n.
The ninth tergite deeply and distinctly incised in the middle............ 6
6. Pleurites subtruncate, or emarginate above............................ 7
Pleurites obtusely pointed above..........................*mitrata* spec. n.
7. Incision of ninth tergite broadly U-shaped............................ 8
Incision narrow, sub-parallel, or V-shaped............................ 9
8. Canthi of the incision acutely pointed, (Pl. I, Fig. 9).........*sinistra* spec. n.
Canthi obtuse, subangulate, (Pl. I, Fig. 4)..................*spernata* spec. n.
9. Incision deep, narrow, sub-parallel; canthi prominent, acute, (Pl. I, Fig. 5).....................................*spaldingi* spec. n.
Incision V-shaped, canthi prominent.................................10
10. Canthi obliquely truncate, slightly emarginate, (Pl. I, Fig. 6b), *impudica* Doane
Canthi very acute, (Pl. I, Fig. 8)........................*dimidiata* spec. n.

AUXILIARY KEY TO THE SPECIES.

1. Costal wing-margin fuscous..............................*pellucida* Doane
Not as in the alternative.. 2
2. Cell C of Wing concolorous.. 3
Cell C and S. c. yellowish*.. 8
3. Cu. and its branches margined with fuscous............................ 4
Not as in the alternative.. 5
4. Thorax grayish; the antestigmal spot extends into cell Cu^1..*diversa* spec. n.
Thorax dark yellow; the antestigmal spot does not extend into cell Cu^1, *spermata* spec. n.
5. Wings pellucid.......................................*spaldingi* spec. n.
Wings grayish.. 6
6. Antestigmal spot small, does not extend beyond R. s.; small form, *dimidiata* sp. n.
This spot attains cell 1st M^2.. 7
7. The dorsal abdominal stripe extends uninterruptedly upon the sixth tergite..*madina* spec. n.
Not as in the alternative..................................*mitrata* spec. n.

---

*Generally Cell C is paler yellow than Cell S. c.; very pale in some species.

8. Cu. and its branches seamed with fuscous.................*sinistra* spec. n.
Not as in the alternative.. 9

9. Thorax and wings more grayish............................*impudica* Doane
Thorax yellowish; wings sub-pellucid, yellowish at the base..............10

10. Thoracic stripes broader..................................*pyramis* Doane
Thoracic stripes narrow....................................*lyrifera* spec. n.

Tipula diversa spec. n.

Large, yellowish-gray. Wings gray, a fuscous dot at origin of R. s. and at end of S. c. Veins Cu and Cu^2 lightly seamed with fuscous. Ninth tergite of male with a narrow and moderately deep incision, its canthi acute. Lower apical appendages long, narrowly lanceolate, divergent and conspicuously extending beyond the ninth sternite.

Male.—Length 19.5 mm.; wing 19 mm.

Head: Rostrum yellow,. beset with rather long, black hairs. Three basal joints of palpi sordid yellow, terminal joint dark fuscous. Flagellar joints of the antennæ emarginate above the basal enlargement, joints ten and eleven much more attenuate, the last thirteened joint, very short; pubescens very fine, white. Face yellowish-white, front and occiput yellowish gray with a distinct median, dark line, extending from the tuberosity to the posterior margin; orbicular margin whitish.

Thorax livid. Pronotal scutum margined with white anteriorly, a dark, median line and a dark spot externally. Pronotal scutellum whitish above, darker laterally. Lines of prescutum chocolate-brown, narrow; the inner pair strongly attenuated in their middle third; the median space with an ill-defined, irregular, darker median stripe; the space, exterior to the inner lines and exterior to the pale line surrounding the outer dark lines, is conspicuously studded with setigerous punctures, bearing blackish hairs. Scutum with a smaller, antera-exterior, and an elongate, inner, brown spot each side. Scutel and postnotum with median, darker line, the postnotum with a lateral, darker spot. Pleura yellowish-gray with whitish pruinosity. Wings grayish, more so in the apical portion. Cells C. and S. c. concolorous, scarcely a shade darker than the general color. A fuscous spot at the beginning of R. s. and at the end of S. c. Antestigmal spot well marked, interrupted immediately behind R. s., extends through outer ends of cells R. and M., basal half of cell 1st M^2, into bases of cells M^4 and Cu^1. Veins Cu, Cu^1 and Cu^2 lightly seamed with fuscous. Cells R. and M. more grayish along the center. Stem of cell M^1 scarcely one-sixth the length of the cell. Legs long and slender, yellowish, with a coarse, short, blackish pubescence, femora and tibiæ infuscate at the apex, the tibiæ longer than the metatarsi; tarsi infuscate.

Abdomen yellowish-brown, lighter basally, segments three to six narrowly edged with white posteriorly, a dark-brown dorsal and ventral stripe, lateral stripes ill-defined; the whole abdomen hirsute with an ill-defined, whitish sheen. Eight sternite with a brush of long, yellow hair. Hypopygium (Pl. I, Fig. 1), yellowish-brown, darker posteriorly; ninth tergite with a broad, deep, basal impression, and narrow, moderately deep, median incision, its canthi acute, exteriorly to the latter, the margin is deeply emarginate, the inflexed portion ends in a spine; the subtergal process is long, laterally compressed and very acute. Ninth sternite with deep, U-shaped emargination. Pleurites ample, subtruncate, emarginate, each end of the emargination ends in a claw-shaped, inward bent hook. The lower apical appendages are long, narrowly lanceolate, somewhat twisted and extend considerably beyond the ninth sternite.

Female.—Length 21 mm.; wing 16.5 mm. The dorsal abdominal stripe entire on tergite one, indicated by a median dash anteriorly on segments two to six; lateral margin of tergites conspicuously white and a large, lateral, fuscous dash on each segment; tergites two to seven with a transverse line each side, anteriorly; venter paler; hirsutity in conspicuous.

Holotype—♂. Vineyard, Utah, June, 1912, (T. Spalding).

Allotype—♀. Silver City, New Mexico, May 24, 1913.

Paratypes—1 ♂. Platt Canyon, Colorado, June 27, 1915. 2 ♂ ♂, Clear Creek, Colorado, June 23, 1914 (Oslar); 3 ♂ ♂ and 2 ♀ ♀, Silver City, New Mexico, May, 1913.

A very distinct species. Its nearest ally is *T. lyrifera*, which it closely resembles in the lower apical appendages, but from which it is distinguished in its general darker coloration, grayish wings, cell C. concolorous and the fuscous spot at the origin of R. s. and at the end of the S. c. vein.

Tipula lyrifera spec. n.

Yellowish. Wings pale. Ninth tergite of hypopygium with deep, narrow incision, its canthi obtuse; lateral lobes with deep, rounded emargination; lower apical appendages elongate-lanceolate, twisted, conspicuously prolonged beyond the ninth sternite.

Male.—Length 17.5 mm.; wing 17 mm.

Head: Rostrum yellow, frontal prolongation beset with short, black hairs; nasus scarcely indicated. Palpi yellowish, light fuscous outwardly. Face and occiput yellowish with whitish pollinosity and darker median line.

Thorax light, grayish-yellow. Pronotal scutum infuscate in the middle; scutel pale yellow. Prascutal lines light brown, the inner pair almost obsolete posteriorly; sides of præscutum light brown. Scutum concolorous, an elongate light brown patch along the median line, another, irregular, curved line externally. Scutel and postnotum slightly darker, the former with an obscure, the latter with a distinct, median fuscous line.

Pleura sordid yellowish, with grayish-white bloom. Legs slender, yellowish; hairy vestiture dense, short, blackish. Femora and tibiæ lightly infuscate at the apex, tibiæ conspicuously longer than the metatarsi; tarsi yellowish-fuscous.

Wings pale with a faint, yellowish-gray tint, more grayish towards the apex; costal cells pale yellow; stigma yellowish fuscous. Ante- and post stigmal spots less conspicuous than in *divergens*, extending through basal half of cell 1st M^2 into cells M^4 and Cu^1; veins brown, not seamed with fuscous; stem of Cell M^1 about one-third the length of the cell.

Abdomen yellowish with ill-defined, pale fuscous dorsal line, interrupted on the segmental incisions; posterior margin of segments one to four pale; hairy vestiture short, sparse, blackish; venter pale. The eight sternite yellowish-fuscous, with a dense brush of stiff, yellow bristles. Hypopygium (Pl. I, Fig. 2) yellowish-brown, appendages yellowish-white. The ninth tergite with deep, narrow, median incision and a longitudinal furrow; canthi somewhat prominent, obtuse—seen from above—ending in an acute tooth directed ventrad; the subtergal process slender, acute; lateral lobes of the somite deeply emarginate, the inflexed portion without perceivable spine. The ninth sternite with a deep, U-shaped emargination, the lateral margin of which bears a pale-yellow, membranous appendage. Pleurites slightly emarginate above, each end of the emargination sharply acuminate, the anterior sharp point incurved; the evoluted portion of the inner lamina of the inner, apical appendage very small and inconspicuous; the lower apical appendage long, lanceolate, twisted, deeply sinuate near its base within and conspicuously extended beyond the ninth sternite; its inner face conspicuously bearded with yellow hair.

Holotype ♂. Vineyard, Utah, June 6, 1912 (T. Spalding).

Closely allied to and congeneric with *divergens*, from which it differs in its somewhat smaller size, paler color of body and wings and absence of fuscous spots at origin of R. s. and end of S. c. vein.

Tipula madina spec. n.

Medium size. Cell C. concolorous. The ninth tergite of the hypopygium produced in the middle with a small central emargination; evoluted portion of the inner lamina of the inner apical appendage large, leaf-like; lower apical appendage not protruding beyond the ninth sternite.

Male.—Length 13.5 mm.; wing 14.7 mm.

Head: Rostrum yellow, shining, nasus distinct, obtuse; hairy vestiture blackish, inconspicuous; palpi pale fuscous. Scapal joints of antennæ yellow. Face, front and occiput, pale yellow with uhitish bloom, the occiput with impressed, darker line.

Thorax livid. Pronotal scutum yellowish; scutel pale yellowish, sides fuscous. Lines of prascutum light brown, narrow, distinct; interspaces with numerous piliferous punctures, hairs very short, blackish. Scutum with a smaller, rounded, antero-exterior spot and an elongated, larger inner patch each side, light brown. Scutel and postnotum with median, darker line, the postnotum darker on the sides. Pleura gray with whitish pollinosity, the pteropleura and pleuro-dorsal membrane sordid yellow. Legs slender, yellowish, pilosity very short, brownish; femora slightly, tibiæ not, infuscate at the apex, the latter distinctly longer than the metatarsi; tarsi infuscate. Wings pale-gray, Cell S. c. and base yellowish, Cell C. concolorous. Stigma pale fuscous. Veins C., S. c. and R. yellowish, other veins brown, not seamed with fuscous; the antestigmal spot inconspicuous, ill-defined, extends interruptedly thru base of cell 1st M^2, into base of cell M^4; post-stigmal spot distinct.

Abdomen yellow with light brown dorsal vitta, extending uninterruptedly from tergite one to the base of tergite six; a lateral, conspicuous dash on tergites one to eight; lateral margin pale, grayish-yellow. Venter somewhat darker along the median line, more so caudally. The eight sternite broadly truncate with a brush of moderately long bristles; central bristles decussating. Hypopygium (Pl. I, Fig. 3) yellowish brown; the ninth tergite produced mesially and slightly emarginate apically, broadly and deeply grooved, lateral lobes with deep, rounded emargination; the subtergal process acute, almost entirely concealed by the large, evoluted portion of the inner apical appendage. The ninth sternite with a broad, U-shaped emargination, the margin pale yellow with a narrow, pale, membranous appendage. Pleurites subtruncate, angles of the truncature acuminate; the inner apical appendages conspicuous, bent dorsad apically, the evoluted portion large, leaf-like, almost completely concealing the subtergal process; the lower apical appendages broad, convoluted, yellow-haired within, with a patch of dark brown hairs; caudal portion subdorsad, apex obtusely rounded. Penis guard large, conspicuous.

Holotype—♂. Prova, Utah, June 24, 1912 (T. Spalding).
Paratype—1 ♂.

The formation of the ninth tergite distinguishes this species from the other members of the group.

Tipula spaldingi spec. n.

Moderately large; general coloration yellowish. The ninth tergite deeply incised and narrowly and deeply channeled its whole length; canthi produced, acute. The lower apical appendages obtusely rounded at the apex.

Male.—Length 17 mm.; wing, 16 mm.

Head: Rostrum yellow, some lustre; frontal prolongation sparsely hairy. Palpi brownish-yellow, darker outwardly. Antennæ rather slender and somewhat elongate; scapal and first flagellar joints, pale yellow, following joints subcylindrical, light brown, outer joints dark, pubescens white. Face, front and occiput yellowish with a white bloom, a dark fronto-occipital line.

Thorax yellowish-gray, mesonotum more livid. Pronotal scutel yellowish above. Prascutal lines light brown, narrow and nearly straight, hairs of the interspaces very fine and short; markings of scutum ill-defined, a smaller, rounded, antero-exterior spot and an elongate blotch along the median line; scutel and postnotum grayish-pollinose with a faint, median line. Pleura yellowish-gray, pollinose; pleuro-dorsal membrane yellowish. Legs slender, yellow; pilosity coarse, short, blackish and somewhat appressed; femora and tibiæ slightly infuscate before the apex, the tibiæ longer than the metatarsi; tarsi yellowish-brown. Wings subhyaline with a yellowish tinge, cell C. concolorous; costal veins and vein R. yellowish, the other veins brown, delicate; stigma light brown; antestigmal spot distinct, extends thru outer end of cell R. extreme point of Cell M, basal portion of cell 1st M^2 into base of cell M^4 and slightly into base of cell Cu^1; post-stigmal spot ill-defined; a whitish streak, not very distinct, in cell A^1.

Abdomen yellow, dark brown dorsal and lateral stripes (very variable in different specimens), lateral margin of tergites yellowish-gray; venter somewhat darker, especially posteriorly. Eight sternite subtruncate with a dense brush of coarse, brownish bristles, longer than the somite. Hypopygium brownish-yellow; ninth tergite deeply grooved in the middle, apical margin deeply and narrowly incised in the middle, canthi prominent, acute, its points slightly depressed, lobes with a deep, rounded emargination, margin of the inflected portion pale yellow; subtergal process compressed, apex bent downward. Ninth sternite with deep, U-shaped emargination, at its lower end, the somite bulges outward in form of an oval appendage; from the upper part of the margin is suspended, a narrow, elongate-triangular, pointed, yellowish, membranous appendage. Pleurites narrowly subtruncate, angles of the truncate cuspidate; evoluted part of the inner apical appendages conspicuous; lower apical appendages relatively short, broad basally, rounded at the tip, a small but deep sinuosity on the inner margin near the base, the inner face of the appendages is coarsely hairy.

Holotype—♂. Eureka, Utah, August 1, 1911 (T. Spalding).

Paratypes—1 ♂. Eureka, Utah, June 30, 1911; 6 ♂ ♂, Prova, Utah, June 24, 1912; 2 ♂ ♂, Stockton, Utah, June 13, 1913, (T. Spalding).

The paratypes from Stockton have the abdomen distinctly darker and the lateral margin of the ninth tergite not paler. The lower appendages in some specimens are conspicuously curved outwardly and visible beyond the ninth sternite. A very distinct species.

Tipula sinistra spec. n.

Moderate size; general appearance yellowish. Cells C. and S. c. yellowish; Cu and its branches broadly seamed with light fuscous. The ninth tergite deeply and broadly emarginate, its canthi acute.

Male.—Length, 15 mm.; wing 17 mm.

Head yellow; rostrum darker, some luster; hairy vestiture sparse, long. Palpi yellowish-fuscous, darker outwardly. Front and vertex with a dense white bloom, fronta-occipital line impressed, fuscous.

Antennæ slender, moderately long; scapal and first flagellar joints yellow, the other flagellar joints uniformly fuscous, subcylindrical, pubescence very fine, white.

Thorax grayish-livid. Pronotal scutel but little paler above. Prascutal stripes light brown, narrow, straight, not curved outwardly in front; the prascutum exterior to the inner lines, grayish pollinose. Markings of scutum ill-defined, a small antero-exterior spot, an elongate spot along the lateral margin and a larger, elongate spot near the median line, light brown; scutel and postnotum brownish-yellow, lateral edge of the latter pale-yellowish. Pleura obscure yellowish with grayish bloom; pleuro-dorsal membrane sordid yellow. Legs brownish-yellow, pilosity coarse, blackish, somewhat appressed; base of femora and coxæ yellow, femora and tibiæ infuscate at the apex, the tibiæ longer than the metatarsi; tarsi fuscous outwardly. Wings pale gray, subpellucid; cells C and S. c. yellowish; veins C., S. c. and R. yellowish, the other veins brown, delicate, especially beyond the cord; vein Cu, and its branches, very broadly seamed with pale fuscous; stigma pale fuscous; the antestigmal spot very distinct, it extends broadly through the outer part of cell R, occupies nearly three-fourths of cell 1st M^2 and the entire widths of basal two-fifths of cell M^4; cell 1st M^2 pentagonal; stem of cell M^1 one-third the length of the cell.

Abdomen yellow with a faint, darker, dorsal stripe; tergites three to seven with fuscous, lateral line; pilosity sparse, short; venter darker yellow. Eight sternite reddish-yellow, apex truncate with a brush of stiff, grayish-yellow, decussating bristles. Hypopygium reddish-yellow; ninth tergite broadly and very deeply emarginate, the canthi very acute, the part of the somite adjacent to the outer half of the emargination, appears to be more membranous than usual; lobes with moderately deep, rounded emargination; the inflexed portion ends in an acute spine; subtergal process broad, obtusely pointed. Ninth sternite broadly and deeply emarginate, lateral margin with a pale-yellowish, narrow, membranous appendage. Pleurites emarginate above, angles of the emargination acutely acuminate; inner apical appendages strongly bent dorsad in front, evoluted portion conspicuous, large; lower apical appendages rather short, twisted, the apical portion bent outwardly, apex pointed, fuscous within; surface covered with yellow hairs.

Holotype—♂. North-Western Colorado, August 11, 1911, (E. J. Oslar).

A distinct species. Its nearest ally appears to be *impudica* Doane, from which it differs in its more slender antennæ, broadly seamed vein Cu and its branches and the difference in construction of the hypopygium.

Tipula spernata spec. n.

Large; general coloration dark yellow. The ninth tergite of the male abdomen with a deep, U-shaped emargination, the canthi nearly rectangular. Lower apical appendages not prolonged, broad, curved outwardly, the inner angle extended, acute. Vein Cu and its branches seamed with fuscous.

Male.—Length 17 mm.; wing 19 mm.

Head yellow; rostrum beset with rather long, black hairs. Palpi yellowish-fuscous, darker outwardly. Antennæ moderately long, scapal joints yellow, first flagellar joint yellowish-fuscous, remainder fuscous, segments elongate cylindroidal. Vertex dark, sordid yellow with strongly marked impressed, dark fuscous line.

Thorax dark yellow. Anterior margin of the pronotal scutum and a stripe each side grayish-white, within this stripe is narrowly edged with fuscous, while externally to it is a wider, pale fuscous stripe; pronotal scutel pale yellow above, pale fuscous laterally. Prascutal lines not sharply defined, the inner lines sinuous, wider in middle third. Markings of scutum indistinct. Scutel and postnotum grayish-yellow with indistinct median line, the postnotum edged with pale, laterally. Pleura concolorous with a grayish bloom, pleuro-dorsal membrane paler. Legs yellow, pilosity short, blackish, appressed; coxæ paler; femora and tibiæ infuscate at the apex, the latter longer than the metatarsi; tarsi-yellowish fuscous. Wings grayish, darker in apical portion; cell C concolorous, cell S. c. yellow; stigma brown, antestigmal spot conspicuous, extends broadly through the outer end of cell R, basal half of cell 1st M^2 into basal third of cell M^4; post stigmal spot obsolete. Veins brown, Cu and its branches broadly seamed with fuscous; cell 1st M^2 about twice as long as its greatest width, pentagonal.

Abdomen brownish-yellow; a fuscous dorsal stripe on tergites one to four; a lateral stripe interrupted before the posterior margin of the segments, posterior and lateral margins, pale gray. Venter dusky-yellow. Eight sternite slightly emarginate each side of middle, the inner end of the emarginations edged with fuscous, a brush of yellowish-gray bristles, longer than the sternite, pale at the base, the inner bristles decussating. Hypopygium (Pl. I, Fig. 4) yellowish-brown; the ninth tergite short with a deep, U-shaped emargination, its canthi approximately rectangular, lobes feebly emarginate, sides strongly incurved and ending in an acute spine; the subtergal process broad. Viewed laterally, its lower edge nearly straight, obtusely pointed; the evoluted portion of the inner apical appendages inconspicuous; the lower apical appendages broad, curved outwardly, the inner part prolonged and pointed, yellow-haired within. Ninth tergite broadly and deeply emarginate with a narrow, pale, membranous appendage from the edge of the emargination. Pleurites emarginate above, angles of the emargination acutely pointed.

Holotype—♂, South Park, Colorado, June 23, 1916.

Paratype—♂, Clear Creek, Colorado, June 11, 1916, (E. J. Oslar).

Similar to sinistra, but larger, and from which it differs in the prescutal markings and hypopygial construction, especially the tergite and the inner apical appendages; the antestigmal spot is well-nigh identical in both species.

Tipula mitrata spec. n.

Medium size. Head and thorax gray, abdomen yellow. Incision of hypopygeal tergite moderately deep, subparallel. Pleurites obtusely pointed; the lower apical appendages broad; the inner angle produced.

Male.—Length 14 mm.; wing 14 mm.

Head: Rostrum reddish-brown, hairy vestiture blackish and rather long; nasus long and acute. Palpi fuscous. Antennæ of moderate length, scapal and first joint of flagellum yellow, flagellar joints cylindroidal. Face yellowish-white; front and vertex gray with well marked, dark fuscous line.

Thorax gray. Pronotal scutum with median dark line; scutel pale yellow above. Prescutal lines brown, narrow, the inner pair wider in its anterior half, slightly curved outwardly anteriorly; interspaces with numerous setigerous punctures, bearing short, black hairs. Scutum more ashen-gray, a dark spot on the antero-exterior angle and an elongate spot near the median line. Scutel yellowish-gray, shining, with darker, median line. Postnotum dark gray, with median, dark line. Pleural episterna yellowish-gray, epimera dark-gray; pleuro-dorsal membrane sordid yellow, the whole pleura with a grayish-white pollinosity. Legs yellow, hairy vestiture short, dense, blackish and appressed; femora conspicuously infuscate at the apex, tibiæ not infuscate at apex and distinctly longer than the metatarsi; tarsi fuscous. Wings grayish, darker in cells R^2 and R^3; cell C concolorous, cell S. c. and stigma pale fuscous, antestigmal spot distinct, extends broadly through outer end of cell R^1 extreme end of cell M^1 basal half of cell 1st M^2 into base of cell M^4 and slightly into cell Cu^1; post-stigmal spot distinct. Cell 1st M^2 about twice as long as wide, pentagonal; a large sub-hyaline space in cell M^1 a sub-hyaline streak in cell A^1; veins C, S. c. and R. yellow-brown, other veins brown.

Abdomen yellow; tergites four to six with fuscous, dorsal streak, each tergite with a lateral curved, fuscous dash, abbreviated posteriorly; margin of tergum grayish-white; venter with dusky, median stripe. Eight sternite subtruncate, with a rather narrow brush of yellowish-gray, not very stiff, bristles and a pencil of three or four bristles from the lateral angle bend inward; from the upper surface of the somite same distance from its free margin, arises a soft, membranous, narrow, white process, extending to about two-thirds the length of the brush. Hypopygium brown, shining; ninth tergite broadly and deeply channeled in the middle, incision V-shaped, subparallel, moderately deep, lobes with deep, rounded emargination, sides scarcely inflexed, angles of the median incision prominent, acute; subtergal process long, obtusely pointed. Ninth sternite with V-shaped emargination, the adjoining part of the somite sub-membranous. Pteurites subangulate, obtusely pointed; inner apical appendages small and inconspicuous, the evoluted portion scarcely perceptible; lower apical appendages (Pl. I, Fig. 10), broad and flat, the inner apical angle prolonged and beset with short, yellow hairs.

Holotype—♂. Silver City, New Mexico, May 26, 1913.

In general appearance, this species closely resembles *impudica* but the hypopygeal structure, especially the lower apical appendages, is very different. The peculiar appendage of the eighth sternite must not be confounded with the median process as found in *pellucida* and *pyramis*, where it arises from the edge of the somite and is not membranous.

Tipula dimidiata spec. n.

Small size. Cell C. concolorous; antestigmal spot very faint. Tergite of hypopygium broadly channeled and deeply incised in the middle, the lower apical appendage turned upward apically, fuscous, broadly rounded at the apex.

Male.—Length 10 mm.; wing 11 mm.

Head yellowish-gray. Rostrum dusky-yellow; frontal prolongation with very few hairs; nasus scarcely evident. Palpi light fuscous, darker outwardly. Face whitish; the fronto-occipital line distinct, expanded into a spot on the frontal tubercle.

Thorax yellowish-gray. Pronotal scutum with a white line each side which is continued along the anterior margin, outer part of somite light fuscous; pronotal scutel whitish above, lateral part fuscous. Prescutal lines dark brown, distinct, the inner pair not sharply defined, nearly straight and a trifle wider anteriorly, the median space mouse-gray. Markings of scutum very indistinct. Scutel and postnotum dark gray with faint median line. Pleura and pleuro-dorsal membrane yellowish-gray with a faint, whitish pollinosity. Legs slender, yellowish, pubescence very fine; femora and tibiæ infuscate at the apex, the tibiæ much longer than the metatarsi; outer tarsal joints fuscous. Wings grayish, a trifle darker in apical portion; cell C. concolorous, cell S. c. light fuscous; stigma light fuscous, the ante-stigmal spot very indistinct, extending as a narrow, pale streak through cell 1st M^2 into cell Mi; past stigmal spot obsolete; cell 1st M^2 scarcely twice as long as wide, pentagonal; stem of cell M^1 one-fourth the length of the cell. Veins brown, Cu not seamed with fuscous.

Abdomen yellow, dorsal stripe ill-defined, more distinct on tergite five; lateral fuscous stripe well marked, lateral margin of tergum not paler; venter paler. Eight sternite light brown, apical margin truncate with a narrow brush of yellowish-gray setæ. Hypopygium light brown. Ninth tergite (Pl. I, Fig. 8), broadly channeled and deeply incised, canthi prominent, acute, lobes with deep, rounded emargination; the lateral margin ends in an acute spine; subtergal process narrowly-lanceolate. Ninth sternite deeply and broadly emarginate, margin of the emargination and lower margin of the somite pale yellow. Pleurites subtruncate above; inner apical appendages bent upward anteriorly, the evoluted portion small, but distinct; lower apical appendages irregularly scalloped exteriorly in their basal part, the distal part semidorsad, tongue-shaped, fuscous.

Holotype—♂. Silver City, New Mexico, June 1, 1911.

At once distinguished by its small size. Superficially it resembles *impudica* and *mitrata*, from both of which it differs in the faint ante-stigmal spot, aside from structural differences of the hypopygium.

Tip. impudica Doane. Type locality, Wawai, Washington. Numerous specimens in my collection from the following localities in Colorado: Clear Creek, July; Chimney Gulch, Golden, June; Four-Mile Creek, September; Bear Creek, Morrison, July; Cardif, June, July; Mancos, August, (E. J. Oslar).

Tip. pyramis Doane. Type locality, Pryamid Lake, Nevada. Specimens in my collection from the following localities in Utah: Provo, June; Deer Creek, Provo Canon, August; Eureka, June; Stockton, June; Vineyard, July, August, (T. Spalding).

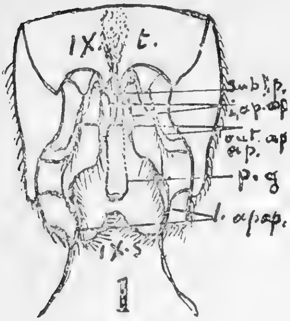
Tip. pellucida Doane. Annals Ent. Soc. of America, Vol. V, p. 61. Tip. clara Doane, syn.

EXPLANATION OF PLATE I.

The following abbreviations attached to the Figures signify as follows:

viii s.—Eighth sternite.
ix t.—Ninth tergite.
ix s.—Ninth sternite.
subt. p.—Suptergal process.
ix p.—Ninth pleurite.
pl. s.—Pleural suture.
I. ap. ap.—Inner apical appendage.
out. ap. ap.—Outer apical appendage.
l. ap. ap.—Lower apical appendage.
p. g.—Penis guard.

1. Tipula diversa. Upper view of hypopygium.
1a. Lateral view of pleurite, showing appendages and pleural suture.
2. Tipula lyrifera. Upper view of hypopygium.
3. Tipula madina. Upper view of hypopygium.
4. Tipula sinistra. Upper view of hypopygium.
5. Tipula spaldingi. Upper view of hypopygium.
6. Tipula impudica. Upper view of hypopygium.
6a. Lateral view of hypopygium.
6b. Ninth tergite from above.
6c. Ninth tergite from below.
7. Tipula pyramis. Lateral view of eighth sternite.
7a. Eighth sternite, seen from below.
8. Tipula dimidiata. Dorsal aspect of ninth tergite.
9. Tipula sinistra. Upper view of ninth tergite.
10. Tipula mitrata. Caudal part of hypopygium showing lower apical appendages, seen from above.



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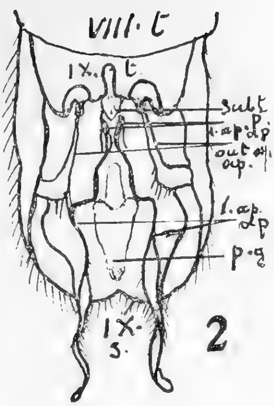

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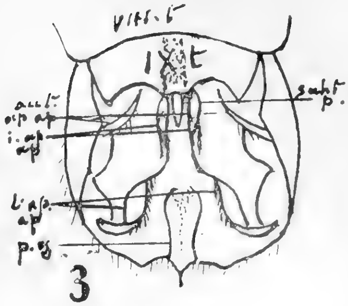

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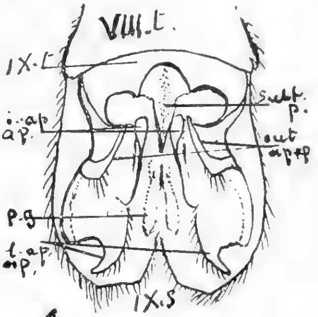

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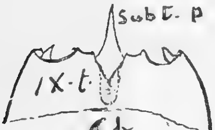

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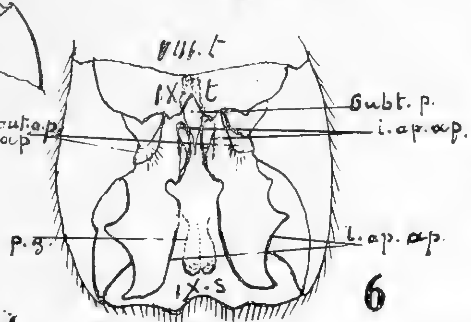

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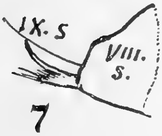

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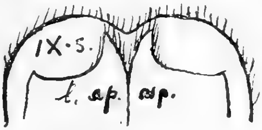

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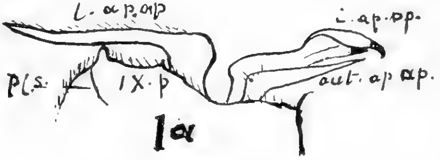

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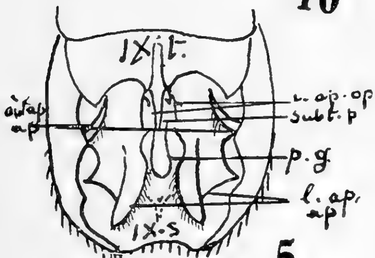

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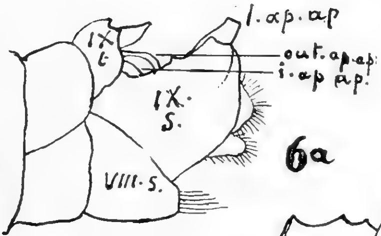

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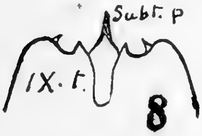

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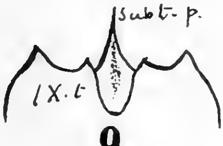

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6c

W. G. Dietz

NEW NEARCTIC FOSSORIAL HYMENOPTERA.

By Nathan Banks.
Museum Comp. Zoology, Cambridge, Mass.

The following new species were found in the course of identification work on the Museum collections. A synoptic table of *Pepsis* is given, and also for most of the Eastern species of *Dasymutilla*. In both of these structural characters are utilized that have not previously been considered. The types are all in the Museum of Comparative Zoology.

Crabronidæ.

Entomognathus memorialis sp. nov.

♀. In structure close to *E. lenapeorum*, that is with the frontal groove evanescent and the front below ocelli tumid; clothed with much pale hair, the clypeus silvery, metanotum with sculpture very similar to that species. Black; the scape beneath, pronotum each side and connected down to the tubercles, tegulæ in part, two small spots on the scutellum, front and mid tibiæ on outer sides, hind tarsus on base, and a spot each side on abdominal segments 1 to 4, yellow. It differs from *lenapeorum* in the spotted abdomen, black tarsi and larger size, and the abdomen is broader, especially at base.

Length, 6.2 mm.

From Glencarlyn, Va., July 26th.

Lindenius wenonah sp. nov.

♂. Structure in general similar to *L. errans*, the ocellar depressions, however, very indistinct, body covered rather more thickly with sericeous pubescence. It differs at once in coloration and anterior tarsi. In the front tarsus the first joint has an expansion on outer side as wide as the joint; this expansion is mostly black. The clypeus, mandibles (except tips), scape, pronotum, tubercles, tegulæ, scutellum and post scutellum (each with borders laterally), most of the legs, and nearly entire dorsal surface of abdomen, yellowish. The flagellum is pale beneath; bases of femora and tips of tarsi dark, the basal half of the first abdominal segment, and the borders of the others narrowly black. The wings have yellowish-brown venation; the venation is on the same plan as in *L. errans*, except that the cubital cross-vein ends near the middle of the marginal cell, instead of plainly before.

Length, 4 mm.

From Tallac, Eldorado Co., Calif., (Giffard).

Rhopalum (Alliognathus) carolina sp. nov.

♀. Shining black, with fine appressed white pubescence, silvery on the clypeus and half-way up the orbits; scape beneath, front tibiæ and tarsi, mid-tarsi (except apical two joints), and the spurs yellowish. Structure in general similar to the western *A. occidentalis*, but smaller. The truncate projection of clypeus barely noticeable; frontal groove and ocellar depressions distinct; first joint of the flagellum barely longer than the second; fovæ at base of the enclosure very small and faint; the Y-ridge distinct and transverse ridges outside of it; hind tibiæ not serrate, but with a row of fine, short bristles; pygidium not very broad, truncate at tip; stigma dark brown, veins much paler brown.

Length, 5.5 mm.

From north fork of the Swannanoa River, Black Mts., N. Car., May.

Thyreopus rufibasis sp. nov.

♀. Black, clothed with sericeous pubescence, dense and silvery on the clypeus. Mandibles (except tip), clypeus, scape, pedicellum, first joint of flagellum, pronotum, tubercles, large spot below fore wing, tegulæ, scutellum, and spot each side in front, first and second segments of abdomen almost wholly, and very narrow spot each side on the third segment, yellow to rufous; the legs largely rufous, femora darkened through middle. Wings brownish, stigma yellowish, veins brown. First joint of flagellum plainly longer than the second; ocelli rather large, hind ones scarcely nearer eyes than to each other; pronotum smooth; dorsulum densely, finely punctate; scutellum more sparsely punctured; postscutellum striate; metanotum coarsely rugose, the groove broad in the middle, each side are several irregular areas, behind on each side is a lateral area which is crossed by two or three ridges, outside of the lateral ridges are a few foveæ; abdomen very minutely punctate, moderately slender, pygidium punctate and hairy.

Length, 9 mm.

From Gulfport, Florida, (Reynolds).

Blepharipus parkeri sp. nov.

♀. Black, more or less sericeous, most distinct on clypeus, but also on lower sides of head, mesopleura and tibiæ. Mandibles in part, scape beneath, anterior tibiæ in front, mid and hind tibiæ at base, front and mid basitarsi and the spurs pale whitish; sometimes a small spot on the pronotum. Wings with black stigma and venation. Enclosure of metanotum strongly marked and margined by impressed foveæ, the surface each side convex and polished, posterior face slightly rugulose at tip, nearly smooth above, lateral ridges distinct on lower half, and outside of it a foveate groove, the pleura smooth and shining. Abdomen polished, apical segments more sericeous, below with row of hairs at tip of each segment; pygidium dull punctate.

Length, 5 to 6.5 mm.

From Lexington, Mass., July. Nearest to *B. ater*, but distinct by the pale marks.

OXYBELIDÆ.

Oxybelus carolinus sp. nov.

♀. Closely similar in most respects to *O. packardi* Rbt.; it differs in that the spine is acute at tip, tapering throughout and the face is broader than in that species, the lateral surfaces of the propodeum are more completely striate; the upper part of the mesepisternum has no distinct oblique rugæ. There are no spots on the scutellum nor is the hind border of mesonotum pale; otherwise it is similar to that species and of the same size.

From Southern Pines, N. Car., May 29th, (Manee).

PHILANTHIDÆ.

Philanthus carolinensis var. **reductus** var. nov.

Polished black and marked with yellow about as in the typical form, but the scutellum has no mark, nor is there an interrupted band on the first abdominal segment, and in the female there is no spot on the pygidium. The first abdominal segment is a little more swollen above than in the type. In the male the hair on venter is mostly confined to the middle area of the last ventral, where it forms a dense transverse row, elsewhere the hair is sparse, (in the typical form the last two ventral segments are densely clothed with hair).

Length, 7 to 9 mm.

From Chesapeake Beach, Maryland, and Black Mt., N. Car. Both this and the typical form differ from *P. bilunatus* in the position of the interrupted band on the second abdominal segment; in the latter species the band is further back, and curves backward, moreover the bands on other segments are subinterrupted each side, and the pit on the metanotum is striate at bottom.

LARRIDÆ.

Tachytes pennsylvanica sp. nov.

♂. Related to *T. pepticus* of the west. Black with black legs, only about two or three joints of tarsi pale, front coxæ without spines and femora without groove. It is a larger and heavier insect than *T. pepticus*, the face of the male is broader below, and clothed with yellowish gray hair, white above near the ocelli, the hair on pleura and especially on the metanotum is much longer and denser than in *T. pepticus*. The clypeus has a broad projection in the middle; the metanotum with a dorsal groove. The third joint of the antenna is plainly a little longer than the fourth; the pygidium is clothed with white hair; the emargination of the ventral plate is broader than in *T. pepticus.*

Length, 13 mm.

From Rockville and West Fairview, Penna., July and August (Knull and Kirk).

Tachysphex maneei sp. nov.

♀. Resembles *punctifrons* in having long antennal joints, but with a narrower vertex, and the face clothed with a silvery pubescence; legs with black (instead of white) spurs; the head is more coarsely punctate than in *T. punctifrons* and the abdomen with four silvery bands. The lower edge of clypeus is evenly rounded; width of vertex about equal to second and third antennal joints together, much less than the third and fourth together, the third barely shorter than the fourth, this and all beyond longer than usual; dorsum of metanotum finely granulate, the sides finely striate; pygidial area slender, and sparsely punctate; marginal cell obliquely truncate. Color, wholly black.

Length, 8.7 mm.

From Southern Pines, N. Car., August 19, (Manee).

Larropsis distincta var. **semirufa** var. nov.

Structurally similar to the typical form, but in both sexes the basal two or three segments of the abdomen are bright red above. In the male the pygidial area is not silvery above as in the typical form, but is punctured in the same way. As large as the typical form, which it appears to replace in the north.

From Lexington, Dennis, Provincetown and Essex Co., Mass., in August and September, (Morse and Banks).

PSAMMOCHARIDÆ.

Psammochares eurydice sp. nov.

♀. Closely resembles *P. tropicus;* black, with reddish on second segment of abdomen extending partly over the first and third segments. Structure of thorax, legs, abdomen, and venation about as in that species; the hair on basal abdominal segment is shorter and the groove on metanotum is not as evident. It differs in that the head is much more narrow, the face at vertex is hardly as wide as the second and third joints of the antennæ together; the third joint of the antennæ is rather longer than in *Ps. tropicus,* the spines of the comb of front tarsi are rather shorter, and the ocellar triangle is more equilateral, the lateral ocelli a little nearer to the eyes than to each other.

Length, 13 mm.

From Spring Creek, Decatur Co., Georgia, July 16, (Bradley).

Psammochares sublaevis sp. nov.

♀. Black. Spines of comb of anterior tarsi very long and curved, as in *P. scelestus* and *P. astur;* third joint of antennæ very long, with the second about equal to vertex width, third and fourth joints subequal; vertex straight across; ocelli as in allied forms; pronotum angulate behind; metanotum rather short, no groove; legs slender and spined as in allied forms. Body throughout with very short hair or almost absent, that on head above antennæ hardly more than one-half as long as in *P. scelestus* or *P. astur*, below antennæ almost without hair; hair on mesonotum very short, that on metanotum fairly long, almost wholly absent from pleura, (which is very hairy in *P. scelestus* and *P. astur*); very few hairs on front of anterior coxæ, mid-coxæ with only few very minute hairs below, (prominent in *P. scelestus*, but not in *P. astur*). Wings black; both submarginal cells longer than high; first recurrent ends near tip of second submarginal, second recurrent bowed out, ends near middle of the third submarginal cell.

Length, 10 to 12 mm.

From Marion County, Indiana, and Sea Cliff, N. Y.

Lophopompilus carolinus sp. nov.

♀. Black, with a red mark on the second abdominal segment partly divided, as in *L. atrox.* Structurally similar to *L. atrox* in face, antennæ, thorax, legs and venation, but only about one-half the size of that species. It differs from *L. atrox* in that there is practically no hair on the pleura, only few fine, scattered hairs, while in *L. atrox* the pleural hair is long and dense; the hair on other parts of the body is, perhaps, a little shorter proportionally than in that species. The emargination of the clypeus is nearly as large as in *L. atrox.*

Length, 12 mm.

From Black Rock, North Carolina, September, (Sherman).

Batazonus flavipennis sp. nov.

Head mostly yellowish, darker in middle above the antennæ; antennæ pale on basal half, beyond dark; thorax mostly dark, hind and lower border of pronotum pale, and some pale on mesonotum and scutellum; abdomen mostly yellow, the basal segments darker on apical part; femora dark on basal half or more, beyond the legs are yellowish; wings yellowish, apex distinctly dark. Vertex rather narrow, not as wide between eyes as the length of third joint of antenna; lateral ocelli nearer to eyes than to each other. The spines in the comb of anterior tarsi are very long and rather flattened, as in *B. algidus* and *ferrugineus;* the clypeal suture is as in *B. algidus;* from this latter it is separated by the very different coloration.

Length, ♀, 20 mm.; ♂, 15 mm.

From Salt Lake, Utah (Garman) and Jemez Springs, New Mexico (Woodgate).

Pedinaspis mariæ var. **antennalis** var. nov.

Colored in general like typical *P. mariæ;* the thorax reddish, abdomen mostly reddish, basal segment rather darker, second with dark tip, third and fourth mostly black, pale on base, fifth and sixth with silvery sericeous hair; venter pale on base, black toward tip; wings marked as in *P. mariæ*, but the pale band broader and more distinct. It differs from *P. mariæ* in having the first and second joints of the antennæ reddish, and in the reddish clypeus; the legs are almost wholly black as in *P. mariæ*. The posterior face of the metanotum is transversely rugose, more than in *P. mariæ*. Smaller than that species.

Length, 11 mm.

Falls Church, Va., 28th July.

In *P. legatus,* which also has the basal joints of antennæ rufous, the whole head is also rufous, and the marks on posterior part of abdomen are different.

Pseudagenia floridana sp. nov.

♀. Metallic blue as in *P. coerulescens;* the head and antennæ rufous, the head with a large quadrate dark spot inclosing ocelli and reaching nearly to the base of the antennæ. Abdomen metallic bluish above, dull yellowish beneath. Legs with the tibiæ and tarsi black; the femora and coxæ rufous, the coxæ and the mid and hind femora with a dark spot or streak above. Wings nearly hyaline, tip darker; spurs black. Structure and venation similar to *P. coerulescens*, the thorax with silvery pubescence.

Length, 6 mm.

From St. Augustine, Florida, 17th April, (C. W. Johnson).

Pepsis novitia sp. nov.

♂. Related to *P. mildei;* black, iridescent purple, legs black, antennæ (except basal joints) yellowish; wings colored as in *P. chrysothemis*, broad basal and apical dark bands, no pale tips, middle yellowish, but not very bright. The fourth ventral segment has two oblique rows of long curved bristles (as in *P. elegans*), and on fifth segment lateral rows of erect hair, between these hair combs the surface of the fourth and fifth segments is polished and slightly depressed. The subgenital plate is elongate, somewhat hairy towards tip, and with a faint basal median carina. The metanotum is transversely wrinkled, no ridge separating the posterior slope, which is also partly wrinkled, the lateral angles fairly prominent, but dentate. Third cubital cell fully as broad as long. Size of *P. mildei.*

From Fedor, Lee County, Texas, 29th May, (Birkman).

Pepsis arizonica sp. nov.

♂. Black; abdomen bluish and parts of the head and thorax also in certain lights. Wings yellowish, about as in *P. formosa*, base and tip broadly black, but the black rather definitely limited, reaching to the third cubital cell, base not black as far out as in *P. ceberus* and *P. chrysothemis;* head and pronotum with long black hair, metanotum with shorter hair, the upper surface strongly striate across, and with a distinct longitudinal depression; suddenly declivous behind, the division marked by a median hump and lateral teeth; genital plate about one and two-thirds as long as broad, sides subparallel, tip deeply emarginate in middle, surface with few short hairs, base with a triangular tubercle, its apex running off into a median carina which extends nearly one-half way down the plate.

Expanse, 54 mm.

From Huachuca Mts., Arizona, (Biederman).

Pepsis augustimarginata Vier.

Palmerlee and Dragoon, Arizona. The male differs from *ceberus* in having the subgenital plate much more slender, the sides nearly parallel. The apex of the wings is only narrowly dark, and the base is dark hardly as far out as in *ceberus;* the metanotum has no distinct division between upper and posterior face, but is strongly striated, and densely clothed with long hair. The ventral hair-tufts are short, and with a wide free space between them.

The species of *Pepsis* which I have seen from our country can be separated by the following table:

1.	Wings black, or mostly so; not yellow or reddish	2
	Wings largely yellowish or reddish	5
2.	Antennae yellowish	*elegans*
	Antennae black	3
3.	Apical third of wings whitish hyaline	*venusta*
	Only a narrow apical margin hyaline	4
4.	Apical margin of hind wings not hyaline in the female; with front femora hairy beneath; male with the subgenital plate elongate and long-haired,	*obliquerugosa*
	Apical margin of hind wings narrowly hyaline in the female; front femora barely, if at all, hairy beneath; male with the subgenital plate short, and with a transverse carina, not noticeably hairy	*mexicana*
5.	Antennae with several joints yellowish or reddish	6
	Antennae wholly black	7
6.	Apex of wings broadly dark banded; male without apical fringe on the fifth ventral segment	*novitia*
	Apex of wings narrowly banded with dark; male with apical fringe to the fifth ventral segment	*mildei*
7.	Males	8
	Females	15
8.	Subgenital plate elongate, more or less hairy, without a median tooth or a transverse ridge	9
	Subgenital plate shorter, with median and apical transverse carinae, the median one curved at ends, the apical one tooth-like at each end; no ventral hair-brushes	*chrysothemis*
	Subgenital plate with a median tooth and an apical or subapical transverse ridge; no ventral hair-brushes	13
9.	No ventral hair-brushes	10
	Ventral hair-brushes present toward the tip of the abdomen	11

10. Subgenital plate slender, densely hairy; wing-tips hyaline.......... *nephele*
Subgenital plate broad, emarginate at tip, scarcely hairy, wing-tips broadly dark.......... *arizonica*
11. Fourth ventral segment with oblique hair-row or tuft; extreme tip of antennae black.......... 12
Fourth and fifth ventral segments with hair-tufts; extreme tip of antennae reddish.......... *boguei*
12. Subgenital plate more than three times as long as broad... *angustimarginata*
Subgenital plate about twice as long as broad.......... *cerberus*
13. Wings not darkened near tip.......... *pallidolimbata*
Wings plainly darkened before tip.......... 14
14. Wing reddish.......... *cinnabarina*
Wings yellowish.......... *formosa*
15. Front femora with long hair beneath; very large species with the preapical dark band of fore wings broad and extending basally into the third cubital cell.......... *nephele*
Front femora with few if any hairs beneath.......... 16
16. The hind tibiae have the bristles among the spines much longer than the spines and curved; no distinct transverse ridge on metanotum separating upper and posterior surfaces.......... *inermis*
The hind tibiae with bristles straight and not longer than the spines; metanotum with a distinct ridge separating the upper and posterior faces.......... 17
17. The posterior part of pronotum very plainly hairy above.......... 18
Posterior part of pronotum not hairy or scarcely so.......... 20
18. Wings reddish, extreme tip pale; posterior face of metanotum striate across.......... *cinnabarina*
Tips of wings wholly dark.......... 19
19. Extreme tip of antennae reddish; tip of wing broadly dark; posterior face of metanotum not striate in middle.......... *boguei*
Extreme tip of antennae black; tip of wing narrowly dark; posterior face of metanotum striate in middle.......... *angustimarginata*
20. Wings without distinct preapical dark band; posterior face of the metanotum striate across.......... *pallidolimbata*
Wings with apical or preapical dark band.......... 21
21. Apical dark band to wings; posterior face of metanotum scarcely striate, *lucasi*
Preapical dark band, extreme tip pale; posterior face of metanotum striate across.......... *formosa*

Three species not placed in the table have been recorded from the United States.

Pepsis charon Mocz.

Recorded from Texas, is similar to *P. elegans*, but the male has short hair on the fourth and fifth ventral segments.

Pepsis sanguiguttata Christ.

Recorded from Texas, is a West Indian species with dark wings on which is a stellate reddish spot.

Pepsis circularis Fox.

Close to *P. chrysothemis;* the subgenital plate is the same; it differs in that the sixth ventral segment is extended above to cover the sixth dorsal segment; but one male is known; it is from Texas.

MUTILLIDÆ.

Nomiaephagus oculatus sp. nov.

♀. Closely related to *N. simillima*, the head fully as broad, and the eyes much more than their diameter from the posterior corners; the thorax is less strongly constricted in the middle, and the posterior slope has the edges less dentate than that species. The coloring is about the same, except that on the abdomen the apical fringe of the second segment is pale, except for a small spot in the middle, where it is dark, (in *simillima* dark except extreme sides), and the pale on the top of the second segment is in the form of two circular spots, quite sharply marked.

Length, 10 mm.

From St. Marys, Georgia, March 6th–April 18th, (O. Bangs). Probably it is the form referred to by Fox from Florida, with the yellow in the form of rounded spots.

Dasymutilla alesia sp. nov.

♀. In the section of *D. cypris*, with an elongate tubercle extending toward eye; eyes moderately large, about their diameter from the apex of the tubercle. Head and thorax with appressed golden hair, and scattered, erect, mostly black bristles; those on the posterior slope of the metanotum are pale; first abdominal segment with pale hair on disc, at apex black, second segment with four large, sharply defined pale spots, the two in front are the smaller, the rest of the segment above deep black, with black hair, the apical margin black-haired, except the extreme sides; third segment black and black haired, except at extreme sides; fourth and fifth with pale hairs; pygidium rather closely and fully longitudinally striate. Carina of first ventral not prominent, an elongate tooth in front; scutellar scale distinct; no transverse carina at end of mesonotum; third joint of the antenna little shorter than fourth and fifth united. Legs pale, tarsi darker, with pale hair.

Length, 8 to 11 mm.

From Falls Church, Va., 13th August to 20th September.

Dasymutilla cypris var. **interrupta** var. nov.

♀. Agrees with *D. cypris*, except that the apical margin of the second abdominal segment is not wholly fringed with pale golden hair; there is a small, median patch of the golden hair, and each side of it is a longer area of black hair; the extreme sides pale-haired.

From Falls Church, Va., July and August.

The Eastern species of *Dasymutilla* that I have seen can be tabulated as below for the females. I have used several of Mr. Rohwer's names, although some may be only varieties, others however are surely distinct species. Mr. Rohwer has kindly examined several of my specimens and furnished notes on the structure of some of his types.

1\. Hair of head, thorax and abdomen long and dense, red or yellow, the abdomen with a median band of black hair, large species................ 2

Hair of head, thorax and abdomen above more sparse, so that the sculpture can be more or less plainly seen; abdomen not red or yellow with a median black band, smaller species............................. 3

2\. Hair red.. *occidentalis*

Hair yellowish.. *comanche*

3\. Temples with a tubercle or carina....................................... 4

Temples without tubercle or carina......................................10

4\. Petiole quadrate, hardly thickened posteriorly; pygidium striate; second segment black haired at tip, others with pale hairs......... *rugulosa* Fox

Petiole plainly enlarged and thickened behind.......................... 5

5\. Antennal scrobes carinate above; tips of second and third segments black-haired; pygidium striate; spurs pale................ *cariniceps* Fox

Antennal scrobes not carinate above.................................. 6

6\. Hair at tip of first segment largely pale; at tip of second pale, with a median black patch.. 7

Hair at tip of first segment largely black; at tip of second segment either all black, or pale in middle; pygidial striae reach the tip................ 9

7\. Temples with an outer carina; pygidial striae weak, hardly reach tip; metathorax strongly rugose; third joint of antenna but little longer than fourth... *chattahoochei* Brad.

Temples with a superior oblique tubercle directed toward eyes.......... 8

8\. Pygidial striae strong, but do not reach the tip, eyes about diameter from tubercles; hair of metanotum pale...................... *allardi* Roh.

Pygidial striae reach tip; eyes less than diameter from the tubercles; hair of upper part of the metanotum black.............. *rubicunda* Brad.

9\. Hair at tips of second and third segments mostly pale........... *cypris* Bl.

Hair at tips of second and third segments mostly black....... *alesia* n. sp.

10\. Pygidium plainly striate longitudinally.................................12

Pygidium not striate longitudinally.....................................11

11\. Pygidium finely granulate; second segment with black hair in middle; no scutellar scale; head broader than thorax........................ *obscura*

Pygidium irregularly rugose, or with short longitudinal rugae; second segment with a pale spot in middle of hind margin; first segment with black hair at tip; head not as broad as thorax................ *harmonia*

12\. No scutellar scale...13

The scale present..15

13\. Hair at tip of first segment pale, that at tip of second pale in middle, but a dark patch each side.................................... *finni* Roh.

Hair at tip of first segment black.......................................14

14\. A small spot of yellow hair in middle of apical margin of second segment, *blawa* Roh.

No such spot, hair of margin black...................... *champlaini* Roh.

15\. A transverse carina at tip of mesonotum..................................17

No such carina...16

16\. Hair at tips of first and second segments pale.................. *sappho* Fox

Hair at tips of first and second segments black................. *zella* Roh.

17\. Tip of second segment with black hair.................... *ferrugata* Lep.

Tip of second segment with a pale median spot; eyes larger in proportion to head.. *georgiana* Roh.

D. ferrugatella Rohwer is practically the same as **D. zella,** in the former the erect hair of head is paler, and that on the apical segments of abdomen white, while in the latter species the erect hair of head is dark, and the hair on apical segments more yellowish.

D. mutata Blake, as I have identified it, is but a form of **cypris** in which the apical hair of abdomen is white, instead of the pale golden of **D. cypris.**

D. plesia Rohwer, I have not seen, but is said to agree with **D. ferrugata,** except that the third joint of antennæ is shorter.

D. errans Rohwer runs to **sappho,** except that there is a median patch of black hair on apex of second segment.

D. segregata differs from **D. champlaini** in shorter thorax, and longer second segment. I have not seen it.

D. virginica Rohwer and **D. carolina** Rohwer I have not seen. According to Rohwer (in litt.) both have the scutellar scale, and lack the carina at tip of mesonotum. They would therefore come close to **D. zella,** but appear to be larger; but I have specimens I believe to be **zella,** which are fully as large and agree with description of **virginica.**

D. vierecki Rohwer agrees with **zella,** except that there is no ventral carina on first segment. Although the shape of this carina varies in **D. zella,** I have seen none without it.

A STUDY OF THE BIOLOGY OF THE CHRYSOPIDÆ.

By Roger C. Smith,
Assistant Professor, Kansas State Agricultural College.

There is much of biological interest to be found in the life history of the Chrysopidæ. The group is a very homogeneous one, varying little in morphology and habits. They are of wide distribution, and one or more species in all localities visited can be appropriately classed among the most common insects. Several species are somewhat rare and difficult to collect, hence, the biological data available concerning these is still somewhat fragmentary. This brief paper is a summary of a large detailed paper, the publication of which has been unavoidably delayed.* A full report of this work is now awaiting publication as a thesis for the doctorate in the memoir series of the Cornell University Experiment Station. This report will be amply illustrated.

Life Cycle.

The total life history of the Chrysopidæ requires a period of approximately 25 to 50 days. Cold weather in the late fall or early spring greatly retards growth and development. From 4 to 12 days were required for embryonic development, the eggs hatching in midsummer in four to six days after deposition. The first molt occurs in three to seven days, or, in cool weather, in 11 days after hatching. The second molt occurs at an interval of two to seven days, the majority molting three and four days after the first molt. The third instar may vary greatly in time. Sometimes it is much prolonged, especially if food is scarce. But from the second molt to spinning the cocoon, there is usually a period of 4 to 10 days, the majority requiring five or six days. The final larval molt to the pupa occurs within the cocoon 5 to 12 days after spinning. However, in

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* The writer has been studying the Chrysopidæ intensively for about five years. During this time some or all of the immature stages of fifteen species have been seen. Collections and rearings have been made at Ithaca, N. Y., where this work was begun under the direction of Professor James G. Needham, of Cornell; at Dayton, Ohio; at Milwaukee, Wisconsin; at Charlottesville, Virginia, and at Manhattan, Kansas. Through the courtesy of Dr. Nathan Banks, the Fitch, Hagen and Banks' types at the Museum of Comparative Zoology, at Cambridge, Mass., were studied.

the case of overwintering generations, which remain in the cocoon as prepupæ, this molt does not occur for a period of four to eight months after spinning. The pupa emerges from the cocoon in a minimum of 10 days after pupation. The pupal molt is at once shed and a full-fledged adult appears which may oviposit after a period of three to six days.

THE EGGS.

The eggs of our Chrysopidæ, as is well known, are stalked, the stalks ranging from about four to eight millimeters in length in the different species. The stalk is composed of a gelatinous substance exuded at oviposition, which hardens quickly after being drawn out into the usual form. The eggs are elongate, ellipsoidal, and light green to distinctly greenish yellow in color. *Chrysopa nigricornis* Burm. has the longest stalks of any eggs seen, and *C. quadripunctata* the shortest. The stalks apparently vary directly as the length of the abdomens in the different species. The eggs of *C. nigricornis* are deposited on the leaves of the trees, maples by preference, and are nearly always in rather closely arranged groups, with the stalks somewhat tangled or entwined. Single eggs of this species are not uncommon, however. The other species deposit their eggs in less closely arranged and often regular groups, in rows or singly. The place of oviposition, the size of the egg, the length of stalk, and the coloration serve in practically all cases to identify the eggs of the different species.

Many abnormalities occur in oviposition which have not been described. Some of our most common species which normally deposit stalked eggs, may, under certain conditions, deposit stalkless eggs, eggless stalks, stalked eggs attached to other eggs or to their stalks. Three eggs of *C. chi* were found with their stalks united into one at about midway. In the case of our common species, these can be explained as accidents occurring during oviposition.

Oviposition has been correctly described, at least in the main, by several writers. No differences of importance have been observed in the different species. No difficulty was experienced in obtaining large numbers of eggs when the adults of our most common species were confined in vials and fed daily on plant lice. Most of this work has been carried on with

C. oculata and *C. nigricornis*. Some species, on the other hand, have consistently refused to oviposit in captivity and could not be kept alive more than a few days.

In the process of hatching, an egg burster serves to cut the initial slit in the chorion. This process has been recently described by the author and the published account will soon appear.

The Larvæ.

Chrysopid larvæ are generally described as spindle shaped. They are thysanuriform, exhibiting at the same time a quite primitive type with some remarkable specializations. Among the latter are the anal silk glands and the sucking mouth-parts. The maxillæ and mandibles are greatly prolonged forward, forming the so-called sickle-shaped jaws. The two halves are mechanically fastened together by means of a flange on the outer edge of the maxillæ working in a groove in the mandibles. A tube extends between them to the pharynx. The mandibles are quite pointed and the whole is well suited to puncturing the bodies of insects. The juices are taken up by suction effected by a heavy pharangeal musculature and by short muscles within the maxillæ which by their contraction dilate the tube leading to the pharynx.

The three parts of the thorax are each divided into two parts or subsegments. The anterior subsegment of each is much smaller than the posterior one. The posterior subsegment in all but the first and last two or three segments bears a pair of more or less prominent lateral tubercles which are beset in the third and last instar with 12–20 strong setæ. The abdomen in all species seen has ten segments. Considerable difference of opinion has arisen concerning this point. The first segment, which is short and without the lateral lobes, has been overlooked by some. It is distinctly marked by the first pair of abdominal spiracles. The last two segments are tubular and partially invaginated within themselves. The terminal segment is applied to the substratum in walking. A clear, gelatinous fluid, secreted by anal glands, gives the larva security in climbing smooth surfaces. It is well known that the larvæ of this family void no excrement. The mid intestine is closed at its posterior end. The hind intestine is quite small, in cross section appearing no larger than a malpighian tubule. The excrement is stored in a large bean-shaped mass in the mid-intestine, and is voided by the adult immediately following the pupal molt to the adult.

The food of the larvæ is predominantly aphids. They exhibit little choice between the different species of aphids, though some are more suitable for feeding them in rearings than others. Other small or soft bodied insects, as Jassids, Capsids, Coccids, small Diptera, and many kinds of insect eggs have been used in rearing work.

The classification and identification of the larvæ of the various species is no more difficult nor complicated than the identification of adults. Most published descriptions of larvæ are inadequate for naming or placing them in a key. The black spots on the dorsum of the head serve to divide the larvæ into three groups, which in the main are most closely related as adults. The first group has two longitudinal and converging spots on the head as in the case of the following species of the genus Chrysopa; *plorabunda*, *rufilabris*, and *interrupta*. *C. bimaculata* has two narrow, black bands on the head, but they extend cross-wise and the larva is a trash carrier. The next group has three black triangular spots on the dorsum of the head. This is characteristic of *C. oculata*, (which includes the two nominal species *albicornis* and *chlorophana*, which the writer places in synonomy with *oculata* on the basis of rearings), *C. chi*, (including also the nominal species *ypsilon* also placed in synonomy with *chi*), and *C. nigricornis*. The next group have four long, narrow bands on the dorsum of the head, a short inner pair, and a longer outer pair arising at the bases of the antennæ and extending to the anterior border of the prothorax. This group contains the trash carriers, *Chrysopa lineaticornis*, *lateralis*, an unidentified species now being reared at Manhattan (thought to be *cockerelli*) and *quadripunctata*. In connection with the latter species, observations at Charlottesville, Virginia, clearly showed this species to be a transition in the trash carrying habit between the true trash carriers and the naked larvæ. Specimens were found with considerable debris on their backs, but it was not definitely arranged into a neat packet. There are more short, minute setæ on the dorsum than in the naked larvæ proper, which suggest the hooked dorsal setæ of the trash carriers.

To identify larvæ to species, the following features have been found useful in addition to the dorsal head spots; first, the general coloration of the larva, including the color, shade of color, whether solid or spotted, the markings either side of the dorsal vessel, the markings in the lateral border, and the color of the jaws and legs; and second, the size and shape of the lateral tubercles, the color and comparative size of the setæ on the same, the comparative length of the stalks of the lateral tubercles and the coloration of the same. The presence of lateral tubercles on the first abdominal segment is useful, especially in the case of *nigricornis*, which possesses them. Furthermore, if the larva carries a distinct packet, identification is simplified, for there are only a few species known to be trash carriers.

Chrysopid larvæ can be readily separated from the larvæ of the Hemerobiidæ, which they resemble closely by the following differences. Hemerobiid larvæ are generally more slender, the first subsegment of the prothorax being especially longer than in the Chrysopidæ, as is also the case with the last two segments of the abdomen. When the larvæ walk rapidly the end segments of the abdomen are lifted and carried horizontally, while the head sways from side to side with a rapid jerky motion. The prominent trumpet-shaped pulvillus which occurs on all species of Chrysopidæ seen by the writer or figured in texts is absent in the Hemerobiidæ. The lateral tubercles are also absent in the Hemerobiidæ. The dorsal and lateral setæ of the latter are very short and inconspicuous, except on the last few abdominal segments. The jaws are heavier and more nearly straight than in the Chrysopidæ. In most species they come to a point rather abruptly. No known species of Hemerobiidæ are trash carriers.

It is frequently said that Chrysopid larvæ cover themselves with the skins of their victims. In the experience of the writer, this habit is confined to a few species of trash carriers which regularly construct a neat hemispherical packet of aphid skins, insect molts or parts of insect's bodies, spider's webs, plant fibers, lichens, and other similar materials.

The writer has seen four species of trash carriers. *C. lineaticornis*, *C. bimaculata*, *C. lateralis*, and a species in Kansas now being reared. *Allochrysa parvula* Banks and *Leucochrysa floridana* Banks are in all probability trash carriers, judging from the cocoons of these species seen at the Museum of Comparative Zoology, Cambridge, Mass. All three instars have these packets, which are constructed anew after each molt. The morphology of the larvæ is considerably modified and specialized for carrying the packet. The abdomen is much shorter, but broader and thicker than in the naked larvæ, causing it to be arched conspicuously from the first to about the seventh segment. The lateral abdominal tubercles are rather small, fleshy lobes without clearly defined stalks and the setæ are likewise short. The dorsal setæ are present and fairly prominent. In the Kansas species there has been observed one to three rows of microscopic hooked setæ on each abdominal segment from one to six, inclusive. There are six in the shortest rows and about thirty in the longest rows. The tips are bent downwards and serve to hold the packet in place. It has been usually stated that there is a gelatinous substance on the setæ holding the debris in place. The writer has not found such a secretion, but would explain the firm security of the packet on the dorsum as due to these hooked setæ, assisted by the larger dorsal and lateral setæ. The thoracic tubercles have stalks much longer than is the case in the naked larvæ, and the setæ on the first two pairs extend outward in a fan-shaped manner, turning upward at the tips. This provides an even and firm support for the anterior rim of the packet. All four of the packet bearers seen are somber gray larvæ, with little of a color pattern. All but *C. bimaculata* have the two pairs of dorsal head bands and in the last instar have posterior spots which suggest a third pair.

The first instar of all Chrysopid larvæ can be distinguished by the presence of two large setæ on each lateral tubercle except the mesothoracic and metathoracic tubercles, which bear three each. The dorsal head spot in the first instar of *C. chi*, *C. oculata*, and the varieties of each, breaks up into three spots in the third instar. In *C. nigricornis* there are three spots of the same pattern as in the preceding on the dorsum of the head in all instars.

THE PUPA.

Grown larvæ normally spin silken cocoons in which to transform. The silk is produced by modified malpighian tubules and is spun through the anus. Some larvæ fail to spin a cocoon, a few apparently making no effort to spin. If the larvæ are disturbed while spinning, they frequently fail to spin further or many spin a mat of silk upon which to transform. Larvæ have repeatedly passed through the pupal stage outside of a cocoon and one specimen wintered without this protection. The cocoons are usually placed near the feeding habitat, i. e., the tree inhabiting species, spin their cocoons on the under side of leaves or under bark. In the case of *C. oculata* it is believed that they generally spin their cocoons just under the loose earth on the ground. Cocoons of this species are not often found on plants in the field. The trash carriers use their packet as a kind of foundation or starting point for their cocoon. It adheres to one side of the finished cocoon.

The main facts concerning the spinning of the cocoon have been noted by several writers, but some interesting details have been overlooked. The larva first forms a framework by attaching the viscid silk thread to whatever supports are near. It requires an hour or more to complete the foundation, depending on how much time has been wasted seeking places to attach the thread. The larva shifts its position frequently so that the cocoon soon assumes a spherical shape. The spinning pattern during the formation of the greater part of the cocoon is a rather constant triangular design. The larva shifts each time a little to one side of a true circle, so that the wall of the cocoon is of approximately uniform thickness throughout. As the larva turns in its cramped quarters, the dorsal and lateral setæ are broken off and are spun into the cocoon structure. The triangles of the spinning pattern grow smaller and the movements of the larva become slower. The final spinning appears to be a general plastering over of the inner wall of the cocoon. This is effected by a copious silk secretion being spread by the last segment of the abdomen. The cocoons are completed in most cases in about 24 hours, some requiring a little more time, a few finish in less time.

Especial effort was made to observe the manner of emergence from the cocoon, but with only partial success. It is believed that the circular lid through which the pupa emerges, tears in that peculiar manner as the result of the spinning pattern, and that it is torn by internal pressure exerted by the pupa. The writer is not positive whether the large pupal mandibles assist in starting the tearing at emergence; in his opinion it is possible that they may assist but probably not necessary. It has been observed in the more transparent cocoons of *rufilabris* and *plorabunda* that the pupæ within the cocoons are capable of shifting their positions very easily and rapidly.

Just before emergence, the pupal coloration and characters can be seen rather clearly in most cocoons. The pupal disc is the old larval molt and immediately before emergence is quite black. The golden or brownish eyes of the pupæ can be seen, while the general color of the cocoon changes from the pearly gray or white of the newly spun silk to yellowish in *quadripunctata* to a distinct green in *harrisii*.

THE ADULT.

The chief points of importance in connection with the adult which it is desired to describe here are the length of life, number of eggs laid, food, and ecological distribution. It is usually stated that the adults are short lived. Some of the less common species could not be kept alive in captivity longer than a few days to a week at the most, but, of the commoner species, two females of *C. oculata* lived 42 and 34 days, depositing 617 and 470 eggs, respectively. Dissections showed that neither had deposited their full quota of eggs. These are records in both cases. Adults of *C. plorabunda* have been be kept alive over winter. *C. rufilabris* and *C. harrisii* were also kept alive from late September until the latter part of December. Overwintering specimens can be distinguished from normal specimens by the brownish color which replaces the green, a change brought about comparable, it is thought, to the discoloration in autumn leaves.

Some confusion exists concerning the feeding habits of adults. Specimens of *oculata*, *rufilabris*, *nigricornis*, *plorabunda*, *chi*, and *quadripunctata* were kept alive for relatively long periods by daily feedings with aphids or weak sugar solution, and water. Our common species feed upon aphids, without doubt, and other small, soft bodied creatures. It is believed that the adults feed upon approximately the same species of aphids as the larvæ of the same species. This explains why adults go to aphid infested plants to oviposit rather than the doctrine of parental solicitude for the young. Adults of *lineaticornis*, *harrisii*, *cockerelli*, *Meleoma signoretti*, and other less common species could not be kept alive very long on common aphids. It was thought that their particular kinds of food were not supplied, rather than that they took no food. It is therefore held that the economic importance of this family is much greater than has been usually stated.

Fairly definite habitats were observed in the species studied. *C. oculata* and varieties are the most common and most widely distributed garden and field types. *C. plorabunda* is here our most abundant field species. *C. nigricornis*, *C. rufilabris*, *C. harrisii* and *C. lineaticornis* are tree forms. *C. harrisii* is especially partial to pine, while *lineatricornis* and *quadripunctata* seem to prefer oaks. *C. nigricornis* and *rufilabris* are found on a variety of trees, but maples probably predominate. Adults can best be collected by beating the bushes with a long stick and then catching the adults with a net as they fly out into the open.

COLORADIA PANDORA BLAKE, A MOTH OF WHICH THE CATERPILLAR IS USED AS FOOD BY MONO LAKE INDIANS.

By J. M. Aldrich,
U. S. National Museum.

In 1911 I made some fragmentary observations on this hitherto unreported Indian food, which I published the following year in the Journal of the New York Entomological Society (vol. xx, pp. 1-4, plate i). At that time I had obtained only the dried larvæ ready for cooking, and the species could not be determined. My account of the methods of the Indians in collecting and preparing this food was obtained from the clerk of the Mono Lake store, and not written down until two or three days later. No further information came to light for several years, but in 1919 I interested Mr. Roy Headley, of the Forest Service, in the matter again, and he caused some inquiries to be made in the vicinity of Mono Lake. The Indians then stated that the caterpillars occur only every alternate year, and there would be none in 1919. In 1920 Mr. Headley interested Mr. Guy S. Way, of Bishop, Cal., ranger in the Inyo Forest adjacent to Mono Lake, who took hold of the subject with enthusiasm, wrote several letters on his observations, and sent a liberal shipment of the caterpillars, which settled the identity of the species. From Mr. Way's letters I compile the following account, making a few direct quotations. It will appear at once that my earlier article contains several serious mistakes.

The Indians call this food Pe-aggie. The first step in the collection of the caterpillars is to make a trench about the base of each tree, the outer edge of the trench as nearly vertical as possible. This is to keep the caterpillars from straying away when they come down the tree. The Indians go from tree to tree in the collecting season and pick them up out of these trenches. The next process is to kill and dry them. A large mound of dry earth is made and a fire built about it. When it is thoroughly heated, the fire is removed, the mound opened, the caterpillars thrown in and mixed with the hot dirt. Here they remain an hour, until partly cooked and dried. The Indians then sift them out of the mixture with a specially made, cone-shaped sieve, so that the insects are free from dirt. The drying is finished by spreading them on the ground in bark huts for two days, after which they are sacked and keep indefinitely in a cool, dry place. The material which I bought from a squaw at Mono Lake in 1911 is still in perfect condition; in fact, I think the odor improves with age.

This is an important food of the Indians about Mono Lake, in spite of the fact that it only lately came to the notice of the whites outside the immediate region. Mr. Way reports that Chief Jake Garrison put up a ton and a half this past summer, in the woods just south of Mono Lake. He says the caterpillars are regarded as a great delicacy, and only a few at a time are used to flavor a stew. In the case already reported by me, however, it appeared that the stew was made entirely of caterpillars; I found the larvæ tough and the stew insipid from lack of salt, the flavor resembling to my palate the taste of linseed oil. I could not from my own experience pronounce it a delicacy; however, *de gustibus non et disputandum.*

Now regarding the life history of the insect. The species is *Colorado pandora* Blake, as above indicated. It was determined by Mr. Wm. Schaus. The foodplant is Pinus jeffreyi. The life cycle of the moth occupies two years, and there is only one brood in the section where the observations were made. This fact has been understood by the Indians from time immemorial, so they count on putting up pe-aggies every other year.

The eggs are laid "in rough, sheltered places in the bark of the pine trees." This is about the latter part of April. On hatching somewhat later, the larvæ ascend the tree and feed on the needles during the short summer of that high altitude (about 7000 feet). By fall they are in the tops of the trees, where "they form a ball in the pine needles—a ball of pe-aggies, not a ball of pine needles, but they form this among the needles." "I have seen them thus many times in falling timber for sawmills in early spring, in Jeffrey pine belts only."

Thus they hibernate, enduring a cold winter with considerable snow. In their second summer they grow rapidly and are through feeding by July first. Then they descend the tree-trunks, and if they escape the Indians, they scatter and dig into the ground to pupate. We received Mr. Way's shipment on July 22nd, and several had pupated on the way; all the rest that were uninjured pupated within a day or so after being placed in rearing cages. None spun any silk whatever. Several adults came out in about two weeks after the specimens arrived, but this premature emergence was probably due to the rough usage of their long trip, which included sixty miles or more by team or auto to get to the railroad. Most of the pupæ are now dormant, and evidently will yield the adult in the spring.

MINUTES OF THE ANNUAL MEETING.

The Fifteenth Annual Meeting of the Entomological Society of America was held in Chicago, Room 20, Kent Hall, University of Chicago, on December 27th and 28th, 1920.

First Session.

The meeting was called to order at 2 P. M., December 27th, by the Secretary, in the absence of the President and Vice-Presidents. Attendance 35, increasing to 70 in the course of the session. Professor W. A. Riley was elected President *pro tem* and took the chair. The following papers were read:

The Immature Stages of Some Chrysopidæ	R. C. Smith
Notes on the Immature Stages of Cladura flavoferruginea O. S.	C. P. Alexander
Wing Venation of Coleoptera	S. A. Graham
The Caterpillar Used as Food by the Mono Lake Indians,	J. M. Aldrich
A Peach-deforming Capsid (read by P. J. Parrott)	Hugh Glasgow
Notes on the Ancestry of the Thysanoptera and Hemiptera-Homoptera (read by C. P. Alexander)	G. C. Crampton
The Attraction of Chloridea obsoleta to the Corn Plant	J. W. McColloch
Distribution and Habits of Cicadellidæ on Presque Isla, Pa.	J. G. Sanders and D. M. DeLong

The chair appointed the following committees:

Auditing—Hinds, Bentley, Rogers.

Resolutions—Satterthwait, Chapman, McIndoo.

Nominating—Osborn, Melander, Swaine.

At 4:40 P. M. the session adjourned.

Second Session.

The Society was called to order at 10 A. M., December 28th, by First Vice-President F. E. Lutz.

This being the business session, the Secretary presented for the Executive Committee the Reports of the Secretary and Treasurer and the Managing Editor of Annals.

Secretary's Report, 1920.

The following members have died during the year:

Dr. C. Gordon Hewitt.
Wilbur Ross McConnell.
Miss Caroline Gray Soule,

The following have resigned:

Dr. Johannes Dewitz.
Mrs. W. R. Thompson.
Dr. A. Fenyes.
Dettmar W. Jones.
Prof. J. E. Guthrie.
Geo. O. Day.
Howard L. Clark.
F. V. Green.
V. L. Wildermuth.

Total, 9.

Dropped from the list for non-payment of dues: Foreign, 18; American, 35. Total, 53. This is an unusual number, as on account of war conditions many names were not dropped in the last two or three years that would ordinarily have been.

Total losses, 66.

The following were voted into membership by the Executive Committee on June 6, 1920.

Wm. E. Hoffman.
Hugh W. Bedford.
Edwin H. Bryan, Jr.
John L. Buys.
Melvin H. Hatch.
Gladys Hoke.
Amy de Horrack Fournier.
Wesley O. Hollister.
Hugh C. Huckett.
Percy Ireland Lathy.
Leonard M. Peairs.
Fred Schwarz.
Chas. K. Sibley.
Ralph P. Thompson.
B. W. Wells.

Total, 15.

Elected at the present meeting:

Alfred B. Baird.
Walter B. Balduf.
Lulu Berry.
Stanley W. Bromley.
John D. Detwiler.
Grace H. Griswold.
Marshall Hertig.
Harry E. Jaques.
Donald S. Lacroix.
O. C. McBride.
Don C. Mote.
Evelyn Osborn.
Faustino Q. Otanes.
Geo. B. Pearson.
Max M. Ruher.
Rudolf G. Schmieder.
Raymond C. Shannon.
Jas. M. Swaine.
O. H. Swezey.
R. J. Tillyard.
Leopoldo B. Uichanco.
Milton F. Webster.
Roscoe W. Wells.
Karl H. Wendler-Funaro.

Total, 24.

On December 21st, when the books for 1920 were closed, it was found that the members had paid dues as follows:

Paid for 1921	281
Paid for 1920	183
Paid for 1919	35
Owing more than 1 year	37
Life Members	11
Honorary Fellows	6
Total membership	543
Elected this meeting	24
Actual present membership	567

Respectfully submitted,

J. M. Aldrich,
Secretary-Treasurer.

December 21, 1920.

Treasurer's Report, 1920.

RECEIPTS.

Balance last Report	$1,235.56	
Dues from members	1,064.50	
From Managing Editor of Annals	319.92	
Interest—Current Account	16.73	
Permanent Funds	30.90	
Total		$2,667.61

DISBURSEMENTS.

Printing Annals for 1919:		
March	$ 177.36	
June	295.77	
September	259.41	
Engraving for Annals	125.73	
Secretary's Office:		
Postage	11.00	
Printing	22.24	
Clerical Assistance	40.00	
Safety deposit box, one-half	2.50	
Cash Book	1.65	
One Liberty Bond	50.02	
Loss on exchange	.29	
Balance, cash on hand	$1,681.64	
Total		$2,667.61

Note—On account of not being able to get the printers of Annals to submit their bills, we now owe for December, 1919, and all of 1920, which accounts for our large cash balance.

Condition of Permanent Funds.

On hand, last report	$794.01
Appreciation of nine War Savings Stamps	1.08
Total	$795.09

In this valuation the Liberty Bonds are estimated at their face value.

SECURITIES HELD.

First Liberty Loan, No. B00911757	$ 50.00
Second Liberty Loan, No. B02787752	50.00
Third Liberty Loan, No. 5876278	50.00
Third Liberty Loan, No. 5876279	50.00
Third Liberty Loan, No. 5876280	50.00
Third Liberty Loan, No. 4203250	100.00
Third Liberty Loan, No. 4203251	100.00
Fourth Liberty Loan, No. 490434	100.00
Fourth Liberty Loan, No. 4714709	50.00
Fourth Liberty Loan, No. 6951394	50.00
Fourth Liberty Loan, No. 14145891	50.00
Victory Liberty Loan, No. A1562358	50.00
Nine War Savings Stamps, present value	40.23
Balance, carried in Current Fund	4.86
Total	$795.09

Respectfully submitted,

J. M. ALDRICH,
Secretary-Treasurer.

December 21, 1920.

REPORT OF THE MANAGING EDITOR.

It may be said that the conditions for publication of the ANNALS have been somewhat as in the previous year and delays in the appearance of the various numbers has been due to difficulty in the matter of paper and printing, which we hope will be improved for the coming year. The Managing Editor has endeavored to secure the opinion of other members of the Editorial Board and of the Executive Committee with reference to the policy of increasing the subscription price and membership fee so that a larger journal may be issued with the result that no very definite conclusion can be offered at present. The Editorial Board would all like to see a larger and more fully illustrated journal but do not all agree as to the advisability of increasing the price of the journal. While there seems to be good argument in favor of increasing the price so as to correspond with other journals of about equal size and probably somewhat nearer the same circulation, we must recognize the possibility of a reduced circulation if the price is much increased and it would seem wise if any increase is made that it should be made large enough to offset any possible shrinkage in subscriptions or membership.

The expenses of the office have been kept down to a very moderate figure, smaller perhaps than can be expected in the future; however, accounts that will be due for reprints issued will help somewhat in the coming year's accounts. We have been favored by a number of the authors of papers in the current year's volume who have agreed to meet the cost of plates and in a few instances have paid for some additional expenses for their published articles. This has made it possible to issue a number of articles much more promptly than would have been possible without such assistance.

The character of papers which have made up the year's volume will, I believe, compare favorably with preceding years and with other journals and I trust that the members will appreciate that the interests of the society are very broad and that while certain articles may seem quite uninteresting to them individually that there may be other members who will find them distinctly interesting. As our society is organized to cover both North and South America and as the members are interested in fauna of related regions it is evident that along with the distribution in the different orders of insects there will be a pretty wide distribution of subject matter. It is also desirable to include papers of ecological character and those relating to morphology or general biology since few of the journals give much space to matter of this kind; in short, there seems every reason to consider the contents as covering a very broad field of Entomology.

The receipts of the office have amounted to $381.25 and the office expenses paid directly from this office have been $61.33. The balance of $319.92 has been transmitted to the Secretary-Treasurer as shown by accounts and vouchers submitted. The itemized statement may be briefly summarized as follows:

RECEIPTS.	
Subscriptions	$262.50
Sale of back volumes	95.25
Reprints and engravings	23.50
Total	$381.25

DISBURSEMENTS.	
Postal Deposits and Stamps	$ 35.54
Clerical assistance and labor	18.80
Supplies and exchange	6.99
Balance paid to Treasurer	319.92
Total	$381.25

Respectfully submitted,
HERBERT OSBORN,
Managing Editor.

The Secretary also reported that the Executive Committee had re-elected Prof. Herbert Osborn as Managing Editor, and had elected the following on the Editorial Board: WILLIAM S. MARSHALL, V. L. KELLOGG, F. E. LUTZ.

The report of the Treasurer of the Thomas Say Foundation had not been received*; the Editor of the Foundation, J. M. Aldrich, made a verbal report to the effect that the prospect is improving for the printing of a second volume by the Foundation, and asking the members to bring desirable manuscripts to his attention.

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*It is appended to the Secretary's Report on the following page.

Report of Treasurer of the Thomas Say Foundation
For the Year 1920.

Receipts for 1920.

Balance on hand January 1st, 1920		$210.93
3 Subscribers at $2.55	$ 7.65	
5 Subscribers at 2.25	11.25	
20 Subscribers at 3.00	60.00	
28 Volumes sold		78.90
Interest on $200 Bonds (to September 15)		8.50
Total Receipts, 1920		$298.33

Expenditures for 1920.

Printing Cards (pd. Mch. 4)	$ 7.00
Postage on 28 Copies	3.92
Total expenditure, 1920	$ 10.92
Cash on hand to balance	287.41
Total	$298.33
Balance on hand January 1, 1921	$287.41

Volume I Sarcophaga & Allies has now paid for the net cost of publication and distribution with a balance of 41 cents in its favor. Of $287.41 now on hand, $260.00 belongs to the original endowment, leaving a cash balance of $27.41 on hand as an offset against the original grant of the Society of $50.00 for the establishment of the *Foundation*. Of the original edition of this Volume, 200 copies were bound and of this number, 19 were distributed to the collaborators of the author, 35 to the subscribers to the Foundation and 143 have been sold, making a total of 197 *copies distributed* to date.

Respectfully submitted,
(Signed) E. D. Ball,
Treasurer.

The Auditing Committee made the following Report:

Your Committee finds the Report of the Managing Editor, showing a total of $381.25, to be correct and properly checked by vouchers except in two small items, amounting to $1.83.

Second, your Committee has carefully examined the account of the Treasurer and finds the same to be well kept and correct, vouchers being presented for all items except: (List omitted, as these mislaid vouchers were all submitted to the Chairman of the Committee later.)

Third, as to the Statement of Permanent Funds, the Treasurer's Report is accepted without evidence as to securities held, as it is manifestly undesirable to transport them to the meeting.

W. E. Hinds, *Chairman.*
G. M. Bentley.

On motion the report was adopted.

The Committee on Resolutions reported as follows:

Your Committee on Resolutions begs leave to submit the following resolutions:

That the Entomological Society of America desires to express to the authorities of the University of Chicago its hearty appreciation for the use of the rooms and the facilities placed at its disposal for the purpose of its annual meeting, and that the Secretary send a copy of the resolutions to the authorities of the University of Chicago.

That the Society keenly feels the loss of our members, Dr. C. Gordon Hewett and Prof. Wilbur Ross McCowell and Miss Caroline G. Soule, whose deaths occurred during the past year. It wishes to express its appreciation of the lifelong work of these members who contributed so much to the advancement of the science of Entomology. Therefore, it instructs the Secretary to write letters of condolence to the families of our deceased members.

Respectfully submitted,
ROYAL N. CHAPMAN,
A. F. SATTERTHWAIT,
N. E. McINDOO.

On motion the report of the Committee was accepted.

The Executive Committee referred the subject of increase of dues to the Society without recommendation. It appeared that the mail ballot taken by the Secretary in connection with sending out the annual notices had resulted in the following vote:

Favoring three dollars	144
Favoring two dollars	68
Not expressing preference	31

After considerable discussion the sentiment appeared to be in favor of waiting another year to see what the trend of printing costs will be, before making a change from the present rate of two dollars per year. So no motion was made and the matter laid aside for the reading of papers. The following were read:

Life History Notes on Some Forest Homoptera	HERBERT OSBORN
A Review of the Known Fulgoridæ of Eastern North America	Z. P. METCALF

At noon the session adjourned.

Third Session.

The meeting was called to order at 2 P. M., December 28th, by President L. O. Howard.

The Executive Committee reported that they have elected the following additional Fellows of the Society:

C. P. Alexander.
Prof. Mario Bezzi,
Turin, Italy.
C. L. Metcalf.
W. D. Funkhouser.
T. J. Headlee.
Warren Knaus.
J. McDunnough.
Edna Mosher.
J. G. Sanders.
V. E. Shelford.
Prof. F. Silvestri,
Portici, Italy.
P. S. Welch.
Wm. Schaus.
Carrington B. Williams.

The Nominating Committee reported the following nominations of officers for the coming year:

President—J. M. Aldrich.
First Vice-President—Arthur Gibson.
Second Vice-President—E. C. Van Dyke.
Secretary-Treasurer—C. L. Metcalf.
Additional Members Executive Committee—E. M. Walker, F. E. Lutz, W. A. Riley, O. A. Johannsen.
Committee on Nomenclature—E. P. Felt, T. D. A. Cockerell, Nathan Banks.

On motion, the Secretary was instructed to cast the ballot of the Society for the Officers nominated; which being done, they were declared duly elected.

On motion, it was voted to combine the evening program with that of the afternoon, so as to avoid a conflict in the evening with the biologists' smoker.

The Society then proceeded with its program, as follows:

The Role of Insects in Zoocecidial Evolution..........B. W. Wells
Attempts to Culture the Bacterial Symbionts of Blattidæ.......Marshall Hertig
Symposium: The Relations between Taxonomic Affinities and Food Habits of Insects, with Special Reference to Parasitism.
  A. Hymenoptera........................Chas. T. Brues
  B. Diptera..............................J. M. Aldrich
  C. Mallophaga........................Vernon Kellogg
A Recent Visit to Certain European Entomologists...L. O. Howard
The Life of the Bumblebee........................T. H. Frison
Annual Address—Some Little-Emphasized Guideposts to Medical Entomology..................................W. A. Riley
The Evolution of the Subterranean Habit in Lepidopterous Larvæ L. B. Ripley

At 6 P. M. the meeting adjourned, the attendance at the last session having been about 135.

J. M. Aldrich,
Secretary.

REPORT OF COMMITTEE ON U. S. NATIONAL MUSEUM.*

Your Committee begs leave to report, as follows:

First: Activities during the year 1920.

In order that all might understand the importance of the Division of Insects of the U. S. National Museum and realize its needs to handle the vast volume of material submitted to it by entomologists for study and information, our report, submitted at the last annual meeting at St. Louis was printed in *Science*, as well as in the entomological journals, and reprints furnished to entomologists throughout the country for their use in advising on the subject. As a result the report was approved and assistance extended by the National Research Council, the Florida Entomological Society and the Indiana Academy of Science.

An itemized budget was not included in our report a year ago but the past year this matter has been carefully studied and a budget totaling $83,660.00 was decided upon as the amount needed at once. This amount is considered adequate to provide the needed curators, assistants and preparators, and will also furnish a suitable allowance for the purchase of needed supplies and equipment and permit a small amount for travel and exploration and in addition make it possible to inaugurate proper facilities for publication. This budget was presented to Dr. C. D. Walcott, Secretary of the Smithsonian Institution, October 1st, with the urgent request that he include the item in his budget for the National Museum. This could not be done as the budget had been sent to Congress previous to June but Doctor Walcott generously agreed to approve the item provided its inclusion by the house committee could be secured. Consequently the matter was taken up with Congressman Good, Chairman of the House Appropriations Committee, Doctor Walcott at the same time approving the item in a letter to Chairman Good. To this request we were advised that owing to the deficiency in the treasury and the many needs confronting Congress that additional appropriations could not be considered at this time. After careful consideration your committee believes it advisable to refrain from pushing the matter at the present session of Congress but to request insertion of the item in the Museum budget at the next session of Congress.

Second: Support needed. Your committee urges every member to be in readiness to secure the indorsement for National Museum support if needed. This refers to personal contact with your representatives in Congress or otherwise securing their support. We would urge especially that the scientific societies of the different states be advised of the needs and that their indorsement be secured and likewise that the approval and support be secured from such agricultural bodies as the state horticultural societies, agricultural societies, etc.

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* This report was adopted as a joint report with the American Association of Economic Entomologists.

We would urge that each one of you take every opportunity to educate the people relative to the importance and needs of the National Museum as a whole for we must build up every branch of the Museum if in future years we are to maintain a normal growth and expansion of the Division of Insects.

Third: Deposition of Types in the U. S. National Museum. Your committee feels that the National Museum should be the mecca for taxonomic entomological activity in the United States and would urge that entomologists make it a point to deposit types in the Museum. We would urge state institutions to likewise place the types, now in their collections, in the custody of the National Museum. This is already being done by certain institutions. Thus the type collections of the Connecticut Agricultural College, Colorado Agricultural College, Kansas Agricultural College, The Norton Collection at Yale, and others, will all probably be in the National Museum. We cannot urge too strongly that other institutions and individuals follow suit. In return the Division of Insects of the Museum promises to give the donors species new to their collections and help to build up their collection along the lines which will be most valuable to them. They further agree that any of the types there deposited are accepted on the condition that they can be borrowed by their institution at any time and for any reason, but they are not to go to any institution, or individual not connected with the institution presenting the material.

Respectfully submitted,

JOHN J. DAVIS,
W. J. HOLLAND,
V. L. KELLOGG,
E. P. FELT,
HERBERT OSBORN,
Committee.

MEMBERS OF THE ENTOMOLOGICAL SOCIETY OF AMERICA.

March 1, 1921.

The date of election as Honorary Fellow, Fellow or Member is shown by the date preceding the name.

Ch. signifies a charter member, December 28, 1906.

In the list of Fellows the date following the address shows the date of election as a Member.

In the list of Honorary Fellows the date of election as a Member is followed by the date of election as a Fellow.

HONORARY FELLOWS.

1914. Bethune, Charles James Stewart, Ontario Agricultural College, Guelph, Ontario, Canada. (Ch., 1906).

1914. Comstock, John Henry, Cornell University, Ithaca, N. Y. (Ch., 1906).

1907. Cresson, Ezra Townsend, Hedgleih, Swarthmore, Pa. (Ch., 1907).

1914. *Fernald, Charles Henry, Massachusetts Agricultural College, Amherst, Mass. (Ch., 1907).

1915. Forbes, Stephen Alfred, University of Illinois, Urbana, Ill. (Ch., 1907).

1914. Schwarz, Eugene Amandus, U. S. National Museum, Washington, D. C. (Ch., 1907).

FELLOWS.

1907. Aldrich, J. M., National Museum, Washington, D. C. (Ch).

1920. Alexander, C. P., 419 West Main St., Urbana, Ill. (1910).

1908. Ball, E. D., Iowa State College, Ames, Iowa. (Ch.).

1914. Banks, Nathan, Museum Comp. Zoology, Cambridge, Mass. (1908).

1913. Barnes, Wm., 152 East Prairie St., Decatur, Ill. (Ch.).

1908. Beutenmuller, Wm., Box 258, Highwood, Bergen County, New Jersey. (Ch.).

1920. Bezzi, Mario, Via Pio Quinto, 3, Torino, Italy. (1918).

1914. Bradley, J. Chester, Cornell University, Ithaca, N. Y. (Ch.).

1914. Britton, W. E., Experiment Station, New Haven, Conn. (Ch.).

1914. Brues, C. T., Bussey Institution, Forest Hills, Boston, Mass. (Ch.).

1907. Bruner, Lawrence, Lincoln, Nebr. (Ch.).

1917. Burgess, A. F., Melrose Highlands, Mass. (Ch.).

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*Died February 22, 1921.

1917. Caesar, Lawson, Ontario Agr. College, Guelph, Ontario, Canada. (1912).
1907. Calvert, P. P., Zoology Dept., Univ. of Pennsylvania, Philadelphia, Pa. (Ch.).
1917. Chamberlin, R. V., Museum Comp. Zool., Cambridge, Mass. (Ch.).
1908. Cockerell, T. D. A., 908 Tenth St., Boulder, Colo. (1907).
1917. Crampton, Guy C., 86 Pleasant St., Amherst, Mass. (1911).

1917. Davis, J. J., Purdue University, Lafayette, Ind. (Ch.).
1917. Davis, Wm. T., 146 Stuyvesant Place, New Brighton, Staten Island, N. Y. (Ch.).
1917. Dean, G. A., Kansas State Agricultural College, Manhattan, Kansas. (1913).

1907. Emerton, J. H., 30 Ipswich St., Boston, Mass. (Ch.).

1907. Fall, H. C., Tyngsboro, Mass. (Ch.).
1908. Felt, E. P., State Entomologist, Albany, N. Y. (Ch.).
1914. Fernald, H. T., Massachusetts Agr. College., Amherst, Mass. (Ch.).
1907. Folsom, J. W., University of Illinois, Urbana, Ill. (Ch.).
1920. Funkhouser, W. D., Dept. of Zoology, University of Kentucky, Lexington, Ky. (1911).

1917. Gibson, Arthur, Central Experiment Farms, Ottawa, Canada. (Ch.).
1907. Gillette, C. P., 620 Elizabeth St., Fort Collins, Colo. (Ch.).

1920. Headlee, T. J., Agricultural Experiment Station, New Brunswick, N. J. (Ch.).
1917. Hebard, Morgan, Chestnut Hill, Philadelphia, Pa. (Ch.).
1907. Henshaw, Samuel, 28 Fayerweather St., Cambridge, Mass. (Ch.).
1914. Herrick, Glenn W., College of Agriculture, Ithaca, N.Y. (Ch.).
1914. Hine, J. S., 363 West Tenth Ave., Columbus, Ohio. (Ch.).
1907. Holland, Wm. J., Director Carnegie Museum, Pittsburgh, Pa. (Ch.).
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THE SCLERITES OF THE HEAD, AND THE MOUTH-PARTS OF CERTAIN IMMATURE AND ADULT INSECTS.

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AUG 15 1921
National Museum.

The external structures of the head, and the mouthparts in particular, are of considerable interest in making a study of the interrelationships and lines of descent of the different orders of insects; and it is of the greatest importance, in such a study, that we should know the correct homologies of the various parts, in order to determine what paths of development have been followed in deriving the higher types of insects from the lower ones. Many investigators have made the mistake of attempting to compare the higher types directly with the lowest ones without tracing the development of these types through a series of intermediate forms, with the result that the interpretations generally accepted as correct are frequently quite the reverse, and the true meaning of the different structures has not been fully grasped in many instances. On this account, I would devote the greater part of the following discussion to the consideration of such intermediate types as the Coleoptera, Neuroptera, etc., which serve to connect the lower insects with the higher ones, since it is these intermediate forms alone which can furnish us with the key to the proper interpretation of the modifications of the parts met with in the higher forms. Consideration has also been given to the condition found in larval insects as well, for, although larval insects are usually modified in adaptation to their own peculiar environmental conditions, they frequently retain the head structures in a more primitive condition than their corresponding adults do, and the clues obtained from an examination of the larval structures have amply justified the time spent in their study.

Dr. F. C. Craighead has very generously permitted me to incorporate his observations on the musculature of the mouthparts of an adult and larval *Corydalis* in this paper, and Figures 11 and 14 of Plate III were drawn by him. Since the advance information which he has kindly permitted me to use, has not yet been published by him, I would emphasize the fact that the statements concerning the musculature of the mouthparts quoted in this paper should be accredited to him, as is indicated where such quotations have been made in the following discussion.

Through the kindness of Mr. Nathan Banks, I was able to examine a number of interesting insects in the Harvard Museum, and many of the drawings of the heads of Neuroptera were made from this material. Since the specimens were dried, however, it was not always possible to see all of the parts very clearly, and many of the drawings from this source are therefore rather diagrammatic. I am also indebted to Dr. Edna Mosher for the loan of a *Hepialis* larva, to Dr. Cornelius Betten for the identification of the trichopterous larvæ here figured, and to Dr. Needham and Dr. Tillyard for some extremely interesting and valuable neuropterous larvæ.

The principal papers dealing with the mouthparts and head structures of insects in general are those of Packard, 1882-1898; Chatin, 1884-1897; Waterhouse, 1895; Kellogg, 1902-1904; Comstock and Kochi, 1902; Verhoeff, 1904; Berlese, 1909; Crampton, 1916-1917, and Yuasa, 1920. Hosford, 1918, has also treated of the head structures of insects in general; but her paper is practically a review of Comstock's work. Peterson, 1916, has recently written a fine paper on the head structures of Diptera, comparing them with the head structures of Orthoptera; but unfortunately he did not make a study of intermediate forms connecting such primitive types as the Orthoptera with such highly specialized types as the Diptera, with the result that certain of his interpretations of the parts in Diptera are quite wrong, and other investigators such as Wesche, who have attempted to compare the structures of Diptera directly with those of Orthoptera, have fallen into the same error.

Despite the fact that a large number of papers have been published dealing with the head structures of insects, the boundaries of the various head sclerites have not in many instances been clearly defined; and in the higher insects, such as the Diptera, the parts of the labium, for example, have not been interpreted correctly in the recent papers dealing with the subject. Even the most basic and fundamental features of the composition of an insect's head are not understood and interpreted aright in most of the recent textbooks and articles which treat of this phase of the subject, and it is quite apparent that there is a decided need of a thorough-going review of the whole subject of the head region of insects and the interpretation of its parts. Thus, for example, everyone who has recently discussed the superlinguæ or "paraglossæ" of insects (i. e., the lobes on either side of the hypopharynx) homologizes them with the maxillulæ (first maxillæ), instead of with the *paragnaths* of Crustacea, as should be done. (See references to origin of superlinguæ, mandibles, maxillæ, etc., in bibliography). In most textbooks one sees the incorrect statement that the maxillary galea and palpus represent the two forks of a biramous limb, instead of the correct interpretation of the palpus as the distal segments of a limb (endopodite) in which the second or stipes segment, and the third or palpifer segment have developed endites or lobe-like processes forming the galea and lacinia. The statement that the parts of the maxillæ are represented in the mandible, which one encounters in many publications, is wholly incorrect, since the mandible represents but a single segment of a limb, while the maxilla is composed of more than one segment of such a limb. The statement that the head of an insect is composed of seven segments, instead of but six (as embryology has long shown to be the case) is another instance of the many glaring inaccuracies one encounters on every hand in reading the literature dealing with the head region of insects; but since these matters have been discussed more at length in a series of articles dealing with each phase of the subject in detail, the following discussion is restricted to an attempt to determine the boundaries of the sclerites of the head in insects in general, and to interpret the structure of the parts of the head of higher insects in terms of those of the lower forms by using for study, as far as possible, the intermediate types serving to connect the higher with the lower insects.

As the study of embryology indicates, six segments enter into the composition of an insect's head. These are the protocephalon, antennal segment, intercalary segment, mandibular segment, first maxillary segment, and second maxillary or labial segment. Janet, 1899, Berlese, 1909, and others who profess to be able to mark off the head capsule of adult insects into rings of sclerites corresponding to the embryonic segments entering into the composition of the head, have simply let their imagination run away with them, and the diagrams which they have constructed do not correspond to the facts at all, for, as embryologists such as Riley, 1904, have pointed out, "the definitive sclerites can afford us little or no evidence as to the primary segmentation of the insects." It is therefore preferable to describe the sclerites of the head with reference to certain "landmarks" which occur in most insects, rather than to attempt to divide the head capsule into rings corresponding to the original segments entering into its composition. It must be borne in mind, however, that these convenient "landmarks" for establishing the boundaries of the head regions are not present in all insects; and in some forms, the sutures, etc., which occur in the lower insects may become obliterated and new ones may be formed, thereby tending to mask the original condition, and making it very difficult to define the regions with any great accuracy throughout the series of insects. In such cases it is often impossible to do more than state that the secondarily formed region is equivalent to the original one only in a general way.

The upper lip or *labrum*, (labeled "1" in all Figures) together with the clypeus, frons, "vertex," and genæ, all arise from the first or protocerebral segment of the embryo, according to Riley, 1904; and the labrum has been compared to the prostomium of annelids by some investigators, although there is some doubt as to the exactness of the homology in the latter case. The anterior (or lower) margin of the labrum is so deeply incised in some insects, as to give the labrum a pronounced bilobed appearance, which has led certain entomologists to conclude that the labrum is the fusion produce of two appendages; but a study of the embryological development of the labrum has shown that this view is entirely fanciful and unfounded. The labrum extends posteriorly to the transverse *labral suture* which usually demarks the labrum from the clypeal region behind it, although the labral suture is obsolete in some insects. When the labrum and clypeus are viewed from the "inner" or buccal surface, a small hinge-like thickening called the *torma* by Peterson, 1916, may be observed near either end of the labral suture, at the junction of the labral and clypeal regions; and these tormæ are frequently of value in determining the posterior boundaries of the labrum.

The labrum may be long and narrow as in certain Diptera, etc., or it may be broader than long, as in the orthopteroid insects. In some Hymenoptera, the labrum is not distinct, and a membranous lobe-like region called the *epipharynx* may project from the anterior region of the mouth to close the base of the tube for sucking honey, etc. In certain Diptera, the epipharynx may become long and stylet-like, forming with the labrum, the so-called labrum-epipharynx. In the orthopteroid insects the epipharyngeal region usually does not project to any great extent, and in such cases consists of the membranous inner lining of the labrum and clypeus (i. e., the "roof of the mouth") bearing hairs and taste organs frequently arranged about a Y-shaped thickening near the median region. In certain of these orthopteroid insects, the labrum may be partially divided into an anterior and posterior area called the *antelabrum* and *postlabrum*, by an incomplete transverse suture or by emarginations of the sides of the labrum.

As was previously mentioned, Riley, 1904, considers that the clypeus, together with the labrum, frons, etc., arose from the first or protocerebral segment of the embryo. The *clypeus*, labeled "cl" in all Figures, extends from the labrum (or the labral suture) posteriorly to the *clypeal suture*, which, however, may be obsolete in some insects. When the clypeal suture has disappeared, the posterior limits of the clypeus are demarked by a line drawn across from the base of one mandible to the base of the other mandible, since the clypeal suture, when present, corresponds in general to such a line connecting the bases of the mandibles, which are therefore the chief "landmarks" delimiting the posterior extent of the clypeus. This fact is of considerable importance, since the area usually called the clypeus in the Psocidæ, etc., lies behind the line connecting the bases of the mandibles, and is therefore in all probability an anterior portion of the frontal region.

The entire clypeal region may be but slightly chitinized and pigmented, giving the appearance of a membranous area, as is the case with the region labeled "cl" in Fig. 79 of a larval Lepidopteron, or in Fig. 39, of the termite *Mastotermes*. In other instances, as is the case in the Neuropteron *Raphidia*, shown in Fig. 33, and less clearly in the earwig shown in Fig. 36, the posterior region "pc" of the clypeus may be strongly chitinized and pigmented, while the anterior region "ac" is not strongly chitinized and pigmented (i. e., has a membranous appearance) thus differentiating the entire clypeal region into an *anteclypeus* "ac" and a *postclypeus*, "pc." Occasionally, the clypeus is divided into an anteclypeus and a postclypeus by a transclypeal suture extending transversely across it.

In the larva of the Neuropteron *Sialis*, shown in Fig. 40, the clypeal region "cl" is retained in a condition more nearly approximating the primitive, or original one. If one will compare this larva with those of the Neuroptera *Raphidia* and *Corydalis*, shown in Figs. 41 and 42, one may see that while the clypeal suture extends clear across from the base of one mandible to the base of the other in the larval *Sialis* shown in Fig. 40, (i. e., the line of the posterior border of the area "cl" extending from the base of one antenna to the other) this same clypeal suture is broken or interrupted in the larvæ shown in Figs. 41 and 42. In other words, the clypeal suture, usually extending from the base of one mandible to the other, extends only from the base of the antenna labeled "bat" to the frontal pit "fp" on either side of the head of the larvæ depicted in Figs. 41 and 42, while the median portion of the clypeal suture has "faded out," leaving no line of demarcation between the regions "pc" and "fr." Anterior prolongations of the arms of the frontal suture "fs" have extended forward into the clypeal region and have marked off a *paraclypeal* or *lateroclypeal* region "pcl" on either side of the median region of the postclypeus "pc." Comstock and Kochi, 1902, call the paraclypeal regions "pcl" the "antecoxal pieces of the mandibles;" but they are no more closely associated with the mandibles than are the lateral regions of the clypeus in any other insects, and the *clypanguli* or postero-lateral angles or lobes of the clypeus, which frequently bear the articulatory areas with which the dorsal condyles (epicondyles) of the mandibles articulate, are very much the same in *Raphidia* (Fig. 41), as they are in any other insect. The antero-ventral arms of the tentorium frequently extend forward to a point at or near the clypanguli. In the water bug *Belostoma* (Fig. 76) the lateral areas labeled "pcl?" which are here referred to as the jugum, (following a suggestion by Dr. Parshley) are possibly homologous with the paraclypeal areas of the Neuropterous larvæ shown in Figs. 41 and 42, "pcl;" but this point has not been definitely established.

Like the labrum and clypeus, the frons is a median unpaired region of the head (the posteriormost of the dorsal unpaired areas), and it also, according to Riley, 1904, arose from the protocerebral segment of the embryo. The frons, labeled "fr" in all Figures, extends from the clypeal suture (or a line drawn between the bases of the mandibles) to the *frontal suture*, labeled "fs" in Figs. 32, 36, etc., the frontal suture, when present, serving to demark the frontal region. When the frontal suture is absent, if a line be drawn across from the top of one antennal fossa to the other, and at either end of this line an angle of forty-five degrees is constructed the sides of the isosceles triangle thus formed, correspond in a general way to the frontal suture, which is formed by the arms of the Y-shaped epicranial suture (i. e., "cs" and "fs" of Figs. 32, 36, 40, etc.) when the latter is present. The frons usually includes the area bearing the *median ocellus*, but this is absent in many insects.

The frontal suture "fs" may extend forward "inside" of (or mesal to) the bases of the antennæ, as in Fig. 32 (a condition typical of many larval insects); or it may extend "outside" of (lateral to) the bases of the antennæ, as in the earwig shown in Fig. 36. In most larvæ (Figs. 32, 40, 79) the frontal suture extends to the epicondyle, or dorsal condyle of the mandible, and this is also true of many of the adult Neuroptera here figured, although in the latter insects, only the anterior portions of the frontal suture are retained, for the most part. A pair of *frontal pits* ("fp" of Figs. 63, 70, 42, etc.) or external manifestations of the internal invaginations of the body-wall forming the antero-dorsal arms of the tentorium, occur on or near the frontal suture in many Neuroptera, etc.

As was mentioned before, the frontal suture may secondarily send down branches into the clypeal region (marking off the lateral areas labeled "pcl" in Figs 41 and 42), while the median portion of the postclypeal region "pc" unites with the frons "fr" to form a compound frontoclypeal region bearing the labels "fr" and "pc" in Figs. 41 and 42, although the original extent of the frons "fr" is retained in the insect shown in Fig. 40.

A line drawn across between the bases of the antennæ divides the frons into an *antefrons* and *postfrons* in certain insects, and in these forms, the postfrons is usually united with the upper region of the head capsule. A narrow transverse region called the *epistoma* "eps" of Fig. 38, becomes secondarily marked off in the anterior region of the frons of certain beetle larvæ, etc., and in certain sawfly larvæ, such as the one shown in Fig. 32, a region labeled "eps," which may correspond to a portion of the epistoma is marked off by a faintly impressed line. MacGillivray, 1913, refers to the region "eps" of the sawfly larva shown in Fig. 32, as the "first clypeus," and to the true clypeus "pc" and "ac" as the "second clypeus." The region "eps," however, is clearly a portion of the frons, since it lies behind the clypeal suture extending across from the base of one mandible to the other, and while the region labeled "eps" in Fig. 32 does not correspond to the entire area bearing the label "eps" in Fig. 38, it does in a way correspond to the epistoma, or to a portion of the epistoma, and may therefore be regarded as a greatly reduced epistoma.

It is possible that the area labeled "fr" in Fig. 76 represents the anterior region of the frons (antefrons) rather than the frons proper, although for the sake of convenience, it has been referred to simply as the "frons" in the following discussion. In the Psocidæ (sensu lato), however, the region usually referred to as the "frons" is clearly the antefrons (or anterior region of the frons) alone, while the posterior region of the frons in these insects is frequently indistinguishably united with the region of the head behind it.

The frons was spoken of above as an unpaired region of the head, and this is true of most insects. In the beetle larva shown in Fig. 38, however, a median dorsal infolding or "implex" of the head capsule is formed, resulting in the production of an internal ridge for muscle attachment, and an external suture (corresponding to the internal ridge) which extends forward into the frontal region "fr," dividing it into equal halves,* as is shown in Fig. 38.

If we adopt from vertebrate anatomy the term "frontal region" for the frons, and the term "occipital region" for the portion of the head capsule about the occipital foramen, it is but logical to call the region between the frontal and occipital regions the "parietal region," since the parietal region occupies this position in the vertebrate skull. The term "parietals" has therefore been adopted for the region between the frons and occiput (i. e., the region labeled "pa" in all Figures) in the following discussion. Some entomologists apply the term epicranium to the parietals; but properly speaking, the epicranium includes not only the parietals, but also the frons, genæ and postgenæ as well, and it is preferable to have a distinct designation for the parietals.

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*It is quite probable that the region labeled "fr" in Fig. 38 represents the post frons, rather than the entire frons, since it lies behind the antennæ (in the postfrontal region).

The term vertex has also been applied to the parietals, and while this term is quite suitable for the parietal region of the Orthopteroid insects, in which the parietal region occupies the upper portion of the head, in other insects, such as the lepidopterous larva shown in Fig. 79, in which the parietals extend far forward, the term vertex is wholly inapplicable for the region in question, and in order to have a suitable term for this region in all insects, and since the sclerites composing this region are *paired*, it is preferable to refer to the sclerites between the frons and occiput as the parietals, as is done in vertebrate morphology.

The stem of the Y-shaped *epicranial suture* "cs" and "fs" forms the *midcranial* or *coronal suture* "cs" dividing the parietal area into symmetrical parts, and it is usually along this suture that the integument of the insect splits at the time of molting. The coronal suture "cs" is likewise an anterior continuation of the middorsal suture along the median region of the back, along which the integument of the body in general is split at the time of molting, thus suggesting a Lamarkian explanation of the origin of the suture in question. Comstock and Kochi, 1902, state that the middorsal suture "represents the line of closure of the embryo." While this suture may coincide with the line of closure of the embryo, I am inclined to consider that the middorsal suture (and its continuation into the head region as the coronal suture "cs") in some cases owes its origin to an infolding of the integument for muscle attachment. In the head region there is frequently a median dorsal "implex" or endoplica formed by an infolding of the integument for muscle attachment, and the lips of such an infolding of the body wall form an external suture.

In certain lepidopterous larvæ, as in the one shown in Fig. 79, an infolding of the integument occurs on either side of the frontal region "fr," and the *frontal sutures*, formed by the lips of these infoldings or endoplicæ, together with the *adfrontal sutures* mark off an adfrontal area (the *adfrontals* "af") on either side of the frons. In the beetle larva shown in Fig. 38, there are also marked off on either side of the region labeled "fr" (which represents a posterior portion of the frons) areas resembling the adfrontals "af" of the Lepidoptera (Fig. 79); the sclerites labeled "af" in Figs 38 and 79, and although the regions are not precisely the same in both insects, may be referred to as the adfrontals, for the sake of convenience.

On either side of the frons "fr" of various Neuroptera (e. g., Figs. 45, 56, 70, 74, etc.) there occurs a *parafrontal region* or *parafrons*, "pf," usually situated between the frontal suture (or the frontal pits "fp") and the compound eyes. The parafrontals are therefore somewhat different from the adfrontals described above, and have been designated by another term, to indicate this fact.

As was pointed out in a paper on the head region of lower insects (Crampton, 1917) a "*paracephalic*" or *laterocephal* suture marks off a laterocephalic area on each side of the head capsule, in some of the lower forms, though these areas may possibly represent secondarily formed regions of no particular phylogenetic significance, since they are not demarked in all of the primitive insects.

The anterior portions of the laterocephalic regions, namely, the areas below and behind the compound eyes, forming the "cheek" regions of the head, are called the *genæ*. An approximately vertical ridge or suture frequently demarks a posterior region of the genæ called the *postgena* by Comstock and Kochi, 1902. When these postgenæ extend along the gular region of the head, they correspond in a way, to the paragular region and hypostoma, described under the discussion of the ventral surface of the head capsule.

At the base of the mandibles (below, or anterior to the genæ) is a small sclerite called the *basimandibula* ("bmd" of Fig. 39) in the article referred to above (Crampton, 1917). This sclerite probably owes its origin to the chitinization of a portion of the membrane between the mandible and the head capsule. Comstock and Kochi, 1902, call the sclerites "bmd" (Fig. 39) the "trochantin of the mandible," thinking that it represents the trochantin or small sclerite at the base of the thoracic legs. This homology, however, is entirely fanciful, and it is misleading to designate the sclerite in question as the "trochantin" of the mandible.

Comstock and Kochi, 1902, describe an *occular sclerite* surrounding the compound eyes; but I am inclined to consider that this area is not marked off by a true suture, and I am very sure that it does not represent the basal segment of an occular appendage as Comstock and Kochi, 1902, are inclined to believe. There is, however, in certain lower insects, a fairly well demarked sclerite at the base of the antenna, called the *antennale* in a previous paper (Crampton, 1917); and a process or projection of this region called the *antennifer* in the paper in question (i. e., the structure labeled "anf" in Fig. 39), frequently supports the antenna in the more primitive insects. At the base of the antenna of many larval insects (particularly those of Coleoptera and Neuroptera) a ring-like area called the *basantenna* ("bat" of Figs. 41, 42, etc.) occurs at the base of the antenna. This area may originate as a projection of the head capsule, or through the chitinization of a portion of the membrane at the base of the antenna, and I am inclined to account for its origin in either of these ways, although this sclerite is regarded as a modified basal segment of the antenna by some entomologists.

Areas called the *postcranial regions*, or the *postcranials* (Crampton, 1920) occur in the posterior portion of the head of certain Trichoptera, etc. Traces of these regions are also found in the lower Lepidoptera, such as the Micropterygids, etc., but I have not traced them through a series of the more primitive representatives of the higher insects, though they will doubtless be found in other orders as well.

The *occiput* labeled "ocp" in all Figures is the dorsal and lateral region about the *occipital foramen*, or posterior opening of the head capsule through which the gullet, nerve cord, etc., pass into the head region. A posterior extension of the midcranial suture "cs" divides the occiput into two parts in the larva of the Neuropteron *Corydalis* (Fig. 42), and in the beetle larva shown in Fig. 38, the occiput consists of two *occipitals* "ocp" separated by a deep incision. The membranous area occupying the region between a similar incision in the posterior region of the head of the caterpillar shown in Fig. 79, and the anterior edge of the pronotum, is called the *vertical triangle* by Fracker, 1915.

In the postero-lateral region of the head, there frequently occurs a narrow area called the *trophifer* (Crampton, 1917) since the mouthparts articulate with this region in the lower insects. The *maxillifer* (or "*maxillary pleurite*" of Comstock and Kochi, 1902) enters into the composition of this region, and Riley, 1904, states that a portion of the postgena together with the "maxillary pleurite" arises from the maxillary segment, while the remainder of the postgena and the sclerites at the base of the mandibles arise from the mandibular segment of the head. It is very strange that if the basimandibulæ "bmd" of Fig. 39 belong to the mandibular segment, the genæ immediately above them do not belong to this same mandibular segment (Riley attributes the genæ to the protocerebral or first primitive segment of the head) and I am not entirely convinced of the correctness of Riley's conclusions in this matter, especially since he wrongly ascribes the cervical sclerites to the labial segment. Riley does not state to which embryonic segment the occiput belongs; but since the occiput occupies a considerable portion of the hinder region of the head, it is quite probable that it is derived from both the maxillary and labial segments.

According to Comstock and Kochi, 1902, the occiput is continued ventrally in the postgenæ, but in certain insects having a well defined occipital region (as in the neuropterous larvæ shown in Figs 14 and 15) the occiput extends ventrally to the gular region "gu." In the beetle shown in Fig. 17, it would appear that the occiput "ocp" is secondarily marked off by the rubbing of the prothoracic parts into which the hinder portion of the head is received in these insects.

The mandible articulates ventrally (by means of the hypocondyle, or ventral condyle labeled "hc" in Fig. 14, etc.) with a region called the *hypostoma*,* labeled "hs" in all Figures. The hypostoma "hs" is an antero-ventral region of the head (a portion of the region called *postgena* by Comstock and Kochi, 1902) situated on either side of, or near, the submentum "sm" (Figs. 15, 17, 18, 9, etc.), and is frequently demarked by a *hypostomal ridge* (or *suture*). Its chief distinguishing feature, however, is the fact that it bears the area with which the ventral condyle of the mandible articulates. In many insects it also bears a "fossa" in which the condyle of the maxilla articulates.

The *paragula* is a region on either side of the gula, labeled "pgu" in all Figures, and is demarked laterally by the paragular ridge or suture. The paragular area is indicated by the shaded area "pgu" (in Figs. 31, 13, 6, 7, 10, etc.) and forms the postero-ventral region of the head on either side of the gula "gu." The paragula and hypostoma together

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* This region in larval Cleridæ is discussed by Boving and Champlain in the Proceedings of the U. S. Nat. Museum, Vol. 57, p. 575, 1920, in which a discussion of the mouthparts of Coleoptera in general are also given. The term paragula is also employed in this paper.

make up the region called the postgena by Comstock and Kochi, 1902, the hypostoma forming the anterior portion near the mouth, while the paragula forms the posterior portion of the postgena. It has seemed advisable to thus divide the postgena, since the hypostoma in particular is of importance in the study of the head structures of larval Coleoptera, Neuroptera, etc. In the beetle larva shown in Fig. 27, a small sclerite "pgu?" situated on either side of the gula "gu," and bounded posteriorly by a paragular suture, has been provisionally homologized with the paragula of other insects, although it very probably represents merely an anterior portion of the entire paragula. The divided areas labeled "pgu" in Figs. 22 and 29 are likewise not strictly homologous with the paragulæ of other insects, but it is not worth while to designate them by a distinct designation, since they occupy approximately the position of the paragular areas.

The throat region, or the median postero-ventral area of the head, labeled "gu" in all Figures, is called the *gula*. The gula "gu" extends from the posterior border of the head capsule proper to the submentum "sm" (Figs. 12, 16, 15, 18, etc.) and is bounded laterally by more or less distinct lines or sutures called the *gular sutures*. Situated on or near these sutures are the *gular pits* "gp" of Figs. 15, 12, 9, etc., which mark the position of the posterior ventral arms of the tentorium. In some insects, the gular pits mark the posterior extent of the submentum, but in others, the gular region extends far forward of these gular pits (as in Fig. 12). In such cases, the anterior extent of the gular region is marked by a line drawn between the bases of the maxillary cardines "car" (corresponding to the submental suture), or, according to Dr. Craighead, the gular region extends forward to the posterior attachment of the muscles labeled "11" in Figs 11 and 14.

The *intersternite*, "is" of Figs 8, 15, 13, etc., one of the anterior plates of the neck region, is ascribed to the gular region by Comstock and Kochi, 1902, Riley, 1904, and others; but this plate becomes attached to the posterior region of the head in very few insects, and then only secondarily. It is homologous with other intersegmental plates occurring between the thoracic segments in the lower insects, as was pointed out by Crampton, 1917. The *pregula*, "prg" of Fig. 17, is apparently a region secondarily marked off in front of the narrow region of the throat labeled "gu" in certain Coleoptera, etc. Its significance is not very clear, and there is need of further study of this region.

In the insects shown in Figs. 20, 21, 24, 26 and 27, the region labeled "gu" may not represent the entire gula, and has therefore been referred to as the *gular plate* in the following discussion. The region labeled "gu" in Fig. 7, likewise may not represent the entire gular region, but such a narrow, transverse, posterior gular plate is characteristic of the Dermaptera, and may serve as one of the diagnostic characters of the order.

The origin of the gular region is a very puzzling feature. It is quite possible that in some insects the posterior portion of the gular region of the adult head may be formed through a chitinization of the membranous area situated between the ventro-median edges of the head capsule and behind the mentum. In the insect shown in Fig. 27, it would appear that the ventro-median edges of the head capsule have become approximated, or "come together," behind the narrow gular plate "gu," and meet along the *midgular suture* "mgs." The fact that there is a narrow membranous space behind the gular plate "gu" in the trichopterous larva shown in Fig. 20, while this space has apparently disappeared through the coming together of the median edges of the head capsule behind the gular plate "gu" in the trichopterous larva shown in Fig. 24 (in which there is a midgular suture "mgs" like that of the beetle larva shown in Fig. 27) would lend weight to the view that the midgular suture "mgs" is formed by the approximation of the ventro-median edges of the head capsule along the median line of the head. On the other hand, the midgular suture "mgs" of Figs. 24 and 27, may have been formed secondarily in the integument of the head capsule as the result of the formation of a midventral implex or infolding of the body wall, such as frequently occurs along the midventral line of the thoracic region. Comstock and Kochi, 1902, suggest that the midventral suture of the thoracic segments "perhaps represents the neural groove of the embryo;" but I am inclined to attribute another origin to the suture in question—which probably arose through the formation of an infolding of the body wall for muscle attachment.

A study of the condition found in the different castes of termites throws some light upon the rather difficult question of the origin of the gular region, since in the termites, at least, the gular region appears to represent the posterior portion of an originally distinct plate which has become adherent to the head capsule. Thus, for example, in the head of a winged termite such as that shown in Fig. 13, the gular region "gu" forms the posterior portion of a distinct *gulamental plate* bearing the labels "gu" and "sm." In the soldier caste of this same termite, on the other hand, the posterior portion of the gulamental sclerite (bearing the labels "sm" and "gu" in Fig. 16) becomes "soldered onto" the head capsule to form the gular region, "gu," while the anterior portion of the gulamental area, bearing the label "sm," remains free and forms the submental region. We may therefore conclude that in some cases at least, the gulamental plate ("gu" and "sm" of Fig. 13) becomes elongate and its posterior portion is more or less closely fused with the head capsule to form the gular region "gu" of Fig. 16. In such instances, the lateral margins of the plate in question may be represented by the *gular sutures* on either side of the gular region "gu" shown in Fig. 16.

The *labium* or under lip is formed by the union of a pair of mouthpart-limbs (second maxillæ) similar to the maxillary mouthparts. The statement so often made that the neck plates, or cervical sclerites, represent the labial segment whose appendages have left the neck region and have migrated into the head region to form the labium, is wholly false, and is unsupported by a single bit of anatomical or embryological evidence. This matter, however, has been fully discussed in an article by Crampton, 1917, and need not be further considered here.

The pleural region of the labial segment is included in the region about the occipital foramen referred to as the "trophiger" or trophi-bearing area, and forms the narrow marginal area shown in Figs. 13, 10, etc. It sometimes bears an *occipital condyle* or process, with which the anterior process of the lateral neck plate articulates to aid in supporting the head capsule, while allowing for the freedom of movement of the head.

Holmgren, 1909, states that "an embryological study (of the second maxillæ or labial appendages) further indicates that the submentum is formed by a portion of the articulatory membrane between the second maxillary segment (or labial segment) and the first thoracic segment, and therefore has nothing to do with the second maxillæ (labial appendages)." Holmgren, Heymons, and other embryologists likewise agree that the hypopharynx or "tongue" is formed in part by the sternum of the labial segment, and Boerner, 1903, states that he considers it quite impossible to regard the mentum, submentum and gula as the sternites of the labial segment, "since in some insects, traces of a true (labial) sternum are retained between the bases of the coxæ of the posterior mouthpart-limbs." In other words, Boerner regards the median triangular area between the bases of the structures labeled "pgr" in Fig. 10, as the representative of the sternum of the labial segment. Whether these views are correct or not, I cannot say, although I have a strong feeling that either the mentum, or a portion of the submentum may be formed from the sternal area of the labial segment (in addition to the basal portion of the hypopharynx which is formed from the sternal area of the labial segment). What proof there is to be drawn from embryology, however, would not bear out the latter view—at least so far as is at present known; and under these conditions, it would be wholly unjustifiable to claim that the mentum, or a part of the submentum are formed from a portion of the sternal region of the labial segment. On this account, I have provisionally accepted the view that the submentum and mentum are secondarily formed sclerites situated behind the true labium, in the following discussion. It has been found convenient, however, to treat the underlip as though it were composed of three principal plates or areas, in comparing this region in the different types of insects; and for the sake of convenience, I have referred to these three plates or areas as the *gulamentum* (i. e., the region bearing the labels "gu" and "sm" in Fig. 23), the *mentum*, labeled "mn" in Fig. 23, and the true labium, or *eulabium*, which bears the labels "prm," "lg" and "lp," in Fig. 23.

The *gulamentum* ("gu" and "sm" of Figs. 23, 13, etc.) becomes divided into a gular region and a submental region in some insects, while the gular portion becomes "soldered" onto the head capsule in some insects (e. g., "gu" of Fig. 16) as was stated above; and the gular region may be further augmented by the addition of portions of the integument behind the gulamentum. The gular region "gu" is separated from the *submentum* "sm" by a *pregular cleft*, or *suture*, in such insects as the caddice fly larva shown in Fig. 24, and the occurrence of such a pregular suture is of value in marking off the posterior extent of the submentum. The suture in question, however, is rarely present in insects in general, and in such cases the posterior limits of the submentum are demarked by an imaginary line drawn across from one gular pit "gp" of Fig. 15, to the other gular pit, or by a line drawn across from the base of one maxillary cardo "car" of Fig. 12, to the other, and corresponding in general to the line behind the label "sm" in Fig. 12. Dr. Craighead informs me that the submento-mental muscles labeled "11" in Figs. 11 and 14, which extend from the posterior border of the submental region to the posterior portion of the mental region, serve to demark the submental region "sm," internally; and since the posterior line of attachment of these muscles corresponds in a general way to the posterior border of the submentum, they offer a valuable means of determining the homologues of the submental region when it is not clearly demarked externally. The most reliable method of determining the posterior limits of the submentum on the external surface of the head, however, is to draw an imaginary line between the bases of the cardines "car" of Figs. 24, 21, 20, 26, 31, 22, 9, 8, 7, etc., since it is not always possible to dissect a specimen (e. g., as is the case with dried material) in order to determine the origin and insertion of the muscles in question.

In the insects shown in Figs. 21, 22, etc., the submental region contains two small plates, the *submentales*, "sml," situated at the base of the maxillary cardines "car." These submentals do not comprise the entire submental region, and in some insects, such as the one shown in Fig. 20, the submentals are represented by the small areas labeled "sml" alone. In the lepidopterous larva shown in Fig. 25, the areas labeled "sml" occupy a position at the bases of the maxillary cardines, "car," as do the submentals of the insects referred to above; and the areas labeled "sml" in Fig. 25, as well as the ill-defined areas bearing the label "sml" in Fig. 29, may therefore be interpreted as representing the submentals of other insects. In the caterpillar shown in Fig. 28, the submentals "sml" are rather heavily chitinized and pigmented, and might be mistaken for the maxillary cardines, but the true cardo of the maxilla is the plate labeled "car" in Fig. 28. The submental region is membranous in some insects, such as those depicted in Figs. 31, 77, etc., while in such insects as the beetle, shown in Fig. 17, "sm," it is strongly chitinized and is deeply emarginate anteriorly.

In the Neuropteron *Nemoptera* (Fig. 86) and in the Mecopteron *Bittacus* (Fig. 85) the principal part of the submentum "sm" forms a portion of the slender column-like sclerite whose anterior region "mn" has been homologized with the mentum; and this tendency toward the formation of a column-like sclerite in the mental region is also found in some Diptera. Whether the submentum includes the entire plate bearing the label "sm" in Figs. 10 and 6, or not, I cannot say; but it is very probable that the plate in question contains the gular region as well. It is also possible that the anterior, paler area bearing the label "sm" in Fig. 6, represents an anterior division of the submentum.

The *mentum*, "mn" of Figs. 5, 6, 7, 8, 9, 10, 23, 31, 12, 15, 77, etc., is the region between the submentum, "sm," and the eulabium, or true labial region bearing the labels "pgr," "ls," "prm," etc., in the figures in question. The mentum "mn" forms the second of the plates forming a series of three in the underlip region of the Neuropteron shown in Fig. 23, which I have taken as the basis for comparison with the higher insects. The mentum, "mn," may be fused with the region "sm" behind it, as in the insects shown in Figs. 85, 86, etc.; it may be separated from the submental region "sm" by a clearly defined *mental suture* as in Figs. 23, 26, 7, etc.; it may be demarked merely by a faint dividing line between it and the submental region as in Fig. 13, etc.; or it may be a distinct plate "mn" as in the insects shown in Figs. 82, 77, 15, 6, etc. In the insects depicted in Figs. 21, 31, 17, etc., the mentum is represented by a membranous area bearing the label "mn." The *mentales* or small sclerites bearing a seta and situated in the posterior region of the mentum, "mn" of the caterpillar shown in Fig. 31, or in the trichopterous larvæ shown in Figs. 21, 20, etc., are possibly homologous with the chitinized areas in the posterior region of the mentum "mn" of the Neuropteron larva shown in Fig. 12.

The *eulabium* comprises the distalmost, or anteriormost portion of the underlip region beyond the mentum, "mn," from which it is separated by a *eulabial suture* in the insects shown in Figs. 23, 20, 27, 13, 15, 17, etc. The eulabium, as was stated above, is the true labium, formed by the union of the second maxillæ. I would emphasize the fact that the labial appendages are homologous with the second maxillæ of the Crustacea (see articles in bibliography) and it is wholly incorrect to maintain that the so-called superlinguæ on either side of the hypopharynx of insects are homologous with the first maxillæ (i, e., the maxillulæ) of Crustacea as is done by practically all recent investigators, since the "superlinguæ" are homologous with the *paragnaths* of Crustacea, and the labial appendages represent the true second maxillæ of Crustacea, as has been brought out in a paper published in the 50th. Annual Report of the Ent. Soc. of Ontario, in a preliminary note in the Transactions of the Ent. Soc. of London, and in a more lengthy paper on this subject, illustrated by drawings of the parts in question in Crustacea and insects, which will soon be published in Psyche, and the Proc. Ent. Soc. Washington for 1921.

As was mentioned in the preceding discussion, the greater portion of the sternum of the labial segment enters into the composition of the *hypopharynx*, or tongue-like structure on the floor of the mouth cavity. It is very probable, however, that the *labiosternite* or median triangular area between the bases of the structures labeled "pgr" in Fig. 10, represents a portion of the sternal region of the labial segment. The *palpigers*, "pgr," or palpi-bearing structures on either side of the median triangular area shown in Fig. 10 (also structures labeled "pgr" in Figs 6, 7, 15, 81, etc.) together with the labiostipes, "ls," represent portions of the basal segments of the modified limbs forming the labium, while the distal segments of these limbs (representing the terminal segments of the "endopodite" of a crustacean limb) form the *labial palpi* "lp" of Figs. 6, 7, 10, 15, etc. Outgrowths of the basal segments "pgr" and "ls" of the limbs (these outgrowths possibly represent endites or "gnathobases" of a crustacean limb) form the *glossa*, "gl," and *paraglossa*, "pg," of the labium (see Figs. 6, 10, etc.) The glossæ, "gl," of Fig. 13, 10, etc., are sometimes referred to as the inner lobes of the labium, while the paraglossæ "pg" are sometimes referred to as the outer lobes of the labium. The sclerite labeled "ls" in Figs. 10, 6, 13, etc., is sometimes called the "stipes," but since the term stipes is restricted to a sclerite of the maxilla, I would refer to the sclerite "ls" as the *labiostipes*, to indicate that it is a labial structure. The labiostipes "ls" bears the inner and outer lobes of the labium (i. e., "gl" and "pg" of Figs. 6, 10, etc.) in some insects.

Various modifications of the above-mentioned structures are met with in different insects. Thus in the beetle larva shown in Fig. 8, a *ligula*, labeled "lg" occurs in the region originally occupied by the inner and outer lobes ("gl" and "pg" of Figs 10, 6, etc.), and it is quite probable that the ligula "lg" of the beetle larva shown in Fig. 8, (or the insects depicted in Figs. 9, 49, 23, 27, etc.) represents the fusion product of the two inner lobes (glossæ) of the labium, with which the outer lobes (paraglossæ) may also have united. In the insects shown in Figs. 17 and 15, on the other hand, the ligula "lg" is apparently formed by the united glossæ only, since the paraglossæ "pg" are apparently still distinguishable. In most instances, however, the general term ligula has been applied to the unpaired median terminal structure projecting between the labial palpi (i. e., "lg" of Figs. 8, 9, 27, 23, etc.) regardless of whether it is formed by the united glossæ alone, or whether the paraglossæ have also entered into its composition.

In the larvæ shown in Figs. 8, 20, 25, 31, 49, etc., there occurs a *basilabium*, "prm," or basal labial plate formed by the union of the labial stipes "ls" of Figs. 6, 10, etc. This basal labial plate may also include the palpigers in its composition, and is typically a transverse chitinization of the area at the base of the labial palpi. In some insects it is not demarked from the ligula "lg" (as in Figs. 23, 9, etc.) while in others, such as those depicted in Figs. 8, 22, etc., it is demarked by a faint line, or is differentiated by a stronger chitinization and pigmentation.

In connection with the discussion of the terminal region of the labium, the *spinneret* "spt" of Figs. 25, 31, etc., should be mentioned. This spinneret is usually closely associated with the ligular region, although a portion of the hypopharynx may possibly be involved in the spinning structure. Whether or no the structure labeled "spt?" in Fig. 30, is homologous with the spinneret of lepidopterous larvæ, is a question which I have been unable to decide, and I have therefore merely offered the suggestion as a possibility, rather than as a definite opinion in the matter. A comparative study of this region in the Trichoptera, Lepidoptera, and other spinning larvæ is greatly needed, and would be of considerable value in the matter of determining the affinities of the insects having caterpillar-like larvæ.

It is very unfortunate that Peterson, 1916, who follows Kellogg, 1899-1902, in his interpretation of the parts, did not study the mouthparts of the Neuroptera such as *Nemoptera* (Fig. 86) and the Mecoptera, such as *Bittacus* (Fig. 85), *Panorpa* (Fig. 82), etc., before attempting to homologize the parts in the highly specialized order Diptera, instead of attempting to compare the Diptera directly with the lower orders such as the Orthoptera, etc., since the Neuroptera and Mecoptera mentioned above furnish the key to the interpretation of the parts in the Diptera, and the evidence they offer is most convincing. Wesche, however, is probably responsible more than anyone else for the confusion of the interpretation of the parts of the trophi by recent Dipterists, and Peterson's work is a great improvement over that of Wesche, Smith and others who have misinterpreted the structure of the mouthparts in a most amazing fashion, due to the fact that they have ignored the intermediate forms between the lower orders and the higher ones in attempting to homologize the parts in Diptera.

As I pointed out in a recent paper (Crampton, 1917) dealing with the head region of Neuroptera, Mecoptera, Diptera, etc., the labial palpi, "lp," of the Neuroptera such as *Nemoptera* (Fig. 86) tend to become approximated in the median line of the head (compare Fig. 86 with the Neuropteron shown in Fig. 81) while the ligula "lg" tends to disappear. A further step is represented by the Mecopteron shown in Fig. 85, in which the ligula "lg" of Fig. 86 has completely disappeared, although the labial palpi, "lp," have retained their typical three-segmented condition, and the palpigers, "pgr," are still partially distinct. In the Mecopteron shown in Fig. 82, the labial palpi, "lp," have been reduced to two segments, the basal one being quite thick and "fleshy," while the terminal one is small and slender. The sclerites which I have interpreted as the palpigers, "pgr," (although they may possibly represent the basal segments of the labial palpi instead) tend to unite, and the mentum "mn" is a broad plate somewhat produced anteriorly. A further modification is shown in the Mecopteron depicted in Fig. 84, the labial palpi being reduced to the fleshly lobes, "lp," while the palpigers have united to form the region "pgr," which is but indistinctly demarked from the mentum "mn" behind it. The labial palpi, "lp," have even developed "pseudotracheæ" like those occurring on the labial lobes of certain Diptera, in some of the Mecoptera; and the whole trend of development in the Mecoptera indicates the origin of the inherent tendencies which find opportunity for fuller expression in the Diptera. Thus in the Dipteron shown in Fig. 83, the labial palpi "lp" are fleshy lobes like those of certain Mecoptera,* and they have even retained traces of two segments in the Dipteron shown in Fig. 83, which in this respect is more primitive than the Mecopteron shown in Fig. 84. The palpigers, "pgr," of Fig. 83 are also distinct, although they have completely united in the insect shown in Fig. 84, to form the region labeled "pgr." The narrow median structure labeled "mn" in Fig. 83, is clearly the mentum. When one compares the Diptera with the

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* Dr. Tillyard, to whom I have shown the accompanying figures, in discussing the interpretation of the mouthparts of the Diptera, informs me that he has come to the same conclusion, independently, in comparing the head structures of Diptera with those of the Mecoptera, thus giving additional weight to the correctness of the interpretation here offered.

Mecoptera and with the Neuropteron shown in Fig. 86, it is thus a very simple matter to determine the interpretation of the parts of the labium of the Diptera, and if Peterson and Wesche had only used these forms instead of trying to compare the Diptera directly with the Orthoptera, etc., they would have had no difficulty in determining the homologies of the Dipteron structures, so far as the principal features of the mouthparts are concerned. I must admit, however, that the interpretation of the slender lobes between the terminal segments of the labial palpi labeled "lp" in Fig. 83, has given some trouble. They may possibly represent the paraglossæ ("pg" of Fig. 77), for example) of other insects, although I am more inclined to regard them as merely lobe-like outgrowths of the segments of the palpi.

The interpretation of the parts of the labium of the hemipterous insects has proven to be a rather difficult problem, largely due to the fact that I have not as yet been able to make a thorough study of the mouthparts of the Psocidæ (which are closely related to the hemipterous insects) due to lack of proper material. From what is known of the tendencies for the parts to unite in the Mecoptera discussed above, however, I think we are justified in assuming that the sclerites labeled "lp" in Fig. 75 (of a species of *Cicada*) represent the more or less closely united labial palpi, while the structures labeled "pgr" in Fig. 75, very probably represent the palpigers "pgr" of Figs. 82, 86, 83, etc., and the plate "mn" of Fig. 75 is therefore largely composed of the mentum; the other basal structures of the underlip region are probably included in the more membranous region behind the mentum "mn." When we turn to the true Hemiptera (Heteroptera), however, the parts have become so modified that it is very difficult to determine their homologies in many instances. Dr. Parshley has called my attention to the fact that hemipterists frequently interpret the structures labeled "ap" in Fig. 76, as the "labial palpi" in the belostomatids; but Heymons does not consider that the structures in question are the true labial palpi, from his embryological studies. I am more inclined to regard the appendages "ap" of Fig. 76, as lateral lobes of the region "pgr," which have become demarked by the formation of a secondary suture; and the appendages "ap" therefore have nothing to do with the true labial palpi, which probably enter into the composition of the sclerite labeled "lp?" in Fig. 76. The structures labeled "pgr" and "mn" in Fig. 76, are possibly the palpigers and mentum, "pgr" and "mn," of the *Cicada* shown in Fig. 75.

I would call attention to the fact that in all of the coleopterous larvæ which I have examined, the labial palpi, when well developed, are made up of not more than *two segments*, while in all of the neuropterous larvæ which might be mistaken for coleopterous larvæ have at least *three segments* in the labial palpi. This distinction may be of value in distinguishing between the two types of larvæ, since it is very difficult to find any characters for differentiating between the two groups of insects, and any distinguishing feature which "holds good" in the majority of cases, should be of considerable interest on this account.

The Dermapteron shown in Fig. 7 is a primitive, but highly aberrant earwig, and the condition occurring in its mouthparts may therefore not be as typical as though another form had been chosen to illustrate the group. In all of the Dermaptera which I have examined, however, the paraglossæ "pg" (Fig. 7) are long and slender, and the glossæ have apparently been lost, so that these features, in conjunction with the peculiar character of the gula "gu" (which is a narrow transverse sclerite in the earwigs) may be of value in characterizing the order Dermaptera.

In the larvæ of the Neuroptera related to the Myrmeleonidæ (Figs. 44 and 47) there is a tendency for the gula, "gu," submentum, "sm," and mentum, "mn," to unite, while the antero-lateral structures labeled "pgr" bearing the labial palpi, "lp," acquire a greater mobility to compensate for the loss of movement on the part of the rest of the labial structures. The structure labeled "pgr" in Figs 44 and 47 may not be the exact homologues of the palpigers "pgr" of other insects; since other portions of the labium probably enter into their composition; but the term palpiger as applied to the structure in question is sufficiently accurate for practical purposes. In the neuropterous larva shown in Fig. 46, the labial palpi are apparently composed of more than the usual three segments found in the palpi of most Orthoptera, etc., and it is quite probable that a secondary segmentation of the palpi has taken place in the Neuropteron in question. Faint indications of such a secondary segmentation of the labial palpi, "lp" are to be found in the larva shown in Fig. 51, in which the labial palpi are either composed of but three actual segments, with a distinct palpiger having the appearance of a fourth segment, or a fourth segment has been formed in an originally three segmented labial palpus. The fact that the palpi are but three-segmented in the primitive neuropterous larvæ shown in Figs. 23, 12, 15, etc., would indicate that three is the original number of the labial segments of the group as a whole. In connection with the discussion of the labial palpi of the Neuroptera, I would call attention to the *palpimaculæ*, "pm," or sense organs borne on labial palps of the Myrmeleonid shown in Fig. 70. A similar sense organ occurs on the labial palp of *Nymphes* (Fig. 72, "pm") and this fact adds weight to the view that the Myrmeleonidæ and Nymphes are quite closely related.

The *maxillæ* of an insect are homologous with the first maxillæ (not the second maxillæ, as Folsom and others maintain) of Crustacea, as may be seen by comparing an embryo of any primitive insect, with the embryo of a crustacean, such as the isopodan *Jaera*, figured by McMurrich. The sternal region of the maxillary segment takes part in the formation of the hypopharynx, or tongue-like structure on the floor of the pharyngeal cavity, while the pleural region of the maxillary segment enters into the composition of the posterior region of the head, called the "trophiger," which is situated near the occipital foramen, or posterior opening through which the nerve cord, gullet, etc., pass into the head capsule. The pleural region of the maxillary segment is demarked from the pleural region of the labial segment behind it by the posterior tentorial invaginations, according to Riley, 1904, in the embryo of the cockroach.

The membrane at the base of the maxilla, labeled "bm" in Fig. 5, etc., may be termed the *basimaxillary membrane.* A plate called the *basimaxilla,* "bm," of Figs. 8, 9, etc., results from the chitinization and pigmentation of the membranous region at the base of the maxilla in certain coleopterous larvæ, etc. This basimaxillary plate, "bm," of Figs. 8 and 9, should not be confused with the subdivision of the cardo labeled "pac" in Figs. 5, 6, etc., since the latter sclerite, "pac," is a demarked subdivision of the cardo, and therefore does not arise through a greater deposition of chitin and pigment in the membrane at the base of the maxilla, as is the case with the basimaxillary plate.

As was pointed out in a paper dealing with the maxillæ of orthopteroid insects (Crampton, 1916) the basal sclerite or *cardo* of the maxilla of the insect shown in Fig. 10, for example, is divided into a *eucardo,* "euc," and a *paracardo,* "pac," while the *stipes,* or second segment of the maxilla, is divided into a *eustipes,* "eus," and a *parastipes,* "pas." The parastipes, "pas," however, is apparently a distinct narrow sclerite formed along the mesal margin of the stipes, and it is doubtful that it arose as a demarked portion of the stipes proper. In fact, it would appear from a comparison with the structures of certain Crustacea, that the parastipes, "pas," originally was a part of the basal segment or cardo, and become secondarily united with the stipes, but it is simpler to treat of the parastipes as a portion of the stipes.

In a paper which will be published in the 1921 volume of the Proceedings of the Ent. Society of Washington, it has been pointed out that the maxilla of a larval neuropteron such as the one shown in Fig. 23, corresponds in a remarkable fashion to the typical crustacean limb represented by the maxilliped of *Gammarus* (an amphipodan crustacean) for example, since in both cases, the mouthpart-limb is composed of seven segments, and the correspondence in the relative sizes of the individual segments, and the processes they bear, is marvellously close, when one takes into consideration the fact that we are dealing with forms belonging to distinct classes of arthropods. Such a comparison of the parts in insects and Crustacea very clearly demonstrates that the basal segment or cardo, "car," of Fig. 23 represents the basal segment, or coxopodite, of a crustacean limb. The second segment, or stipes, "bs," of Fig. 23, which bears a median process, "la," (the lacinia) in the insect there figured, clearly corresponds to the second segment or basipodite which also bears a median process or endite in a crustacean mouthpart-limb. The third segment, or palpifer, "ds," of Fig. 23, which bears a median process, "ga," (the galea), evidently corresponds to the third segment or ischiopodite, which also bears a median process or endite in the crustacean mouthpart-limb. The four segments of the maxillary palpus, "mp," of Fig. 23, correspond (even to the relative lengths of the component segment) very closely to the four segments of the endopodite of the maxilliped or *Gammarus,* and there can be no doubt that the maxillary palpus of an insect's maxillary appendage corresponds to the endopodite of a crustacean limb, while the palpifer with its endite (the galea) and the stipes, with its endite (the lacinia) correspond to the third and second segments of a crustacean mouthpart limb (which also bear endites in *Gammarus*' maxilliped), and the cardo corresponds to the basal segment of such a crustacean mouthpart-limb.

A *basistipes*, "pst," is demarked in the basal region of the stipes, "sti," of the Dermapteron shown in Fig. 7, and if one compares the entire stipes region, bearing the labels "eus" and "pas" in Fig. 10, of a blattid, with the region labeled "pst" in Fig. 7, it should be clear to anyone that the small basal area, "pst," of Fig. 7 is not the entire stipital region "eus" and "pas" of Fig. 10—which may be taken as the basis for comparison with the higher forms. Similarly, when one compares the maxilla of a primitive Coleopteron, such as that shown in Fig. 4, with the maxilla of the Dermapteron (earwig) shown in Fig. 7, it should be perfectly evident that the latero-basal area, "pst" of the stipes of the beetles maxilla (Fig. 4) is in every way homologous with the latero-basal area, "pst," of the stipes of the earwig's maxilla (Fig. 7). On this account, it is quite incorrect to term the area "pst" the "stipes" in beetles (Figs. 4, 3, etc.), as is done by coleopterists in general. In fact, if one compares the maxilla of the beetles shown in Figs 4, etc., with that of the beetle shown in Fig. 1, in which the stipes, "sti," is retained in a condition more nearly approaching that typical of the lower insects, it is at once apparent that the small area, "pst," of the beetle shown in Fig. 4 cannot possibly be homologized with the entire area, "sti," of the beetle shown in Fig. 1, and since the area "pst" of Fig. 4 evidently represents a basal subdivision of the entire stipes, it has been referred to as the basistipes in the present paper. A basistipes, "pst," is demarked from the stipial region only in certain Coleoptera (Fig. 4) and Dermaptera (Fig. 7) so far as I am aware, and the presence of this peculiar subdivision of the stipes in the Coleoptera and Dermaptera alone, would add further support to the view that the Coleoptera are extremely closely related to the Dermaptera—which is borne out by the study of numerous other structural details as well.

In the Dermapteron shown in Fig. 7, the *palpifer*, "pfr," is clearly demarked from the stipes, but the palpifer is not closely associated with the galea, "dg," in this insect, as is the case with the larva shown in Fig. 23. On the other hand, if one compares the larval Neuropteron shown in Fig. 23, with the larval Coleopteron shown in Fig. 27, it will be noted that the palparium or palpifer, "ds," which bears the galea, "ga," is slender, and resembles a basal segment of the palpus in both of these insects, thus adding further support to the view that the Coleoptera are very closely related to the Neuroptera (as well as to the Dermaptera). The Coleoptera are anatomically intermediate between the Dermaptera on the one side and the Neuroptera on the other, and, strange to say, an adult Coleopteron is, as a rule, more like a Dermapteron in structure than it is like a Neuropteron, while a larval Coleopteron is usually more like a larval Neuropteron in structure (although in some features larval Coleoptera are very like immature Dermaptera also).

In the Neuropteron shown in Fig. 86, the palpifer is adherent to the stipes, while in the Mecopteron shown in Fig. 85, it is less closely associated with the stipes, and in the Mecopteron shown in Fig. 84 it has the appearance of a basal segment of the maxillary palpus, "mp." I am not sure of this interpretation, however, since the structure interpreted as the palpifer may actually be a basal segment of the palpus, and on this account no label was affixed to the structure in question. In the beetle shown in Fig. 3, the palpifer, "pfr," is much larger than in most Coleoptera (Figs. 1, 3, etc.); it has also developed a peculiar prominent *palpiferal angle* or projecting angle-like process in the region bearing the label "pfr," and through a distortion or shifting of the parts, the maxillary palpus, "mp," comes to lie over the surface of the palpifer in a peculiar fashion.

I had at first considered that the areas labeled "bs," "in" and "ds" in Fig. 25, for example, represent three divisions of the stipes (i. e., basistipes, interstipes and dististipes) and therefore affixed to these areas labels indicating that they are divisions of the stipes. After the blocks for the plates had been made, however, and it was therefore too late to change the labelling, a further study of the palpiferal region brought to light considerable evidence for considering that the sclerite labeled "ds" in Fig. 25 represents the true palpifer or palparium, and is therefore not a part of the stipes. The area bearing the label "bs" in Fig. 25, however, is apparently a *proxistipes*, or proximal subdivision of the stipes, and the area labeled "in" is apparently a *dististipes*, or distal subdivision of the stipes. In Figs. 31, 23, 27, 22, 21, 20, 24 and 26, on the other hand, the sclerite labeled "bs" apparently represents the entire stipes, rather than a proximal subdivision of the stipes, as the label indicates, while the sclerite labeled "ds" in these figures apparently represents the true palpifer instead of a distal subdivision of the stipes, as the labels indicate. It thus comes about that the label "bs" indicates a basal subdivision of the stipes in Figs. 25, etc., but in the other figures mentioned above, the label "bs" indicates the entire stipes, but I have been unable to change the labeling in the plates to indicate this fact.

In the sawfly larvæ shown in Fig. 49 and 54, a narrow marginal region bearing the label "gg," bearing the galea "ga" is demarked by a well defined suture. The area labeled "gg" in these figures may represent the palpifer, since it bears the galea—as is true of the palpifer in Fig. 23, etc. If this be correct, the sclerite labeled "pfr" in Figs. 49 and 54, is merely a modified basal segment if the maxillary palpus, "mp," instead of representing the palpifer as indicated by the label. Provisionally, however, I have followed the customary usage of hymenopterists in referring to the sclerite labeled "pfr" in Figs. 49 and 54, as the "palpifer." In the sawfly larva shown in Fig. 30, the so-called palpifer, "pfr," curves outward and forward to form the peculiar *palpiferal process*, while the stipes extends laterally in the *stipital angle* or *process*, bearing the label "sa." There is also a small *cardine angle*, "ca," in the sawfly shown in Fig. 30; and the peculiar processes and angles formed by the parts of the maxillæ in the sawfly larvæ may offer points of value in their classification.

The *galea* is divided into a basal segment, or *basigalea*, "bg," and a distal segment, or *distigalea*, "dg," in the sawfly larvæ shown in Figs. 54 and 49, as is also the case with the galea "ga" of the larvæ shown in Figs. 20, 22, etc. These segments of the galea are apparently homologous with the two segments of the galea, "ga," of the beetle shown in Fig. 3, and with the structures labeled "bg" and "dg" in lower insects (Figs. 10 and 7). These parts of the galea were designated as the basigalea and distigalea in a paper dealing with the maxillæ of Orthoptera (Crampton, 1916); but Yuasa, 1920, in his paper on the mouthparts of the Orthoptera has substituted a terminology of his own for the parts in question. Since the designations originally applied to the parts are as suitable as those which Yuasa has attempted to substitute for them, the original terminology has been retained in the present paper.

Since the galea, "ga," of the larva of *Corydalis* (Figs. 15 and 14) is not like that of the adult ("ga" of Fig. 11) in appearance, and since the lacinia, "la," of an adult *Corydalis* (Fig. 11) cannot be readily detected in the larval stages (Fig. 15), there might be some doubt as to the interpretation of the parts in the larva and adult. I have therefore included Dr. Craighead's figures of the musculature of an adult and larval *Corydalis* (Figs. 11 and 14) in order to show that practically the same muscles occur in both stages (so far as the type of muscle is concerned) and furnish an excellent means of determining the homologies of the parts. As is shown in Dr. Craighead's figures, the tentoriocardine muscles labeled "3" and "4" in Figs. 11 and 14 extend from the tentorium to the cardo in both adult and larval stages of *Corydalis*, and the same paragula-cardine muscles bearing the label "5" extend from the paragular region to the cardo in both larval and adult head. Dr. Craighead states that "the cardo always articulates to the hypostoma and carries at least two muscles, one (number 3) attaching it to the tentorium, and the other (number 5) attaching it to the epicranium."

The tentorio-stipital muscle labeled "2" and the paragula-stipital muscle labeled "6" connect the tentorium and paragular region with the base of the stipes in both stages. With regard to the muscles to the galea and maxillary palpus, Dr. Craighead states that "the upper limit of the stipes, or more correctly, the insertion of its appendages, the galea and lacinia, is indicated by muscles "7" and "8," one attached to the base of the galea, the other to the basal joint of the palpi or palpifer and extending to the base of the stipes, or occasionally one may go to the cardo or a part of it may extend down further to the tentorium." It is quite apparent that muscles "7" and "8" are the same in both adult (Fig. 11) and larva (Fig. 14) of *Corydalis*, so that the structure labeled "ga" in Fig. 14 must be the homologue of the galea "ga" (Fig. 11) of the adult insect, since the same stipito-galeal muscle "7" is attached to the structure labeled "ga" in both larva and adult. The lacinia, "la," of the adult (Fig. 11) is apparently wanting in the larva (Fig. 14) of *Corydalis*, and Dr. Craighead states that "it (the lacinia) is considered to be lacking in most coleopterous larvæ. However, in certain larvæ two lobes appear, and, as far as I know, only one carries muscles." (The lacinia, "la," of Fig. 11 is thought by Dr. Craighead to carry no muscles, thus resembling the inner lobe of the maxilla of the larval Coleoptera, in this respect). He also states that "in certain forms there are indications pointing toward a maxilla with only lacinia or only galea present." In this connection, it may be remarked that the tentorio-labiostipital and tentorio-palpigeral muscles labeled "9" and "10" in Figs 11 and 14, as well as the submento-mental muscles labeled "11" in these figures are the same in adult and larva of *Corydalis*, so that all of the important parts of the trophi (with the exception of the maxillary lacinia) of an adult *Corydalis* are represented in its larva.

Although there is a slight difference between the mouthparts of an adult and larval *Corydalis*, as was mentioned above, the mouthparts are essentially the same in both larva and adult of the lower Neuroptera (*Corydalis*, *Sialis*, *Raphidia*, etc.), the resemblance between the mouthparts of the two stages being very marked in *Raphidia* (a larva of which is shown in Fig. 12), thus indicating a much feebler tendency toward complete metamosphosis in lower Neuroptera. When we turn to the larvæ of the higher Neuroptera, however, we find a much stronger tendency toward complete metamorphosis, and the mouthparts for the most part have become so greatly modified in adaptation to the "larval" methods of getting food, etc., (most of these larvæ suck the blood of their prey) that it is very difficult to determine the interpretation of the terminal portions of the maxillæ, and until suitable material for dissecting the muscles has been obtained, the interpretation of the homologies of the terminal portions of the maxillæ is largely a matter of guesswork. Dr. Tillyard has suggested to me that the slender terminal portion of the maxilla bearing the label "mx" in the neuropterous larvæ shown in Figs. 46, 44, 51, etc., may represent the lacinia labeled "la" in Fig. 23 of the larva of *Sialis*, and there is much to be said in favor of this view. On the other hand, the structure in question may not represent the lacinia "la" of Fig. 23, but may rather be homologous with the galea-bearing (or palp bearing) structure labeled "ds" in Fig. 23, with which the galea (or the palp) has fused, and the interpretation of the structures in question can be definitely determined only when material suitable for study has been obtained for an examination of the musculature—although the remarkable larvæ of *Ithone* recently discovered by Dr. Tillyard may throw some light upon this subject.

The *mandible* of an insect represents a single basal segment of a trilobite limb, as can be seen by tracing the development of the mandibular appendage through a series represented by the trilobite *Triarthrus*, the Crustacea *Nebalia*, *Mysis*, *Apseudes*, etc., and the insect *Machilis*—as has been done in a paper soon to be published in the Journal of the N. Y. Ent. Soc., 1921. When one studies such a series, it becomes apparent that the gnathobase region of the basal segment of the trilobites limb becomes differentiated into a biting region and a grinding region as we pass through the series of Crustacea mentioned above, and the biting region become the *incisor region* bearing the "teeth" for cutting food, while the grinding region (which projects quite markedly in some

Crustacea) forms the so-called *mola* or *molar region* in insects, the molar or grinding region of certain coleopterous larvæ being a region of some interest in the classification of the larval forms. In the mandibles of Crustacea, a fringe of flattened seta-like hairs occurs below the incisor region, between the latter and the molar region of the mandible. Some of the flattened seta-like structures fuse to form a movable appendage called the "*lacinia mobilis*" by carcinologists, and some entomologists have thought that a similar "lacinia mobilis" in the mandibles of insects represents the lacinia of an insect's maxilla. The idea that the various parts of the maxilla are repeated in the mandible (proposed by Packard, Smith, and other entomologists), which has received a rather widespread acceptance, is wholly unfounded and misleading, since the mandible represents only one segment (the coxopodite) of a limb, while the body of the maxilla (i. e., the part at the base of the maxillary palpus) is formed of more than one segment of such a limb (i. e., the basipodite and ischiopodite) and the parts are not at all comparable in the mandible and maxilla, since they are formed in different ways in the two structures. Furthermore, the palpus of the mandibular limb is lost in many of the higher Crustacea, and a structure homologous with the mandibular palpus of the Crustacea has not been found in any insects, despite the statement to the contrary made by several persons who have not properly studied the evolution of the mandibular appendage in insects and related Crustacea.

With regard to the portions of the head capsule formed by the mandibular segment, there is a considerable difference of opinion on the part of embryologists in this matter. Thus Riley, 1904, states that a part of the postgena is formed by the pleural region of the mandible, while a portion of the hypopharynx is formed by the sternum of the mandibular segment. Holmgren, 1909, on the other hand, ascribes the "vertex" and genæ to the mandibular segment, in addition to the upper portion of the hypopharynx. It is difficult to believe that the genæ which are situated immediately above the mandibles and bear the mandibles in most insects, are not portions of the mandibular segment, rather than parts of the protocerebral segment to which Riley, 1904, assigns the genæ. I have, therefore, followed Holmgren in ascribing the genæ to the mandibular segment. As far as the *basimandibula* "bmd" of Fig. 39 is concerned, this sclerite is apparently formed by a chitinization of the articulating membrane at the base of the mandible and is not homologous with the trochantin or plate at the base of the leg in the thorax, as Comstock and others have maintained. Since the sclerite "bmd" of Fig. 39 is formed by the chitinization of the basimandibular membrane, or the articulatory membrane at the base of the mandible, it is also a part of the mandibular segment, as Riley, 1904, states, although it is strange that Riley did not also consider that the gena "ge" of Fig. 39, which is so closely associated with the region "bmd" is not also a portion of the mandibular segment.

The mandibles have two principal articulations with the head capsule. The dorsal articulation of the mandible occurs near the posterolateral angles of the clypeus, and the condyle of the mandible which articulates with this region is called the ***epicondyle***, or dorsal condyle of the mandible. A ventral condyle of the mandible called the ***hypocondyle*** articulates in an acetabulum or groove of the hypostomal region of the under side of the head. Comstock and Kochi, 1902, use the terms dorsal and ventral articulations of the mandible in the opposite sense from that employed here; but it is more logical to refer to an articulation which is on the dorsal surface of the head as the "dorsal articulation of the mandible," and the articulation which takes place on the ventral surface of the head as the "ventral articulation of the mandible," without reference to any supposed original position of the sclerites involved in these articulations.

The ***hypopharynx***, in the broad sense of the term, includes not only the median tongue like organ or ***lingua***, which projects from the floor of the mouth cavity, but also the ***paragnaths*** (called "superlinguæ" and "paraglossæ"), or lobe-like structures on either side of the median tongue, in such insects as *Hemimerus*, immature ephemerids, etc. Since the median tongue-like lingua is usually the only portion of the hypopharynx to be retained in certain insects, the term hypopharynx is usually applied to the lingua alone. The lingua is formed by the sternites of the labial, maxillary and mandibular segments, according to the embryological investigations of Heymons, Holmgren, and others; and a study of the Crustacea would indicate that this view is the correct one, since a ridge which is apparently the forerunner of the lingua of the hypopharynx of insects, is formed in the sternal region of the mouthpart segments of certain Crustacea.

The paragnaths ("superlinguæ") or lobe-like structures on either side of the median tongue or lingua of the hypopharynx of insects are clearly the homologues of the paragnaths of Crustacea, as may be seen by comparing the structures in question of an immature mayfly with the paragnaths of Crustacea such as *Asellus*, various Isopoda, Amphipoda, etc., (see article in Psyche, 1921) so that it is preferable to apply to these structures of insects the term applied to their homologues, the paragnaths, in Crustacea, instead of employing the term "superlinguæ" or the incorrectly applied term "paraglossæ" (which should be restricted to the labial structures of this name) for them. The paragnaths of Crustacea are apparently detached lobes of the first maxillæ which take up a position behind and slightly mesal to the bases of the mandibles in the higher forms; but in *Apus* and other primitive Crustacea, they are evidently lobes of the first maxillæ. It is wholly incorrect to homologize the paragnaths of insects with the first maxillæ (maxillulæ) of Crustacea, and to homologize the first maxillæ of insects with the second maxillæ of Crustacea, as is done by practically all recent investigators, since the paragnaths of insects are in every way homologous with those of Crustacea, and the first maxillæ of insects represent the first maxillæ (not the second maxillæ) of Crustacea, as has been shown in an article in the Transactions of the Entomological Society of London, 1921, and in an article which will shortly appear in the Proc. Ent. Soc. Washington, 1921.

The *tentorium* is apparently formed by three pairs of invaginations, two of which are anterior (a dorsal and ventral anterior pair of invaginations) forming the dorsal and ventral anterior arms of the tentorium, while the posterior ventral pair of invaginations form the posterior ventral arms of the tentorium. These tentorial arms, whose position is marked by the *frontal pits*, *gular pits*, etc., extend internally to the body of the tentorium. The ventral anterior arms of the tentorium may meet and unite to form a plate called the frontal plate of the tentorium by Comstock and Kochi, 1902.

Infoldings of the integument called *implexes* or *endoplicæ* are frequently formed in the different regions of an insect's body, for the attachment of muscles, or for the strengthening of the body wall somewhat after the manner of corrugations in sheets of metal. In the head capsule, however, these internal folds for the most part form ridges for muscle attachment. These have been described under the discussion of the regions of the head capsule in which they occur.

The foregoing description of the parts in insects in general, is offered merely as the basis for a further more detailed discussion of those external features of insect morphology which appear to be of value in determining the phylogeny and interrelationships of the various groups of insects (and their arthropodan relatives), and on this account the modifications occurring in many of the orders have not been treated of in the present paper, since these can be taken up more profitably in a detailed discussion of each group taken separately. The evidence bearing upon the question of the phylogeny or of the interrelationships of the different groups of insects which have been described in the present paper, may be briefly summarized as follows, leaving the more detailed comparison of the parts in the different orders to be discussed later.

Relationships Indicated by the Head Structures.

A comparison of the head structures of the Diptera with those of the Mecoptera would indicate a very close relationship between these two orders. The fact that the labial palpi, "lp," assume the form of fleshy lobes at the end of the labium in the Mecopteron shown in Fig. 84, the fact that the lacinia of the maxilla is lost, and the galea, "ga," is reduced to a short slender structure, and the presence of the sense organ labeled "so" in the maxillary palpus of the scorpion fly shown in Fig. 84, all point to a close relationship to the Dipteron shown in Fig. 83, in which the same tendencies occur, and the sense organ, "so," occurs on exactly the same segment of the maxillary palpus as in the Mecopteron shown in Fig. 84. These facts are in full accord with the evidence of relationship between the Diptera and Mecoptera drawn from the study of the other regions of the body, such as the thoracic terga and wing bases, the genitalia and terminal abdominal structures, etc.

The Mecoptera may, therefore, be regarded as the nearest living representatives of the types ancestral to the Diptera, although it is by no means certain that both Diptera and Mecoptera were not derived from Neuroptera-like ancestors. In fact the latter is even more probable, since the tendencies present in such Neuroptera as *Nemoptera* (e. g., the reduction of the hind wings to mere ribbon-like structures, suggesting the precursors of the halteres of Diptera, the elongation of the head region and the slender character of the mouthparts, which apparently presage similar tendencies occurring in the Diptera, the nature of the male genitalia, etc., which are somewhat like those of certain Diptera) are those which one finds recurring in many Diptera, and a number of these tendencies are also exhibited by certain Mecoptera. In fact, *Nemoptera* has more features suggestive of affinities with the Mecoptera and the Diptera than any other Neuropteron which I have been able to examine, and it serves as a connecting-link between the Neuroptera on the one side, and the Mecoptera, with the Diptera, on the other. *Nemoptera*, however, is a rather highly specialized Neuropteron, and, since the Mecoptera (and even the Diptera also) have retained certain features (genitalia, etc.) in a more primitive condition than *Nemoptera* has, the probabilities are that the Mecoptera (and Diptera) were derived from a common ancestral type which gave rise both to Nemoptera and to the Mecoptera, etc. Aside from the presence of the ligula, "lg," in *Nemoptera* (Fig. 86) the mouthparts of this insect are apparently even more like the mouthparts of the Mecopteron *Bittacus* (Fig. 85) than they are like the mouthparts of other Neuroptera, as one can see by comparing Fig. 86 of *Nemoptera* with Fig. 81 of a Neuropteron fairly closely related to *Nemoptera*, since the slender columnar structure bearing the labels "sm" and "mn" in Fig. 86 of *Nemoptera* bears a much stronger resemblance to the region bearing these labels in Fig. 85 of the Mecopteron *Bittacus*, than it does to the region bearing these labels in the Neuropteron shown in Fig. 81. Similarly the long slender maxillary galea, "ga," and the slender lacinia, "la," with its peculiar fringe in *Nemoptera* (Fig. 86) resemble the structures bearing the same labels in Bittacus (Fig. 85) much more closely than they do the structures bearing the same labels in the Neuropteron shown in Fig. 81. These and many other features of the body in general indicate a close relationship between *Nemoptera* and the Mecoptera (with the Diptera), and I am convinced that the immediate ancestors of the family to which *Nemoptera* belongs (i. e., the Nemopteridæ) bore a very striking resemblance to the ancestors of the Mecoptera (with the Diptera). At any rate, we must admit that in order to properly interpret the homologies of the mouthparts, etc., of the Mecoptera and related forms, it is necessary to first study these structures in *Nemoptera*, so that there can be no possible objection to regarding *Nemoptera* as a form morphologically annectant between the rest of the Neuroptera and the Mecoptera (with their allies) even though *Nemoptera* itself may not stand in the direct line of descent of the Mecoptera and Diptera.

The Hymenoptera exhibit some very close resemblances to the Neuroptera in the nature of the mouthparts, and I am rather surprised that the points of similarity between the Coleoptera and Hymenoptera found in other structures, are not more evident in the mouthparts, although when more favorable material has been studied, other forms will doubtless be found which exhibit a greater resemblance between the mouthparts of the two groups. The character of the structures bearing the label "pg" in Fig. 77 of a Hymenopteron is somewhat suggestive of the condition found in the Neuroptera (Fig. 81), and the tendency for the cardo, "car," of Fig. 77 to straighten out in line with the stipes, "sti," occurring in the Hymenoptera is also found in certain Neuroptera. On the other hand, the tendency to lose the lacinia, and the character of the galea, "ga," of the Hymenopteron shown in Fig. 77 are features suggestive of the Mecoptera, such as the one shown in Fig. 84. In fact, the Mecoptera are related to *both* Neuroptera and Hymenoptera, and have apparently inherited tendencies from both sources.

In many respects, the Hymenoptera are fully as primitive as the Neuroptera, and in certain features are even more primitive than the Neuroptera (e. g., nature of the genitalia, retention of cerci, etc.), and I am inclined to seek for the types ancestral to the Hymenoptera among the forms related to the Isoptera (with the Psocida and Zoraptera) on the one hand, and to the Coleoptera (with the Dermaptera) on the other. The mouthparts, however, do not furnish as instructive evidence as might be desired, since even in such primitive Hymenoptera as the one shown in Fig. 80, the mouthparts are quite highly modified. Even the larval mouthparts are very disappointing in this respect in the Hymenoptera, since they do not bear a striking resemblance to the mouthparts of any of the larvæ here figured, although one can detect a slight suggestion of affinities with the Coleoptera, on the one side, and with the Lepidoptera on the other. The Mecopteron shown in Fig. 19 is also disappointingly unlike any of the other insects figured, though it has a few features suggestive of affinities with the Trichoptera. It certainly is much more specialized than the primitive Neuroptera studied, and unless Dr. Tillyard can find some Mecopteron larva of a far more primitive character, he is not justified in assuming that the Mecopterous type is more primitive than the Neuropterous one (taking the group as a whole).

The evidence offered by the head structures is in full accord with the former contention (Crampton, 1920) that the Coleoptera are anatomically intermediate between the Dermaptera on the one side and the Neuroptera on the other, and this may have some bearing upon the question of the origin of the Neuroptera. Of the two groups (Coleoptera and Neuroptera) the Coleoptera are clearly the more primitive, with the exception of the feature of the highly modified fore wings. Other very lowly organized insects such as certain Blattidæ have fore wings quite as highly modified as the most primitive Coleoptera, however, and the fore wings of the Dermaptera are even more highly modified than those of the primitive Coleoptera, so that this feature is of no great importance in determining the relative primitiveness of a group of insects as a whole. The occurrence of the peculiar sclerite, "pst," found only in the maxillæ of Coleoptera (Fig. 4) and Dermaptera (Fig. 7), in addition to other features of resemblance in the two groups (e. g., the nature of the antennal segments, the segmentation of the cerci in certain immature Coleoptera and Dermaptera, the character of the thoracic terga, etc.)

indicates a close relationship between the Coleoptera and the Dermaptera. On the other hand, the occurrence in coleopterous and neuropterous larvæ of the peculiar type of maxillæ with both palp, "mp," and slender galea, "ga," borne on a slender segment-like structure, "ds," (see Figs. 23 and 27) in addition to other features of resemblance in the larvæ of the two groups (e. g., nature of the thoracic sclerites, etc.), indicates a close relationship between the Coleoptera and the Neuroptera. In fact, it is extremely difficult to discover any features which will distinguish a larval Coleopteron from a larval Neuropteron in every case, and certain coleopterous larvæ might readily be mistaken for neuropterous larvæ, so great is the similarity between the two groups. The Coleoptera, however, are the more primitive of the two orders (Neuroptera and Coleoptera) and serve to connect the Neuroptera with the insects related to the Dermaptera on the one side and with those related to the Isoptera (with the Zoraptera) on the other. In some respects, the Coleoptera are very like the Embiidæ, particularly in the nature of the head capsule and certain of the mouthparts, as may be seen by comparing Fig. 17 of a beetle with Fig. 18 of an embiid; and the "roots" of the Coleopteron line of development strike down deeply into the group of insects related to the Dermaptera (i. e., the Embiidæ and Plecoptera), some of the coleopterous features being even more primitive than these features in the Dermaptera although the Dermaptera as a whole are much more primitive than the Coleoptera.

The head region of certain Psocidæ (sensu lato) is very like that of some of the Neuroptera (and Hymenoptera also), particularly in the frontal region of the head. The fact that the head region of some Hemiptera (Corixidæ, etc.) overlaps the pronotum is a feature indicating a relationship to the Psocidæ, when taken in conjunction with other resemblances in the head capsule of the two groups (Hemiptera and Psocidæ). The type of head found in the Psocidæ was apparently derived from the Zorapteron type, which in turn was derived from a Plecopteron type (although the Zoraptera are undoubtedly related to the Isoptera as well). From the morphological standpoint alone, the line of development of the Hemiptera would therefore be suggested by the series Plecoptera, Zoraptera, Psocidæ, Homoptera (the Psyllidæ approach the Psocidæ in many respects) and Hemiptera. The Thysanoptera also approach the Psocidæ in many respects, and I have found a psocid whose head is very suggestive of the type leading to the Thysanopteron type, as will be brought out in a later publication. Not only does the typical psocid head approach the Neuropteron type in many respects, but the head of a sawfly also resembles both of these types very markedly and the evidence offered by a study of the head structures is quite in accord with the former contention (Crampton, 1920) that the Hymenoptera are anatomically intermediate between the Psocidæ and the Neuroptera.

THE HEAD CAPSULE OF THE NEUROPTERA.

Since the Neuroptera are an extremely important group from the standpoint of the study of the phylogeny of the higher insects, I have drawn as many types of neuropterous heads as I have been able to examine, in order that anyone wishing to find out what modifications of the head capsule are to be found in the group, may be able to determine which families give indications of being of value for a phylogenetic study. Furthermore, although a study of the head region alone is of no great value in determining the interrelationships of the members of the order Neuroptera, there are certain features of the head region which offer indications of relationship between certain insects, and the evidence of the head region should be added to that drawn from the study of other parts of the body, in attempting to determine the interrelationships of the families of Neuroptera.

The character of the mouthparts of the larval *Sialis* shown in Fig. 23 would indicate that *Sialis* is as primitive as any of the Neuroptera, and the head capsule in general (Fig. 40) of the larva is as primitive as any. The secondary marking off of the areas labeled "pcl" on either side of the clypeus of the larvæ of *Raphidia* and *Corydalis* (Figs. 41 and 42) represents a higher degree of specialization than is exhibited by the larva of Sialis (Fig. 40). On the other hand, the nature of the occipital region, "ocp," in the head region of the larvæ of Raphida and Corydalis (Figs. 41 and 42) in addition to the presence of the peculiar sclerites, "pcl," in these larvæ indicates a rather close relationship between the two, and the line of development of the Rhaphididæ and Corydalidæ apparently quickly merge as we trace them back to that of the *Sialis* type. The head of a *Chauliodes* larva is so like that of a *Corydalis* larva that there is practically no difference between the two, and there can be no doubt that *Chauliodes* is extremely closely related to *Corydalis*. The head capsule of *Chauliodes* (Fig. 34) furnishes an excellent starting point in taking up the study of the head region of the higher Neuroptera, and it is approached by *Polystochoetes* and also by *Oliarces*, *Ithone* and other Ithoniidæ as closely as any other higher forms. *Oliarces*' head is remarkably similar to that of *Ithone*, as may be seen by comparing Fig. 53 with Fig. 52, and there can be no doubt that these two insects belong to the same family (Ithoniidæ) as is also true of *Raphisma*, although Tillyard in his monograph of the Ithoniidæ does not include these insects (Oliarces and Rhapisma) in the family. Furthermore, the head capsule of the Ithoniidæ is remarkably like that of the primitive Lepidoptera and Trichoptera described by Crampton, 1920, and I am convinced that the Lepidoptera and Trichoptera were descended from ancestors very similar to those of the Ithoniidæ.

With regard to the relationships of the Nemopteridæ, which are of great interest from the fact that they approach the Mecoptera and Diptera in many respects, it must be admitted that the adult heads give but few clews as to their nearest relatives. The head structures of the Nemopterid *Croce*, however, have been figured by Imms, 1911, and indicate that the Nemopterid type was probably derived from forms related to the Ascalaphidæ and Myrmeleonidæ. The head of a larval Ascalaphid (Fig. 47) is extremely similar to that of a larval Myrmeleonid (Fig. 44) and the head of an adult Myrmeleonid such as that shown in Fig. 70 is very like that of *Nymphes* (Fig. 72) even to the presence of the sense organ, "pm," in the labial palpi of both insects, so that the Nymphidæ very probably represent the types ancestral to the Myrmeleonidæ, etc.

The head and mouthparts of Psychopsis (Fig. 46) are somewhat intermediate between the Myrmeleonid type (Fig. 44) and the Hemerobiid type, which is extremely like that of the Chrysopidæ (Fig. 51) and *Psychopsis* may, therefore, be regarded as a connecting link between the two groups. The head of an adult *Psychopsis* (Fig. 71) is very like that of the Myrmeleonid shown in Fig. 70, and so far as the evidence of the head alone is concerned, *Psychopsis* is quite close to the Myrmeleonids in many respects. Whether *Psychopsis* leads back through the Hemerobiid and Chrysopid type to the Ithoniid type of Neuropteron, I cannot say, since the head alone offers insufficient evidence upon which to base one's conclusions in this matter.

The head of *Nothochrysa* (Fig. 66) is extremely like that of *Apochrysa* (Fig. 67), while that of *Euporismus* (Fig. 68) has many features suggestive of affinities with *Stenosmylus* (Fig. 63). *Miodactylus* (Fig. 69) resembles *Stenosmylus* (Fig. 63) on the one hand and *Nymphes* (Fig. 72) or the Myrmeleonids, on the other. *Porismus* (Fig. 65) is quite like *Euporismus* (Fig. 68) in many respects, but also shows some points of resemblance to *Psectra* (Fig. 62). *Psectra* (Fig. 62) is very like *Sisyra* (Fig. 59) and *Climacea* (Fig. 60) also, and *Climacea* in turn bears a resemblance to *Conwenzia* (Fig. 61). *Osmylus* (Fig. 58) is obviously related to the other Osmylidæ, Hemerobiidæ, and Chrysopidæ, but it also bears a resemblance to *Climacea* and *Conwenzia*. *Sisyra*, *Climacea*, *Conwenzia* and similar forms were probably derived from ancestors resembling the Ithoniidæ (Figs. 52 and 53), a family which should include the genera *Oliarces* and *Rhapisma*, as well as *Ithone*, although *Oliarces* has never been included in the family (excepting by Crampton, 1920) despite the fact that its head is exactly like that of Ithone (compare Figs. 52* and 53) as is also true of the thoracic sclerites, etc.

Mantispa (Fig. 57) is a very peculiar form, and its affinities cannot be determined from the adult head alone. Its head resembles that of Chrysopa, in some respects, and its closest affinities may be with these insects. On the other hand, the head of *Mantispa* exhibits some similarities to the head of *Nemoptera*, although these resemblances are probably more superficial. The resemblance to the head of *Conwenzia* is more marked, and it is possible that *Mantispa* may be related to both *Chrysopa* and *Conwenzia*.

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* Dr. Tillyard has very kindly given me some specimens of *Ithone* preserved in alcohol, and an examination of this material (made after this paper had been prepared) would indicate that the labial region in Figs. 52 and 53 was so distorted as to be quite "unnatural" in the dried specimens from which the drawings were made.

SUMMARY.

The principal structures of the head, the sclerites of the head capsule, and the subdivisions of the mouthparts may be briefly summarized in the following table in which the relations of the parts to one another are also shown.

- Epicranium
  - Occiput
    - Trophiger
  - Parietals
    - Postcranials
    - Vertex
    - Adfrontals
  - Facies
    - Parafrons
    - Frons
      - Antefrons
        - Epistoma
      - Postfrons
    - Clypeus
      - Anteclypeus
      - Postclypeus
  - Laterocranium
    - Genæ, with Basimandibula
    - Postgenæ
      - Hypostoma
      - Paragula
- Gulamentum
  - Gula
  - Submentum
- Mentum
- Eulabium
  - True labium
    - Labial palpi
    - Palpiger
    - Labiosternite
    - Labiostipes
    - Ligula
      - Glossæ
      - Paraglossæ
- Maxilla
  - Basimaxilla
  - Maxillary palpus
  - Body of maxilla
    - Cardo
      - Eucardo
      - Paracardo
    - Stipes
      - Eustipes
        - Dististipes
        - Proxistipes
        - Basistipes
      - Parastipes
    - Palpifer
    - Galea
    - Lacinia
- Mandible
- Labrum
  - Antelabrum
  - Postlabrum
- Epipharynx
- Hypopharynx
  - Lingua
  - Paragnaths (parts of maxilla associated with hypopharynx)
- Endoplicæ
- Tentorium
  - Body of tentorium
  - Frontal plate of tentorium
  - Dorsal anterior arms
  - Ventral Anterior arms
  - Posterior arms

A study of the embryological development of the head of an insect and a comparison with the head region of the Crustacea (which are like the ancestors of insects) would indicate that six primitive segments enter into the composition of the head of an insect. The protocephalon, antennal, intercalary, mandibular, first maxillary, and second maxillary (labial) segments of an insect's head correspond to the protocephalon, antennular, antennal, mandibular, first maxillary, and second maxillary segments, respectively, in a crustacean's head. The so-called "superlinguæ" of insects are homologous with the paragnaths, not with the "maxillulæ" (first maxillæ) of Crustacea. The mandible of an insect represents only one (the basal) segment of a crustacean's limb, while the body of the maxilla of an insect is composed of several segments of such a limb, so that the parts of an insect's maxilla are not represented in the mandible.

In conjunction with other structures of the body, the head region of insects furnishes indications of a relationship to the Crustacea on the one side, and to the Symphyla on the other. *Machilis* among the Apterygota, and the ephemerids among the Pterygota have retained a number of features suggestive of affinities with the Crustacea, and the head region of *Machilis* would indicate that it is an extremely ancient type related to such forms as *Lepisma Nicoletia*, etc. (and also to *Japyx* and *Campodea*) on the one hand, and to the Collembola on the other. The head of *Machilis*, *Lepisma* and *Nicoletia* among the Apterygota have more suggestions of crustacean affinities, while the head of *Japyx* and *Campodea* is very like that of *Scolopendrella* and other Symphyla-like forms.

Lepisma offers a connecting link between *Machilis* (which leads to the crustacean forms) and the lower winged insects such as the Plecoptera, ephemerids, etc., and the head of immature Plecoptera approach as closely as any type, to that of *Lepisma*. The head of an immature Plecopteron on the other hand, is extremely similar to that of *Arixenia* among the Dermaptera. The head structures of the Dermaptera (and the Embiidæ also) in turn lead to the type found in Coleoptera, particularly in the structure of the maxillæ. As we trace the head types from the Coleoptera upward, the Neuroptera appear to be the next of kin, since the head structures of larval Coleoptera and Neuroptera are astonishingly alike. The Neuroptera in turn lead to the Mecoptera, Diptera, and Siphonaptera, on the one hand, and to the Trichoptera and Lepidoptera on the other, the neuropterous head which most resembles the head of the Mecoptera and Diptera being that of *Nemoptera*, while the neuropterous head which most resembles that of the Trichoptera (such as *Philopotamus*) and Lepidoptera (such as the micropterygids) is the head of *Oliarces* and other Ithoniidæ.*

The head of a Zorapteron is intermediate between that of certain Plecoptera such as *Capnia*, *Leuctra*, etc., and the Psocid type. Certain of the Psocidæ, in turn, have elongate heads suggestive of affinities with the Thysanoptera, while others exhibit undoubted affinities with the Homoptera and Hemiptera. The head of a mallophagan was undoubtedly derived from the psocid type, and the head structures of the Pediculidæ exhibit affinities with the Mallophaga, etc., as well.

The head structures of Hymenoptera are rather puzzling. They exhibit features suggestive of the Mecoptera on the one side, and with the Neuroptera, as well as the Zoraptera and Psocidæ, on the other. The Psocidæ likewise exhibit certain features very suggestive of a relationship to the Neuroptera, and there is apparently a rather complicated interrelationship between these groups, as is shown in the head structures as well as in other features of the body, such as the ovipositor, etc. In certain respects, the head structures of Hymenoptera (even of the sawflies) are rather highly modified, but the sawfly type is a far more ancient one than it is commonly supposed to be, and probably arose from ancestors intermediate between the Zoraptera (with the Isoptera) on the one side, and the Coleoptera (with the Dermaptera) on the other.

The study of the head and its appendages has shown that these structures are of prime importance for a study of the interrelationships and phylogeny of insects, and before we can arrive at the correct conclusion concerning the evolution of the various orders, and the origin of the Hexapoda, it will be neces-

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*The Hemiptera (and Homoptera) are related not only to the Psocidæ, but to the Lepidoptera, Mecoptera, and Neuroptera, as well and exhibit many features suggestive of affinities with the Lepidoptera and Mecoptera. The lines of development of these forms apparently arose at the point where the Neuroptera and Psocidæ began to diverge, and therefore took over in their development, features common to both. Under these conditions it is readily seen that the Lepidoptera may resemble the Psocidæ and Hemiptera (Homoptera) on the one side, and the Neuroptera, etc., on the other, and this fact has not been sufficiently emphasized by students of insectan phylogeny.

sary to make a detailed study of the head, neck plates, thoracic sclerites and appendages, and the terminal abdominal structures, if the results are to be based upon a firm foundation, since any view based upon the study of the wings alone, and not supported by the evidence drawn from the study of other parts of the body as well, can be accepted only with reservation. So far as the study of the origin of insects and their immediate relatives is concerned, I have found the head structures, and the mandibles in particular, to be of the greatest value; and the study of the head structures in the various orders of insects promises to be of equal importance in determining the interrelationships of insects themselves.

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ABBREVIATIONS.

ac	anteclypeus.
af	adfrons.
anf	antennifer.
ant	antennæ.
ap	labiappendices.
bat	basantenna.
bg	basigalea.
bl	basilacinia.
bm	basimaxilla.
bmd	basimandibula.
bs	stipes, or its basal portion.
ca	cardine angle.
car	cardo.
cl	clypeus.
cs	coronal suture.
dg	distigalea.
ds	palparium, or palpifer.
ec	epicondyle.
eps	epistoma.
euc	eucardo.
eus	eustipes.
f	laciniafimbrium.
fp	frontal pits.
fr	frons.
fs	frontal suture.
g	galeafimbrium.
ga	galea.
ge	gena.
gg	galeafer (possibly palpifer).
gl	glossa.
gp	gular pits.
gu	gula.
hc	hypocondyle.
hs	hypostoma.
in	dististipes.
is	intersternite (postgula).
l	labrum.
la	lacinia.
lc	lacinial cleft.
lg	ligula.
lp	labiopalpus (labial palp).
ls	labiostipes.
m	myocicatrix.
md	mandible.
mgs	midgular suture.
mn	mentum.
mp	maxillipalpus (maxillary palp).
mx	maxilla.
oc	ocelli.
ocp	occiput.
pa	parietals.
pac	paracardo.
pas	parastipes.
pc	postclypeus.
pcl	paraclypeus ("jugum?").
pf	parafrons.
pfr	palpifer (in some cases basal segment of palp?).
pg	paraglossæ.
pgr	palpiger.
pgu	paragula.
pm	palpimacula.
poc	postorbital crest.
prg	pregula.
prm	basilabrum (premental plate).
ps	laterocranial (paracephal) sutures.
pst	basistipes.
sa	stipital angle.
sar	sensarea.
se	sensorium.
sm	submentum.
sml	submentales.
so	sense organ.
spt	spinneret.
sti	stipes.
stm	stemmata (larval "ocelli").
x	attachment of stipital plica.

MUSCLES.

1. tentorio-intramaxillary muscle.
2. tentorio-stipital muscle.
3. tentorio-paracardine muscle.
4. tentorio-eucardine muscle.
5. paragulo-cardine muscle.
6. paragulo-stipital muscle.
7. tentorio-galeal muscle.
8. stipito-palpal muscle.
9. tentorio-labiostipital muscle.
10. tentorio-palpigeral muscle.
11. submento-mental muscles.

EXPLANATION OF PLATES.

(Unless otherwise stated, all Figures are of adult insects).

Plate II.

Fig. 1. Posterior view of right maxilla of *Chauliognathus marginatus* (Coleoptera).
Fig. 2. Posterior view of right maxilla of *Corydalis cornutus* (Neuroptera).
Fig. 3. Posterior view of right maxilla of *Harpalus* (Coleoptera).
Fig. 4. Posterior view of right maxilla of *Necrophorus* (Coleoptera).
Fig. 5. Posterior view of head of larval Silphid (Coleoptera).
Fig. 6. Posterior view of head of *Gryllus* (Orthoptera).
Fig. 7. Posterior view of head of *Arixenia* (Dermaptera).
Fig. 8. Posterior view of head of larval Pyrochroid (Coleoptera).
Fig. 9. Posterior view of head of larval *Tenebrio* (Coleoptera).
Fig. 10. Posterior view of head of *Periplaneta orientalis* (Blattida).

Plate III.

Fig. 11. Posterior view of head of *Corydalis* (Neuroptera).
Fig. 12. Posterior view of head of larval *Raphidia* (Neuroptera).
Fig. 13. Posterior view of head of alate *Termopsis* (Isoptera).
Fig. 14. Posterior view of head of larval *Corydalis* (Neuroptera).
Fig. 15. Posterior view of head of larval *Corydalis* (Neuroptera).
Fig. 16. Posterior view of head of *Termopsis* soldier (Isoptera).
Fig. 17. Posterior view of head of *Harpalus* (Coleoptera).
Fig. 18. Posterior view of head of *Embia major* (Embiidina).
Fig. 19. Posterior view of larval *Panorpa* (Mecoptera).

Plase IV.

Fig. 20. Posterior view of mouthparts of larval *Limnephilid* (Trichoptera).
Fig. 21. Posterior view of mouthparts of larval *Psilotreta* (Trichoptera).
Fig. 22. Posterior view of head of larval Elaterid (Coleoptera).
Fig. 23. Posterior view of mouthparts of larval *Sialis* (Neuroptera).
Fig. 24. Posterior view of mouthparts of larval *Polycentropid* (Trichoptera).
Fig. 25. Posterior view of mouthparts of larval *Prionyxtus* (Lepidoptera).
Fig. 26. Posterior view of mouthparts of larval *Rhyacophila* (Trichoptera).
Fig. 27. Posterior view of head of larval *Hydrophilus* (Coleoptera).
Fig. 28. Posterior view of right maxilla of larval *Schizura concinna* (Lepidoptera).
Fig. 29. Posterior view of head of larval *Achroia grisella* (Lepidoptera).
Fig. 30. Posterior view of mouthparts of larval *Cimbex* (Hymenoptera).
Fig. 31. Posterior view of mouthparts of larval *Hepialus* (Lepidoptera).

Plate V.

Fig. 32. Frontal view of head of larval *Neurotoma* (Hymenoptera).
Fig. 33. Frontal view of head of *Raphidia* (Neuroptera).
Fig. 34. Frontal view of head of *Chauliodes* (Neuroptera).
Fig. 35. Frontal view of head of *Sialis* (Neuroptera).
Fig. 36. Frontal view of head of *Anisolabis maritima* (Dermaptera).
Fig. 37. Frontal view of head of male *Corydalis* (Neuroptera).
Fig. 38. Dorsal view of head of larval *Chalcophora* (Coleoptera).
Fig. 39. Frontal view of head of alate *Mastotermes darwinensis* (Isoptera).
Fig. 40. Frontal view of head of larval *Sialis* (Neuroptera).
Fig. 41. Frontal view of head of larval *Raphidia* (Neuroptera).
Fig. 42. Frontal view of head of larval *Corydalis* (Neuroptera).

PLATE VI.

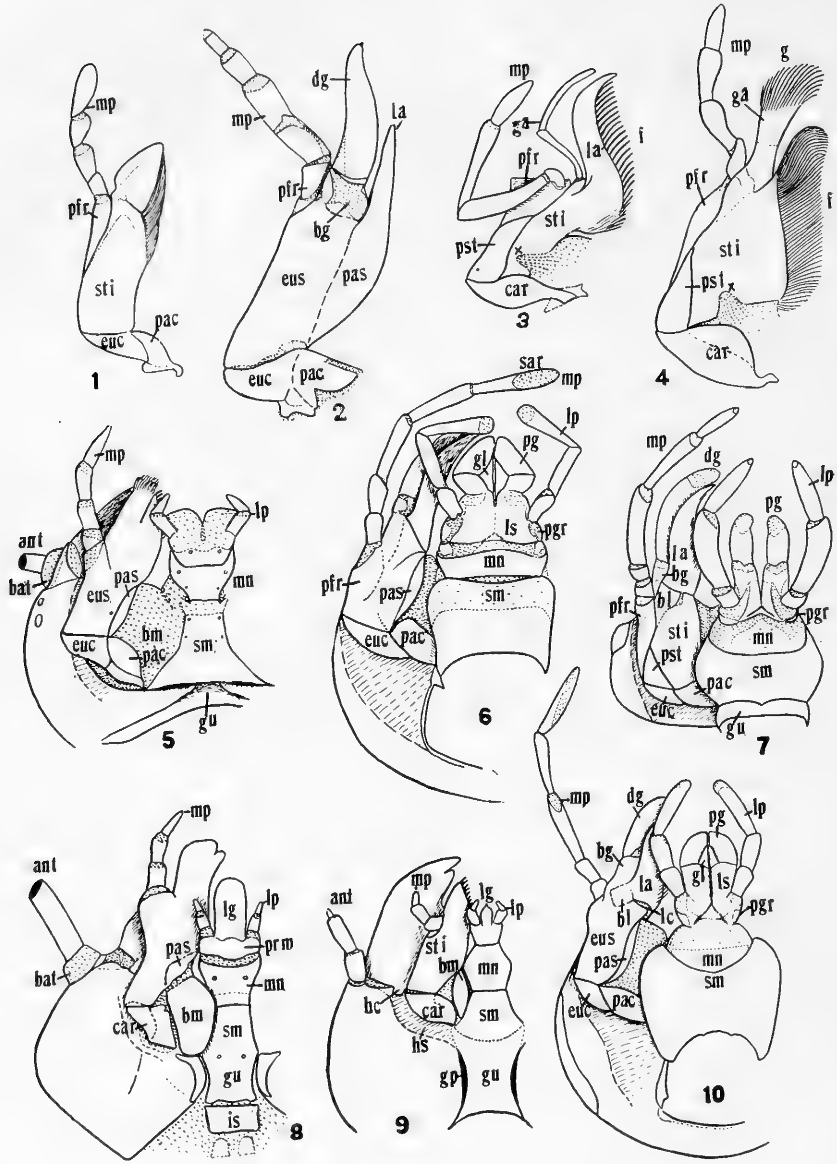
Fig. 43. Frontal view of head of *Berotha piepersii* (Neuroptera).
Fig. 44. Posterior view of mouthparts of larval *Myrmelionid* (Neuroptera).
Fig. 45. Frontal view of head of *Polystochoetes* (Neuroptera).
Fig. 46. Posterior view of mouthparts of larval *Psychopsis elegans* (Neuroptera).
Fig. 47. Posterior view of mouthparts of larval Ascalaphid (Neuroptera).
Fig. 48. Frontal view of head of *Dilar corsicus* (Neuroptera).
Fig. 49. Posterior view of head of larval *Megaxyela* (Hymenoptera).
Fig. 50. Ventral view of head of larval *Climacea* (Neuroptera).
Fig. 51. Posterior view of head of larval Chrysopid (Neuroptera).
Fig. 52. Frontal view of head of *Ithone fusca* (Neuroptera).
Fig. 53. Frontal view of head of *Oliarces clara* (Neuroptera).
Fig. 54. Posterior view of head of larval *Neurotoma* (Hymenoptera).
Fig. 55. Posterior view of head of larval *Cowenzia hageni* (Neuroptera).
Fig. 56. Frontal view of head of *Nemoptera sinuata* (Neuroptera).
Fig. 57. Frontal view of head of *Mantispa pagana* (Neuroptera).

PLATE VII.

Fig. 58. Frontal view of head of *Osmylus maculatus* (Neuroptera).
Fig. 59. Frontal view of head of *Sisyra* (Neuroptera).
Fig. 60. Frontal view of head of *Climacea* (Neuroptera).
Fig. 61. Frontal view of head of *Conwenzia hageni* (Neuroptera).
Fig. 62. Frontal view of head of *Psectra dipterum* (Neuroptera).
Fig. 63. Frontal view of head of *Stenosmylus tenuis* (Neuroptera).
Fig. 64. Frontal view of head of *Chrysopa perla* (Neuroptera).
Fig. 65. Frontal view of head of *Proismus strigatus* (Neuroptera).
Fig. 66. Frontal view of head of *Nothochrysa evanescens* (Neuroptera).
Fig. 67. Frontal view of head of *Apochrysa bellula* (Neuroptera).
Fig. 68. Frontal view of head of *Euporismus albatrox* (Neuroptera).
Fig. 69. Frontal view of head of *Miodactylus pubescens* (Neuroptera).
Fig. 70. Frontal view of head of *Acanthaclistes americana* (Neuroptera).
Fig. 71. Frontal view of head of *Psychopsis insolens* (Neuroptera).
Fig. 72. Frontal view of head of *Nymphes* (Neuroptera).
Fig. 73. Frontal view of head of *Ululodes* (Neuroptera).
Fig. 74. Frontal view of head of *Stilbopteryx* (Neuroptera).

PLATE VIII.

Fig. 75. Posterior view of labium of *Cicada* (Homoptera).
Fig. 76. Lateral view of head of *Belostoma* (Hemiptera).
Fig. 77. Posterior view of mouthparts of *Bracon liberator* (Hymenoptera).
Fig. 78. Frontal view of head of *Macroxyela* (Hymenoptera).
Fig. 79. Frontal view of head of larval *Pyrausta ainsleii* (Lepidoptera).
Fig. 80. Posterior view of mouthparts of *Macroxyela* (Hymenoptera).
Fig. 81. Posterior view of mouthparts of *Nymphes* (Neuroptera).
Fig. 82. Posterior view of labium of *Panorpa lugubris* (Mecoptera).
Fig. 83. Posterior view of mouthparts of *Asyndulum montanum* (Diptera).
Fig. 84. Posterior view of mouthparts of *Nannochorista dipteroides* (Mecoptera).
Fig. 85. Posterior view of mouthparts of *Bittacus* (Mecoptera).
Fig. 86. Posterior view of mouthparts of *Nemoptera sinuata* (Neuroptera).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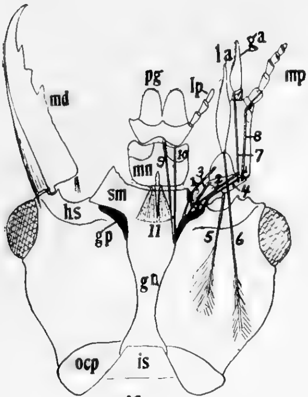

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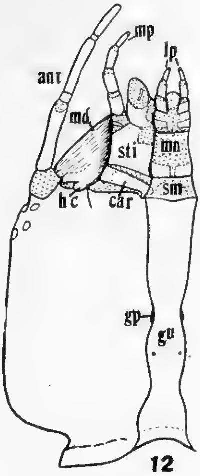

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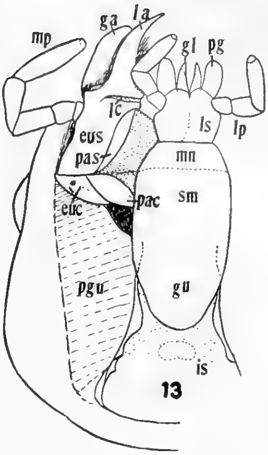

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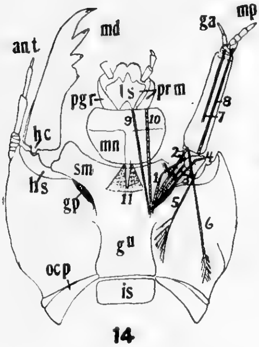

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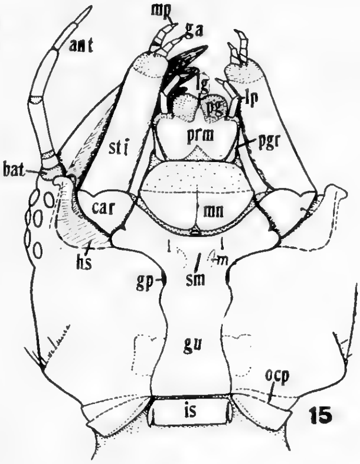

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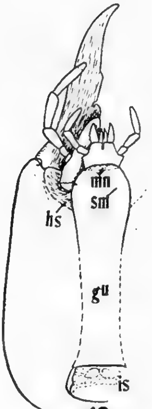

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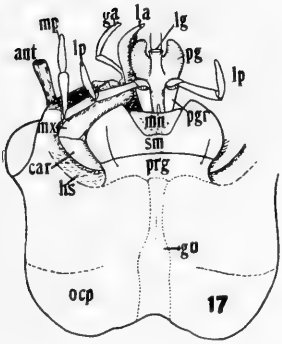

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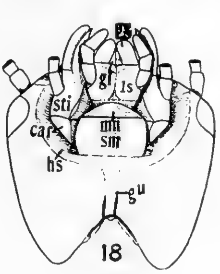

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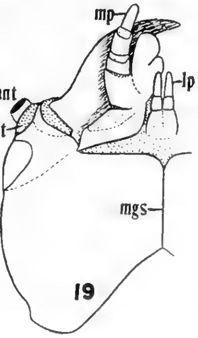

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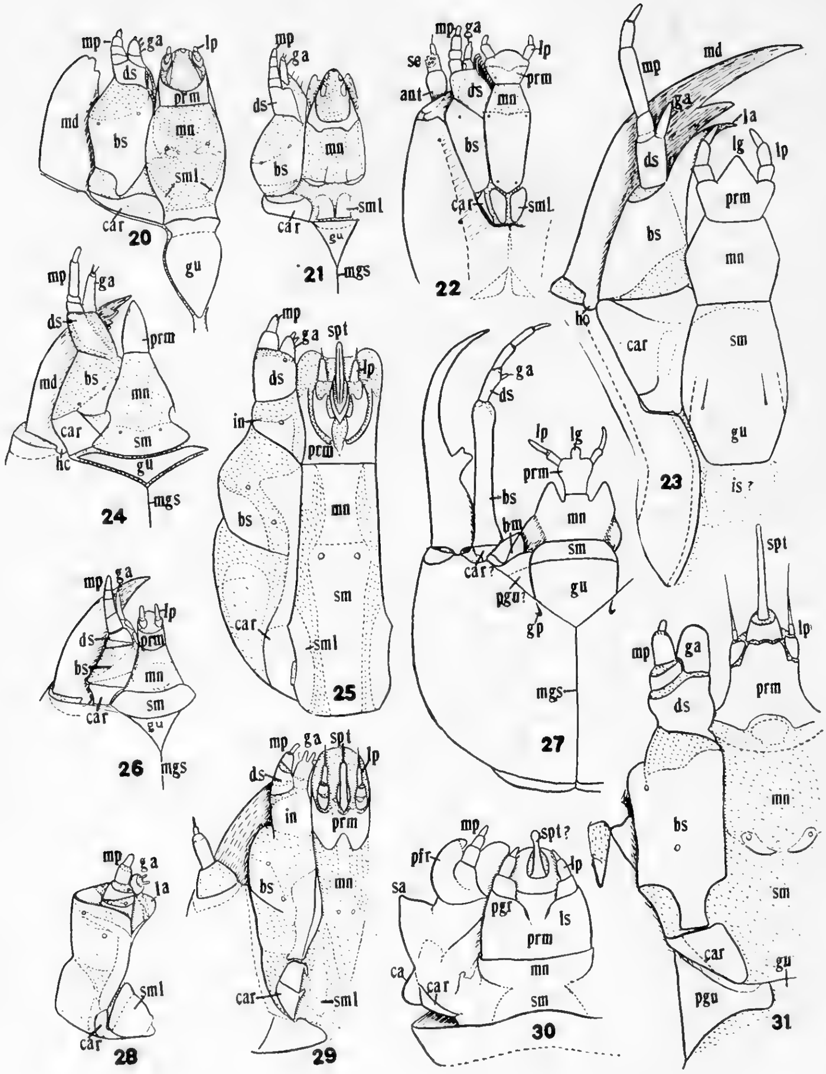
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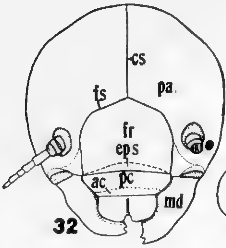

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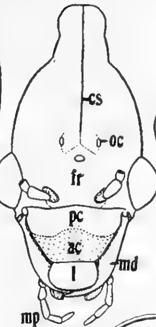

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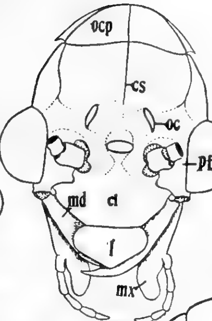

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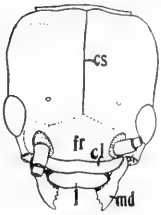

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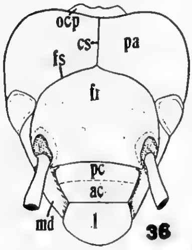

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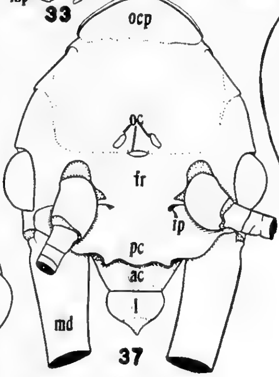

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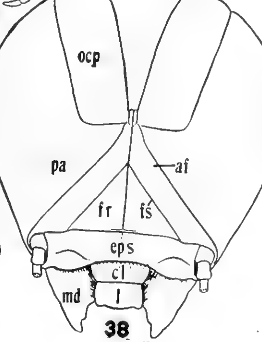

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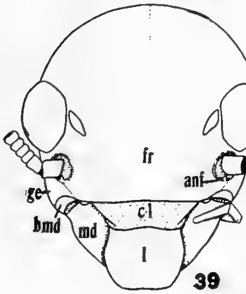

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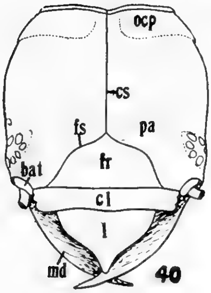

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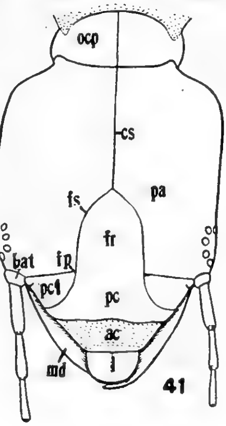

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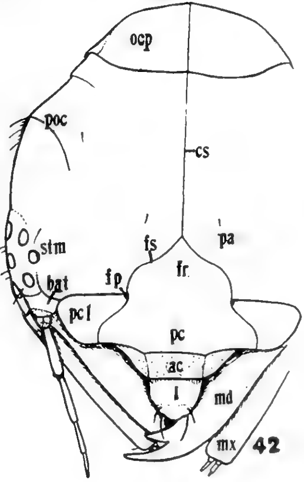

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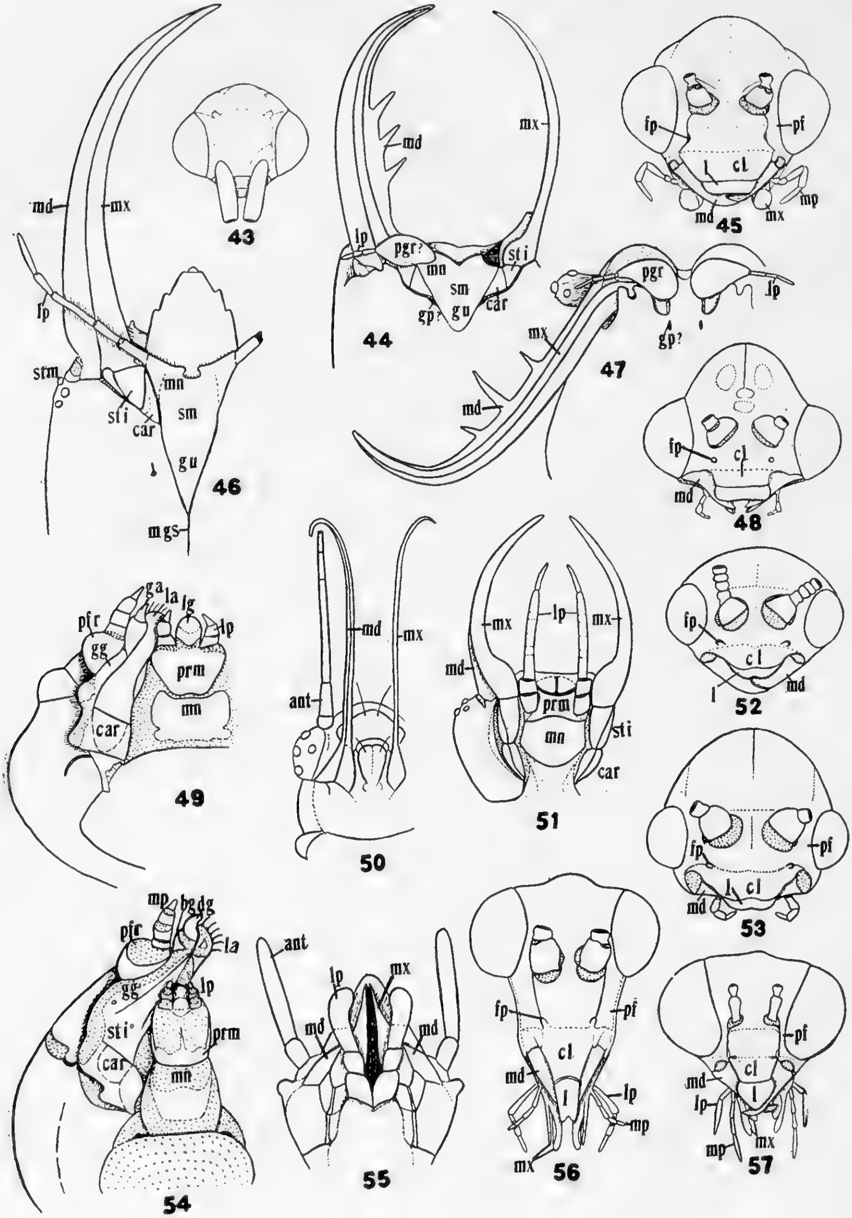
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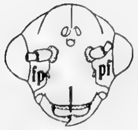

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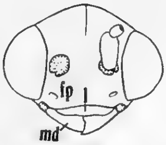

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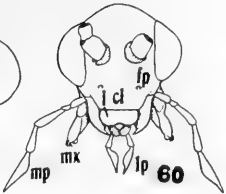

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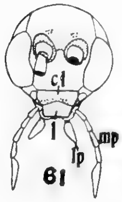

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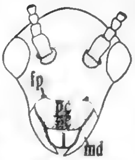

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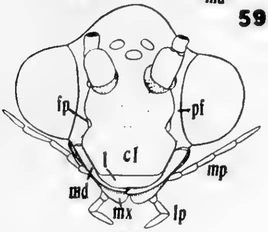

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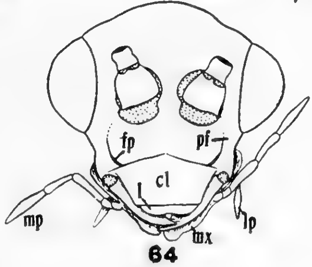

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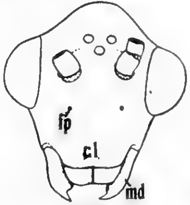

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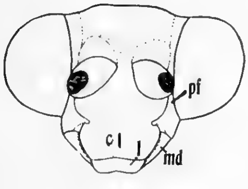

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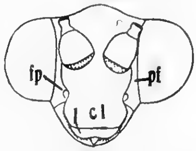

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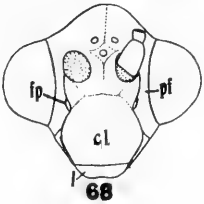

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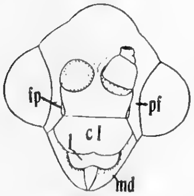

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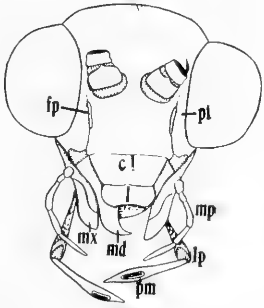

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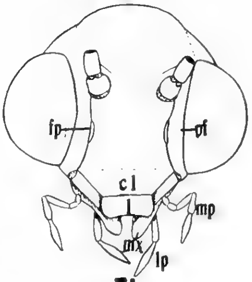

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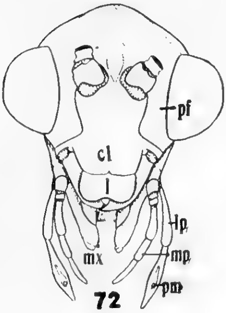

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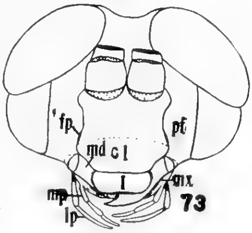

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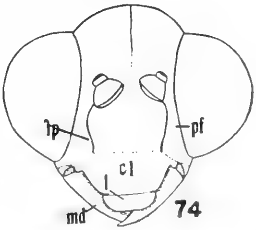

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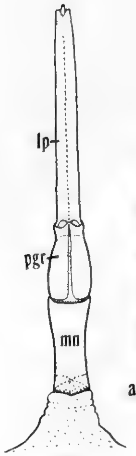

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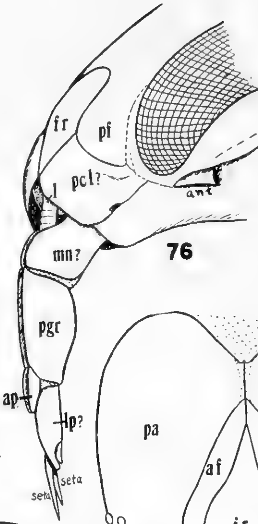

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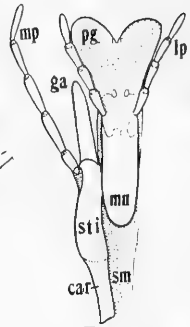

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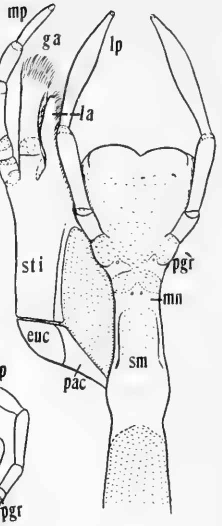

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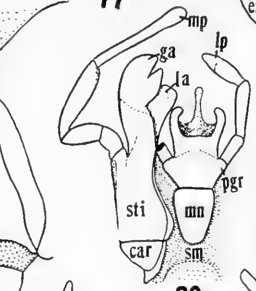

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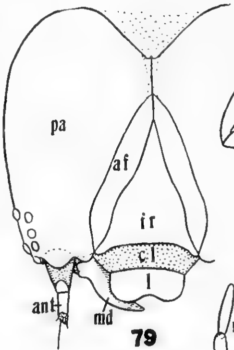

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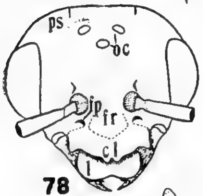

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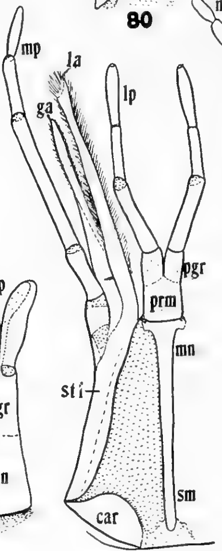

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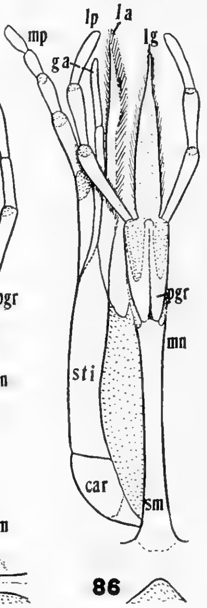

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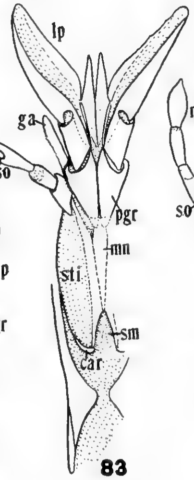

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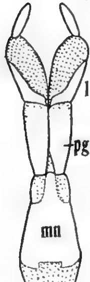

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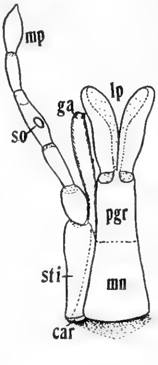

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G. C. Crampton.

UNDESCRIBED SPECIES OF JAPANESE CRANE-FLIES (TIPULIDÆ, DIPTERA).

Part II.

By Charles P. Alexander.

The present paper is a continuation of the first part published under this title (Ann. Ent. Soc. Amer., vol. 12, pp. 327-348; 1919). The material upon which this report is based was received from many different sources. Dr. Kuwana has sent material collected in various parts of Honshu by his assistant inspectors, Mr. Tanaka and Mr. Teranishi. Dr. Machida has collected numerous crane-flies in the vicinity of Tokio and near Tamagawa in the province of Saitama. Mr. Takeuchi sent an interesting series from Gifu. Mr. Kuwayama supplied a series of Tipulinæ from Hokkaido, mostly from the immediate vicinity of Sapporo. One additional species was included in extensive collections of exotic crane-flies belonging to the Paris Museum and sent to me for naming by Mons. Séguy. I express my great indebtedness to all of the gentlemen named for this important series of Japanese Tipulidæ. Unless stated otherwise, the types are preserved in the writer's collection.

Limnobia Meigen.

Limnobia tanakai sp. n.

General coloration yellow; pronotum and anterior portion of mesonotal praescutum with a median brown line; antennæ yellow; vertex with a brown crossband; legs yellow, the tips of the femora and tibiæ narrowly dark brown; wings with a yellowish tinge, sparsely variegated with brown; *r* removed from the tip of R_1; basal deflection of Cu_1 before the fork of M.

Male—Length, 8 mm.; wing, 8.7 mm. *Female*—Length, 9 mm.; wing, 8.8 mm.

Rostrum and palpi dark brown. Antennæ uniformly pale yellow; flagellar segments with long verticils. Anterior part of vertex yellow with a sparse whitish pubescence; a dark brown band extending across vertex between the posterior margins of eyes; remainder of vertex and occiput obscure yellow.

Pronotum dark brown, passing into yellow on the sides. Mesonotal praescutum reddish yellow, the anterior median area slightly infuscated; remainder of mesonotum light yellow. Pleura reddish yellow. Halteres obscure yellow. Legs with the coxæ and trochanters yellow; femora yellow, the tips narrowly dark brown; tibiæ obscure yellow, the tips very narrowly dark brown; metatarsi obscure yellow, the tips brown; remainder of tarsi brown. Wings with a strong grayish yellow tinge, clearer yellow in cells *C* and *Sc;* stigma brown; narrow brown clouds at origin of *Rs; Sc_2;* along cord and outer end of cell *1st* M_2 and less distinctly along the other longitudinal veins; veins dark brown, paler in the costal area. Venation: *Sc* long, Sc_2 ending about opposite two-thirds *Rs;* Sc_2 much longer than Sc_1; *Rs* angulated and spurred at origin; *r* far from tip of R_1, about one-half the latter; basal deflection of Cu_1 far before the fork of *M*, the distance about one-half of the deflection.

Abdomen obscure yellow; in the male, the hypopygium is more infuscated.

Habitat: Japan. Holotype, ♂, Ikaho, Gumma-Ken, July 7, 1920 (K. Tanaka). Allotopotype, ♀, in copula with the type.

Limnobia tanakai is named in honor of its collector. It is more closely related to *L. stigma* Meigen (Europe) than to any other described Palaearctic species.

Dicranomyia Stephens.

Dicranomyia paupercula sp. n.

Antennal flagellum dark brown; head dusted with gray; mesonotum pale, covered with a sparse yellow pollen; wings with a faint yellowish tinge; *Sc* short, Sc_2 apparently lacking.

Male—Length about 4.5 mm.; wing 4.6 mm.

Rostrum brown, dusted with gray; palpi obscure brownish yellow. Antennæ with the scapal segments brown; flagellum dark brownish black; flagellar segments oval. Head dark, dusted with gray.

Mesonotum pale with a sparse yellow pollen, without darker markings; scutellum and postnotum sparsely pruinose. Pleura with a yellowish gray pollen, becoming more yellowish on the mesosternum. Halteres pale, the knobs darker. Legs with the coxæ and trochanters concolorous with the pleura; remainder of the legs yellowish testaceous, the tarsi slightly darker. Wings with a faint yellowish tinge, the stigma entirely lacking; veins pale. Venation: *Sc* short, Sc_2 apparently entirely lacking; *Rs* nearly twice the deflection of R_{4+5}; cell *1st* M_2 closed, about as long as the outer section of Cu_1; basal deflection of Cu_1 at or slightly before the fork of *M*.

Abdominal tergites light brown, the sternites brownish yellow.

Habitat: Japan. Holotype, ♂, Koiwai Farm, near Morioka, September 2, 1920 (C. Teranishi).

Dicranomyia paupercula is allied to *D. depauperata* Alex., but is much smaller and with the details of coloration distinct.

Dicranomyia machidai sp. n.

General coloration brownish yellow, the mesonotum marked with darker; a broad, longitudinal dark brown stripe on pleura; antennæ entirely dark; wings brown, stigma oval, dark brown; *Sc* long, Sc_2 at tip of Sc_1; cell *1st* M_2 closed; abdominal tergites dark brown, sternites indistinctly bicolorous; male hypopygium with a single pleural appendage, the terminal beak unprovided with spines.

Male—Length, about 5 mm.; wing, 6.5 mm. *Female*—Length, 6.6 mm.; wing, 5.5–7.2 mm.

Rostrum and palpi dark brownish black. Antennæ dark brownish black throughout; flagellar segments cylindrical, each with a short pedicel. Head dark brownish gray.

Pronotum dark brown, the lateral margins of the scutellum obscure yellow. Mesonotal praescutum brownish yellow with a broad, dorsomedian darker brown stripe that is greatly widened before the suture; lateral margins of praescutum narrowly infuscated; scutal lobes dark brown, the median area obscure yellow; scutellum and postnotum dark brown. Pleura obscure yellow with a very broad and conspicuous dark brown longitudinal stripe extending from the cervical sclerites to the base of the abdomen, passing immediately beneath the halteres; dorsal pleurites darker than the ventral sclerites; mesosternum a little darkened. Halteres dark brown, the base of the stem more yellowish. Legs with coxæ and trochanters yellowish; remainder of the legs brown. Wings with a strong brownish tinge; stigma oval, darker brown; very indistinct seams along the cord and outer end of cell *1st* M_2; veins dark brown. Venation: *Sc* long, Sc_1 extending to about opposite one-half the length of *Rs*, Sc_2 at its tip; *Rs* long, arcuated to feebly angulate at origin; *r* at tip of R_1; basal deflection of R_{4+5} almost straight; cell *1st* M_2 elongate rectangular, subequal to or a little shorter than the ultimate section of M_{1+2}; basal deflection of Cu_1 beyond the fork of *M*; Cu_2 a little shorter than the deflection of Cu_1; vein *2nd A* slightly extended.

Abdominal tergites dark brown; sternites with the basal half of the segments yellowish, the apices dark brown; genital segment in the female brighter. Male hypopygium with the pleurites relatively slender, with a conspicuous fleshy lobe on the proximal face; a single pleural appendage, the tip of which is produced into a curved chitinized beak that bears a few delicate bristles near its apex, but is unarmed with spines. Gonapophyses flattened, broad-based, suddenly narrowed to the slender apex, this latter with a blunt blackened tubercle on the outer side some distance before the tip.

Habitat: Japan. Holotype, ♂, Nakano, May 28, 1920 (H. Machida). Allotype, ♀, Shibuya, October 12, 1920 (H. Machida). Paratopotype, ♀; paratypes, 5 ♂ ♀, Shibuya, June 24-September 29, 1920.

This interesting and very distinct *Dicranomyia* is named in honor of its collector, Dr. Hachiro Machida.

Dicranomyia unispinosa sp. n.

General coloration light brown; antennæ dark brown; wings with a strong brownish tinge; stigma oval, dark brown; Sc long; basal deflection of R_{4+5} arcuated; abdomen dark brown; male hypopygium with two pleural appendages; inner face of the ventral pleural appendage with a fleshy lobe that bears a single long spine before its tip.

Male—Length about 4 mm.; wing, 4.3 mm.

Rostrum and palpi dark brown. Antennæ moderately elongate for a member of this genus, if bent backward extending beyond the base of the abdomen; dark brown, flagellar segments suboval, covered with a dense white pubescence. Head dark brown, the anterior part sparsely pruinose.

Mesonotum light brown without distinct darker stripes or other markings. Pleura testaceous, the dorsal region very slightly darker. Halteres testaceous, the knobs brown. Legs with the coxæ and trochanters testaceous, concolorous with the ventral sclerites of the pleura; remainder of legs dark brown. Wings with a strong brownish tinge; stigma oval, darker brown; veins dark brown. Venation: Sc long, Sc_1 ending about opposite two-fifths the long Rs, Sc_2 at tip of Sc_1; Rs long, gently angulated near base, in alignment with R_{2+3}; tip of R_1 and r pale, subobsolete; basal deflection of R_{4+5} strongly arcuated; inner end of cell *1st* M_2 gently arcuated; basal deflection of Cu_1 immediately before the fork of M.

Abdomen dark brown. Male hypopygium with the pleurites stout, provided with a large, conspicuous lobe on the proximal face; two pleural appendages; dorsal hook straight basally, gently curved on the outer half, the tip acute; ventral pleural appendage a large fleshy lobe whose proximal face near the base is produced into a fleshy rostrum that narrows gradually to the blunt apex; far before the tip on the caudal or outer face a single powerful spine that is about as long as the fleshy tip beyond it. Gonapophyses appearing as broad-based flattened plates that gradually narrow to the apices, the latter slender, with the tips feebly notched. Penis-guard slightly shorter than the apophyses.

Habitat: Japan. Holotype, ♂, Gifu, October 9, 1920 (K. Takeuchi).

Dicranomyia unispinosa bears a strong superficial resemblance to *D. machidai*, but is readily distinguished by the very different structure of the male hypopygium and other smaller characters.

Geranomyia Haliday.

Geranomyia (Geranomyia) gifuensis sp. n.

General coloration light gray; rostrum and antennæ dark brown; humeral angles of praescutum testaceous yellow; pleura yellowish; legs dark brown; wings gray, stigma oval, dark brown; very narrow seams along the cord and outer end of cell *1st* M_2; *Sc* long; cell *1st* M_2 long and narrow.

Female—Length (excluding rostrum), 6.6 mm.; wing, 7.8 mm.; rostrum alone, 3–3.5 mm.

Rostrum and palpi black. Antennæ black; flagellar segments cylindrical. Anterior part of the vertex light gray pruinose; remainder of the head dark brown.

Pronotum brown medially, gray pruinose. Mesonotal praescutum brown with a conspicuous light gray bloom, the interspaces darker; humeral angles light testaceous yellow to flesh color, this color continued around the anterior margin of the praescutum as a narrow seam; lateral margins of the praescutum caudad of the pseudosutural foveæ dark brown; scutum light gray, the proximal edge of the lobes with a longitudinal dark line; scutellum brownish testaceous, gray pruinose; postnotum dark, gray pruinose. Pleura testaceous yellow anteriorly, sparsely pruinose, especially on the posterior pleurites. Halteres yellow, the knobs and outer end of the stem dark brown. Legs with the coxæ and trochanters yellowish testaceous; remainder of the legs dark brown, bases of the femora paler. Wings with a gray tinge; stigma oval, dark brown; very narrow and indistinct brown seams at the supernumerary crossvein in cell *Sc;* origin of *Rs;* Sc_2; along the cord and outer end of cell *1st* M_2; a narrow seam along the wing-apex in cells *2nd* R_1 and R_3; veins dark brown. Venation: *Sc* long, Sc_1 ending about opposite two-thirds *Rs*, Sc_2 at the tip of Sc_2 deflection of R_{2+3} shorter than the basal deflection of Cu_1; cell *1st* M_2 long and narrow, rectangular, slightly widened outwardly, about as long as vein M_{1+2} beyond it; basal deflection of Cu_1 before or beyond the fork of *M*.

Abdominal tergites dark brown, sternites paler brownish testaceous. Ovipositor reddish horn-color.

Habitat: Japan. Holotype, ♀, Gifu, October 10, 1920 (K. Takeuchi). Paratopotype, ♀.

Erioptera Meigen.

Erioptera (Erioptera) dictenidia sp. n.

General coloration brown, the thoracic pleura gray; femora brownish yellow with a narrow brown subterminal ring; wings faintly brownish; a narrow and very indistinct brown seam along the cord; male hypopygium with the outer pleural appendage stout, chitinized, the apex densely set with parallel rows of small chitinized spinules; inner pleural appendage pale, an acute point on cephalic margin at about two-thirds the length; gonapophyses two, appearing as flattened blades, the outer margin with a comb of about a dozen teeth.

Male—Length about 3.8 mm.; wing, 4.5 mm. *Female*—Length about 4.5 mm.; wing, 5.7 mm.

Rostrum obscure brownish yellow; palpi dark brown. Antennæ dark brown. Head dark gray, paler adjoining the eyes.

Pronotum pale laterally. Mesonotum uniformly light brown, the dorso-median area darker. Pleura light gray pruinose. Halteres pale, the knobs and apices of stem dark brown. Legs with the coxæ concolorous with pleura; trochanters obscure yellow; femora brownish yellow, a narrow dark brown subterminal ring; tibiæ and tarsi obscure brownish yellow, the latter darkened towards the tip. Wings with a faint brown tinge; a narrow and very indistinct brown seam along the cord; veins dark brown. Venation: Vein *2nd A* only moderately sinuous, the distal quarter bent towards the *1st Anal* vein.

Abdominal tergites dark brown; sternites obscure brownish yellow; pleurites of male hypopygium obscure reddish brown. Male hypopygium with the pleurites stout, the inner angle produced into a short, stout lobe provided with several setigerous tubercles; outer pleural appendage a large, stout chitinized arm, densely provided with parallel rows of small, chitinized spinules; inner pleural appendage a pale blade with an acute point on the cephalic or inner margin at about two-thirds the length. Gonapophyses two in number, appearing as flattened chitinized blades, the proximal edge straight, the outer edge with a comb of about a dozen small, acute teeth, the outermost tooth largest, chitinized.

Habitat: Japan. Holotype, ♂, Shibuya, August 7, 1920 (H. Machida). Allotopotype, ♀. Paratopotypes, ♀, June 30, 1920; ♂, October 10, 1920. Paratypes, 7 ♂ ♀, Keijo, Corea, September 6, 1920 (K. Doi.)

Erioptera (Erioptera) bicornifer sp. n.

General coloration brown; pleura sparsely gray pruinose; wings pale gray, veins pale brown; male hypopygium with the inner pleural appendage recurved into an elongate point; gonapophyses appearing as two slender curved horns, blackened at their tips.

Male—Length about 3 mm.; wing, 4.2 mm.

Rostrum and palpi dark brown. Antennæ dark brown. Head brown, discolored in the type.

Mesonotum brown, without distinct markings; pseudosutural foveæ elongate, shiny brown. Pleura brown, sparsely gray pruinose. Halteres obscure yellow, knobs brown. Legs with the coxæ, trochanters and femora light brown; tarsi dark brown. Wings pale gray, unmarked; stigma lacking; veins pale brown. Venation: *2nd Anal* vein very strongly bisinuous.

Abdominal tergites dark brown; sternites slightly paler. Male hypopygium with the pleurites moderately stout; two pleural appendages; outer appendage subclavate, the apex blackened; inner appendage a pale flattened blade, the outer angle of which is recurved into an elongate acute point. Gonapophyses appearing as two slender curved horns, contiguous basally, diverging apically, the tips heavily blackened.

Habitat: Japan. Holotype, ♂, Nakano, May 27, 1920 (H. Machida).

Ormosia Rondani.

Ormosia nantaisana sp. n.

General coloration light gray; mesonotal praescutum with a median brown stripe; halteres golden-yellow; wings brownish gray, stigma and wing-tip darkened; cell *1st* M_2 closed, *m* short, Anal veins convergent; male hypopygium with the inner pleural appendage stout, subclavate, the apex set with microscopic black points.

Male—Length, 6 mm.; wing, 7.3 mm.

Rostrum and palpi dark brown. Antennæ with the scapal segments dark brown, the remainder broken. Head light gray, the vertex provided with numerous setæ, those of the disk yellow, the lateral bristles longer, dark brown.

Pronotum dark gray, provided with very long and conspicuous yellow setæ. Mesonotal praescutum light gray with a broad, indistinct, brown median stripe; lateral stripes indistinct; pseudosutural foveæ conspicuous, elongate, black; remainder of mesonotum gray pruinose. Pleura clear light gray, provided with groups of long yellow setæ on the mesepisternum and on the mesosternum. Halteres golden-yellow. Legs with the coxæ dark, sparsely pruinose, provided with conspicuous yellow setæ; trochanters dull yellow; remainder of the legs broken. Wings with a brownish gray tinge; stigma darker brown; wing-tip and the cord narrowly margined with brown; veins dark brown, *Sc* yellow. Venation: Sc_1 longer than *Rs;* R_{2+3} a little longer than the basal deflection of Cu_1; *r* on R_2 shortly beyond its origin; cell *1st* M_2 closed; *m* short, between one-third and one-fourth the outer deflection of M_3; basal deflection of Cu_1 slightly sinuous, beyond the fork of *M;* Anal veins strongly convergent.

Abdomen dark brown with conspicuous yellow setæ. Male hypopygium stout; two pleural appendages, inner appendage subclavate, the tip truncated, densely set with microscopic blackened points; outer appendage a slender flattened yellow blade, the apex subacute.

Habitat: Japan. Holotype, ♂, Nantaisan, August 16, 1909. Type in the Collection of the Paris Museum.

Ormosia takeuchii sp. n.

Related to *O. takahashii;* general coloration pale brownish testaceous; thoracic pleura and abdomen darker; wings pale gray; cell *1st* M_2 open by the atrophy of the outer deflection of M_3; Anal veins convergent; male hypopygium with the outer gonapophyses simple.

Male—Length about 4 mm.; wing, 4.3 mm. *Female*—Length about 3.8 mm.; wing, 4.4 mm.

Rostrum and palpi dark brown. Antennæ short in both sexes, pale brownish testaceous; flagellar segments with a conspicuous pale pubescence. Head pale with abundant yellow setæ.

Mesonotal praescutum pale brownish testaceous, unmarked with darker, the interspaces with conspicuous erect yellow setæ, lateral margins paler; remainder of the mesonotum brownish testaceous.

Pleura brown, very sparsely pruinose. Halteres pale yellow. Legs with the coxæ and trochanters obscure yellow; femora pale brown with yellow appressed setæ; tarsi brown. Wings pale gray, the stigma brown; veins pale brown; cells with an abundant pubescence. Venation: Cell *1st* M_2 open by the atrophy of the outer deflection of M_3; Anal veins convergent, the outer half of the *2nd Anal* vein bent towards the *1st Anal.*

Abdomen dark brown, the genital segment brighter; valves of the ovipositor horn-color. Male hypopygium very similar to that of *O. takahashii*, but the outer gonapophyses simple, conical, there being only six points surrounding the genital field.

Habitat: Japan. Holotype, ♂, Gifu, October 1, 1920 (K. Takeuchi). Allotopotype, ♀, October 10, 1920.

This interesting species is named in honor of its collector, Mr. K. Takeuchi, to whom I am indebted for much valuable material.

Gonomyia Meigen.

Gonomyia (Ptilostena) teranishii sp. n.

General coloration light gray; mesonotal praescutum with two narrow brown lines; pleura yellow, the dorsal pleurites brown; legs yellow; wings yellowish gray, the costal region yellowish; brown spots at arculus; origin of *Rs;* along the cord; tips of the radial veins and near the tip of vein *2nd A;* Sc_1 about equal to R_{2+3}; R_3 strongly recurved at its tip; abdominal tergites dark brown, the caudal margins of the segments very narrowly grayish.

Female—Length, 7.2 mm.; wing, 6 mm.

Rostrum and palpi dark brown. Antennæ with the first scapal segment light gray pruinose; second segment light yellow; flagellum dark brown, the segments oval. Head brown, the front and anterior part of the vertex light gray pruinose.

Pronotum dark brown, obscure yellow laterally. Mesonotal praescutum dark brown, gray pruinose, on either side of the broad median gray line a narrow brown line extending to the suture; humeral angles and lateral margins obscure yellow; scutum light gray, the centers of the lobes brown; scutellum and postnotum dark, gray pruinose. Pleura light yellow, the dorsal half dark brown, deepest anteriorly. Halteres obscure yellow, the knobs dark brown. Legs with the coxæ and trochanters light yellow; remainder of the legs yellow, the terminal tarsal segments brown. Wings yellowish gray, the costal and subcostal cells clearer yellow; brown spots at the arculus; stigma; along the cord; basal deflection of Cu_1; tips of veins R_2, R_3 and near the tip of the *2nd Anal* vein; extreme wing-tip cream-color, preceded by a faint brown suffusion; veins brown, *C* and *Sc* more yellow. Venation: Sc_1 extending to just beyond the origin of *Rs*, Sc_2 far from the tip of Sc_1, the latter alone about equal to R_{2+3}; *Rs* very strongly angulated and slightly spurred at origin; R_{2+3} gently arcuated; R_2 short, straight, subperpendicular, nearly its own length beyond the end of R_1; R_3 curved strongly cephalad before its tip; inner ends of cells R_3, R_5 and *1st* M_2 in alignment; petiole of cell *2nd* M_2 a little shorter than R_{2+3}; basal deflection of Cu_1 far before the fork of M, about one and one-half times its length before the fork of M.

Abdominal tergites dark brown, the caudal margins very narrowly grayish; genital segment obscure brownish yellow; basal sternite yellow; intermediate sternites black, variegated with black, this coloration probably due to eggs beneath the surface; caudal margins of the segments narrowly yellowish.

Habitat: Japan. Holotype, ♀, Koiwai Farm, near Morioka, August 17, 1920 (C. Teranishi).

This handsome crane-fly is named for its collector.

Trentepohlia Bigot.

Trentepohlia (Trentepohlia) septemtrionalis sp. n.

General coloration brownish yellow; mesonotal praescutum with an indistinct brown stripe; femora yellow, the tips dark brown; tibiæ yellowish white, the bases and tips blackened; wings yellowish gray, stigma and the wing-axil darkened; Rs about two-thirds the deflection of R_{4+5}; petiole of cell R_5 short, about equal to Rs.

Female—Length, 8.4 mm.; wing, 6.5 mm.

Rostrum, maxillary and labial palpi dark brown. Antennæ dark brown, the second scapal segment paler, obscure yellow. Head dark brown, sparsely grayish.

Pronotum dark brown. Mesonotum obscure brownish yellow, the praescutum with an indistinct darker brown median line; scutal lobes darkened; postnotum testaceous. Pleura yellowish testaceous, sparsely dusted with yellowish pollen. Halteres pale. Legs with the coxæ concolorous with pleura; trochanters testaceous; femora yellow, the tips broadly but gradually dark brown; tibiæ yellowish white, the bases and tips narrowly darkened; metatarsi pale yellow; terminal tarsal segments brown. Wings yellowish gray; a small brown stigmal spot at r; Cu and branches narrowly seamed with brown; a conspicuous brown cloud in the anal angle of the wing; veins pale brown, C, Sc and R pale yellow. Venation: R straight, about two-thirds the deflection of R_{4+5}; basal section of R_{2+3} about one-half longer than the second section;petiole of cell R_5 about as long as Rs or the basal deflection of Cu_1, the latter immediately before the fork of M; fusion of Cu_1 and *1st* A about equal to the basal deflection of R_{4+5}.

Abdomen light brown, more yellowish basally. Ovipositor horn-colored.

Habitat: Japan. Holotype, ♀, Nakano, June 2, 1920 (H. Machida).

Trentepohlia septemtrionalis is the most northerly species of the genus yet discovered. Its closest relative is *T. nigro-apicalis* (Brunetti) of British India, which differs in the size, body-coloration and, especially, the coloration and venation of the wings.

Limnophila Macquart.

Limnophila (Phylidorea) melanommata sp. n.

General coloration shiny reddish yellow; antennæ with the basal segment dark brown, the remainder yellow; mesonotal praescutum with a narrow, dark brown median line that is narrowed behind; legs brownish yellow; wings light yellow, the wing-tip narrowly darkened; cord and inner end of cell *1st* M_2 narrowly darkened; *r* at the tip of R_1; cell M_1 present.

Female—Length, 9 mm.; wing, 8.2 mm.

Rostrum and palpi dark brown. Antennæ with the first scapal segment dark brown; remainder of the antennæ conspicuously and abruptly light yellow. Head dark brown, conspicuously silvery pruinose.

Pronotum obscure yellow, dark brown medially. Mesonotal praescutum shiny reddish yellow, with a narrow, dark brown median stripe, broadest in front, gradually narrowed behind, becoming obsolete before the suture; remainder of the mesonotum obscure yellow. Pleura reddish yellow. Halteres yellow, the knobs faintly darkened. Legs with the coxæ and trochanters yellow; femora obscure yellow, the tips very narrowly and indistinctly darkened; tibiæ obscure brownish yellow; tarsi darkening into brown. Wings with a uniform light yellow tinge; wing-tip narrowly margined with dark brown, this color extending from cell *2nd* R_1 to cell R_5, and thence more narrowly and less distinctly to cell M_3; narrow and indistinct brown seams at the origin of *Rs;* along cord and outer end of cell *1st* M_2; forks of R_{2+3} and M_{1+2}; stigma appearing as a narrow seam along *r* and the tip of R_1; veins yellow, darkened in the infuscated areas. Venation: *Sc* long, Sc_2 extending to about opposite one-half to two-thirds R_{2+3}, Sc_2 much longer than Sc_1; *Rs* moderately long, nearly twice R_{2+3}, strongly angulated at origin; *r* at the tip of R_1; inner ends of cells R_3, R_5 and *1st* M_2 nearly in alignment; petiole of cell M_1 a little shorter than the cell; cell *1st* M_2 rectangular, widened distally; basal deflection of Cu_1 shortly beyond midlength of cell *1st* M_2.

Abdomen yellowish testaceous.

Habitat: Japan. Holotype, ♀, Koiwai Farm, near Morioka, September 4, 1920 (C. Teranishi).

Limnophila melanommata is a strikingly beautiful member of the *ferruginea* (*adusta*) group.

Rhaphidolabina Alexander.

Rhaphidolabina gibbera sp. n.

General coloration pale brownish yellow; antennal scape dark brown, flagellum brownish yellow; mesonotum exceedingly gibbous; mesonotal praescutum with a median brown line that splits at the suture into two parallel branches which continue to the abdomen; legs pale yellow; wings relatively broad, yellowish gray, sparsely marked with dark brown; cell *1st* M_2 open by the atrophy of *m.*

Male—Length about 5.5 mm.; wing, 6.9 mm. *Female*—Length about 5 mm.; wing, 6 mm.

Rostrum and palpi brownish black. Antennæ 15-segmented; scape brownish black, flagellum conspicuously light brownish yellow; basal flagellar segments short-cylindrical, the terminal segments more attenuated. Head dark brown, sparsely pruinose.

Pronotum brown, darker medially. Mesonotum exceedingly gibbous, pale brownish yellow, the insect appearing hump-backed; praescutum with a median brown line that divides at the suture, each branch continued to the abdomen, the pale area enclosed including the centers of the scutum, scutellum and postnotum. Pleura whitish testaceous. Halteres brownish testaceous, the knobs dark brown. Legs with the coxæ whitish testaceous, the fore coxæ a little darkened; remainder of the legs pale yellow, only the tarsal segments a little darkened. Wings relatively broad, with a yellowish gray tinge, sparsely variegated with dark brown spots, arranged as follows: At Sc_2; a large area at the origin of *Rs;* along the cord; outer deflection of R_2 and along R_{1+2}; tips of all the longitudinal veins at the wing-margin; forks of M_{1+2} and $M_{3+}Cu_1$; stigma feebly indicated; veins pale yellow, darker brown in the infuscated areas. Venation: Sc_2 some distance before the origin of *Rs*, the distance about one-half longer than the basal deflection of Cu_1; *Rs* relatively long, strongly angulated at origin; R_{2+3+4} shorter than the basal deflection of Cu_1, a little longer than *r–m;* deflection of R_2 close to the tip of R_1; cell *1st* M_2 open by the atrophy of *m;* petiole of cell M_1 a little more than twice the length of the cell; petiole of cell M_3 a little shorter than the cell; basal deflection of Cu_1 at the fork of *M*.

Abdominal tergites brown, the basal segments paler; sternites pale brown. Ovipositor elongate, dark brown, the tips of the valves bright horn-yellow.

Habitat: Japan. Holotype, ♂, Gifu, October 10, 1920 (K. Takeuchi). Allotopotype, ♀, October 2, 1920.

Rhaphidolabina gibbera is to be referred to *Rhaphidolabina* although cell *1st* M_2 is open and there are other slight differences between this fly and the genotype, *R. flaveola* (Osten Sacken) of Northeastern North America.

Oropeza Needham.

Oropeza candidipes sp. n.

Antennæ pale basally, intermediate segments bicolorous, terminal segments dark; general coloration buffy gray, praescutum with three darker gray stripes; pleura testaceous gray, striped longitudinally with dark gray; legs yellow, tibiæ and tarsi snowy-white; wings yellowish; stigma conspicuous, dark brown; abdominal sternites testaceous yellow, each segment with a small, triangular median dark brown spot at the caudal margin.

Female—Length, 14–14.5 mm.; wing, 12–14 mm.

Frontal prolongation of head short, pale above, slightly darker laterally palpi with the basal two segments pale, the terminal segments dark brown. Antennæ very pale, almost white, terminal segments darker, the intermediate segments bicolorous, the base of each segment being darkened. Head gray, darker gray behind.

Mesonotal praescutum buffy gray, with three broad darker gray stripes, the intermediate stripe narrowly split by a pale line; scutal lobes dark, pale medially; scutellum pale testaceous, dark brown basally; postnotum buffy gray. Pleura testaceous gray, longitudinally striped with darker gray along the ventral margin of the mesepisternum; mesosternum dark gray; dorso-pleural membrane almost whitish. Halteres pale, the knobs dark brown. Legs with the coxæ testaceous, the fore coxæ darker; trochanters whitish; femora yellow; remainder of legs snowy-white. Wings with a strong yellowish tinge; stigma dark brown; veins dark brown, those in the costal region more yellowish. Venation: *Rs* pale, without macrotrichiæ, one-half longer than the deflection of R_{4+5}; cell *1st* M_2 long and narrow; basal deflection of M_{1+2} longer than *m;* petiole of cell M_1 about two-thirds as long as cell *1st* M_2.

Abdominal tergites dark brown, about the basal third or less of each segment paler; sternites one to six pale testaceous yellow, the posterior median area of each segment with a small dark brown triangle. Ovipositor with the slender tergal valves dark brown; sternal valves flattened, pale.

Habitat: Japan. Holotype, ♀, Tamagawa, Saitama-Ken, August 30, 1920 (H. Machida). Paratype, ♀, Ikaho, Gumma-Ken, July 7, 1920 (K. Tanaka).

Tipula Linnaeus.

Tipula shomio sp. n.

Head dark gray; antennæ of male moderately elongate, indistinctly bicolorous; thorax gray, the praescutal stripes and scutal lobes shiny black; fore femora black, except the basal fourth, hind femora yellow with the apical fourth black; wings pale yellowish, the base and subcostal cell brighter yellow; disk variegated with brown and gray; abdomen yellow, with a subterminal brownish black ring; male hypopygium large, the ninth tergite produced into a hood-like median lobe; ninth pleurite complete.

Male—Length, 13 mm.; wing, 16 mm.

Frontal prolongation of the head dark brown above, paler laterally, black ventrally; palpi dark brown. Antennæ of the male moderately elongated, if bent backward extending a little beyond the wing-root; scape and basal two segments of the flagellum reddish yellow; remaining flagellar segments brown, the basal enlargement of each segment darker to give to the flagellum an indistinctly bicolorous appearance; terminal segments uniformly dark brown. Head dark gray pruinose.

Pronotum dark gray. Mesonotum with the praescutal stripes and scutal lobes shiny black, the former confluent or nearly so; median area of the scutum, scutellum and postnotum dark gray pruinose. Pleura dark, gray pruinose, an indistinct longitudinal stripe paler gray. Halteres obscure yellow, the knobs dark brown. Legs with the coxæ dark brown, gray pruinose, the tips of the posterior coxæ pale; trochanters obscure yellow; fore femora black with about the basal fourth abruptly brownish yellow; middle femora with the apical third black; hind femora with a little more than the apical fourth black; tibiæ obscure brownish yellow, the apical half brown; tarsi brownish black. Wings pale yellowish subhyaline, the wing-base and subcostal cell conspicuously light yellow; costal cell dark brown, pale at the base and apex; stigma dark brown, continued as a slightly paler brown seam along the cord to the posterior margin; wing-tip faintly darkened, this including the outer halves of cells R_2, R_3 and R_5, and as a very narrow seam around the wing-tip to Cu_1; a faint brown seam at the origin of *Rs;* brown seams along *Cu* and its branches and vein *2nd A;* grayish brown clouds in the ends of the Anal cells and as a faint cloud across the basal cells, beginning at the origin of *Rs;* the subhyaline color beyond the cord appears as a broad band in the basal half of cells R_2, R_3, R_5 and all of cell *1st* M_2; very narrow brown seams along the veins beyond the cord; veins dark brown, yellow in the yellowish areas. Venation: *r* joining R_{2+3} at its fork; R_2 oblique; *Rs* longer than R_3; cell *1st* M_2 small, pentagonal, about as long as cell M_1.

Abdomen obscure yellow, the tergites with three very indistinct capillary dark brown lines; a subterminal dark brownish black ring occupying segments six to eight, these segments broadly margined with obscure yellow; hypopygium yellowish brown. Male hypopygium large. Ninth tergite extensive, the median area produced caudad into a blunt black median lobe; viewed from beneath this lobe is seen to be hollowed out into a hood-shaped structure; dorsal-median area of the tergite sunken. Ninth pleurite complete, large; outer pleural appendage flattened, angularly bent, provided with a fringe of long yellow bristles; inner pleural appendage flattened, heavily chitinized; from the inner margin of the pleurite juts a small flattened blade, with a powerful chitinized spine along the margin. Ninth sternite feebly notched. Eighth sternite broad, the caudal margin broadly and very shallowly notched, the lateral angles with a sparse fringe of long, pale bristles.

Habitat: Japan. Holotype, ♂, Koiwai Farm, near Morioka, September 8, 1920 (C. Teranishi).

Tipula flavocostalis sp. n.

General coloration of the head and thorax gray, mesonotal praescutum trivittate with dark brown; halteres and legs yellow; wings subhyaline, wing-base and costal region conspicuously light yellow; stigma brown; sparse gray clouds on the wing; tip of R_2 atrophied; abdomen yellow, tergites trivittate with dark brown; a subterminal brown ring; male hypopygium cylindrical, tilted at an angle to the remainder of the abdomen; ninth tergite tridentate, the median blade very compressed.

Male—Length about 11 mm.; wing, 12.4 mm. *Female*—Length, 13–15 mm.; wing, 13–14.5 mm.

Frontal prolongation of the head dark brown above and beneath, brownish yellow laterally; palpi dark brown, terminal segment elongate. Antennæ of moderate length; scapal segments obscure yellow, the basal segment darkened basally; first flagellar segment brownish yellow; remaining flagellar segments dark brown, covered with a dense white pubescence; basal enlargement of each segment relatively small; in the female, the antennæ are more uniformly yellowish. Head light gray.

Pronotum obscure gray, indistinctly trinotate with brown. Mesonotal praescutum light gray with three indistinct dull brownish gray stripes, the intermediate stripe conspicuously margined with darker brown and split by a capillary dark brown line to appear trilineate cuneiform; remainder of mesonotum light gray, the centers of the scutal lobes darkened. Pleura uniformly gray. Halteres pale, the knobs yellow. Legs with the fore coxæ dark gray, the other coxæ obscure yellow, darkened basally, less extensive on the hind legs; trochanters and femora yellow; tibiæ and tarsi brownish yellow, the terminal tarsal segments passing into dark brown. Wings subhyaline, the base, costal and subcostal cells yellowish; stigma dark brown; vein *Cu* and branches seamed with dark brown; very pale gray clouds in the medial and anal cells; wing-tip slightly darkened, occupying the apices of cells R_2, R_3 and R_5; the subhyaline band beyond the stigma is broad and conspicuous; veins dark brown, *C*, *Sc* and *R* conspicuously light yellow. Venation: *Rs* long, a little shorter than R_3, about one-half longer than R_{2+3}, the extreme base indistinct; tip of R_2 beyond *r* atrophied in the male, in the female only the distal half of the outer section atrophied; cell *1st* M_2 relatively small, pentagonal; second section of M_{1+2} about twice the first section; *m* about one-third the outer deflection of M_{3+4}; petiole of cell M_1 about equal to cell *1st* M_2; *m-cu* distinct.

Abdomen dull yellow, the tergites narrowly trivittate with dark brown; a brown subterminal ring occupying segments six to eight, with the exception of the apex of the eighth sternite; hypopygium brownish yellow. In the female the abdomen is yellow, the tergites trilineate with dark brown, the fifth to seventh segments dark brown. Ovipositor chitinized, acicular. Male hypopygium cylindrical, tilted at an angle to the remainder of the abdomen, as in the *unca* (*hebes*) group, to which, however, the species does not appear to belong. Ninth tergite extensive, the caudal margin tridentate, the lateral lobes heavily chitinized, the apices truncated and directed slightly proximad; median lobe a highly compressed blade; viewed from above appearing as an acute edge that is a little shorter than the lateral lobes; the notches between the lateral and median lobes are subcircular. Ninth pleurite complete; outer pleural appendage very short and stout; inner pleural appendage relatively small, the interior ends produced into curved, blackened hooks, the caudal angles produced caudad and slightly ventrad into slightly expanded blades. Ninth sternite extensive. Eighth sternite with the broad median lobe rounded, provided with a fringe of long setæ.

Habitat: Japan. Holotype, ♂, Tamagawa, Saitama, September 25, 1920 (H. Machida). Allotopotype, ♀, September 26, 1920. Paratypes, ♀, Gifu, October 1, 1920 (K. Takeuchi); ♀, October 10, 1920.

Tipula taikun sp. n.

General coloration gray; mesonotal praescutum with a narrow, brown median line; thoracic interspaces with small brown punctures; antennæ of the male moderately elongated; intermediate flagellar segments indistinctly bicolorous, the base of each segment yellowish; femora brownish yellow with a narrow subterminal brown ring; wings faintly brownish, the base yellow; costal and subcostal cells dark brown; subhyaline areas before and beyond the stigma; cell *1st* M_2 small, pentagonal; abdomen yellow, narrowly trivittate with dark brown; a brown subterminal ring; male hypopygium with the ninth tergite having a small median notch.

Male—Length, 11.5 mm.; wing, 13 mm.

Frontal prolongation of the head dark brown; palpi dark brown, the basal segment a little brighter. Antennæ of the male rather elongate, if bent backward extending about to the base of the abdomen; scape and first flagellar segment yellow; remainder of the antennæ dark brown, the basal half of the knobs of the intermediate segments yellow, producing an indistinct bicolorous appearance; terminal flagellar segments uniformly dark brown. Head gray.

Pronotum buffy, with a dark brown median mark. Mesonotal praescutum brownish gray with three nearly concolorous stripes; intermediate stripe narrowly margined for most of its length with dark brown, split medially by a narrow dark brown line; thoracic interspaces with brown setigerous punctures; remainder of the mesonotum brown, sparsely pruinose, split by a slightly interrupted capillary brown line. Pleura light gray pruinose, the dorso-pleural areas more brownish. Halteres light brown. Legs with the coxæ and trochanters obscure yellow; femora brownish yellow with a very narrow and indistinct dark brown subterminal ring; tibiæ brownish yellow, passing into dark brown at the tip; tarsi dark brown. Wings with a faint brownish tinge, variegated with subhyaline areas; wing-base yellow; cells *C* and *Sc* dark brown; stigma dark brown; brown seams along *Cu* and its branches, the *2nd Anal* vein and the wing-tip; the subhyaline areas appear before the stigma in cell *1st* R_1, as a broad seam beyond the stigma, occupying the bases of cells R_2 and R_3; a small area near the end of cell *M* adjoining vein *Cu;* a small blotch in the *1st Anal* cell near vein *2nd A;* veins dark brown. Venation: Sc_2 ending beyond two-thirds the length of *Rs;* tip of R_2 pale, subatrophied; cell *1st* M_2 small, pentagonal; first section of M_{1+2} about one-half the second section; *m* about two-fifths of the outer deflection of M_3; petiole of cell M_1 about one-half the cell and about equal to cell *1st* M_2; *m-cu* short.

Abdomen yellow, the tergites narrowly trivittate with dark brown; caudal lateral angles of tergites two to six paler brown; an indistinct dark brown subterminal ring, including segment seven, and the adjoining parts of tergites six and eight; hypopygium obscure yellow. Male hypopygium with the ninth tergite extensive, the dorsal surface densely covered with long yellow hairs, the caudal margin with a small circular median notch, the broad lateral lobes thus formed produced into short, blackened, lateral points, the caudal margin of the tergite narrowly chitinized. Ninth pleurite relatively small, complete; outer pleural appendage flattened, moderately broad, narrowed basally. Caudal margin of the eighth sternite with a broad median notch, the margins provided with tufts of long bristles.

Habitat: Japan. Holotype, ♂, Koiwai Farm, near Morioka, September 8, 1920 (C. Teranishi).

Tipula autumna sp. n.

Related to *T. pluriguttata* Alexander (Formosa); coloration of thorax, including the pleura, clear gray; femora unicolorous brownish yellow; male hypopygium with the caudal margin of the ninth tergite broadly notched, with a small median tooth in the notch.

Male—Length about 12 mm.; wing, 13 mm. *Female*—Length, 15–16 mm.; wing, 13.8–15 mm.

Frontal prolongation of the head yellowish brown, above dusted with gray; palpi dark brown. Antennæ of the male relatively short; scape and first flagellar segment obscure yellow; remainder of the flagellum indistinctly bicolorous, the basal enlargement of each segment dark brown, the remainder of the segment paler brown; terminal segments uniformly darkened; basal enlargement of each segment relatively conspicuous. Head gray; vertical tubercle between the eyes relatively prominent, indistinctly bifid.

Pronotum light yellowish gray. Mesonotal praescutum yellowish gray with three clear gray stripes, the intermediate stripe margined and split by a capillary brown line; lateral stripes faintly darkened; thoracic interspaces with brown setigerous punctures; humeral region and lateral margins of praescutum paler; scutum gray, each lobe with two small brown areas; remainder of mesonotum gray with a very indistinct median brown line. Pleura gray. Halteres pale yellow, the knobs a little darker. Legs with the coxæ pale, sparsely pruinose;

trochanters yellow; femora and tibiæ brownish yellow, the tips not darkened; tarsi brown. Wings with a faint yellowish gray tinge, the base, costal and subcostal cells brownish yellow; stigma relatively small; wing-tip in cells R_2, R_3, R_5, M_1, *2nd* M_2, M_4 and Cu_1 slightly darkened; *Cu* and branches indistinctly seamed with brown; small obliterative areas before and beyond the stigma and across cell *1st* M_2. Venation: Sc_2 extending to about opposite three-fourths the length of *Rs*, the latter relatively long and straight; tip of R_2 pale; cell R_2 relatively small; cell *1st* M_2 pentagonal; *m* about one-third the outer deflection of M_3; petiole of cell M_1 a little shorter than cell *1st* M_2; *m-cu* short.

Abdomen obscure yellow, the tergites trivittate with dark brown, the dorsal stripe interrupted, on each segment appearing as a roughly triangular mark that is narrowed behind, scarsely attaining the posterior margins of the segments; lateral stripes relatively narrow and indistinct; a narrow subterminal brown ring, most evident on segment eight; hypopygium reddish yellow. In the female, the dorsal abdominal stripe is broad, in some cases continuous, in others interrupted at the posterior margins of the segments. Male hypopygium relatively incrassated. Ninth tergite having the caudal margin with a conspicuous median notch as in the related *T. taikun* sp. n., but in the present species there is a small, acute tooth at the base of the notch; lateral lobes terminating in small, truncated, chitinized points. Ninth pleurite complete; outer pleural appendage broad, flattened; proximal face of pleurite near the ventral caudal angle produced into a small, digitiform lobe. Ninth sternite with a broad V-shaped median notch. Eighth sternite narrowed posteriorly, the caudal margin with a broad V-shaped notch, each side of which bears a flattened sheaf of long, reddish bristles, decussate across the median line.

Habitat: Japan. Holotype, ♂, Gifu, October 1, 1920 (K. Takeuchi). Allotopotype, ♀, October 19, 1920. Paratopotypes, 2 ♀'s, October 19, 1920; paratype, ♀, Shibuya, Tokio, September 29, 1920 (H. Machida).

Tipula subcunctans sp. n.

Allied to *T. cunctans* Say (Eastern North America); general coloration gray, praescutal stripes brown; tips of femora and tibiæ brownish black; abdomen brownish gray, the tergites with an indistinct, capillary, brown median line.

Female—Length about 20 mm.; wing, 18 mm.

Frontal prolongation of the head obscure yellowish laterally, broadly gray above; palpi dark brown. Antennæ with the first scapal segment dark brown; second segment obscure reddish brown; first flagellar segment brownish yellow; intermediate flagellar segments indistinctly bicolorous, the base of each segment darker than the remainder of the segment; terminal flagellar segments uniformly dark brown. Front surrounding the antennal bases ochreous; remainder of the head buffy gray with a conspicuous brownish black line.

Mesonotal praescutum gray with three rather indistinct brown stripes, the intermediate pair narrowly separated by a pale line; lateral stripes paler, narrowly margined with darker brown; scutal lobes gray with two brown marks; scutellum and postnotum light gray pruinose. Pleura gray, the dorso-pleural membranes brownish yellow. Halteres dark brown. Legs with the coxæ gray, concolorous with the pleura; trochanters brownish yellow; femora brownish yellow, the tips broadly brownish black, broadest on the fore legs, narrowest on the hind legs; tibiæ light brown, soon passing into dark brown; tarsi dark brown. Wings brownish gray, the costal margin darker brown, this including the costal and subcostal cells and the stigma; veins dark brown. Venation: Cell *1st* M_2 short, a little longer than the petiole of cell M_1.

Abdominal tergites brownish gray, the basal tergites clearer gray; a narrow, interrupted, capillary, dark brown, median stripe extending from tergite to caudad, becoming indistinct at about segment six; caudal and lateral margins of the tergites rather narrowly pale, ochreous. Ovipositor with the dorsal shield black; the valves castaneous.

Habitat: Japan. Holotype, ♀, Sapporo, October 3, 1920 (S. Kuwayama).

Tipula latemarginata sp. n.

General coloration gray; antennæ of male elongate, black; mesonotum gray, the praescutum with three dark gray stripes that are indistinctly margined with brown; femora yellow, the tips broadly dark brown; wings comparatively long and narrow, with a strong brownish yellow tinge; stigma and a faint seam along the cord darker brown; abdominal tergites gray with a broad brown sublateral stripe; lateral margins of the tergites broadly buffy yellow; male hypopygium with the tergites fused with the pleurites; tergal region with a short, broad median lobe.

Male—Length, 13.5 mm.; wing, 15.4 mm.

Frontal prolongation of the head gray; nasus very long and slender; palpi dark brown. Antennæ of the male somewhat elongated, if bent backward extending about to the base of the abdomen; basal segment of the scape gray pruinose; second scapal segment reddish brown; flagellum black, the intermediate and terminal segments rather deeply incised, the basal enlargements of each segment subglobular. Head gray with a capillary black median line.

Mesonotal praescutum gray with three darker gray stripes that are very indistinctly margined with brownish; a capillary dark brown median line; scutellum and postnotum clear gray. Pleura gray, the dorso-pleural membrane light yellow. Halteres brown, the base of the stem brighter, the knobs darker brown. Legs with the coxæ gray pruinose; trochanters obscure yellow; femora yellow, the tips broadly dark brown, broadest on the fore legs, somewhat narrower on the posterior femora; remainder of the legs brownish black. Wings comparatively long and narrow, with a strong brownish yellow tinge; wing-base and cell *Sc* more yellowish; stigma brown; narrow brown seams along the cord and at the origin of *Rs;* veins dark brown. Venation: *Rs* about one-half longer than R_{2+3}; cell *1st* M_2 comparatively long and narrow; petiole of cell M_1 shorter than *m; m-cu* distinct.

Basal tergite gray; second tergite reddish on basal half, sparsely gray pruinose; remaining abdominal tergites with a broad dorso-median gray line that is narrowly interrupted at the posterior margins of the segments; a broad dark brown sublateral stripe; lateral margins of segments one to seven broadly buffy yellow; caudal margins of tergites very narrowly pale; sternites gray pruinose; hypopygium dark, the outer pleural appendage pale. Male hypopygium with the sclerites fused into a ring, the suture between the pleurite and sternite indicated. Region of the ninth tergite with a short, broad median lobe, the caudal margin narrowly blackened, truncate or feebly bilobed. Outer pleural appendage short and broad, covered with a mixed short and long pubescence. Ninth sternite with a deep and very narrow median notch, the tumid lobes slightly pointed outwardly. Eighth sternite unarmed.

Habitat: Japan. Holotype, ♂, Kairakuyen, Sapporo, May 27, 1916 (S. Kuwayama). Paratype, ♂, Fukagawa, Ishikara-Ken, August 30, 1916 (S. Kuwayama).

Tipula trifida sp. n.

Male—Length 13.5 mm.; wing, 15.6 mm.

Generally similar to *T. latemarginata,* from which it differs in the following regards.

The type is badly discolored by moisture and the coloration of the body can be discussed in general terms only. Antennæ of the male shorter, the flagellar segments not so distinctly binodose. Wings slightly broader, the cord not seamed with darker. Venation: R_{2+3} shorter, less than the ultimate section of R_2; cell *1st* M_2 shorter and broader. Abdominal tergites with the pale lateral margins narrower. Male hypopygium of the general type of *T. latemarginata,* the tergite being entirely fused with the pleurite; median lobe of the tergite subtended on either side by a more slender, pointed lobe that is a little longer than the truncate median lobe. Ninth sternite not tumid as in *T. latemarginata.* Eighth sternite narrowly margined with pale, unarmed.

Habitat: Japan. Holotype, ♂, Sapporo, May 17, 1919 (S. Kuwayama).

Tipula nikkoensis sp. n.

Closely related to *T. insulicola,* but much darker colored throughout.

Female—Length, 12 mm.; wing, 11 mm.

Closely related to *Tipula insulicola* Alexander (Japan).

Frontal prolongation of the head dark; palpi brownish testaceous, the terminal segment dark brown. Antennæ indistinctly bicolorous, the basal enlargement of each segment dark brown, the color continued onto the pedicel. Head pale brownish testaceous.

Thorax badly crushed, dark brown, praescutal stripes not apparent in the unique type. Pleura dark brown. Halteres pale yellow, the base of the knobs a little darkened. Legs with the femora brownish yellow, the tips dark brown; tibiæ and tarsi dark brown. Wings with a brownish yellow tinge, cells *C* and *Sc* more yellowish; stigma oval, dark brown; wing-tip in cells R_2 and R_3 indistinctly darkened; branches of *Cu*, the cord and most of the veins beyond the cord indistinctly seamed with brown; an obliterative area before and beyond the stigma; another obliterative area crossing cell *1st* M_2 from the end of cell *M* into the base of cell M_4; veins dark brown, more yellowish in the costal region. Venation: *Rs* short, arcuated; R_2 straight, the distal section in alignment with the basal section; cell *1st* M_2 irregularly pentagonal; *m* punctiform or nearly so; petiole of cell M_1 longer than cell *1st* M_2; *m-cu* obliterated by the long fusion of Cu_1 and M_{3+4}.

Abdominal tergites obscure yellow, conspicuously margined laterally and caudally with dark brown; sternites obscure yellow, the margins indistinctly darker.

Habitat: Japan. Holotype, ♀, Nikko, Tochigi-Ken, July 9, 1920 (K. Tanaka).

Tipula kuwayamai sp. n.

Allied to *T. serricauda* Alex.; antennæ of male moderately elongate, the intermediate flagellar segments bicolored; mesonotal praescutum with four gray stripes that are narrowly margined with dark brown; wings whitish subhyaline, variegated with light and dark brown; abdomen reddish brown, the terminal segments dark brown; male hypopygium with the ninth tergite a chitinized saucer; female ovipositor with the tergal valves serrated.

Male—Length, 16 mm.; wing, 18–20 mm. *Female*—Length, 29 mm.; wing, 25 mm.

Frontal prolongation of the head grayish pruinose; palpi dark brown. Antennæ of male moderately elongate, if bent backward extending about opposite or slightly beyond the wing-root; first flagellar segment yellowish orange, the base pruinose; second and third segments yellowish orange; fourth and fifth segments bicolorous, the basal enlargement black, the remainder of each segment brownish yellow; the succeeding segments gradually darken into uniform brown; flagellar segments rather deeply incised beneath. Head gray with a capillary dark brown median line; vertical tubercle with an impressed line.

Mesonotal praescutum clear gray, the interspaces behind more buff-brown; four clear gray praescutal stripes, the intermediate pair more brownish except at their anterior ends, these stripes widely separated behind by a median stripe of the ground color; praescutal stripes narrowly margined with dark brown; scutum clear gray, each lobe with two brown circles, the anterior one with a clear gray center, the posterior one with a darker gray center; scutellum and postnotum gray, the latter with a capillary dark brown line. Pleura dark gray; dorso-pleural membrane obscure yellow. Halteres testaceous, the base of the knobs dark brown. Legs with the coxæ dark gray; trochanters yellowish; femora and tibiæ yellowish, broadly tipped with dark brown; tarsi dark brown. Wings whitish subhyaline, variegated with light and dark brown; base of the wing, costal and subcostal cells more yellowish; stigma dark brown, this marking extending onto the fork of *Rs;* the white areas appear as a zigzag crossband beyond the wing-base, extending from cell *R* to the posterior margin of the wing in cell *2nd A;* an oblique line in cell *M* near midlength of the cell; a conspicuous white band beyond the cord; cells R_1 and R_5 largely whitish subhyaline; veins dark brown. Venation: Tip of R_2 preserved.

Abdomen with the basal five segments light reddish brown, the first segment more grayish laterally; segments six to nine dark brown, appearing as a subterminal dark ring; hypopygium more or less pale apically. Male hypopygium as in *T. centralis* Lw. and allied forms; ninth tergite appearing as a heavily chitinized saucer, the posterior lateral angles jutting caudad and dorsad as subacute blades; from each of these blades a narrow, oblique black ridge extends proximad near the median line deflected towards the caudal margin of the sclerite and becoming obsolete; anterior margin of the saucer a high ridge with a low, obtuse elevation near each end.

Female larger and much heavier bodied than the male. Lateral margins of the tergites narrowly pale. Ovipositor of the *arctica* type, the five basal teeth subacute, the outer teeth fused into a sinuous blade.

Habitat: Japan. Holotype, ♂, Maruyama, Sapporo, June 1, 1919 (S. Kuwayama). Allotype, ♀, Sapporo, 1916. Paratype, ♂, Sapporo, 1916.

This interesting fly is named in honor of its discoverer.

Nephrotoma Meigen.

Nephrotoma stygia sp. n.

General coloration shiny black; vertical tubercle orange; pleura with a whitish yellow spot before the base of the halteres and on the dorsopleural membrane; halteres yellow; femora yellow with the tips blackened, broadest on the fore legs, narrowest on the posterior legs; wings hyaline, stigma dark brown, a narrow brown seam along the cord; abdomen entirely black.

Male—Length about 12 mm.; wing, 10.5 mm. *Female*—Length, 15 mm.; wing, 11.5 mm.

Frontal prolongation of the head shiny black; palpi black. Antennæ with the scapal segments reddish brown; first flagellar segment dark brown; remaining flagellar segments obscure brownish yellow, on the terminal segments passing into brown. In the female, the flagellar segments are uniformly brownish black. Head black, the vertical tubercle conspicuous, orange.

Pronotum black, the lateral margins of the scutellum yellow, confluent with the dorsal pleural spot. Mesonotum entirely shiny black.

Pleura black; a small whitish yellow spot immediately cephalad of the halteres; a second spot of the same color on the dorso-pleural membrane. Halteres with the stem pale brown, the knobs light yellow. Legs with the coxæ black; fore trochanters brown; middle and hind trochanters black; femora yellow, the tips broadly blackened, on the fore femora including the apical two-thirds; on the mid-femora, about the apical fifth; on the hind femora only the apical eighth, or thereabouts; tibiæ obscure brownish yellow, the tips blackened; tarsi black. Wings hyaline, the base and subcostal cell more yellowish; stigma dark brown, conspicuous, continued along the cord as a conspicuous seam to cell *1st* M_2; extreme tip of the wing darkened; veins black. Venation: *Rs* short, about one-half longer than the deflection of R_{4+5}; cell M_1 narrowly sessile.

Abdomen shiny black. In the female, the basal half of the abdominal segments are shiny black, the apical half deep velvety-black. Outer pleural appendage of the male hypopygium elongate, tapering to the narrow point. Ovipositor reddish horn-color.

Habitat: Japan. Holotype, ♂, Ikaho, Gumma-Ken, July 7, 1920 (K. Tanaka). Allotopotype, ♀. Paratype, ♀, Chujenji, Tochigi-Ken, July 9, 1920 (K. Tanaka); ♂, Nikko, Tochigi-Ken, July 9, 1920 (K. Tanaka).

Nephrotoma neopratensis sp. n.

General coloration black; antennal scape orange-yellow, flagellum dark brown; anterior part of vertex orange-yellow; a dark brown spot adjoining the inner margin of eye; general coloration of thorax dull black; femoral bases yellow; wings grayish yellow, the cord and wing-tip infuscated; cell M_1 broadly sessile; abdominal tergites brown, the lateral margins of the segments obscure yellow.

Female—Length about 17 mm.; wing, 15.4 mm.

Frontal prolongation of the head obscure brownish yellow, black above. Antennal scape orange-yellow; flagellum dark brown. Head orange-yellow, the occiput and posterior part of the vertex dark brown, this color extending cephalad onto the vertical tubercle; a conspicuous brown blotch on either side of the vertical tubercle adjoining the inner margin of the eye; a narrow pale ring surrounding the eyes.

Pronotum dark brownish black, the scutellum yellow. Mesonotal praescutum dull black, the interspaces between the praescutal stripes gray pruinose; extreme humeral regions narrowly and obscurely yellow; scutum and central lobe of scutellum dull black; lateral sclerites of scutellum obscure yellow; postnotum black. Surface of mesonotum in fresh specimens probably pruinose. Pleura almost entirely dark, very sparsely variegated with obscure yellow. Halteres yellow, the knobs a little darker. Legs with the coxæ concolorous with the ground-color of the pleura; trochanters obscure yellow; femora yellow basally, the tips broadly blackened, broadest on the fore legs where they include about the distal two-thirds, narrowest on the hind legs where about the distal third is darkened; tibiæ and tarsi brownish black. Wings with a faint grayish yellow tinge, more saturated at the wing-base and in cell *Sc;* stigma oval, dark brown; distinct brownish gray seams along the cord; faint gray seams along the cubital and median veins; wing-tip broadly darkened, this including the outer ends of cells R_2, R_3, R_5, M_1, *2nd* M_2, M_4 and Cu_1. Venation: Cell M_1 very broadly sessile.

First abdominal tergite brown, light gray pruinose, the lateral margins broadly yellow; remaining abdominal tergites dark brown, only the anterior lateral margins obscure yellow; posterior segments uniformly dark brown; sternites brown, pale caudally. Ovipositor with the basal shields shiny black, the valves light horn-yellow.

Habitat: Japan. Holotype, ♀, Maruyama, Sapporo, May 26, 1916 (S. Kuwayama).

Nephrotoma neopratensis is allied to *N. pratensis* (L.) of Europe. It resembles *N. pullata* (Alex.) but has the dark coloration even more extensive and with the venational details distinct; R_{2+3} considerably longer than *Rs;* cell *1st* M_2 larger and with *m-cu* at the fork of *M*.

Nephrotoma microcera sp. n.

Antennæ short in both sexes; flagellar segments unicolorous; mesonotal praescutum with three shiny reddish stripes; a velvety black mark at the ends of the transverse suture; a capillary brown line on the scutellum and postnotum; legs pale brownish yellow, tarsi darker; veins yellow, costal region more saturated; stigma pale; abdomen yellow, tergites trilineate with black; sternites with a capillary black median line.

Male—Length, 13–13.5 mm.; wing, 12–12.5 mm. *Female*—Length, 19 mm.; wing, 14.5–15 mm.

Frontal prolongation of head pale yellow above, brownish laterally; palpi brown. Antennæ short, in the male, if bent backward, not attaining the wing-root; scapal segments pale yellow, flagellum passing into dark brown before the tip. Head pale testaceous yellow, shiny; occipital mark not distinct.

Pronotum pale yellow. Mesonotal praescutum yellow with three shiny reddish to reddish brown stripes that are sometimes only faintly indicated; scutal lobes reddish, the median area yellow; a semilunate velvety-black line at the ends of the suture above the wing-root; scutellum reddish yellow with a capillary dark brown median line; postnotum yellow, with a conspicuous elongate triangular dark brown mark, the point directed caudad and not attaining the posterior margin of the sclerite. Pleura yellow, indistinctly variegated with reddish. Halteres pale brown. Legs with the coxæ shiny yellow; trochanters yellow; remainder of the legs pale brownish yellow; tarsi darker. Wings with a yellowish tinge, more saturated in the costal region, this color continued to the wing-tip; extreme wing-apex very narrowly margined with dark brown; stigma pale yellow; veins dark brown, more yellowish in the costal region. Venation: Cell M_1 very short petiolate to narrowly sessile.

Abdominal tergites dull yellow, trilineate with black, the median line broader, very narrowly interrupted at the posterior margins of the segments; lateral margins narrower, very indistinctly interrupted at about one-third the length of each segment; sternites yellow with a capillary black median line that is slightly interrupted. Male hypopygium having the ninth tergite with a very deep U-shaped median notch. Outer pleural appendage elongate, tapering to the slender apex. Ninth sternite deeply incised, each half tumid. Eighth sternite with the margin feebly notched, without lobes or conspicuous bristles, the basal half of the sternite dark brown.

Habitat: Japan. Holotype, ♂, Komaba, Tokio, June 6, 1920 (H. Machida). Allotopotype, ♀, May 29, 1920. Paratopotypes, 3 ♂'s, 2 ♀'s, May 29 to June 6, 1920. Paratypes, ♂, Maruyama, Sapporo, July 18, 1916 (S. Kuwayama); ♂, Sapporo, August 25, 1916 (S. Kuwayama).

Nephrotoma minuticornis sp. n.

Generally similar to *N. microcera,* differing as follows: Lateral regions of the frontal prolongation of the head not conspicuously darkened. Mesonotal praescutum with the stripes black, the median stripe split by a capillary reddish line; each scutal lobe with two confluent black marks; no dark mark at the ends of transverse suture; scutellum and postnotum without a dark median vitta. Legs with the tips of femora and tibiæ narrowly darkened. Wings with cell M_1 subsessile to very short-petiolate. Abdomen obscure yellow; tergites with three very narrow black lines, the dorsal stripe much narrower than in *N. microcera.* Tergites seven to nine dark brown, with the caudal margins yellow; sternites with the capillary dark line more interrupted; eighth sternite dark brown basally. Male hypopygium with the notch of the ninth tergite much broader U-shaped. Eighth sternite with a deep notch, the margins of which are clothed with long, conspicuous, yellow bristles that are contiguous or decussate across the median line of the body.

Habitat: Japan. Holotype, ♂, Sapporo, (S. Kuwayama).

THE SYSTEMATIC VALUE OF THE MALE GENITALIA OF DELPHACIDÆ (HOMOPTERA).

By Walter M. Giffard.

During the past three years the writer has had an exceptional opportunity to study the male pygofer and genital organs of large collections of Dephacidae, including many types and paratypes, representing most of the species described from North America and the West Indies. Because of their constancy and reliability as a specific character these organs (which of course include the aedeagus or penis) are unquestionably of first importance to the student in making correct determinations. The use of color as a specific character has led to synonomy on account of there sometimes being four color forms in a species, the sexes of both the brachypterous and macropterous forms being different. And among these forms there is often considerable color variation. This naturally results in much perplexity to the student of these insects.

There have been and there are still strong objections by some workers (perhaps rightfully so) to base generic determinations on any *one* constant character, these preferring to accept a natural assemblage of characters from which to found the genus. A close examination and study of the collections previously referred to revealed in each of the genera (taking the genotype itself or its congeneric representative as a guide) a marked similarity in the form and character of the male genitalia within each genus, so that each of the genera studied could in a very large measure be determined at a glance by the structure of the pygofers and of the exposed genital organs alone, without recourse to other external characters. Within certain genera, as they stand at present, two or more types of genitalia are present and the question arises if such sexual characters, found only in one sex, should be used to erect new genera. In such cases it is highly improbable that the genus is monophylogenetic. In the erection of genera the hind tibial spur or calcar has not been considered as much as it should have been, even by Kirkaldy, Muir and Crawford, who have used it for subfamily and tribal divisions. In discussing the Liburnia ("Delphax") group, Kirkaldy[1] states "the characters which appear to me to be of generic value in this section, lie in the genitalia and the tibial spur, though I am not prepared, without the examination of a large series of European and American forms, to formulate genera based on them." Again referring to genitalia in general, Kirkaldy[2] further suggests "that the genitalia in the male are the final test of a species and even afford generic criteria."

Fieber[3] appears to have been the first to use characters found in the pygofer, anal segment and genital styles for specific purposes and most workers, with a few notable exceptions, have continued their use in certain groups of genera. Edwards[4] appears to have been the first to dissect and figure the aedeagus to distinguish certain allied species. Muir[5] in working out the Hawaiian Delphacidæ, placed greater weight upon the aedeagus and used the male genitalia not only for specific purposes, but also to rearrange the genera. He afterwards found other characters that confirmed his conclusions drawn from the genitalia alone.

In anticipation of using the genitalia in a similar manner Mr. Muir and the author are at present at work upon the North American and West Indian species. In the hopes of interesting students in these organs as characters of systematic importance, the following short description of the methods employed and the terminology decided upon, is presented. Morphologists may disagree with these terms and suggest using others that show the homology with other insects, but until we are sure what those homologies really are it is best to use purely descriptive names, most of which are already in use.

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[1] Kirkaldy, Haw. Sug. Pl. Ass. Report 1907 Div. of Ent. Bull. III, p. 150.

[2] Op. cit. page 124.

[3] Fieber Verhandl. Zool. bot. Ges. XVI, 1866, p. 517-534, Pl. VIII.

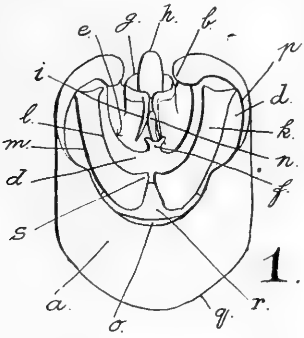
[4] Edwards Hom. British Islands, 1896, pl. 6.

[5] Muir Proc. Haw. Ent. Soc. III, 3, 1916, pp. 221, pls. 2, 3, 4.

Nomenclature of Genitalia.

(*See Figures 1, 2 and 3*).

What is apparently the ninth abdominal segment in Delphacidæ is specialized into a more or less long, chitinous ring (*the pygofer* (*a*)) without any clear trace of tergum, sternum or pleura. The posterior dorsal edge is more or less deeply emarginate (*anal emargination* (*c*)) and more or less surrounds the *anal segment* (*g*); the corners of this emargination are more or less angular (*anal angle* (*b*)) and in some species are considerably produced; the *lateral margins* (*p*) vary in shape, being straight and entire, produced or excavated; the *ventral margin* (*o*) also varies in the different species. The relative length and breadth of the opening (a_1, a_2) is also important. The tenth and eleventh abdominal segments form a small tube (*the anal segment* (*g*)) which lies more or less surrounded by the *anal emargination* (*c*) *of the pygofer.* The anus opens on this latter segment and below or ventrad of the anus is the *anal style* (*h*); on the ventral surface of the anal segment are the processes of the anal segment (*anal processes* (*i*)) generally in the form of a pair of spines. Looking into the opening of the pygofer one sees a more or less chitinous wall dividing it into an outer and inner chamber. This is the *diaphragm* (*d*) the *dorsal margin* (*e*) of which is generally V-shaped and often in the middle there is developed an *armature* (*f*); near the *ventral*



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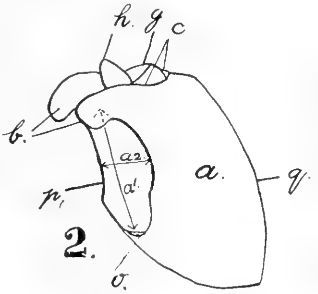

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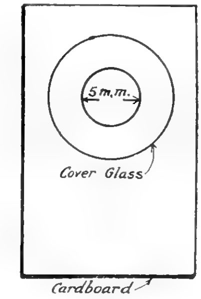

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Figs. 1 and 2.

a. pygofer; a^1, a^2, opening of pygofer (a^1 length, a^2 breadth).
b. anal angle of pygofer.
c. anal emargination of pygofer.
d. diaphragm.
e. margin of diaphragm.
f. armature of diaphragm.
g. anal segment.
h. anal style.
i. anal process of spine.
k. genital style.
l. inner margin of genital style.
m. outer margin of genital style.
n. aedeagus (or penis).
o. ventral margin of pygofer.
p. lateral margin of pygofer.
q. base of pygofer.
r. orifice of diaphragm.
s. basal angle of genital style.

Fig. 3.

n. aedeagus.

Fig. 4.

Details of card mount.

edge or margin (*o*) of the pygofer the diaphragm is pierced by an *orifice* (*r*), through which the genital styles pass. The length of the diaphragm is from the dorsal margin in the middle to the orifice. In the Delphacidæ there is always one pair of *genital styles* (*k*) which are of various size and shape; the terms *inner* (*l*) and *outer* (*m*) margins are of use in descriptive work, also the *basal angle* (*s*). The *aedaegus* (*n*) arises from the bottom of the inner chamber and when at rest its apex generally projects over the middle of the dorsal margin of the diaphragm, just above the armature. There is an internal structure connecting the anal segment to the base of the genital styles, which can be termed the connecting structure.

THE DISSECTION AND TREATMENT OF THE PYGOFER AND GENITAL ORGANS.

For ordinary purposes, when comparing the margins of the pygofer and exposed genital organs of a species under examination with any illustration or figure, the binocular microscope is much preferable to the hand lenses ordinarily in use and students should by all means use the former when possible. The size and opaqueness of these organs in very many of the species are such that in careful systematic work even the binocular, without an electric illuminator or condenser,* is insufficient to secure a proper and correct view of their structure. With an abundance of material to choose from, one might, on occasion, select an example which would result satisfactorily without the illuminator, but otherwise the student is quite apt to draw wrong conclusions.

The structures of the genital organs contained within the aperture of the pygofer are, as previously stated, of the greatest importance for correct determination of the species and these must therefore not only be viewed by the observer under the best of conditions, but on occasion the aedeagus, genital styles and anal tube must be dissected out. The aedeagus itself is so hidden behind the diaphragm of the pygofer that it is seldom visible, even with the strongest of illuminations and magnification. The anal tube, whilst visible, in a measure, with the hand lens or binocular, has in very many instances spines or processes of various lengths attached to its medio ventral surface, which are either quite invisible or are obscured by the genital styles. In many instances specimens, as ordinarily viewed, have their genital styles resting at a different angle than when they are normally at rest, which fact is quite sufficient to alter the outline and lead to error. This can easily be overcome if the styles are dissected out and a flat view taken.

The dissection of the genital organs is simple, if reasonable care is used. The method adopted by Mr. Muir and the author is to carefully sever the pygofer from the abdomen, transferring it to a 50% or 60% solution of Caustic Soda and boiling it over an alcohol flame in an

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* The author has used with much success the B. & L. micr. lamp with aspheric condenser and transformer for 110 V. alternating current. The smaller and cheaper B. & L. illuminator and condenser has not been altogether satisfactory for this special work.

ordinary test tube for a few seconds only. The success of the method depends largely on the boiling process, for if it is boiled too long the clearness of structural detail is spoiled, whilst if it is not boiled enough, much fatty matter will remain attached to the organs to be observed, thereby causing some slight inconvenience in their further dissection and observation. It is, however, far better to underboil than otherwise. The student will soon learn to detect by the size, condition and appearance of the pygofer just what time is required in this boiling process. From the Caustic Soda the specimen is immediately transferred to water in order to wash and clear it. For this, it appears preferable to use a concave glass slide, so that the object may be kept under better control whilst under the binocular microscope. During this clearing process in water, the genital organs should be dissected out from the pygofer. This is done by means of fine needle points, with handles attached, holding the pygofer down with one needle whilst inserting the other through its anterior opening and pushing outwards the organs until all these are plainly visible. If it is intended to make a microscopic slide of the genitalia further manipulation and dissection under the binocular will be necessary in order to free the organs from the diaphragm or wall of the aperture of the pygofer, but for ordinary purposes of identification the pygofer together with the protruding organs can, without further process, be transferred with a very fine camel's hair brush or the point of a needle to the card point on which the insect specimen is mounted. Care must however be taken not to crush or smother the parts during manipulation and the mounting on the card point must also be carefully done, otherwise the organs will appear distorted and useless. Before mounting in balsam it is necessary to transfer the pygofer and genital organs into absolute alcohol in order to dehydrate and harden these. A few minutes only is required and the organs should then be cleared by transferring them from the alcohol to clove or cedar oil. In either one of these latter they may remain for a few hours, if necessary, but if speed is desired, four or five minutes is all that is required.

Some have objections to the microscopic slide process, as the slides have to be kept apart from the cabinet specimens; and again others claim that there is apt to be an absence of detail as shown by the "card point" system. To these may be suggested another and very acceptable method of permanently disposing of their dissections and at the same time keeping these attached to, or alongside, the insect specimen in their cabinets. This system has been called the Balsam card cell process,* and it has been used to an appreciable extent for the mounting of the genitalia of type specimens. For the purpose, rather stout Bristol board mounts of uniform size should be used (See Figure 4).

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* Similar cells to these can be used without balsam for mounting delicate types, the insect being fastened with a small drop of clear gum to the bottom cover glass. Dr. David Sharp has types of small Staphalinidæ so mounted which can be viewed dorsally and ventrally under a fairly high power. The probability of damage or destruction of such specimens is greatly reduced by using this method.

A cell about 5 mm. in diameter must be smoothly punched towards one end and a 12 mm. circular or square cover glass be gummed or otherwise attached to the underside of the mount and allowed to dry (under cover) for several days before using. A stock of these may be prepared ready for use when necessary. Instead of entirely dissecting out the genital organs from the pygofer, as would be done for making a slide, manipulate and prepare the object as would be done for mounting on card point, taking care, however, that the dissection has later been transferred to alcohol and then into either Xylol or Clove oil before it is finally transferred to the Canada Balsam cell. The transfer from Clove oil or Xylol to the cell (in which a drop of Balsam has been placed) and the manipulation required to secure a proper lateral view of the margin of the pygofer, the armature if any, the anal tube and spines, the genital styles and aedeagus, is a delicate process, but fairly easy after a little experience. Before placing the final cover glass over the object it is well to wait a day or two and be sure that the object has not changed the desired position and that further manipulation is not required. Should a change be necessary, soften the Canada Balsam by passing the mount quickly, for a second or two, over the alcohol flame then using Xylol on needle points to alter the position of the objects. Once assured that the mount is satisfactory, another drop of Canada Balsam to take the final cover glass will end the process and give the student a perfect and permanent specimen of the genital organs. The pin of the insect mount can be run through the end of card cell and so allow the specimen and mount to be placed in the cabinet together. If the card cell sags, a small piece of cork can be glued to the underside of the card cell where the pin pierces it.

THE HAWTHORN BLOSSOM WEEVIL (ANTHONOMUS NEBULOSUS LEC.)*

WALTER H. WELLHOUSE.

One of the most interesting and injurious of the insects found on the hawthorns is this member of a very destructive genus of blossom weevils. Its mode of life resembles in a general way that of the Mexican cotton boll weevil, *Anthonomus grandis*, and is almost identical with that of the European apple blossom weevil, *A. pomorum* (see Theobald, 1909, p. 104-110).

The original description of *A. nebulosus* by Dr. Leconte may be found in the Proceedings of the American Philosophical Society 15:197, 1876, and a more complete description is given by Dietz in the Transactions of the American Entomological Society, 18:203, 1891. In the present account it is sufficient to say that *A. nebulosus* is a brown or grayish oval beetle, 3.75–4.25 mm. long, generally with a whitish V-shaped mark on the fore part of the elytra, with a long slender curved beak, and the front femur bearing two teeth on its apical portion, one a large and the other a small tooth.

It has been found in New York, New Jersey, Michigan, Indiana, Missouri, Arkansas and Louisiana, so it seems probable that it is present wherever its hosts are found East of the Rocky Mountains. Although Dietz considers this species to be more characteristic of the European fauna than of our own, no record can be found of its occurrence in Europe or elsewhere outside of our country.

Its hosts include a number of the larger flowered species of hawthorns, such as *Crataegus punctata*, *C. brainerdi*, *C. pruinosa* and *C. mollis*. The smaller flowered species such as *C. oxyacantha* are not selected by the beetles for oviposition, probably because there is not space enough for the full development of the larva within the bud.

The injury caused by the hawthorn blossom weevil is most apparent while the trees are in full bloom. At that time infested blossoms are brown and remain closed. On badly infested trees fully 50 per cent of the blossoms may be in that condition and the trees present a scorched appearance. As

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* Contribution from the Entomological Laboratory, Cornell University, Ithaca, N. Y.

the young fruit begins to set the infested blossoms commonly fall to the ground, but may sometimes be seen on the trees even after the beetles have emerged in June.

They come out of hibernation and appear on the branches of the hosts about mid-April, feeding ravenously on the buds which are showing green. It is not uncommon to see a beetle with feet braced and beak inserted up to the eyes in a bud while it hurriedly eats the tender leaves within. As soon as all the food within reach of the entrance hole is eaten, the beetle seeks another bud on the twig and repeats the process. The puncture in the bud is round, .3 mm. in diameter, and turns dark as soon as the beak is withdrawn. The presence of the beetles may be detected by these dark round holes in the buds before the egg-laying period arrives. They continue to feed on the buds during suitable weather until the clusters have separated enough for oviposition in the blossoms.

During cool weather they remain inactive, generally in the axils of the twigs with heads down. A few observations on the relation of temperature to their activities were made, and these indicate that the beetles remain inactive while the temperature is below 50° F. The optimum temperature is 60° to 70° and when it is raised to 78°, they rush about like mad, attempting to oviposit in every bud. Under most conditions they seem reluctant to fly, but when placed on distasteful food they fly away. They continue their activities on cloudy or rainy days and at night if the temperature is sufficiently high.

The period between the opening of the blossom clusters and the opening of the blossoms themselves is the time of oviposition, and the length of this period probably influences the amount of injury to a considerable extent. If it is prolonged by cool, cloudy weather, then eggs may be placed in more blossoms before they open. The oviposition period comes about May 15 at Ithaca.

After selecting a suitable blossom bud the female makes a hole in the side of the calyx with her beak, then turning around she thrusts the egg into the hole with her ovipositor and moves to another bud to repeat the process. A clear liquid fills the hole where the egg is thrust in, which soon hardens and seals the opening completely. The act of oviposition requires about 10 minutes when the temperature is 68° or 70°, but requires an hour at 54°.

The egg is pearly white, .6 mm. long, .36 mm. wide, elliptical generally the same size at both ends, but when tucked in tightly between the anthers it may be narrower at one end to conform to the space it fills. It is almost the same size and color as the anthers and difficult to distinguish from them. The corium is smooth, unsculptured, delicate, drying and collapsing when exposed to the air for one hour.

After about a week the young white curved legless larva is found within the bud. It feeds upon the anthers and as it grows consumes all the internal parts of the flower, but leaves intact the wall of the receptacle and the closed petals which form the roof of its house. The petals become stiff, as if they were starched, and do not shrink away as they turn brown. After feeding a couple weeks, the larva is dirty white, 6 to 8 mm. long, legless, has a small brown head and lies in a curved position. At about this time it moults and changes to a white free pupa 6 mm. long, with a dark caudal spine, 2 dark prominent spines on the apex of the head and several smaller spines farther back on the head. After pupating during a week or a little longer, the beetle makes a hole in the top or side of its house with the beak and emerges.

It begins to feed a few minutes after emergence, choosing for its food the first young thorn or fruit in its pathway as it wanders along the branch. The thorns of the current season's growth seem to be a very attractive food. A hole is drilled near the base of the thorn and the beetle will spend hours with the beak inserted in the hole clear up to the eyes, prying and straining to enlarge the cavity within the thorn. The round hole at the base of a thorn does not heal during the season's growth and the presence of such holes will indicate at any time of the year the presence of the blossom weevils. The beetles also attack the fruit and make several round holes in a single fruit before seeking another. The holes become brown almost immediately. I have never found the beetles eating leaves or tender twigs, but they sometimes feed on the succulent globular leaf galls of cecidomyiid larvæ. They will puncture and feed on young apples in the cages when fresh haws are not to be had, but I have found none feeding on apples in the field.

After feeding for a week or ten days the beetles may be found in copulation on the branches, and a week or so later, as warm July weather comes, they disappear from the trees. Those kept in breeding cages remained hidden in fallen curled leaves and hollow twigs on the ground all summer and winter without feeding until the next spring. A search for their hiding places in the field revealed a score of the beetles enclosed in curled dried leaves on the ground beneath their host trees.

The life cycle may be summarized as follows: The immature stages (egg, larva and pupa) are completed within the closed blossom in from 27 to 35 days and the remainder of the year is passed in the adult stage. The adults feed on thorns and fruit for two or three weeks after emerging from the blossoms, then remain quiescent among fallen leaves on the ground until the next spring, when they feed for about a month on the buds before ovipositing. Soon after oviposition the beetles die. In New York the eggs are laid about mid-May and the beetles emerge from the blossoms in June. Pierce says the beetles emerge in late March and early in April in Louisiana. The time of their development in different latitudes is dependent on the opening of the hawthorn blossoms in those latitudes.

A number of natural enemies of the blossom weevil have been observed. Various birds and especially sparrows pick open the brown blossoms to eat the larvæ and pupæ. Pierce found them to be parasitized by *Catolaccus hunteri* and *Sigalphus* sp. (U. S. Bur. Ent. Bull. 100, p. 77). The writer has bred another chalcid, *Habrocytus piercei* Cwfd. from the larva of the weevil, the adult parasites emerging June 16th and 17th.

SOME NEGLECTED SETÆ OF LEPIDOPTEROUS LARVÆ.

By Harrison Garman.

A study of the corn-ear worm larva with reference to its external structure* has revealed series of microscopic setæ, some of which appear to have been overlooked by other writers when dealing with the Noctuidæ and are thus not recognized in the systems employed, though they are as constant in every way as the larger setæ to which numbers, or Greek letters, have been assigned. As opportunity arose the author has examined larvæ of other families of moths and finds the same setæ present, though showing some variations with family, in their numbers, in position on the body, and in their relation to each other and to certain of the large setæ. As examples of these variations I am presenting figures made from greatly enlarged photographs of the skins of one of the Cossidæ, *Prionoxystus robiniæ*, the well known Carpenter worm of black locust trees, and of *Tholeria reversalis*, one of the Pyralidæ.

The body of the carpenter worm when about half grown bears round brownish tubercles upon which the setæ arise, the pigment of the tubercles serving as a guide in locating the setæ and enabling one to find with no special difficulty even the smallest of them. This larva bears six large setæ on each side of its neck plate, and one microscopic seta at the posterior edge of each half, the latter being the homolog of the one noted on the neck plate of Chloridea. The neck plate bears also on each side three sense pores, the lateral one minute, and a gland outlet outside and a trifle posterior to seta IIa. A ventral microscopic seta is present on the prothorax anterior to the base of the jointed leg, and a second just in front of the base.

The mesothorax and metathorax are alike in the number and arrangement of setæ. A single microscopic seta is present at the anterior edge nearly in line with seta IIb of the neck plate. Exterior to these setæ, in line with the ventral sense pore of the neck plate, is on both meso- and metathorax a pair of microscopic setæ; otherwise the microscopic setæ are like those of the prothorax. The fourth body somite (1st abdominal) bears a seta at its anterior edge, in line with the one on the thoracic somites, but lacks the lateral pair of microsetæ as does also the succeeding abdominal somites, but the microscopic seta IIIa appears before the spiracle as an independent seta. The more

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* Bulletin No. 227, Kentucky Experiment Station.

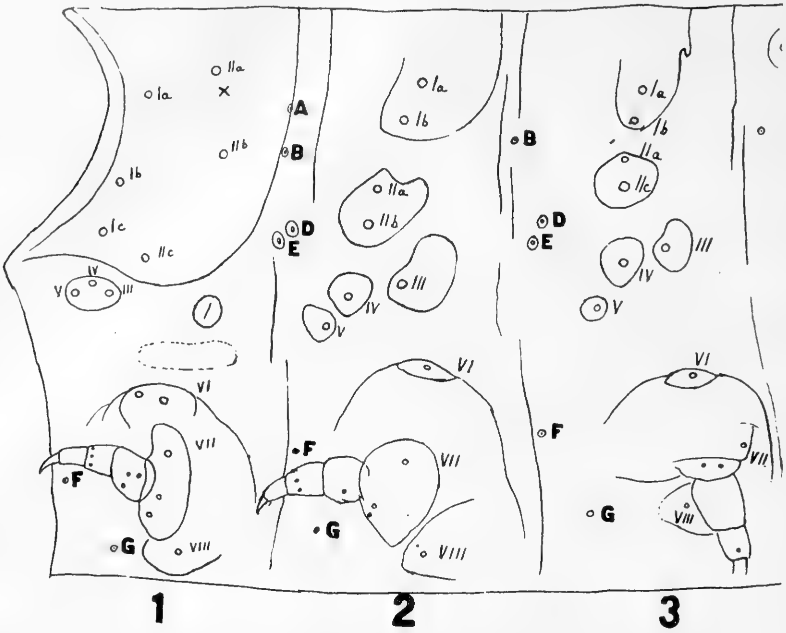

Fig. 1. Left side of larva of *Prionoxystus robiniæ*, showing the three thoracic somites. Sockets of large setæ (and IIIa) numbered by Dyar's system. Microscopic setæ indicated by letters. Gland of neck plate indicated by x.

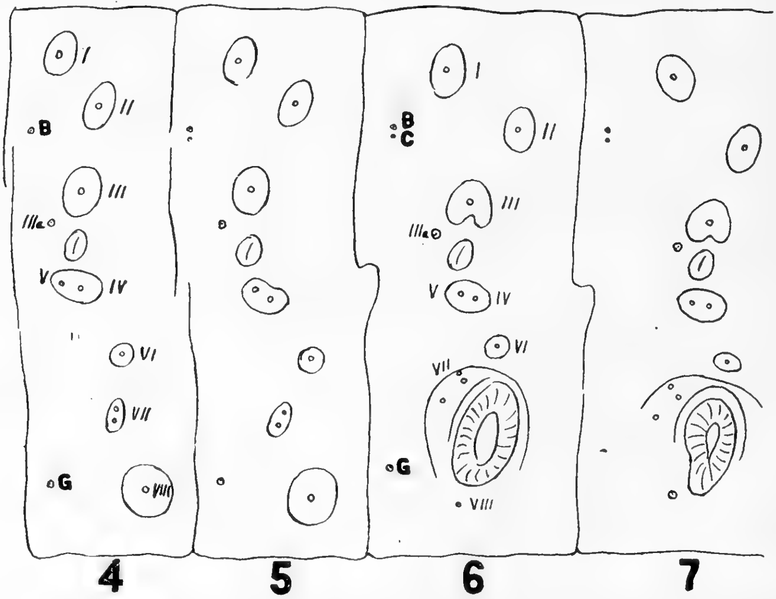

Fig. 2. Left side of larva of *Prionoxystus robiniæ*, showing body somites 4 to 7, inclusive (abdominal somites 1 to 4, inclusive). Letters and numbers as in Fig. 1.

dorsal of the two ventral microscopic setæ of the thorax disappears, and is lacking also on succeeding abdominal somites.

The fourth body somite (2nd abdominal) bears a pair of microscopic setæ in the dorsal series, the outermost vestigial; and on all following somites to and including the 12th body (9th abdominal) this pair is present, the two becoming somewhat widely separated on the 11th and 12th.

The larva of *Tholeria reversalis* has been taken in some numbers on several occasions from Laburnum in nurseries in Kentucky. It is a particularly fine larva for the study of setæ, because the bristles are borne on dense black, often angular, plates, and can be even more readily located than in the larva of *Prionoxystus robiniæ.* The same number (6) of macroscopic setæ is present on the neck plate, with three sense pores, as in Noctuidæ and Cossidæ. A microscopic seta is present at the posterior edge of the neck plate. The microscopic setæ of the meso- and metathorax are as in Prionoxystus, except that the pair is mounted on a pinaculum on each of these somites, the plates having apparently united. The dorsal series of microscopic setæ consists of a single seta near the anterior margin of somites 4 to 12 inclusive. The microscopic seta IIIa is in this larva associated on a hammer-shaped plate with the larger seta III, and is to be recognized on body somites 4 to 11 inclusive. The presence of IIIa with III on a pinaculum is a feature in which it agrees with Hepialus and certain Tortricids and differs from Prionoxystus.

A singular dermal gland with contorted chitinous efferent tubule opens on each side just posterior and a trifle ventral to the dorsal microscopic seta, on body somites 2 to 11 inclusive. Each efferent tube opens by a funnel-shaped enlargement in the cuticle. One of these glands and tubes opens also in the neck plate, and one in the base of each jointed leg. These are probably glands of the same nature as those described by E. Verson (See Packard's Text Book of Entomology) and said to give off oxalate of lime at an early stage, and later, uric acid. But it seems unlikely that special excretory organs are needed in this larva and not also in Noctuidæ. They have not at any rate been observed in Chloridea. In Prionoxystus there is a small aperture outside seta IIa of the neck plate, that probably represents these glands. It is liable to be mistaken for a fourth sense pore. The glands may produce some defensive excretion, but the efferent ducts are suggestive of the nephridia of Annelids, and it may prove that they are accessory renal organs as has been suggested. In the figures, the outlets of these glands are marked by an x.

The large setæ that have received numbers according to Dr. Dyar's system are indicated by these numbers in accompanying drawings, the homologies being determined by comparison of the photographs with figures published by Mr. Carl Heinrich* and made from larvæ of the same family in each case. In my own figures the microscopic setæ not represented by Mr. Heinrich are indicated by letters.

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* Proc. U. S. Nat. Mus., Vol. 57, pp. 53-96, 1920.

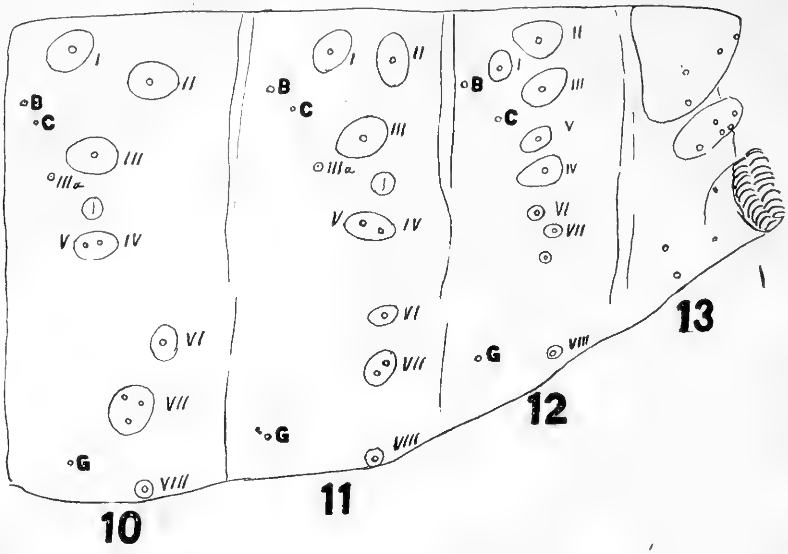

Fig. 3. Left side of larva of *Prionoxystus robiniæ*, showing body somites 10 to 13, inclusive. Letters and numbers as in Figs. 1 and 2.

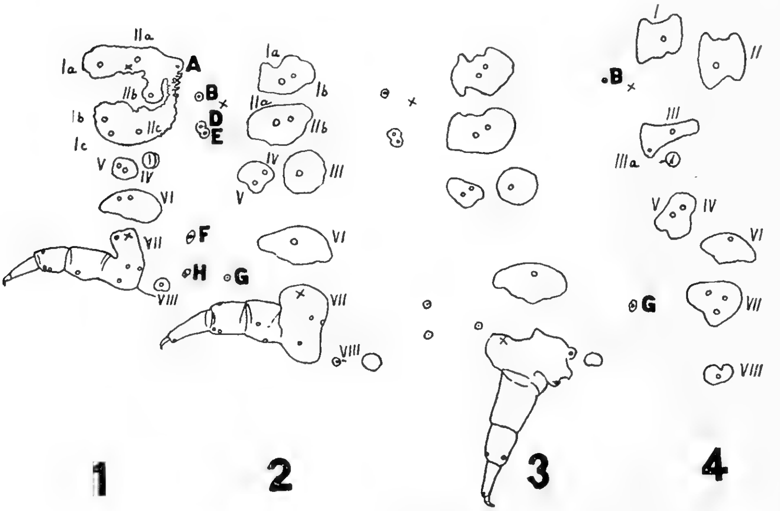

Fig. 4. Left side of larva of *Tholeria reversalis*, showing body somites 1 to 4, inclusive. Letters and numbers as in Figs. 1–3. Location of dermal glands marked by x.

It is evident from an examination of these larvæ that Dr. Dyar's numbers will some time require rearrangement so as to include in their appropriate places all of the setæ now known to be present on the bodies of lepidopterous larvæ.

The microscopic setæ must be considered in any complete system showing the chaetotaxy of our species. They are clearly a long-established feature of the structure of many families, and their vestigial character appears to denote some change in the integument of somites the nature of which we do not at present understand. Some or all of the setæ appear even among the confusing development of secondary setæ in such families as Arctiidæ and Notodontidæ. On the larva of *Acrolophus mortipenellus* (Acrolophidæ) the paired setæ (D. and E. of my Figures) of the thorax are borne by a sclerite of some size, not different from those bearing the large setæ. The minute seta (A) of the neck plate is present in most of our families of moths. Seta IIIa is also generally present, though it has often been overlooked.* The others when sought out have proved not less constant, and once their location on the body is known, one can on a large number of our genera count with certainty on finding them when this portion of the cuticle is brought under the microscope.

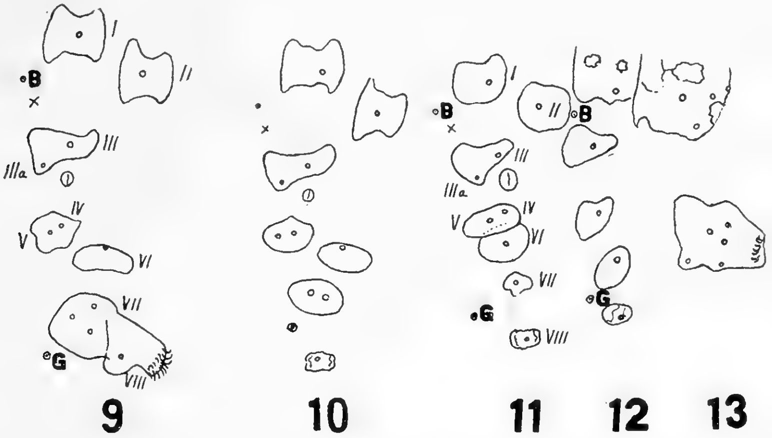

Fig. 5. Left side of larva of *Tholeria reversalis,* showing body somites 9 to 13, inclusive.

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* It does not, however, always bear the same relation to III even in the same subfamily. Thus in *Tholeria reversalis* it is associated with III, but in *Desmia iuneralis* it is independent.

STUDIES ON THE RESPIRATION OF INSECTS.

I. THE GASES AND RESPIRATORY PROTEINS OF INSECT BLOOD.

RICHARD A. MUTTKOWSKI, Ph. D.

(Contribution from the Zoological Laboratory of the University of Idaho, Moscow, Idaho).

I. INTRODUCTORY.

The following paper aims to present certain phases of investigations on the respiration of insects. In a recent article (see Bull. Brooklyn Ent. Soc., 15, pp. 89-96, 131-140) I called attention to the fixation of oxygen by the blood of some aquatic insects. "In a few rare cases," it was stated (p. 94), "the carrier is colored. Thus, in some species of Chironomidæ, the pigment is hemoglobin, like that of Vertebrates, except that it is found in the plasma, not within the corpuscles. * * * The oxygen diffuses through the epidermis just as in the case of vertebrates, and is fixed by the hemoglobin or other carrier (perhaps hemocyanin?) in the blood. Just what this other carrier may be is not definitely ascertained. But by far the larger number of aquatic insects have no visible colored carrier or respiratory pigment. Thus, for example, Trichoptera larvæ, the larvæ of Simulium, of Culicidæ, and of most Chironomidæ, have gill pouches, usually placed at the caudal end, but all without any visible indication of a respiratory pigment."

As at present understood, respiration among Tracheates proceeds directly; atmospheric oxygen is led directly to the cells by the tracheae, while the blood acts primarily in the transportation of food and metabolic products. The question whether or not the blood may play a certain part in the transportation of gases is a point that merits investigation.

The following experiments on this subject were performed during spring, summer and fall of 1920, although some earlier observations are included in this paper.

II. OXYGEN AND RESPIRATORY PROTEINS IN INSECT BLOOD.

To determine the oxygen content of insect blood directly is a matter of some difficulty, primarily because such reagents as are available are suitable only for considerable quantities of material, and are not adaptable for use with the microscopic quantities dealt with in the present experiments. For instance, an excellent reagent is pyrogallic acid, which in presence of an alkali absorbs oxygen with avidity. When testing for oxygen in the few drops of blood obtained from an insect, the difficulty lay in occluding atmospheric oxygen. Yet several experiments indicated the presence of oxygen in the blood; for the reagent darkened much more rapidly when applied to insect blood (pyrogallic acid turns brown to black with absorbed oxygen) than in the blank control tests. Yet at best this was unsatisfactory, as at least some portion of the reagent was in contact with atmospheric oxygen and tended to obscure the blood reaction. Nor could this be obviated with the use of cell slides and vaselined cover slips.

However, the same reagent was applied to Dytiscus larvæ by another method which was more effective. Freshly prepared pyrogallic acid solution was injected into the body cavity of the larvæ, followed by weak hydroxide. Death ensued quickly, in periods ranging from ten seconds to three minutes. Even before dissection the semi-transparent larvæ showed brown stains inside. The dissected larvæ showed brown blotches in the haemocoel and among the tissues, indicating that oxygen had been absorbed by the reagent. In the vicinity of the tracheæ the reagent was deeper brown, while the tracheæ themselves were almost black. Here, too, once the animal was cut open, atmospheric air had access to the reagent, which then blackened rapidly, obscured the tissues, and prevented more detailed study.

No doubt some of this reaction was due to oxygen dissolved in the blood serum, although the serum has no power to combine with oxygen like a respiratory protein. This oxygen, in mammalian serum, amounts to 94% of the amount soluble in water and the serum loses its supply with increased temperature.

These experiments, which were repeated a number of times with Dytiscus, Aeshna, Chironomus, and other larvæ, are significant from at least the qualitative standpoint. They do not indicate whether an active agent was present which combined loosely with the oxygen, or if the gas was in physical solution as in the water. The topic was, therefore broached from another angle—namely, that of the presence or absence of respiratory proteins. The obvious postulate was: If a respiratory pigment can be demonstrated in the blood of insects, its purpose must be to fix and transport oxygen. In that case, the blood of insects has the additional function of aiding in the respiration.

Such a respiratory protein need not necessarily be visible to the naked eye. For, in the first place, among the insects we are dealing with minute quantities of blood. Secondly, such a pigment would play only a subsidiary role, as the primary supply of oxygen is received by way of the tracheæ. The quantities of gas in solution in the blood would, therefore, be minimal. Besides, even in such animals as crayfish, where the respiratory protein is known to be hemocyanin and bluish in color, when fully oxidized, the blood generally shows no color at all. It may be entirely transparent, or a pale to definite blue. Or it might be a pink to bright red, depending upon the amount of non-respiratory pigment (Tetronerythrin) present. In insects the blood, if colored at all, is bluish or greenish, forming black clots. There are exceptions to this, such as adult Dytiscus, in which the blood is saffron yellow to orange in color, although blue to purple in the larvæ. This color is not due to any respiratory protein, but to non-respiratory pigments, which are stored in the blood and elaborated into the external colors of the adult.

Assuming a respiratory pigment for the moment, there are two possibilities—the carrier in question may be either hemoglobin, or hemocyanin, or both, as in some mollusks. As far as known to the writer, hemocyanin has not been definitely reported for insects, while hemoglobin is known only for the Chironomid "blood-worms."

A considerable number of experiments were performed in the ensuing investigations. These experiments on respiratory proteins in insects have been described elsewhere, but since they bear on this discussion, a summary of the salient points will be necessary.

The problem as studied, presented the following phases: (1) Considering that conditions as met in aquatic insects postulate the presence of a respiratory protein, can such a protein be demonstrated? (2) If present, what is its nature? (3) Is it confined to aquatic insects possessing blood gills, or is it universal among insects?

For the first of these it was shown that the blood of insects reacts with the oxidation tests for hemoglobin (Guiac, O-tolidin, Benzidine), regardless of the species. Only Chironomid blood reacted with the hemin tests for hemoglobin. These tests showed that a respiratory protein was present.

In the second phase, considering the nature of this protein, two possibilities offered themselves. Of known proteins in Arthropoda, there are only hemocyanin and hemoglobin. The first of these has a copper nucleus, the second is an iron compound. The hemin tests for hemoglobin showed that this protein is restricted to Chironomid "blood-worms" among the insects. It is a fact, however, that the blood of Aeshna, Anax, Dytiscus, and other insects showed isolated crystals resembling the hemin prisms. If present at all, therefore, hemoglobin is available only in infinitesimal quantities and may be disregarded.

For hemocyanin no direct tests are known. It was held, however, that if by some means copper could be shown to be present in insect blood in quantities as large as found in crayfish blood where the copper has a known function, then its role in both is identical. For this purpose a number of incinerations of insect and crayfish blood were made and the ashes tested for copper. Both reacted positively, showing copper in approximately equal amounts. It was therefore concluded that insects contain a respiratory of a nature similar to that of the crayfish, namely a hemocyanin.

In the third phases of that study, the distribution of copper in insects, the following list of animals were incinerated. (Numbers refer to number of separate incinerations, not to number of specimens):

Coleoptera: Dytiscus, 19; Gyrinus, 1; Harpalus, 1; Leptinotarsa, 1.
Hymenoptera: Apis, 2; Bombus, 1; Polistes, 2; Formica, 1.
Lepidoptera: Pieris, 4; Noctuidæ, 2.
Diptera: Musca, 4; Stomoxys, 2; Tachinid, 1; Stratiomyia, 1.
Hemiptera: Belostoma, 17; Ranatra, 1; Notonecta, 3; Gerris, 1; Corixa, 2; Aphis, 1, Leptocoris, 2.
Odonata: Anax and Aeshna, 4; Anax, 2; Aeshna, 15; Sympetrum, 4; Libellula, 4; Enallagma, 6.
Ephemeridæ: Several spp., 1.
Trichoptera: Several spp., 1.
Neuroptera: Myrmeleon, 3.
Megaloptera: Sialis, 1.
Isoptera: Termes, 1.
Orthoptera: Gryllus, 1; Ceuthophilus, 1; Locusta, 1; Melanoplus, 1; Dissosteira, 1.
Crustacea: Cambarus, 36; Hyalella, 2; Plankton, 1; Daphnia, 2; Microcystis, 1; Limnocalanus, 1.
Arachnida: Argiope, 1; Phaleana, 1; Spiders, 1.
Myriapoda: Centipeds, 1; millipeds, 1.
Annulata: Lumbricus, 1.
Mollusca: Snails, 5; slugs, 2.
Nemathelminthes: Ascaris, 1.
Protozoa: Volvox, 1.
Chordata: Snake blood, 1; human blood, 1; mouse, 1.

All of these, except human blood, reacted positively for copper, showing varying amounts.

As a final phase, the sources of copper were studied. Some 30 incinerations were made of twelve species of plants, all of which showed traces of copper. The soil and water were also tested, with positive results.

All of the Arthropoda studied showed a surprising uniformity in their reactions for copper. In practically all cases copper was present in quantities nearly equal to that of crayfish blood. This uniformity must have its significance. Copper in the quantities found could not come to the insects in their daily feeding, unless the tissues exercised a discriminating selection for the copper in their food. This copper must be functional, and because of the analogies pointed out it is interpreted as forming the nucleus of a respiratory protein, hemocyanin.

There is a further point to be considered. Unless we assume a blood protein to fix the oxygen, we cannot account for the presence of oxygen in the blood of insects living under practically anaerobic conditions, that is, insects living in warm and stagnant water.

Physically, oxygen tends to form a balance on both sides of a moist or immersed membrane. But since in the summer there are two factors which tend to decrease the oxygen supply available to insects in the water, namely organic decomposition and the heat of the water, the amount of oxygen, on a purely physical basis, would diminish also within the insect. Water contains its largest amount of dissolved oxygen at zero, and as the temperature rises this amount becomes less and less, until it is zero at boiling point of the water. Furthermore, as the temperature of water rises above zero, decomposition and oxidation of wastes increase, so that the available supply of dissolved oxygen is used up in inverse ratio to its absorption by the water.

If respiration in aquatic insects, specifically in water-breathers, proceeded on the basis of a physical gas equilibrium on two sides of a membrane, the insect would soon show a deficiency of oxygen, and that at a time when it is most active and its metabolism demands a high rate of oxygenation. Yet this is precisely what we do *not* find. Regardless of the impoverished oxygen in warm pond or swamp water, the insect blood contains a plentiful supply of oxygen, and metabolism proceeds at its normal rate. Thus, in Aeshna, Dytiscus, and Chironomid larvæ, purposely kept in covered jars filled with decaying plant and animal matter, I found normal activity and the blood reacted copiously with injections of Pyrogallic acid. It is evident, therefore, that the blood possesses a protein which is capable of binding oxygen in excess of the amounts dissolved in the water. The incinerations showed that this protein is a copper compound.

From this standpoint, the various respiratory structures of insects, especially the gill filaments and gill pouches of Trichoptera larvæ and aquatic caterpillars, the caudal blood gills of Chironomus larvæ, of Culicid larvæ, Simulium larvæ, etc., acquire a real significance. These structures are purely blood gills, consisting of a thin cuticle and epidermis and their lumina are continuous with the haemocoel, so that the blood courses freely through them. With this type of gill, a respiratory protein to fix oxygen is very effective. On the other hand, unless such a protein is present, these structures loose their significance, in fact, appear useless as organs and inefficient physiologically.

III. Carbon Dioxide in Insect Blood.

The presence of carbon dioxide in insect blood has been reported frequently. During the summer of 1920 I was able to verify this fact in several series of experiments. The insects used were the same species utilized in the incinerations listed in the preceding section. The reagents employed were Potassium and Barium hydroxides, Lead acetate, Rosolic Acid, and halogen acids, the latter for carbonates. Of these Potassium hydroxide was perhaps the least satisfactory, as it is difficult to find the proper concentration of this reagent to give a definite reaction. Barium hydroxide reacts well with insect blood, yielding an amorphous precipitate. Lead acetate when applied directly will precipitate some of the blood proteins in addition to the carbon dioxide. When used with a micro-still, however, it is more effective and conclusive. I have used it as follows: A few drops of insect blood are caught on glass wool in a small glass or porcelain crucible, over which is placed a slide with a hanging drop of Lead acetate. Gentle heating releases the carbon dioxide, which forms Lead carbonate with the reagent.

As in the incinerations of insects for copper, crayfish blood was used as a control, with identical results. It seems then that in the latter the hemocyanin serves as a carrier for both oxygen and carbon dioxide, analogous to hemoglobin; and the presumption is that the same applies to insect blood.

Among other items, the Malpighian tubules of insects were studied as a possible exit for Carbon dioxide and carbonates. A number of experiments were made with the reagents mentioned on a variety of tubules, including those of bumblebees, larval and adult Dytiscus, Anax and Aeshna larvæ, Belostoma, Enallagma, and others. In summary, ten of eighty-one experiments showed positive results, the remaining seventy-one negative or doubtful. Even with a liberal allowance for error, these results are too insufficient to permit of any conclusions.

Elsewhere I have offered the suggestion (L. c., p. 93) that at least in aquatic larvæ the external chitin membrane may serve for the passage of carbon dioxide. This suggestion was based on some experiments on the permeability of the chitin membrane to gases, performed some years ago. However, this might apply to aquatic insects, it would not cover the conditions met in terrestrial stages.

IV. The Role of Insect Blood.

Hitherto our interpretation of the role of insect blood has been that the blood transports food, glandular products, waste, and pigments, and that it takes no part in the process of respiration. From the foregoing experiments it is evident that this interpretation must be amended to include respiration.

That the blood is active in transporting foods can be readily shown in testing fed and starved insects. After a meal the blood shows a large supply of nitrates, nitrites, and phosphates, the latter depending on the quality of food, whether rich or poor in phosphates. In a starved specimen, not fed for three or more days, none or only traces of these substances are indicated.

Glandular products include corpuscles, enzymes, some form of coagulin, and pigments. The pigments are carried passively in the blood stream, to be elaborated during the pupal period. The enzymes present are chiefly of the oxidative, histolytic, and autolytic types. Here also should be placed hemocyanin and hemoglobin, the respiratory proteins. In what tissues or organs these are elaborated has not been ascertained. Coagulin in some form must also be present, as the blood of insects clots readily on exposure to atmospheric air. This clot is generally black, but brown in adult Dytiscus. Whether this coagulin originates as a zymogen of the prothrombin type, forming thrombin, and combining with fibrinogen to form fibrin, as postulated for mammalian blood, is unknown.

Of gases the blood contains both oxygen and carbon dioxide, some probably dissolved in the blood serum, the major portion held by the hemocyanin present.

On this basis, the role of insect blood may be summarized as follows: The blood is instrumental (1) in circulating food, (2) transporting metabolic products (enzymes, pigments, etc.), (3) in respiration in the distribution of oxygen and removal of carbon dioxide.

Be it noted that the last of these, the role in respiration, is not confined to aquatic larvæ alone—that is, larvæ provided with blood gills. On the contrary, the role of the blood is identical in all insects, regardless of the stage. For the tests for respiratory proteins (oxidation and incineration) were performed on all types of insects, regardless of habitat, stage, and food habit of the species.

V. SUMMARY.

1. Both oxygen and carbon dioxide are present in insect blood. A small portion of these gases is probably dissolved in the blood serum, the major portion is held by a respiratory protein.

2. A respiratory protein was demonstrated for all insects through reactions with oxidation tests for hemoglobin. Hemoglobin is possessed exclusively by Chironomid "blood-worms" among insects. All other insects show the presence of copper, which is interpreted as forming the nucleus of another respiratory pigment, hemocyanin.

3. This hemocyanin is possessed by all insects, regardless of stage, habitat, or food. The source of this copper was shown to be the water, soil, and food plants.

4. The role of insect blood is therefore, in addition to its recognized function of circulating food and metabolic products, to aid the tracheal system in the distribution of oxygen to the tissues and to remove the carbon dioxide.

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The fine old Entomological Society of London, founded in 1834, and which, since 1875, has been meeting at 11 Chandos Street by the courtesy of the Medical Society of London, has, through the growth of its library, outgrown its quarters and is practically forced to move. It has bought a house at 41 Queen's Gate, South Kensington, near the Natural History Museum, and is leasing a portion of the building to the Imperial Bureau of Entomology. The cost price of the property was ten thousand pounds, and an additional sum is required for furnishing.

The cost price has been largely met by subscriptions from members, both as donations and as loans, the loans being secured by a debenture on the property and bearing five per cent interest. After exhausting the available resources of the resident members, there still remains a sum approximating fifteen hundred pounds, and the Society is making an appeal to foreign members, to entomologists in the dominions, and to interested entomologists in other parts of the world. Donations and loans are received by the Treasurer of the Society, Mr. W. G. Sheldon, who may be addressed at 11 Chandos Street, Cavendish Square, London, W. I.

The London Society is the oldest of the great entomological societies, excepting the Entomological Society of France, which was founded a year earlier. Its Transactions and Proceedings have been largely used by American entomologists, and many of the latter when traveling abroad have been welcomed at the meetings of the Society and have cordially been given the use of the magnificent library.

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ANNALS
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SOME LITTLE EMPHASIZED GUIDE-POSTS TO MEDICAL ENTOMOLOGY.*

William A. Riley.

To address the members of the Entomological Society of America on the subject of the history of medical entomology may seem a needless presumption. Immediately when the topic is mentioned there occurs the thought that medical entomology is a branch of our favorite study too young to have a history.

The discoveries of the relations of insects to disease which have revolutionized the attempts to control some of the most devastating diseases of man and animals have been made within the memory of even the younger in this audience. So spectacular have they been in some instances, and so far-reaching in their application that they have been featured by the popular magazines and by the daily press. Today it is common knowledge that many diseases, whose origin and spread were shrouded in mystery a few short years ago are insect borne.

It is often said that these discoveries have all been made within the past twenty-five years. And yet, the worker in science knows that no new discovery—no pregnant theory—originates suddenly. There is no more a spontaneous generation of important scientific theories, uninfluenced by pre-existing knowledge and thought than there is spontaneous generation of the higher forms of life.

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*Annual address before the Entomological Society of America, Chicago, Ill., December, 1920.

To trace the development of science, or some particular phase of a science is not a mere idle amusement. Regarding history Emerson has said it is "A looking both before and after as, indeed the coming Time already waits unseen, yet definitely shaped, pre-determined and inevitable, in the Time come; and only by the combination of both is the meaning of either completed." So, too, in the field of biology the discovery of today is but the fruitage of a tree rooted deep in the past. And this fruitage in turn though many of its seeds may fall by the wayside will yield the germ from which will come still better fruit.

Many workers have already called attention to early suggestions or even carefully worked out theories regarding the relation of insects to disease. In some cases these suggestions have been over-valued, through being interpreted in the light of present day knowledge. In some instances it is evident that a keen pioneer worker had grasped and all but established the truth which was first to be accepted many years later.

Yet these suggestions were largely lost sight of, and lay dormant for decades and even for centuries. Why was not this also the fate of the suggestions of twenty-five years ago? The answer lies in the history of zoology, and it is this general topic in its relation to medical entomology which I wish to touch upon tonight. This phase I have already presented in outline in an earlier discussion.

The subject is a broad one—it might well serve as the occasion for pointing out that there are no unrelated truths and that all branches of science contribute to genuine advancement in the field of human knowledge.

It is obvious that the work of Pasteur and Koch, resulting in the development of the science of bacteriology, has had a most intimate and profound influence in bringing about an understanding of the role which insects and their allies play in the transmission of disease.

However much the influence of modern bacteriology is recognized, it is not so generally known that from the time of the discovery of bacteria by the Jesuit priest, Athanasius Kircher, in 1658, and by Leeuwenhoek, there was a period of over a century when the germ theory of disease was the dominant one in medicine and most profoundly affected workers in biology. Though this influence was an intangible one, it must nevertheless be reckoned with. However important this intangible influence may have been and however fundamental bacteriology has been to the development of medical entomology, the outstanding guide-posts of a century and more ago were in the field of helminthology, or the study of the grosser parasites of man and animals.

We laugh today at the crudities of the early zoologists who taught in the most matter-of-fact manner, amazing theories of heterogenesis, according to which the offspring of a given animal may be something utterly different from itself. However deeply ingrained they were in the popular mind, theories of the development of geese from barnacles, or of the spontaneous generation of frogs from mud, of mice from grain, and of bees from dead oxen were discarded by the advanced scientists of the 17th century.

Much more slowly did this changed viewpoint apply to the various helminths or intestinal worms. We know that Redi with all of his keenness and daring was unwilling to commit himself to the view that the endo-parasites of animals might not originate spontaneously. It is more surprising to find that as late as 1819 the noted parasitologist Bremser presents a careful, and, for the period, convincing argument in favor of the spontaneous origin of these forms. The noted medical treatise by Roche and Sanson, in 1828, declares that the opposing view according to which the helminths are transmitted from animal to animal, being introduced into the body through the air, or food, or drink, demands such a measure of credulity that it is surprising that it has found any defenders.

But even as Bremser wrote he and scores of indefatigable workers were accumulating data which were to completely reshape the attitude of the zoological and medical world towards these parasites. In the first place, there was a growing recognition of the fact that the grosser parasites which, from the time of the ancients, had been known to occur in the bodies of man and animals, did not constitute a group absolutely apart, but were animals subject to the same fundamental laws of development as were free-living forms. Thus helminthology, or the study of parasitic worms was recognized as having more than medical interest, and attracted the attention of leading zoologists of the period.

To these workers it was no longer sufficient to explain the occurrence of a tapeworm as due to spontaneous generation from the slime or mucus of the intestine or from the digested food. As early as 1776 Pallas had called attention to the fact that within the little bladders or cysts which occurred within the liver tissue of the mouse there was a jointed worm whose head structures were wholly comparable with those of tapeworms to be found in the intestine of cats. In 1851, the problem was solved by Küchenmeister who proved by experimental feedings that similar bladders from the viscera of rabbits developed into complete tapeworms when fed to dogs. This introduction of the experimental method is justly regarded as the basis of our modern conceptions of the development of internal parasites.

Parallel with and in some important conceptions preceding this discovery of the typical life cycle of a tapeworm was the interpretation of the still more complicated life cycle of the liver fluke. So universally is this form used in class work that we forget the marvel of the story. The steps that led up to its solution are rarely mentioned:

Baker, Adams, and other early microscopists had figured little tadpole-like organisms which they found rarely in pond-water. In 1773, O. F. Muller constituted for these the genus *Cercaria*, which in the light of his times he naturally placed among the Protozoa. It seems to have escaped notice that before 1680 our old entomological friend, Swammerdam had found similar organisms and what we know today as rediæ, in the snail and had figured them.

In his work on the anatomy of "the wonderful viviparous chrystalline snail," as he calls *Paludina*, he tells us that the uterus of the snail "I immediately met under its upper coat which it has in common with the coat of the verge, a congeries of oblong little parts (Fig. vii, a) which were very numerous, and differed somewhat in their length, figure and thickness, and when I removed them from their places, I found they were all alive, and were so many living little worms, as there appeared particles of that sort. On the inside of these worms was seen an oblong transparent ash-gray colored furrow or ridge. When I began to dissect one of these worms, two, nay three, and sometimes four inclosed worms of the same kind issued forth having almost the same figure, that is, a thick head, Fig. viii, a, and *a* small tail *b*, like young frogs or tadpoles." Swammerdam well adds: "I must confess the sight of these astonished me, as I never expected to have met such, and so many miracles in one little creature, or that I should have been so well convinced of my own ignorance and blindness in a single subject."

In 1831 Mehlis made the remarkable discovery that the eggs of certain flukes "contained an embryo which in shape and ciliation resembled an Infusorian; it was occasionally provided with an eyespeck and after being hatched swam about like an Infusorian." (Leuckart.)

The discoveries of Swammerdam, a century and a half before might well have formed a link in the chain, but this link was to be formed anew by Bojanus and by Von Baer. In 1818 Bojanus described brightly colored worms which we now know as rediæ, in pond snails. Von Baer in 1824 showed that these rediæ give rise in their interior to the above-mentioned tailed cercariæ which, becoming free, swim about in the water.

Numerous other workers contributed observations but it remained for Steenstrup to correlate and interpret the data. He pointed out that the embryo escaping from the egg became the free-swimming larva, that this entered the snail and formed a generative sac (the sporocyst) which gave rise to rediæ. From these in turn arise cercariæ which developed into the adult flukes. Remarkable advances in the study of the flukes have been made since 1842, when Steenstrup published his conclusions but the essential facts were made clear by him. It is worth pausing to note that these facts which are fundamental to any control measures against some of the most dangerous of the parasitic worms were obtained through work on forms of no economic importance.

The early workers on insect anatomy occasionally noted the presence of parasitic worms within their specimens. Reference to such are found in Roesel, DeGeer, and Reaumur. The earliest which I have seen is that of Lister who in 1672 not only demolished the view that horse hairs gave rise to snakes, but showed that the so-called "hair-snake" lived for part of its life within "Black-beetles." Von Linstow's epochal studies on the development of Gordius were on a species found in *Pterostichus niger*, possibly this same "black beetle."

As the interest in helminthology grew these scattered references were rapidly multiplied. This is not surprising when we consider the amazing diligence with which the early workers on animal parasites pushed their work. Ten years before his death Bremser wrote that he had with his own hand dissected over 25,000 animals in search for endo-parasites. The collection under his direction, which he was constantly working over, contained specimens from 50,000 hosts.

Rudolphi in 1819 lists 29 species of insects in which had been found nematode worms. Von Linstow 1878, in his Compendium der Helminthologie, lists 220 insect hosts and to these he added 43 species in his "Nachtrag" of 1889.

Some of the most significant of the observations along this line were made by Stein, in the course of his comprehensive work on the female reproductive organs, published in 1847. He found many instances of larval nematodes and cestodes encysted in his specimens.

In a most significant paper, published in 1853, he calls especial attention to these finds and suggests that the larval worms which he found were taken up with their insect host by some other animal in which they reached maturity. His most noteworthy discovery was that in the body cavity of the meal-beetle, *Tenebrio molitor* and its larvæ, there were occasionally to be found numerous microscopic cysts enclosing a tapeworm-like head. These he found in all stages from the recently liberated embryo to the completed cysticercoid, and he suggests that they might be the larvæ of a tapeworm of cats, dogs, rats or mice, or even of man. In the light of our present day knowledge, there is every reason to believe that Stein had found the larval stage of *Hymenolepis diminuta* of rodents and occasionally of man. As we shall see later this tapeworm has as intermediate host a variety of insects, including Tenebrionid beetles.

The first complete life cycle of a parasitic worm involving an insect as intermediate host seems to have been worked out by Leuckart in 1867 for *Protospirura muris* (Spiroptera obtusa), a small, round worm found in the stomach of mice. The eggs of this worm are discharged with the droppings of mice, and are picked up by meal worms and the escaping embryos make their way to the body cavity of the larva and become encapsuled, there to remain until the insect is eaten by a mouse, within which the worm can mature. This case has acquired added significance through recent discoveries that a related worm, developing in the cockroach, is capable of causing cancer of the stomach in rats.

Two years later, in 1869, Leuckart and his student Melnikoff, discovered in the body cavity of the dog louse, cysts which proved to be those of the double-pored tapeworm of dogs, the commonest species infesting these animals. In reality, the worm infestation is more common than is the louse infestation, a fact which was puzzling until 1888, when Grassi found that the dog flea also serves as an intermediate host for the worm. The cysts are so minute that as many as fifty have been found in a single flea. The dog becomes infested solely through swallowing an infested louse or flea. In rare cases this tapeworm is also found as a human parasite, usually in children.

We have seen that Stein early suggested that insects might serve as intermediate hosts for tapeworms of various animals. Of a number of such cases worked out may be cited that of *Hymenolepis diminuta.* This parasite of rodents and occasionally of man is noteworthy for the number and wide range of arthropod hosts in which it may develop. There have been reported the meal-infesting lepidopter *Asopia farinalis,* the Forficulid, *Anisolabis annulipes,* two tenebrionid beetles and three fleas. Recently, there was brought to my attention evidence that the larvæ of this same tapeworm may develop also in myriapods.

An exceedingly common disease in many tropical and subtropical countries is elephantiasis, a disease marked by an enormous swelling of the extremities or affected parts. An apparently isolated endemic center is Charleston, S. C. Typical cases are shown by the lantern slides, the second of which is from a Japanese makimona of the 12th century. Though several conditions may give rise to this disease, it is most commonly due to the presence in the lymphatics of parasitic roundworms, upwards of four inches in length. These discharge living larvæ which are to be found in the blood stream. The life history is especially significant because it is that of the first human parasite found to be dependent upon a mosquito for its development. The larvæ were first noted in 1863, and in 1872 Lewis recognized that the blood of man was their normal habitat and gave to them the name *Filaria sanguinis hominis*. In 1876 Manson discovered the adults and in the following year he and Bancroft simultaneously suggested that they underwent a part of their life cycle in mosquitoes. This fact was very soon demonstrated by Manson, though many of the details have since been worked out.

The larvæ occur in myriads in the blood of the affected individual but are found in the peripheral blood only at night. They are taken up by feeding mosquitoes and within the body muscles of the insect must undergo a development before they are capable of further development in man. In about three weeks they leave the muscles of the mosquito and settle down in its mouthparts, there to await the visit of their host to man. When the mosquito now feeds the larvae are not injected, but escape from the proboscis of the mosquito and actively bore into the skin of their new host, as does the hookworm. In this respect the procedure differs from that of malaria, in which the spores are directly injected by the mosquito.

A related filarial worm *Filaria immitis* lives as adult in the heart of the dog. In this as in the preceding species the larvæ are discharged into the blood and are taken up by mosquitoes. From the stomach of the insect they pass to the excretory or Malpighian tubules, and undergo their metamorphosis there instead of in the muscles. In about two weeks they are ready to enter the dog in the same manner as the preceding.

The guinea worm, *Dracunculus medinensis*, is a filiform parasite of man, upwards of three feet in length, which lives under the epidermis, usually in the leg or foot. Over the vulva of the worm a small hole opens through the epidermis to the surface and through this the microscopic larvæ escape.

The presence of the worm and its products often leads to very severe inflammation, to abscess and sloughing, and even death from secondary infections. The usual method of extraction practiced by natives where the parasite is endemic is to wrap the protruding worm around a stick which is every day given a turn or two until the entire worm is drawn out. The parasite has been known since very remote periods. An illustration in Pigafatta's account of his voyages to the Congo show that this method of extraction was practiced there in 1598. Agitharchides, 150 years B. C., gives an account of the disease as seen on the shores of the Red Sea. It has even been suggested that the fiery serpents which attacked the Israelites in the desert were guinea worms and that Moses set up the serpent on the stick as an illustration of the method of extraction.

As is to be expected, many theories as to the origin of this famous parasite were proposed. Mercurialis, the Italian physician who about 1590 so clearly outlined the theory of the carriage of contagion by flies, ventured again into medical entomology, when he suggested that the guinea worm was contracted from eating grasshoppers. Others believed it identical with the "*Gordius aquaticus*" or hair snake. It was often maintained that infection was conveyed through drinking water and probably many a traveler followed the example of Baron von Jacquin who declared "Well, then, I'm safe enough for I shall not drink a drop of water." We read that in spite of his self-denial he was the only one of his company who became infested.

The prevailing view was that the Guinea worm, lying under the skin instead of in a cavity of the body, afforded conclusive proof of the origin of parasites within the host.

In 1870 Fedschenko first found that if the larvæ discharged by the parent worm escape into water they may be taken up by the little crustacean, *Cyclops* and within its body they develop to a certain stage. Man becomes infested by swallowing the Cyclops in drinking water. Since Fedschenko's announcement there has been abundant verification. We can only conclude that the Baron von Jacquin must have broken his pledge, for we have no evidence that Cyclops will thrive except in water.

Among the worms found to require an arthropod as intermediate host were several species of thorn-headed worms. In 1873 Leuckart showed that *Echinorhynchus proteus* and *Echinorhynchus angustatus* of fish develop as larvæ in two Crustaceans, respectively *Gammarus pulex* and *Asellus aquaticus*. One of this same group of worms which sometimes occurs in man was found by Grassi and Calandruccio, 1888, to develop in the meal infesting larva of Blaps. Still another, the largest of the group, develops in the larva of the June bug.

Other instances might be cited, but it is not my purpose to make this a mere catalogue of the parasites which were early known to undergo a part of their development in insects. It is rather my desire to show that long before the amazing discoveries of the relation of mosquitoes to malaria, and the other contributions of the past twenty-five years, the foundation was being laid. Without that foundation the building could not have been erected. Would it not be interesting if today we could tell what stones are being rejected which may become the cornerstones of the future?

Above all, a review of the history of any theory emphasizes the fact that no man lives to himself alone, and that no honest effort to get at the truths of nature, no matter how insignificant they may seem, is without its value. The man who scorns scientific work which has not an obvious utilitarian trend is ignorant of the history of applied science. The scientific worker who tries to build about himself and his subject a wall of defense against impractical ideas or against what he regards as rival subjects, will merely succeed in insuring himself against recognition by his followers.

THE GENITALIA OF MALE SYRPHIDÆ: THEIR MORPHOLOGY, WITH ESPECIAL REFERENCE TO ITS TAXONOMIC SIGNIFICANCE.*†

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The Syrphidæ are a group of very handsome flies, variously known as hover flies, flower flies and sweat bees; and, indeed, most often passed by the layman as stinging wasps or bees.

There are perhaps 500 known species from North America and the individuals are very numerous so that it has been an attractive field for the systematist and there are many students of the group. A very excellent monograph of the family by Dr. S. W. Williston[10], written in 1886, has also been influential in attracting attention to this family.

Unhappily the impression has prevailed that these flies are easily classified; and many amateurs who would not have ventured to name a bug or a beetle or a mosquito, have created synonyms in this group after the most meager study.

Nor has the confusion been confined to the collections of amateurs. I was surprised to find in the collections of four of the best known specialists of this group in America, four distinct species under the name *Sphegina lobata*, and four different species named *Sphærophoria cylindrica*. On the other hand in a number of cases the members of a single species were passing under two or three different names in these collections; *e. g.*, *Pipiza femoralis*.

This is not a reflection upon the systematists, but it is a good indication that the characters we have been using for this family (so largely color markings) are insufficient or untrustworthy and misleading in many cases. The conviction seems to be general that the more trustworthy, taxonomic characters are the *structural* ones of shape or architecture, sculpturing or puncturation, and variations in the number, position, structure and proportions of the appendages.

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Of such structural features the latest to be discovered and generally adopted as of vast importance in the taxonomy of insects are those of the genitalia. When one considers the great number of characters, many of them intricate and trivial, that students have invoked for use in this family, one who has studied the genitalia cannot but marvel at the extent to which these characters have been neglected by even the most careful students.

Of course in those families of insects where the parts are, at least in part, normally exposed they could not be entirely neglected by systematists. But in the groups where their examination requires some preliminary preparation or manipulation, they have been most persistently ignored; and, indeed, the presence of any variable structures appears to have been altogether unsuspected. For example, for the Diptera, the only reference that Peytoureau[6] as late as 1895, gives to the genitalia of this enormous order is to the work of Dziedzicki and Wagner on certain genera of the Siphonaptera!

Many a writer has taxed his eyesight and racked his nerves trying to separate, by minute differences in color markings or vestiture, species that were provided with structural characters by which any novice could place them. The reason for it is that these parts are normally almost entirely concealed from view (See Figs. A to I, Plate IX), and require a little special preparation before they are available for use. One can almost fancy that Nature has indulged in a kind of practical joke in hiding these excellent structural features from the curious eye; for in the Syrphidæ the most beautifully variable appendages are often concealed beneath the most unpromising and discouragingly homely tergites of the postabdominal segments. (Note Figs. A to I and cf. Plates X to XIX). One can hardly restrain one's enthusiasm upon relaxing and exposing from the exactly similar genital pouches of species after species, a complex of appendages that show an abundance of characters and furnish much ground for speculation regarding homologies, phylogeny and relationships.

Since Peytoureau's time, much work has been done on the genitalia of the Diptera, most noteworthy of which is that of Howard, Dyar and Knab[3] on the Culicidæ, Johannsen[4] on the Mycetophilidæ and Snodgrass[7] on the Dolichopodidæ. Those families are all ones in which little or no color differentiation is available for use. Hence, it has been particularly interesting in this family of large, brilliantly-marked flies to see how color markings would stand the acid test of comparison with really tangible structural features.

So far as the Syrphidæ are concerned, only scattered references to the genitalia are to be found. Verrall[8] observed that the parts are unsymmetrically twisted to the right and, in several cases (*e. g.*, *Sphærophoria* and *Tropidia*), he gave superficial drawings of the parts. Walter Wesché[9] makes frequent reference to the condition of the parts in the Syrphidæ and gives figures of three species. Berlese[1] has given an excellent figure of the genitalia of *Eristalis tenax*. J. Herve-Bazin, in his treatment of the Syrphidæ of the Congo[2], makes occasional reference to the exposed parts, but gives no description of the concealed parts. Lundbeck[5] gives especially valuable observations upon the condition of the segments of the postabdomen and remarks upon the appendages of certain species, but I feel sure that neither he nor Verrall had ever seen a cleared specimen and had little intimation of the valuable characters to be drawn from these parts.

SCOPE AND AIM.

In the present investigation the genitalia of only the male sex have been studied. The aim has been to determine the general character of the genitalia for this family, for the various genera, and for the several species; primarily as a help in limiting and clearly defining species and in fixing the limits of many of the genera now hopelessly intergrading and admittedly unsatisfactory. Furthermore, in these characters have been found some evidence regarding the phylogeny of the family and some good sub-family or tribe characters. The present paper is intended as an introduction to a series of taxonomic papers based on genitalic characters that are now prepared and in preparation and it is hoped also that it may serve as an introduction to this method of study for other specialists on this family. The writer must confess that his interest has been primarily taxonomic and that he has been least of all concerned in the much-mooted question of homologies and nomenclature of parts.

ACKNOWLEDGMENTS.

Nearly ten years ago, in a letter commenting upon my work with the biology of the Syrphidæ, Dr. Raymond C. Osburn, then of New York City, made the following suggestion:

> "If you can secure the material, the study of the development of the genitalia in the pupa would be most interesting, as nothing has been done on that point in the Syrphidæ."

However, it seemed most expedient to determine first the actual condition of the parts in the adult before attempting the more difficult task of elucidating their embryonic development. Ever since that time I have had in mind an investigation of the hidden treasure of characteristics to be found in the male genitalia of these flies. Occasional specimens have been examined from time to time, but it was not until 1918–19 that an opportunity was afforded for a comprehensive study of the problem. The writer acknowledges with gratitude the early suggestion of the problem and also the interest shown in its solution and fruition by Doctor Osburn since he and the writer became associated in the same department.

A paper such as this, the value of which depends fundamentally on the correct identification of the materials used, and which requires a large series of specimens and species, is not possible without much aid and assistance from fellow workers. I feel that I have been unusually fortunate in this respect, for in almost every case the material desired has been given with the utmost generosity.

Much of the material studied is from my own collection. This has been supplemented in many cases by specimens from other collections and determined by other workers. In a number of cases I have been fortunate in securing type material. All of the important American genera and most of the minor ones have been studied, about sixty in all, represented by about two hundred species. To attempt a detailed statement of the materials loaned to me would require too much space; but I wish to express my gratitude for such aid to the following gentlemen:

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ILLUSTRATIONS.

The drawings have been made with several objects in mind: first of all, to exhibit the characteristic structures which may be used again and again by taxonomists in determining the species; but also to record the morphological structure of the parts, even those which are obscure, in order that homologies might be traced throughout this group and eventually with other families and even the other orders; and finally not without some joy in presenting the intricate and often artistically beautiful structures which Nature has here hidden from the cursory observer.

Hence, much more extensive drawings have been made than would be necessary to illustrate the points needed in taxonomy; the characteristic structures are not unduly emphasized in the figures, although they are pointed out in the text; and no uniform position, such as strictly dorsal or strictly lateral, has been regularly chosen for the views presented. The attempt has been made to place the parts in the position which would show the characteristic features to good advantage and also give, so far as possible, an *ensemble* of all the structures present. Most often this has been a ventral or cephalic view; although the lateral aspect shows almost as many of the features. In a good many cases both views are presented. The drawings have been outlined with the aid of a camera lucida, the outlines then proved under the binocular and finally again examined under higher powers of the compound microscope as they were inked. The writer believes that the drawings given herewith, which show the parts all assembled, will make it easily possible for any taxonomic worker to use these characteristics in determining and defining species. When isolated appendages alone are figured, the tyro finds great difficulty in determining what part is represented and what view of it is figured.

METHODS OF WORK.

I am so much interested in seeing the general adoption of the genitalic characters as an aid in the characterization of species that I venture to describe, somewhat fully, the methods I have found useful in preparing these parts for study, in the hope that even the isolated worker, not accustomed to laboratory methods, may not hesitate to make use of the valuable characters to be found in the terminal appendages of these flies.

Every worker will, of course, develop his own particular methods of procedure, and there is little if anything new in the methods which I have used. But it will at least serve as a starting point, for it has enabled me to prepare hundreds of these parts without the loss of, and almost without damage to, a single one.

Three kinds of material will ordinarily fall to one's hands for use: freshly killed specimens, alcoholic ones and dried, pinned ones. All of them are valuable: indeed, for the chitinous parts with which the systematist is concerned, I believe the pinned specimens are as good as fresh ones, although the worker would do well to secure fresh material whenever possible as a check upon preserved material.

(1). In any case I always first pin the specimen and then attach to the pin a serial number which is also placed (together with the name of the insect and any other data) in a notebook. Personally I use the space provided in most slide boxes, putting the number and name of the insect opposite the space which will eventually receive the prepared slide of the genitalia.

(2). If the material is freshly killed, this step is to be omitted. With material which is set, however, the next step is to relax the insect by placing in a moist chamber or relaxing jar. The length of time required for this process will vary with the species, the degree of chitinization of the specimen and the length of time it has been killed. As a rough average, I have found about thirty-six hours to be sufficient. A reliable test is to leave them in the moist jar until a wing or leg can be moved without breaking.

The relaxation can be accomplished almost instantly if necessary by applying boiling water in a small camel's-hair brush directly to the parts, or by plying a tiny jet of steam against the genitalia, or even by dropping the specimen briefly in boiling water. Owing to the greater injury to the colors and vestiture of the specimens likely to be caused by these methods, I prefer the moist chamber. For the same reason it is important to leave the specimens in the relaxing jar, only so long as is necessary to accomplish the purpose.

(3). The fresh or relaxed and pinned specimen is then held ventral side up, by the left hand under the dissecting microscope, while with a fine needle the retracted genitalia are pried or drawn out of the cavity formed by the invagination of the terminal segments at the ventro-caudal extremity of the abdomen. I have found by removing the metal stage of the binocular and placing a microscope slide across to bisect the field of vision that the tip of the abdomen can be rested against the edge of the slide and the parts pried out most easily. Any elevated, sharp edge at the middle of the field so that the head of the pin is not in the way, will do as well. With properly relaxed specimens, and a little care, one can remove these genital segments and leave the rest of the specimen in almost perfect condition for cabinet purposes. Of course, if one does not care for the specimen, it will suffice to simply clip off the tip of the abdomen a little beyond the middle with a fine scissors. Or, indeed, the whole of specimens not needed for the cabinet may with great interest and profit be carried through the successive stages, thus revealing many features of the chitinous structure not readily made out from uncleared specimens.

Before severing the genital segments it is well to study the relations of the modified segments (postabdomen) to the unmodified segments (praeabdomen), noting any variation in number of segments involved or characteristics of length, shape, size and arrangement of these parts. It is also well at this point, to make an examination, descriptions and preliminary sketches of the separated, opaque parts, since in this condition certain features are better revealed than in the cleared preparation. Indeed if several specimens of the same species are available, it is advisable at this point to preserve one without clearing, using for the purpose small gelatine capsules which are securely sealed by closing and thrusting on to the pin bearing the insect itself. This also affords a precaution against being misled by any possible artifact due to subsequent treatment.

(4). A duplicate of the serial number (in carbon ink on a tiny slip of paper and thoroughly dried) is now placed, together with the detached genital segments, in a container for treating with caustic potash. For this purpose I use small shell vials or test tubes, about 8 x 70 mm., that have had a part of the bottom removed by means of a diamond point, or by heating the bottom in a gas jet and blowing out the molten glass. This bottom is then replaced by a plug of cotton. Sections of glass tubing may be used, but I prefer the vials, as the partial shelf of glass prevents the cotton plug from dropping out. With this arrangement the specimens can be passed rapidly through the remaining treatment without the necessity of once touching the parts themselves. It is only necessary to raise the vial until the liquid has drained out through the cotton bottom, rinse it with a few dropper-fulls of fresh liquid, and then place it in the next reagent, which will rise and promptly envelop the specimen.

By the use of these small containers it is convenient to carry through the subsequent operations a considerable number of specimens at a time without any danger of loosing them or separating the parts from their key numbers.

When the desired number of vials, each with its genitalia and serial number, (from a dozen, or less, to a hundred, as the case may be), have been prepared in this way, they are placed in a shallow dish with straight sides or cross partitions, to keep them upright; and into the dish is poured an aqueous solution of caustic potash, 10 to 15% strength, sufficient to bring the solution to a depth of a half inch or an inch in each vial. They are then allowed to remain in this condition, occasionally raising and lowering the vials to bring in a fresh supply of caustic, until the parts are almost transparent. The length of time required for this again varies with the degree of chitinization, but I have found it takes much longer than usually estimated to reach a degree of clearness which gives the best results. In fact, after soaking the parts in cold potash for a day or so, I have usually boiled them for from three to six hours in the same solution. In this process the cotton-plugged vials are very useful; for if the cotton plug is made just tight enough it will not be raised by the boiling and this prevents the boiling over so often experienced with materials in a test tube. The shell vials in a small staining dish may be placed in a casserole; or a cluster of them, tied with cord to keep them upright, may be placed directly in the casserole. It is a wise precaution to use a shallow casserole, in which the tops of the vials will come above the edge, so that the contents will not be lost or mixed by the liquid in the enclosing dish boiling over into the vials, or vice versa.

(5). When the parts have been thoroughly cleared, the vials are lifted separately or collectively from the potash and placed in a second dish containing distilled water, and thoroughly washed. Two or three changes are sufficient, especially if the fresh liquid be added through the mouths of the vials, by means of a pipette.

(5a). If the specimens are large and not thoroughly cleared, they may now be improved by placing for some hours in glacial acetic acid. This dissolves any fat that may have escaped the action of the potash and also any crystals of potash that may have evaded the washing.

(5b). Again wash thoroughly in water.

At this point the worker has a choice of several methods successively described:

A.

The specimen can now be placed on a microscope slide with a few drops of water and a cover glass, for temporary examination. It can be kept indefinitely in splendid condition in a small vial of equal parts 95% alcohol, glycerine and water. If a permanent mount is desired, method B, C or D must be followed.

B.

If the slides are not to be transported, and can be protected from rough handling, a very satisfactory plan is to mount them simply in a drop or two of glycerine. This has the advantage of allowing one to move the specimen about very freely under the cover glass, to study it in all aspects. To make a really permanent mount, however, follow either method C or D.

C.

(6). The vials are transferred to a dish containing glycerine, for an hour or more. Proceed with step 10.

D.

(6). The vials are placed in a jar containing a stain made of one gram of acid fushsin and 25 cc. of 10% hydrochloric acid in 500 cc. water, for from ten to fifteen minutes. If the strength is reduced to half, the specimen can usually be safely left over night.

(7). Wash in water and

(8). Pass through several grades of alcohol, as 30%, 85%, 95%, two changes, and into absolute alcohol.

(9). Transfer a few at a time into xylol or carbol-xylol, so that no one remains longer than about a half hour, before you can arrange it on its slide.

(10). Prepare a microscope slide by scratching on it the number of the genitalia to be mounted, or by attaching a gummed label which may also bear the name of the insect, by whom determined and also locality and date if desired.

C.	D.
(11). Place on the slide a drop of glycerine jelly, melted by gentle heat and	(11). Place on the slide a drop of Canada balsam, dissolved in pure acetone and

with a brush or needle, quickly transfer the specimen to it. Under the microscope make sure the parts are spread to the best advantage and arrange them in the position desired.

C.	D.
(12). Now quickly place the slide on a small piece of ice, if available, or allow to cool, in the meantime examining carefully to see that the parts remain in the desired position until the jelly has consolidated enough to hold it.	(12). Maintain them in position until the rapid evaporation of the acetone leaves the balsam firm enough to hold it. If necessary to change the position, a little fresh acetone-balsam can be added as many times as necessary to soften the balsam. When firmly set and covered with balsam, the slide may be allowed to harden in a place free from dust for a day or so, or one may at once—

(13). Place around the specimen several pieces of a crushed glass slide, or glass beads, of a proper size to just keep the cover from crushing the mount, and then:

C.	D.
(14). Add some more of the liquid jelly, and finally a cover glass. Chill thoroughly and set aside until wanted. When the specimen has been studied in this position, it can readily be changed by gently heating and manipulating under the cover glass with a fine needle.	(14). Add a little fresh balsam and finally a cover glass. If it is necessary to change the position of the object, the cover must be removed by soaking the slide in xylol or acetone, rearranging and remounting.

While the above procedure may appear rather complicated, it may be noted that by a simple short cut, one may prepare a mount of the genitalia in a very short time, as follows:

Relax the specimen with hot water; boil the postabdomen in caustic potash solution until clear; and then mount in either a drop of water, in glycerine, or in glycerine jelly.

THE MALE GENITALIA.

By genitalia is meant the group of appendages at the caudal end of the abdomen, surrounding the genital and anal orifices* of male and female insects. Their dominant functions are the reproductive ones of mating, oviposition, etc., but they are also involved to some extent in defaecation and sensation.

These organs appear to consist primitively of four pairs of appendages (Newell[11]). The most prolonged and voluminous debate has ensued regarding the homology, and morphological composition of these appendages and the primitive numbers of the urites to which they belong. The evidence appears convincing that they are entirely homologous with the thoracic or ambulatory appendages. And, according to the concensus of opinion of morphologists, these four

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*The term is more strictly limited to the genital appendages. In this family, however, the *cerci* are so intimately associated with the other appendages that they are, throughout this paper, treated as a part of the genitalia.

primitive pairs of appendages belong primarily to urites eight, nine, ten and eleven.

The most varied names have been applied, not only to the group of structures (genitalia, hypopygia, *genital apparats*, *l'armature genitale*, *armature copulatrix*, *geschlechtsanhange*, terminalia, pygidia, etc.), but also to each of the several parts. But in spite of the elaborate protest of almost every author who has dealt with these parts, at the confusion of names and lack of any knowledge of the homology of the various parts exhibited in the work of their predecessors; and in spite of several recent ambitious attempts to homologize the structures in all the orders of insects the problem remains today much as in the past. Each worker must select such names as are evidently appropriate for application to as many as possible of the structures that he finds; and, when this is done, must still devise names of his own for convenience of handling many other parts, the homology of which with other groups is absolutely unknown. The fact is that the variations of these parts in the orders of insects is so unlimited; and so relatively little detailed study of the conditions in various families has been completed; that the time is not ripe to attempt to construct an ancestral, hypothetical form from which the variations in the various groups can be derived, or even to say which of the parts in the groups described have had the same origin. Much as a more uniform nomenclature is to be desired, it seems to me that real, ultimate progress in this direction must await further isolated investigations, until we begin to comprehend something of the range of variation in the orders.

The posterior half of the abdomen of the males of the Syrphidæ has been completely transformed (See Figs. A to N, Plate IX) and curiously modified for the support, protection and manipulation of the genitalia proper. This has resulted in dividing the abdomen sharply into two groups of segments; a caudal portion that is reduced in size and modified in shape or position or both, until it is quite distinct from the normal urites of the cephalic portion. I have found it convenient to designate these two divisions *the preabdomen* and *the postabdomen*.

NUMBERING OF THE SEGMENTS.

The following assumptions, in line with the conclusions of morphologists, but still assumptions, I believe, have been made in interpreting the identity of the segments in the postabdomen.

(1) The anus opens primitively between the eleventh tergite and its corresponding sternite, though these sclerites may not be recognizable in the highly specialized insects.

(2) The genital orifice is primitively between the ninth and tenth sternites, though the development of the penis may carry it to a point without any evident relation to the tenth urite.

(3) There are never more than eight pairs of spiracles on the abdomen.

(4) In the Diptera the style-bearing segment is the tenth.

If these premises be sound, it is evident that a complete renumbering of the segments of the abdomen is called for.

There has been great discrepancy in the numbering of these segments by various taxonomic and morphological students. Lundbeck (*5*, p. 23), for example, considers that the ultimate, or style-bearing segment is the ninth; that the postabdomen has four segments if the preabdomen has five and the postabdomen five when there are but four not transformed; although the most cephalic of the postabdomen may be hidden. Like all taxonomic workers, he calls the first apparent urite next the thorax the first abdominal segment. Berlese (*1*, p. 327), in his treatment of *Eristalis tenax*, interprets the numbers of the segments very differently. The apparent first next the thorax is, according to this author, in all the Diptera, number three; and consequently the last of the preabdomen in *Eristalis* (number four of taxonomists) he calls the sixth. His interpretation of the postabdomen is also at variance. He considers that the style-bearing segment is number ten, which I think is correct. But there are clearly *four* sclerites between this one and his so-called sixth, as shown by his own figure, (*1*, Fig. 395, p. 327). This would make the style-bearing segment the eleventh, or else the last of the preabdomen would be five. This difficulty he obviates by calling the basal *two* sclerites of the postabdomen together tergite seven, explaining that "the seventh has a large basal expansion." In this, I am convinced Berlese is in error, as the condition in the various genera and species clearly shows. (Follow Figs. M. and N. of Plate IX). The short, wide, chitinous bow ("large basal expansion" of the seventh urite), sometimes retracted under the last sternite of the preabdomen, is a modified sternite, as shown by the position of the spiracles, and, if the style-bearing is in reality number ten, then at most only one (and not two urites, as Berlese claims) has been lost between the thorax and abdomen in this family. His "large basal expansion" of the seventh segment is in reality the sixth sternite. Lundbeck has had the truer understanding of the abdomen, his position being correct as to the *number* of segments present in the abdominal region (namely, nine); but probably not as to the correct *primitive numbers* of these segments. That is, he recognizes no lost or transformed urites at the base of the abdomen and consequently calls the style-bearing urite number nine instead of number ten.

The evidence appears to me conclusive enough to warrant taxonomists making a change in nomenclature to conform with the morphological evidence in this and other families. There are nine discernible urites cephalad of the anal segment (eleventh), the first urite apparently having fused with the thoracic mass. Therefore, the segment of the abdomen which has hitherto been called the first in all taxonomic writings, should be numbered *two;* the so-called second, *three;* three, *four*, etc. While this will seem radical to systematists, it is clear that a nomenclature founded on error cannot permanently endure and if the change must come, the sooner and more generally it is adopted the more rapid and stable our progress will be. In this paper, therefore, the writer has adopted this nomenclature for the abdominal segments.

PREABDOMEN: URITES TWO TO FIVE OR SIX.

I have made no attempt to study urite one, though I believe it may be found by a careful examination of the thoracic mass.

URITE TWO is generally small, usually much shorter and also narrower than the succeeding ones. It is overhung by the scutellum (Fig. A), and has in some systematic descriptions been entirely overlooked—urite three being called the "first" abdominal segment. In *Chilosia* spp., *Xylota*, etc., it is unusually large, sometimes nearly equaling the third segment in length.

URITES THREE, FOUR AND FIVE are generally subequal in size and the largest of the abdomen. Their tergites are typically considerably wider than long, convex dorsad, the convexity in the transverse direction greater than that in the longitudinal direction. In some genera and species however, as in *Baccha*, *Ocyptamus*, *Sphegina* and *Sphaerophoria*, all or a part of the tergites may be much longer than wide. The sternites are invariably narrower than the tergites and less convex, but of about equal length. Typically in a cross section the sternite would occupy the diameter of the half circle or ellipse made by the tergite. Between tergite and sternite the body wall is unchitinized and these portions of the urite, the *lateral conjunctivæ*, bear the spiracles. In certain genera the chitinized ventral sclerites (sternites) are much reduced in area and the lateral conjunctivæ become proportionately larger. This is particularly noticeable in *Helophilus*, *Tropidia*, *Sphegina* and *Syritta*.

SIXTH URITE. The transformation from pre-abdomen to postabdomen comes in the region of urites five to seven and the sixth shows the greatest variation in its development from genus to genus. In a few cases the sixth urite terminates the preabdomen; that is, it is not transformed, or but slightly so, and one can recognize five segments in the preabdomen (Fig. K, Plate IX). The sixth is then always shorter than the preceding segments and generally somewhat narrower. Both tergite and sternite clearly belong to the preabdomen in the following genera: *Platychirus*, *Pyrophaena*, *Allograpta*, *Baccha* and *Mesogramma* (Figs. K, L, Plate IX). In these cases the sixth tergite is about equally developed and quite similar in position and appearance to the fifth tergite in some of the other genera, (cf. Terg. VI, Fig. K, with T5, Fig. A). It is frequently a little unsymmetrical, as in *Platychirus* for example, where it is shorter and more bent downward on the right side. In *Baccha* it is of considerable length and nearly as wide as, or sometimes actually wider than the preceding. The sixth sternite in these cases is shorter than its tergite, but it is of about equal length throughout its width and not modified except perhaps a little depressed toward its right side.

From such a condition one can follow a clear series of specializations as a result of which urite six becomes more and more transformed in adaptation to the distorted postabdomen. Since the postabdomen as a whole is the result of an adaptation to the accommodation and manipulation of the genital appendages, it is clear that the distortion has progressed cephalad and that the genera just decribed are more primitive in this respect than those which have the sixth urite variously transformed.

As urite six becomes more affected the sternite first becomes transformed while its tergite may retain practically its normal shape and position. In the genus *Syrphus* the sixth sternite is variable; in some species (e. g., *S. arcuatus*) it stands full width of the hind margin of the fifth sternite, only shortened toward the middle or right side (Fig. F, Plate IX); in other species it is confined in its chitinized portion more or less completely to the left half of the abdomen, when it may be more properly be called a part of the postabdomen. The latter condition is found also in *Chrysotoxum* (Fig. H, Plate IX) *Sphærophoria* (Fig. 1, Plate XV), *Paragus* and *Eupeodes* (Fig. 134, Plate XIX).

In *Sphærophoria* (Fig. 1, Plate XV) the sixth tergite is large, in the common species being roughly two-thirds as long as the fifth. It is unsymmetrical, the right hand corner being prolonged into a triangular or rounded lappet. This sclerite is also a little unsymmetrical in *Eupeodes*. The sixth sternite in *Eupeodes volucris* (Fig. 134, Plate XIX), is longest and reaching nearly to the apex of the sixth tergite on the left side but much shorter a little to the right of the middle line (f, Fig. 134), where it is depressed to form a cavity for the apex of the penis.

In *Melanostoma, Didea, Xanthogramma* and *Syrphus* some species show urite six entirely untransformed, others have the sternite confined to the left side and the tergite normal or nearly so; while still others reflect the next condition in which the tergite likewise becomes involved in the distortion. Thus in *Didea fasciata fuscipes* it is somewhat upturned at apex and broadly and shallowly emarginated on the caudal margin. In *Melanostoma mellinum, Syrphus ribesii*, et al. the sixth tergite is much shorter on the right side.

Finally there is a large series of genera in which urite six has become completely transformed into a part of the postabdomen. In these cases it is usually not visible from above in the unrelaxed specimens and urite five terminates the preabdomen (Figs. A, C, E, G, Plate IX). Generally the fifth tergite is of about the same size as tergite six of the genera described above. Thus the preabdomen consists of only four discernible segments (Fig. A, Plate IX). This is the case in the following genera: *Psilota, Cnemodon, Chrysogaster, Sphegina, Rhingia, Hammerschimidtia, Volucella, Copestylum, Eristalis, Helophilus, Mallota, Sericomyia, Condidea, Arctophila, Pyritis, Tropidia, Teuchocnemis, Triodonta, Pterallastes, Syritta, Xylota, Calliprobola, Brachypalpus, Myiolepta, Criorhina s. s , Blera, Somula, Crioprora, Milesia, Callicera, Spilomyia, Meromacrus, Ceriodes, Temnostoma, Microdon, Mixogaster*. The fifth tergite is unusually elongate in *Myiolepta* and *Microdon*. It is unsymmetrical in *Criorhina*. A part of the postabdomen is almost always visible caudad of tergite five (usually urite nine and more or less of the adjoining sclerites) (Figs. A. C, E, G, I, Plate IX), and this has in some systematic papers been designated "segment five" or the hypopygium.

In the genus *Chilosia* (Figs. A and B, Plate IX) there are only four distinct segments in the preabdomen (urites two to five inclusive) but retracted underneath the fifth is a very short sixth of nearly equal width; and projecting slightly from under the fifth tergite on its left side, are two very small unsymmetrical tergites (seven and eight) that narrow rapidly toward the right side where they become entirely concealed by the fifth tergite. In some species tergite six is also normally slightly exposed at the extreme left (Fig. A, Plate IX).

THE GENITAL POUCH. As indicated above it is chiefly the adaptations to the large genital appendages, when at rest, that are responsible for the transformation of the basal segments of the postabdomen—especially urites six, seven and eight. The same stimulus has resulted in a depression near the apex of the venter of the preabdomen, into which the penis, styles, etc., are received when not in use. This depression I have called *the genital pouch.* (Figs. 95, Plate XVI; 134, Plate XIX; 73, 69, 77, Plate XIV). It is developed to the most variable degree, showing a high correlation with the size of the postabdominal appendages. Its beginnings are shown in the cases already described (Fig. F, Plate IX) in which sternite six is first depressed toward its right side then looses its chitinization in this region.

However, in cases where the genitalia are larger, the terminal segment of the preabdomen, namely tergite five and sternite five, (Figs. 69, Plate XIV; 95, Plate XVI), gape apart toward their apex and the transverse conjunctivæ become actually introverted beneath sternite five carrying with them to a variable degree urites six and seven.

Correlated with this movement we find a further tendency to modify especially sternite five to aid in grasping the female abdomen. In *Helophilus* the fifth sternite is strongly drooping and has the caudal margin emarginated and sometimes sharply keeled at the middle, but symmetrical. In *Teuchocnemis* and *Triodonta* the caudal margin of the fifth sternite is much thinned, looking something like a short broad additional sternite fused to it. In *Syritta pipiens* there is a strong, V-shaped emargination of the caudal margin that reduces the median length of the sternite to about half that on the sides. In *Somula decora* the fifth sternite has a short rectangular prolongation of its caudal margin covering the middle fourth. In *Ceriodes tridens* there is a sharp median keel narrowing cephalad. In *Mallota* there is a fringe of long hairs a short distance removed from the caudal margin of the fifth sternite.

The genus *Sphegina* shows some interesting modifications of the fifth sternite. In *S. infuscata* this sclerite is hardly at all specialized either in shape or in vestiture, being only a little longer on the left side. In *S. clunipes* there is a narrow, shallow emargination of the caudal margin near the middle and about this emargination are many, much elongated, but not at all stout hairs, not divided into two groups. In *S. rufiventris* (Fig. 77, Plate XIV) there is a shallow, rounded emargination of the caudal margin near the middle (d) and this is bordered with several dozen very heavy short hairs tending to divide into a right and left group. At each side of these spiny hairs the vestiture is three or four times as long and more delicate. In *S. petiolata* (Fig. 73, Plate

XIV) the distal emargination is unsymmetrical and about this emargination the hairs are elongated and thickened, but not sharply distinct from the others on this sclerite. Projecting strongly from under the left side of the fifth sternite and between it and the sixth sternite the transverse conjunctiva on the left side forms a large blunt somewhat chitinized lobe (o, Fig. 73, Plate XIV,). The ventral body wall is then strongly introverted so that the sixth sternite is entirely hidden underneath this lobe, forms the ventral floor of the genital pouch and lies with its venter directed dorsad. In *Sphegina lobata* (Fig. 69, Plate XIV) we have a very similar condition except that in this case the ventral wall of the projecting lobe is covered by a strong protuberance of the left side of sternite five instead of being made up wholly of the transverse conjunctiva. The vestiture about the strong unsymmetrical caudal emargination of the fifth sternite is short and stiff. There is a similar, though not so prominent projection of the left side of the fifth sternite in another species of *Sphegina*, and the genital pouch is still more strongly developed (Fig. 78, Plate XIV). In *S. campanulata* the genital pouch is also very large.

The way in which the development of the genital pouch has influenced these remarkable emarginations of the caudal margin of sternite five is indicated in an unnamed *Sphegina*, where the genital pouch is but slightly introverted but the part of the fifth sternite directly underlying and adjoining it (in a large U-shaped area reaching three-fourths the way to the base of the sternite) is exceedingly thinly chitinized and but one step removed from a very strong emargination of this sclerite. In *S. latifrons* the fifth sternite is quite symmetrical and unusually long, though its apex hardly reaches the caudal third of its tergite. On the basal third is a median swelling bearing about a dozen spinose hairs on each side. Between this and the apex the segment is transversely concave and the distal margin is bituberculate—the tubercles as far from each other as from the lateral margin, each semi-globular and with a dense tuft of hairs, much as in *Tropidia quadrata* (see below). Of these hairs, some are similar to those on the median tubercle, but many are four times as long and stiff. These tufts when the parts are at rest, guard the apices of the elongate styles. The genital pouch is but feebly developed, its place being taken in part by the tubercles.

A condition remarkably similar to that in *S. latifrons* is found in our common *Tropidia quadrata* (Fig. 95, Plate XVI). The fifth sternite has a median caudal emargination, guarded by two very densely hairy tubercles that help to complete the genital pouch formed by the introversion of the sixth sternite and the transverse conjunctivæ bordering it.

In *Eumerus strigatus* the caudal margin of the fifth sternite is produced into two large sub-quadrangular plates separated only by a linear incision on the middle line.

THE POSTABDOMEN: URITES SIX OR SEVEN TO ELEVEN.

Previous writers appear to have completely misinterpreted the condition of the postabdominal segments in these males. Berlese, in particular, has, for some reason that I cannot understand, in his Gli Insetti (*1*, Fig. 395, A, B, p. 327) mistaken the tergites of the postabdomen for the sternites and vice versa.

The only reasons I can see for this are (a) the *superficial resemblance* of the prominent sclerites in this region to tergites of the preabdomen and (b) *their similarity in position* to the style-bearing, tenth, tergite (?). The position of the appendages (styles) of this tenth urite appear to prove that the heavily chitinized convex sclerite marked Terg. X, (Figs. D, L, N, Plate IX) is the tergite; and by analogy one might easily assume that the preceding sclerites of similar appearance (Urite IX, Stern. VIII, Stern. VII, Figs D, L, N, Plate IX) are the preceding tergites. This Berlese appears to have done. Such assumption would presuppose a most remarkable twisting of the abdomen on its long axis between preabdomen and postabdomen. Berlese assumes that this twisting has been counter-clockwise, so that the mid-dorsal line of the sclerites that he calls *tergites seven and eight*, lies at the left side. As a matter of fact, as I shall show, the flexure has been in the opposite direction (clockwise); and what Berlese calls tergites seven and eight are sternites, while his sternites seven, eight and nine are the tergites, not of seven, eight and nine, but of six, seven and eight.

The evidence for this is perfectly conclusive. The most important landmarks for determining homologies in this region are the spiracles and the longitudinal tracheal trunks. In fact, in certain species one can follow the lateral conjunctivæ between the preabdominal and postabdominal segments; and it is perfectly evident that the sclerite marked Stern. VI (Fig. N, Plate IX) is homologous with that marked Stern. V, and so with those marked Stern. VII and Stern VIII. Likewise in Figure M, the sclerites marked Terg. VI, VII and VIII are unquestionably homologous with that marked Terg. V. More conclusive evidence is the course of the tracheal trunks which, as shown in Figures 69A and 69B, Plate XIV, have no twisting or crossing over. By following the latter it is perfectly evident that no such remarkable flexure as that demanded by Berlese's interpretation has taken place, (follow Figures 69A and 69B, Plate XIV). The left tracheal trunk passes directly back to the spiracles 6, 7 and 8; the right one bends to the left and passes as directly as may be to the right spiracles 6, 7 and 8.

The peculiar condition of the terminal urites (postabdomen) in this family will be best understood if we consider the changes that must have taken place in their development from the primitive condition of the abdomen. *First*, the caudal part of the abdomen must have become bent underneath, so that the sternites of the last few segments are in apposition to those immediately preceding (Figs. D, K, L, Plate IX). Following this, another important flexure has taken place as a result of which the segments after number seven are, *secondly*, successively displaced toward the right, curling about in a semicircle from left to right (Figs. B, D, F, H, and L, Plate IX). This has resulted, *thirdly*, in crowding the basal segments of the postabdomen (urites six, seven and eight) more or less completely over to the left side of the apex of the preabdomen (Figs. D, L) to accommodate the enlarged tip of the abdomen. Accompanying this bending under and curling around toward the right, has occurred *fourthly*, a rotation clockwise on the long axis (Figs. M, N) usually for about one-fourth of a revolution on the seventh urite and progressively more on the eighth and ninth. As a result of the above modifications, we find in the present-day species that the apex of the postabdomen points cephalad instead of caudad, (Figs. B, D, F, H, K, L) and that the *mid-dorsal* line of the tenth urite (its tergum) lies near the *mid-ventral* line of the preabdomen and its sternite lies practically dorsad of its tergite. *In the fifth place*, in many genera, the terminal tergite and sternite of the preabdomen have gaped apart at their apex (Figs. 69, 73, Plate XIV; Fig. 95, Plate XVI), and, *sixthly*, the transverse conjunctivæ bordering the sixth sternite have often become introverted between these two sclerites to form a sort of genital pouch, often carrying inward also one or two of the basal segments of the postabdomen. When at rest then the apices of the appendages borne by urites nine and ten often lie in such a pouch, sometimes to their very bases (Figs. B, D, F, Plate IX).

URITE SIX IN THE POSTABDOMEN. In the completed condition, then, (Figs. B, D, H), urite six, when not a part of the preabdomen (see above) is often found as a very short and narrow sclerite, underneath the left side of the fifth tergite; or it may be nearly as broad as the fifth sternite, but mostly or entirely hidden under this sternite.

URITES SEVEN AND EIGHT are small, short, and more or less strictly confined to the left side; the former wholly, in part or not at all received into the genital pouch; the latter wholly, in part of not at all projecting beyond the last tergite of the preabdomen in dorsal view (Figs. A, C, I). They are twisted clockwise on their long axis, so that their mid-dorsal line points almost directly dextrad (Fig. M) and their mid-ventral line nearly directly senestrad (Fig. N).

In contrast with the condition in the preabdomen, the sternites of the postabdomen are more heavily chitinized and more convex and often of greater actual area than the tergites. Generally, however, the area of the tergites is greater than at first appears, because they are so greatly distorted and folded upon themselves. The only way in which boundaries can be clearly recognized is to follow the lateral conjunctivæ and particularly note the spiracles. The lateral conjunctiva of the right side (Fig. M) lies just dorsad of the right margin of sternites six to eight. When the parts are extended, it therefore bends sharply to the left and ventrad (Figs. L, M) after the last segment of the preabdomen (five or six) and beyond this point its course describes part of a circle or ellipse with the concavity toward the right.* In the retracted

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*A condition which may have a great deal of significance, but which I am not able to interpret at present is shown in a specimen of *Eristalis arbustorum*. In this specimen the right lateral conjunctiva appears to continue directly into what we have called the mid-dorsal line of the tenth tergite.

position of the postabdomen the right lateral conjunctiva often makes a loop cephalad under the terminal sternite of preabdomen, following the segments introverted into the genital pouch. The right spiracle of urite six, when this segment is transformed into postabdomen retains its nearly normal position near the caudo-lateral corner of the preceding untransformed segment (Figs. L, M); that of urite seven may lie near the right side of the preabdomen or, together with the eighth, may be displaced far ventrad and often senestrad (Fig. L) to well beyond the mid-ventral line of the preabdomen.

The lateral conjunctiva of the left side is much less distorted (Fig. N). It bends dorsad and slightly toward the right beyond the apex of the preabdomen, following the spiral twist of this part of the abdomen. The left spiracle of urite six usually lies very close to the caudo-senestral corner of the fifth sternite, though it may be withdrawn underneath (dorsad of) the latter into the genital pouch. The left spiracles of urites seven and eight are displaced dorsad and also often caudad to near mid-length of their respective segments (Figs. K, L). They are not much displaced toward the right, so that *both* spiracles of urites seven and eight often lie to the left of the mid-ventral line of the preabdomen.

The true relationship of the sclerites in the postabdomen is much obscured in many genera by three specializations. (1) The left lateral conjunctiva has practically disappeared in some cases by the fusion of sternites seven and eight to tergites seven and eight respectively, on their left side (Fig. K); thus making practically a single sclerite of each of these segments with an evident break only at the right conjunctiva. However the spiracles clearly remain on the left side to show the homologies. In *Mesogramma geminata* for example (Fig. K, Plate IX), the break between sternite seven and tergite seven on the left side is indicated only by a slight change in density of chitin and a trace of a suture in front and behind, while on the eighth urite all that remains of the lateral conjunctiva is a trace of the suture over the cephalic half leading back to the spiracle.

(2) The second obscuring tendency is toward the disappearance of the tergites of six, seven and eight or rather, their dechitinization. It is as though the pressure from the genital appendages prevented in some way the laying down of chitin in those parts of the segments that line the genital pouch.

The tergites of six, seven and eight are very well chitinized in at least a part of the species of the following genera: *Chilosia*, *Mesogramma*. *Sphegina*, *Baccha*, *Milesia*, *Hammerschmidtia*, *Brachyopa*. and *Microdon*.

These tergites are moderately to feebly chitinized in the following genera: *Pipiza s. l.*, *Chrysogaster*, *Syrphus*, *Catabomba*, *Didea*, *Chrysotoxum*, *Melanostoma*, *Pyrophaena*, *Sphegina*, *Baccha*, *Rhingia*, *Eristalis*, *Helophilus*, *Tropidia*, *Xylota*, *Calliprobola*, *Eumerus*, *Syritta*, *Sericomyia*, *Condidea*, *Spilomyia*, *Teuchocnemis*, *Triodonta*, *Somula*, *Criorhina*, *Blera*, *Crioprora*. *Mallota*, *Merodon*, *Temnostoma*, *Ceriodes*, *Volucella*, *Copestylum*, *Mixogaster*.

In the following genera the tergites of the sixth, seventh and eighth urites are apparently not at all chitinized, the area occupied by these sclerites being thin and membranous: *Paragus, Syrphus (pars), Xanthogramma, Sphærophoria, Allograpta, Eupeodes, Platychirus.*

(3) The third specialization of the postabdomen that tends to make interpretation difficult is the tendency for certain segments to fuse. The fusion of segment eight with nine is shown in the genus *Paragus.* In this genus there are five tergites in the preabdomen while the sternite of five has been transformed. In *P. tibialis* the postabdomen shows five distinct segments of which three (6, 7 and 8) are small, confined to the left side, and subequal. In all the other species examined, however, one can find only four segments in the postabdomen, there being only two small subequal urites on the left side between the fourth sternite and the large penultimate segment (nine). However when one clears the specimens and examines this ninth segment carefully an obscure suture becomes evident which is undoutbedly a line of fusion between segments eight and nine. The cephalic portion so marked off is of the right size and shape for the eighth segment and the caudal portion of this compound segment about equals in size segment nine of *tibialis.*

Another example of the fusion of segment eight to nine is furnished by the species, *Eupeodes volucris.* (Fig. 134, Plate XIX). In this species a triangular eighth segment is fused to the left basal corner of the enormous ninth. The suture in this case is distinct toward the lateral margin but has wholly disappeared toward the median line.

URITE NINE appears to consist of a single sclerite; and in the absence of any spiracles on this segment it is a little puzzling to know whether it is sternite or tergite. Its relation to sternites eight and seven (Figs. B, D, K, L, N) makes it seem almost certainly a *sternite;* while the interpretation we have made of the tenth urite (calling the larger more convex sclerite the tergite) and the position of the penis (which we consider the appendage of urite nine) makes it seem equally certain that it is the *tergite* of nine that is represented. Most likely it is a fusion of both sclerites, completing the tendency cited above for these sclerites to fuse on the left side. In the absence of proof on this point we shall call the sclerite *urite nine.* This urite may extend farther basad on the right (Figs. A, B) or on the left or about equally on both (Figs. E, G, F, H), depending on the relative size of segments eight and ten. It is almost always larger than the preceding segments of the postabdomen and very frequently also much larger than the succeeding ones. It is very convex, the entire convexity forming about half a spheroid against the median diameter of which rests the base of the penis (Fig. O).

In the description of the segments of the postabdomen and of their appendages the peculiar flexure is of course kept in mind and the cardinal directions, aspects and margins are described *as they would appear if the abdomen were in the normal position.*

TERGITE TEN. Urite ten is the most highly developed of the postabdomen; and, in some of the genera (notably *Cnemodon* and *Pipiza*), (Figs. 17, 19, 23, Plate XI), it is the largest. Both tergite and sternite become very highly specialized. The tergite (see Figs. O, D, L, Plate IX) bears, towards its disto-lateral corners a pair of appendages, the styles, while its baso-lateral corners are a little, to much, produced ventrad and articulate to the sides of the basal rim of the penis (Figs. O, Plate IX; 6, Plate X; 34, Plate XII; 49, Plate XIII; and 76, Plate XIV). Its shape varies greatly, but is typically somewhat quadrangular in dorsal outline (Fig. 17, Plate XI; 69, Plate XIV), strongly convex dorsad and the sides flexed ventrad especially toward the base.

Its shape is much modified by the condition of the cerci or appendages of the eleventh urite, which are sunken into its distal margin to the most variable extent, sometimes almost imperceptibly so (Figs. 36, 38, 42, Plate X; 91, 95, Plate XVI; 133, Plate XIX; 109, Plate XVII), often about for half their length (Figs. 17, Plate XI; 2, Plate XV; 69, Plate XIV), in many other genera fully received (Fig. 55, Plate XIII), their apices just about reaching the apex of this segment. In *Pipiza* and its allies (Figs 20, 23, 25, Plate XI; 35, Plate XII) the tenth tergite is relatively very long and the cerci lie somewhat beyond midlength, while its much produced lateral arms extend far beyond them. In *Sphærophoria* (Figs. 1, 60, 63, Plate XV), the climax is seen; for the lateral arms have, in some species, entirely fused beyond the cerci so that the latter lie in the middle of the large hemispherical enveloping tergite. See below under cercal emargination.

THE TENTH STERNITE (Fig. O, Plate IX), has taken on peculiar modifications of function and structure. The caudal part of the basal rim of the penis articulates to it along its basal margin; while distad it articulates to the mesal face of the styles. It thus comes to serve in many genera as a lever between the powerful clasping organs (styles) at its apex and the rigid penis rim at its base. (Figs. 14, 18, 19, 20, 23, 25, Plate XI; 34, Plate XII). This has originated a strong tendency for the sclerite to divide on the middle line from apex more or less completely to its base, as, for example, in *Cnemodon*, *Pipiza*, *Psilota*, *Milesia*, etc., (Figs. 14, 25, Plate XI; 35, Plate XII; 119, Plate XVIII); and in a number of species it is completely modified into a pair of rod-like, heavily chitinized levers, between which is only a thinly chitinized membrane. In *Microdon tristis* (Fig. 129, Plate XIX) the median margins of these two rami are bent ventrad at right angles to stand upright, closely parallel to each other. In *Volucella* spp. it is produced into a curious erect finger-like projection near the point of articulation to the penis rim. It also enters into an elaboration with the mesal face of the style in several cases; for example, in *Blera badia*, to form a sharp thorn, and in *Eumerus* a rounded, hairy elevation, both directed toward the penis.

THE ELEVENTH URITE is for the most part represented only by its appendages, the cerci. However, in *Pipiza* and *Cnemodon* we find minute, chitinous sclerites, basad of these appendages, which may be the remnants of the tergite (Figs. 20, Plate XI; 35, Plate XII). In *Mesogramma* a transverse, triangular sclerite closing the cercal emargination (Fig. 43, Plate XIII) and in *Mixogaster* (Fig. 133, Plate XIX) a similar transverse piece I have interpreted as the eleventh sternite. In a good many other species there is a small hairy region, ventrad of the cerci, which I interpret as the remnant of the eleventh sternite (Figs. 122 and 127, Plate XVII; 31, Plate XII). And then there are the remarkable cases of *Cnemodon* and *Sphærophoria*. In these genera there are rather prominent processes (the sternal cornua and the post-anal hood) caudad of the cerci, which are continuous with the distal margin of sternite ten and which are possibly the much modified sternite of the eleventh urite.

The most reduced condition of the eleventh sternite (if indeed these structures be the eleventh sternite) that I have found is in the species *Sphærophoria novæangle*. In this species the tenth sternite is emarginate distad and in this emargination stands a small, quadrangular, almost hour-glass shaped plate, placed transversely and with a basal arm to each side of the tenth sternite. It is not produced beyond the base of the styles although very slightly beyond the tenth tergite and tends to close in the floor of the cercal emargination beyond the cerci. It is thus only a little displaced from relation to its tergite which, when present, subtends the cerci.

In *S. cylindrica*, *scripta*, *menthastri*, etc., with the fusion of the arms of the tenth tergite along the middle line closing the cercal emargination (*vide infra*) we believe that this eleventh sternite has become pushed distad and produced into two separate processes standing mesad of the styles. These are the processes referred to as sternal cornua (Figs. 1, 65, 66, Plate XV). They are outstanding, variously-pointed, compressed plates, the mesal walls of which are continuous at their bases with the tenth sternite while their lateral walls continue into the mesal faces of the styles.

In the genus *Pipiza* we find a structure that is unique among the sixty genera that I have studied and that may represent a greatly elaborated eleventh sternite. I have called it the post-anal hood. It consists of a prominent, thin, membranous expansion between the styles, with which it articulates at their bases, and it is also continuous basad with the tenth sternite. (See figures 12 to 26, Plate XI).

It is my belief that this simple plate of *S. novæanglæ*, the sternal cornua of *Sphærophoria* spp., and the post-anal hood of *Pipiza* spp. are homologous structures and they may represent the eleventh sternite.

THE CERCAL EMARGINATION. In the process of compacting the segments of the postabdomen into a more or less globose mass, the eleventh segment and its appendages (the cerci) have been received to a varying degree into the apex of the tenth tergite. This is made possible by the emargination of the caudal margin of this tergite and this emargination is called *the cercal emargination*. It varies extensively and affords many good generic characters. It is very deep and large in many of the Syrphinæ (Figs. 6, Plate X; 31, Plate XII; 51, 55, 57, 58, 59, Plate

XIII), often reaching nearly to the base of the tergite on the middle line. In *Pipiza* (Figs. 17, 23, 26, Plate XI) and *Sphærophoria* (Figs. 1, 60, 63, 68, Plate XV) it is remarkably deep and in some species of *Sphærophoria* it has completely closed caudad of the cerci so that the latter are embedded in tergite ten. In the *Milesinæ* and *Eristalinæ* it is relatively slight, but has the margin often somewhat elevated, rim-like (Figs. 90, 95, Plate XVI). In some genera (e. g., *Chrysogaster*, Figs. 36, 42, Plate X), it is practically undeveloped.

THE CERCI (acrocerci, Berlese; appendage iv, Newell; lamellæ, Lundbeck; epiproct, Crampton; forceps superiores, Wesche) are the simplest and least variable of the appendages. They are typically one-segmented, sessile, semi-oval, compressed and lie closely parallel at either side of the anal opening. They are covered with minute microtrichia and also scattered, longer hairs, usually arising from rather prominent basal rings and doubtless tactile or otherwise sensory in function. Since they are so closely incorporated into the structure of the tenth tergite, it has seemed best to describe their directions and margins like those of this sclerite. Their length, therefore, is the distance parallel to the mid-longitudinal line of the tenth tergite and their width the transverse distance perpendicular to this. In cases where they become elevated and protruding, their heighth is the maximum distance more or less perpendicular to the plane of the tenth tergite.

A part of the species of the genus *Chrysogaster* shows a peculiarity of the cerci not noted elsewhere in the entire family for they are sometimes (for example, *C. pulchella*), distinctly two-segmented. (Note Fig. 36, Plate X). In the other species they are one-segmented; but in several of them (for example, *C. pictipennis*), very distinctly emarginated about the middle. So that it is possible, in this genus alone, to arrange a series in which the cerci show a very gradual transition from the one-segmented, not emarginated condition, through various degrees of emargination to the distinctly two-segmented condition. If we consider this a stage in the specialization, by fusion, from an earlier multi-segmented condition, it places this genus as the most primitive of the family in this respect. But if we assume that the cerci in this group have, after an ancestral reduction to a single segment, again become divided, due to the emarginating tendency (noted also in other genera) it falls in line with the otherwise much specialized condition of the genus.

In correlation with the slighter development of the cercal emargination in some genera is the greater elevation of the cerci, either on their more basal end or on a slightly chitinized, bare, membranous petiole. In *Eristalis*, *Tropidia*, *Syritta*, *Ceriodes* and especially *Xylota*, they become very prominent relatively to the styles (see Figs. 91, 95, Plate XVI; 106, 110, Plate XVII; and 129, 131 and 132, Plate XIX), and the hairs, especially toward the apex, are larger and bristle-like. In *Microdon* they stand erect on a slender base, expanded, somewhat bilobed at apex. They are unusually poorly developed in *Brachyopa notata*.

STYLES (mesostyli, Berlese; appendage I, Newell; claws, Lundbeck; forceps inferiores, Wesche). The largest paired appendages of the postabdomen, with rare exceptions, are the styles. They are the appendages of the tenth segment (Fig. O, Plate IX), and stand more or less parallel to each other at the caudo-lateral corners of this segment. They articulate at base, typically broadly, to the tergite on the caudo-lateral margin and to the sternite on the cephalo-mesal margin; often the points of articulation are much restricted by emarginations of the tergite or the attenuation of the arms of the sternite.

The shape of the styles varies endlessly in the different genera and species. They usually afford a generic character and also frequently valuable specific characters. Typically they are erect, somewhat compressed and more or less adapted to clasp together, forceps-like. Such a simple condition is found in species of *Chrysotoxum* (Fig. 59, Plate XIII), *Syrphus* (Figs. 55, 56, Plate XIII), and *Mesogramma* (Figs. 43, 46, Plate XIII). Even in the most primitive that I find, there is a strong tendency toward the excavation of the mesal face, while the lateral surface is generally convex. From this medium condition there are several lines of departure. In one of them the style is progressively longer and more nearly cylindrical. Note *Paragus quadrifasciatus* (Figs. 9 and 10, Plate X), species of *Pipiza* (Figs. 12, to 26, Plate XI), *Chilosia* (Figs. 27 to 29, Plate XII), *Chrysogaster* (Figs. 36 to 41, Plate X), *Sphegina* (Figs 73, 74, Plate XIV), *Syritta* and *Eupeodes* (Fig. 134, Plate XIX). Almost invariably accompanying this elongation is a greater distortion evidenced by sharp curving mesad at apex (Figs. 12, 14, 17, 20, 21, Plate XI; 50, Plate XIII; 73, Plate XIV; 108, Plate XVII; 133, Plate XIX); by a curve near the base (Fig. 18, Plate XI; 40, 42, Plate X; 72, Plate XIV); or by curious bends and twistings somewhere about mid-length (Note Figures 2, Plate XV; 41, Plate X; 71, 79, Plate XIV, and 134, Plate XIX). The vestiture is almost always longer on the lateral surface and very often short and stiff or peg-like on the surfaces which are brought to contact when clasping, i. e., usually toward the apex on the mesal face. The apex also frequently becomes capitate, or serrate, or spurred or claw-like (Note Figures 24, Plate XI; 36, Plate X; 69, Plate XIV; 108, 109, Plate XVII; 134, Plate XIX).

A second line of departure from the typical, erect, compressed style is toward a greater broadening out cephalo-caudad to make an erect, short, thin style very wide cephalo-caudad. This is particularly characteristic of the genus *Sphaerophoria*, (Note Figures 1, 60, 66, Plate XV).

A third line of specialization is shown by many genera in the tendency to become forked or biramous or to develop an accessory lobe in addition to the principal one. This takes many forms and may be associated with either of the above types of style, i. e., with a long slender or a short broad one. This bilobed condition is very pronounced in *Sphaerophoria* spp., in which the lobes may be about equal in size (Fig. 66, Plate XV) or the caudal one much larger (Figs. 63 and 64) or the cephalic one larger (Fig. 60). Small lobes of various kinds and situations are found among the species of *Pipiza* (Note Figures 12, 16, 17, 20, Plate XI; Fig. 35, Plate XII) and *Sphegina* (Figs. 69, 70, 79, Plate XIV) in which species it is usually caudad of the principal ramus.

In spite of the numerous variations there is one general type so predominant that it would seem to have some value as indicating relationships. I refer to the style that shows a massive, erect, more or less pointed or attenuated ramus and from its base on the cephalic side a more or less compressed, orbicular lobe that guards the penis at either side and that very often is densely spinose on its mesal face. The general type and also something of the endless variations will be evident from a study of Figures 4, Plate XV; 83, 84, 88, 89, 92, Plate XVI; 102, 103, 105, 106, 107, 122 and 127, Plate XVII; 115, 116, 118, 120, Plate XVIII; and 129, Plate XIX. It is almost the predominant condition among Williston's groups *Eristalinæ* and *Milesinæ*, and almost entirely wanting among the *Syrphinæ*. Sometimes this cephalic lobe nearly equals or even exceeds in size the caudal lobe as in Figures 94, Plate XVI; 110, 126, Plate XVII, and 132, Plate XIX. Either one of the lobes may bear teeth or hooks or be otherwise modified away from the general type as in Figures 87, Plate XVI; 100, Plate XIX; 124, Plate XVII.

Finally in regard to the styles we may note certain very characteristic types for some of the genera so characteristic that I consider them of value in defining the limits of the genus. In *Sphaerophoria* (Figs. 1 and 60 to 66, Plate XV) there are short, very broad, much compressed styles, convex laterad, with a more or less rounded, very hairy caudal lobe and a more angular cephalic one, often with one or two spurs or sharp angles on the mesal face. In *Pipiza* (Plate XI, Figs. 12 to 26) there are erect, slightly compressed, forceps-like styles, bowing outward, curving, with an expansion usually toward the caudal side at base, slenderest about the middle with the apex expanded and typically provided with short, stout, peg-like hairs, about the point of contact with the one of the opposite side. In *Chilosia* (Figs. 27 to 29, Plate XII) we find an erect, almost straight style of varying length with sharp meso-caudal and meso-cephalic margins, the mesal surface between them slightly concave and with short spiny hairs toward its apex. Very often on the lateral face toward the caudal side there is a ridge or keel, in the more typical species highest basad and usually bearing long hairs.

In *Mesogramma* (Figs. L, Plate IX; 45, 46, Plate XIII) we note a thin, broad, flat somewhat quadrangular style, little specialized. The styles, alone, of the genus *Platychirus* will characterize the genus. They are bicornuate, the caudal horn from half as long as to of equal length with the cephalic horn; both compressed and convex laterad, and looking very much like the thumb and forefinger of one's partly opened hand.

In the genus *Sericomyia* (Figs. 108, 109, Plate XVII) we find a condition so peculiar and characteristic that on this basis one would feel justified in submerging the weakly characterized *Condidea*, since it has exactly similar styles. The styles are unsymmetrical (see discussion under this heading below). The right one is elongate, gradually attenuated and bent mesad in a long sharp claw. The left style terminates in a blunt rounded process, the base of which is encircled by an elevated keel, something like a single turn of the thread ridge on a screw.

The styles in *Tropidia* (Figs. 91, 92, 93, Plate XVI) are not only bilobed as in many of the *Eristalinæ* and *Milesinæ*, but the caudal, erect lobe has further developed a third lobe between the other two. The first one next the cerci is erect, thick and more or less clavate; the median one or baso-cephalic portion of the first (Figs. 91, 92, *a*) is strongly compressed, concave mesad, on which face it bears dense, short, stiff pile. The third lobe (*b*) stands erect and compressed alongside the penis. It is very wide, but short baso-distad.

In *Spilomyia* also the more caudal of the lobes of the style is likewise bilobed, but in this case it is brought about simply by an emargination near the apex of the caudal lobe. (See Figures 124 to 126, Plate XVII).

Irregular styles of noteworthy character are the bicornuate condition of a species of *Sphegina* (Fig. 80, Plate XIV) and of *Psilota buccata* (Figs. 33 and 34, Plate XII); and those of *Didea fasciata fuscipes* (Fig. 51, Plate XIII) which are shaped like an amphitheatre, with nearly perpendicular sides; they are very short and present the appearance of having been mashed over and then twisted around in a semicircle.

In *Xanthogramma* the style differs from its nearest ally, *Syrphus*, in having the caudal margin somewhat produced mesad, as a thin plate, reaching well toward that of the opposite side.

In describing the styles, besides base, apex, mesal and lateral, I have used especially caudal and cephalic margins or faces, (Fig. O, Plate IX). These relations are considered the same as those of a leg, with which the style is probably homologous.

Penis (phallus, Berlese; theca, Wesche; appendage II, III, Newell; copulatory or intromittent organ of authors). The penis is invariably the largest appendage of the postabdomen. It is unpaired and generally considered to represent the fused appendages of segment nine. It arises from the caudo-ventral portion of the ninth segment and is articulated also to the base of segment ten; both to the inflexed and more or less produced, basal corners of the tergite by the sides of its basal rim (Figs. O, Plate IX; 1, *a*, Plate XV; and 34, Plate XII) and to the cephalic margin of the tenth sternite on the caudal part of its basal rim (Fig. 14, Plate XI).

The penis is a complicated organ that may be understood best if we consider it as being composed of two systems: (I) The axial system, composed of the ejaculatory duct and its associated structures and (II) The peripheral system, composed of the penis sheath and its appendages. The latter may be thought of as a hollow cylinder or truncated cone, open at each end, within which the former system lies along the axis. But the two systems do not ordinarily articulate with each other at any point.

The parts of each system will now be considered as follows: I, The axial system: *a*, the ejaculatory process; *b*, the chitinous box; *c*, the ejaculatory hood; *d*, the internal lobes; *e*, the sustentacular apodeme; *f*, the ejaculatory sac and *g*, the ejaculatory apodeme. II, The peripheral system: *h*, the penis sheath and its basal rim; *i*, the cephalic emargination; *j*, the lingula; *k*, the superior lobes and *l*, the inferior lobes.

A. THE AXIAL SYSTEM OF THE PENIS.

The terminal continuation of the ejaculatory duct, called the ejaculatory process, and the associated structures present a surprising variation in the different genera and even in very closely related species. All these parts are evidently in a process of rapid evolution and hence afford excellent specific characters, but yield a very meager amount of data as to phylogeny of groups. The entire known range of variation may be found almost in a single genus.

(a). THE EJACULATORY PROCESS: The orifice of the duct, one of the important landmarks, is often difficult to locate. It varies from a very minute aperture (*Chrysogaster*, *Mesogramma*, *Helophilus*, *Criorhina*, *Microdon*, etc., Figs 37, 38, 41, Plate X; 86, 91, Plate XVI; 97, 129, 130, Plate XIX; 111, 112, 115, 129, Plate XVIII) to a moderate sized one, (*Sphegina*, *Didea*, Figs. 51, *d*, Plate XIII; 75, *d*, 76, Plate XIV; 100, *d*, Plate XIX) to a comparatively large mouth (*Baccha*, *Chilosia*, *Rhingia*, Figs. 21, 25, 26, Plate XI; 3, 4, Plate XV; 5, 11, Plate X; 32, 33, 34, 30, Plate XII; 102, Plate XVII). In position it varies from being sessile on the face of the globular or hood-like chitinous box (*vide infra*) as in *Hammerschmidtia*, *Eumerus strigatus*, *Copestylum marginatum*, *Cynorhina analis*, *Milesia virginiensis*, *Helophilus*, (Figs. 115, 117, Plate XVIII) to being elevated at the apex of a tube, short and delicate in *Helophilus* spp., (Fig. 86, Plate XVI), *Criorhina nigripes* (Fig. 111, Plate XVIII) and *Mesogramma* (Fig. 45, Plate XIII, in some species of which it turns a complete loop before its termination), heavy in *Rhingia*, *Chrysogaster* spp., *Pipiza*, *Sphegina*, (Figs. 40, 41, Plate X; 19, 24, 26, Plate XI; 32, 34, Plate XII; 69, Plate XIV), longer and delicate in *Criorhina nigra*, still longer and heavy in other species of *Criorhina*, and long, very heavy and distorted in *Baccha* sp. In other cases it is continued to the termination of a long, sometimes extremely long and slender tube, single in *Chrysogaster* spp., *Mallota posticata*, *Mixogaster breviventris*, *Crioprora cyanella* (Figs. 118, Plate XVIII; 133, Plate XIX; 36, 37, 38, Plate X); double in *Microdon* and *Ceriodes*, (Figs. 129 to 132, Plate XIX); in the former the two tubes both on the median line, the split transverse, and one tube may be much shorter; in the latter the two placed right and left, the split longitudinal. And from being thus subtended by a rigid, chitinous support, we find variations to a support, chitinous, basad, but delicate, inflated and collapsable at apex, (*Chilosia*, *Syrphus*, *Chrysotoxum*, *Eupeodes* Figs. 27, 29, Plate XII; 49, 50, 53, 59, Plate XIII; 134, Plate XIX); and to a condition in which it is surrounded by a delicate flexible and inflated hyaline membrane as in *Sphaerophoria* (Figs. 1, 60, 63, 64, 67, 68, Plate XV).

(b). THE CHITINOUS BOX: There is often near the apex of the penis, standing mediad, a more or less globose or pyriform or variously shaped expansion called by Berlese the chitinous box (Figs. 27, Plate XII; 49, 50, 56a, 53, Plate XIII; 62, 67, 68, Plate XV; 76, Plate XIV; 91, Plate XVI; 97, 100, 129, 130, Plate XIX; 102, 105, *a*, 127, Plate XVII; 112, 118, *d*, 119, Plate XVIII). This is variously supported as described for the different species, but typically rests on the apex of the sustentacular apodeme (*vide infra*). The ejaculatory duct may pass through such a chitinized body before its termination and the orifice of the duct, when sessile, is usually toward the apex on its cephalic face. When an ejaculatory process is present it is an outgrowth of the chitinous box either from its cephalic face (Figs. 38, 40, 41, Plate X; 45, Plate XIII; 119, 120, Plate XVIII), from its apex (Figs. 1, 60, Plate XV; 27, 28, Plate XII), or as in *Syrphus* and the related genera (Figs. 49, 50, 54, Plate XIII; 67, 68, Plate XV) the box is collar-like, widely open distad, and the ejaculatory process arises from within the box towards its caudal side. When the ejaculatory process is greatly elongated, the chitinous box is often displaced well toward the base of the penis sheath (e. g., *Microdon*, *Ceriodes* and *Mixogaster*, Figs. 129 to 133, Plate XIX).

(c). THE EJACULATORY HOOD: Besides the ejaculatory aperture and process the chitinous box often bears a median structure on the caudal side, that, from its more typical shape, has been called the *ejaculatory hood*. It overhangs the aperture of the duct when it is sessile or on a short process (Figs. 2, 3, Plate XV; 5, 6, 9, 10, 11, Plate X; 13, 18, 19, 21, 23, 25, Plate XI; 27, 30, 32, 35, Plate XII; 40, 41, 47, 48, Plate X; 45, 46, 51, *c*, Plate XIII; 74, 75, 76, *c*, 77, *c*, 81, 82, Plate XIV; 89, Plate XVI; 102, 103, 105, 106, 107, Plate XVII; 111, 112, 113, 114, 115, 119, 120, Plate XVIII; 97, 131, 132, 133, 134, Plate XIX) or, if the process is very long, it may support and protect the apical part of it as in *Chrysogaster* spp. (Figs. 38, 39, Plate X) in *Xylota* spp., and in *Mallota posticata*.

In other cases it is difficult to decide whether to consider the elaborations of the chitinous box an ejaculatory hood (*Syrphus*, *Sphaerophoria*) or internal lobes (*vide infra*) or simply a part of the chitinous box. The ejaculatory hood may be entirely wanting as in *Xylota* spp., *Chilosia*, and *Microdon*. When present it almost always affords a specific character. In some cases it helps to define a genus as in *Paragus*, *Cnemodon*, *Calliprobola*, *Xylota*, *Criorhina*, etc. Or it may serve to show something of the relationships of certain genera as in the *Xylota*, *Cynorhina* and *Criorhina* groups, which show a rather characteristic cordate hood in many of their species, (Figs. 105 to 107, Plate XVII; 111 and 115, Plate XVIII).

A few of the more remarkable developments of the ejaculatory hood are in *Chrysogaster pulchella* where, with the ejaculatory process, it resembles one of a pair of tongs (Figs. 36, 37, Plate X). In *Chrysogaster* generally it is much elaborated, often simulating a bird's head, (Figs. 38, 41, 48, Plate X). In *Teuchocnemus* (Figs. 96 and 100, Plate XIX) it is a long V-shaped affair, and in *Xylota fraudulosa* and *Mallota posticata* it takes the form of a long, shallow trough that forms a beautifully-adapted support for the remarkable ejaculatory processes of those species. It is remarkably long in *Ceriodes* spp., and shows some very interesting specializations in *Mesogramma.* In this genus there is also sometimes a short, erect, subcylindrical process *cephalad* of the ejaculatory aperture that looks very much like an ejaculatory process and would be mistaken for such if one did not follow the ejaculatory duct, which does not open into it.

(d). INTERNAL LOBES: For those appendages or projections of the chitinous box that neither immediately surround and support the ejaculatory duct, as the ejaculatory process does, nor stand in the median caudal position, as the ejaculatory hood does, I have used the term *internal lobes.* These are lateral in position, are paired and are claspers in function. They are at most of two pairs, respectively caudal and cephalic in point of attachment to the apex of the chitinous box. Such lobes are developed in *Pipiza* (Fig. 35, Plate XII), in which they are a pair of erect, narrow plates prolonged into acute points; in *Mesogramma* (Figs. 45, 46, Plate XIII). In *Sphegina lobata* (Fig. 70, *e*, Plate XIV), they are flattened plates; in an unnamed species of *Sphegina* they are remarkably developed and remarkably unsymmetrical cornua as shown in Figure 72, Plate XIV; in *S. petiolata* (Figs. 74 and 75, Plate XIV) and *S. rufiventris* (Figs. 76 and 77) they are symmetrical and not greatly unlike those of *Pipiza femoralis.* In *Baccha* sp. they are large thin plates guarding the sides of the remarkable ejaculatory process. Other examples of the internal lobes are shown in *Pterallastes* and *Teuchocnemis* (Figs. 96, 97, 100, Plate XIX) in *Xylota* spp. (Fig. 106, Plate XVII), *Chilosia* spp., *Sericomyia* (Fig. 109, Plate XVII), *Criorhina* spp. (Figs. 112, 113, Plate XVIII), *Milesia* (Fig. 119), *Mallota posticata* and *Temnostoma* (Figs. 123, 128, Plate XVII).

Besides the external parts certain internal structures have been considered. The gonads and their efferent ducts and accessory glands have not been studied; but the ejaculatory sac, the piston-like ejaculatory apodeme often associated with it, the efferent ejaculatory duct, and the chitinous, reinforcing sustentacular apodeme, (which gives support to the penis, especially to the chitinous box at its apex, and to which muscles attach that serve to rotate and protrude the parts); these parts are generally evident in the cleared preparations, they often show characteristics of systematic value and consequently they have been described in connection with the external genitalia.

(e). THE SUSTENTACULAR APODEME has been called by Wesche the double apodeme, and he states that it is often a paired organ in many families of the Diptera; in others partially fused; and again entirely united on the median line. In the Syrphidæ it is typically a single rod, having its base in segment nine and projecting to a variable distance into the penis along or near the long axis. It does not articulate with the body wall of segment nine, nor with the penis sheath except rarely as in *Sphegina rufiventris* and *petiolata;* but is held in place by muscles, some of which originate on it and others of which attach to it. At its apex it supports the chitinous box together with any ejaculatory process, ejaculatory hood and internal lobes that may be present. It evidently functions in supporting, reinforcing and directing these latter parts during copulation; at which time they apparently have movements somewhat independent of the penis sheath and its appendages.

Some idea of its variations will be gained from the following statement. It is practically straight and cylindrical in *Chilosia*, *Lasiophthicus*, *Eristalis*, *Volucella*, *Copestylum*, etc., and may be either long and slender as in *Pipiza* and *Hammerschmidtia* or short as in *Baccha* (Note Figures 17, 19, Plate XI; 56, Plate XIII; 67, Plate XV) or long very heavy and enlarged basad, as in *Mesogramma*. Very commonly it is a bent rod, conforming often to the general shape of the penis sheath as in *Allograpta*, *Blera*, *Condidea*, *Brachyopa*, *Tropidia*, *Syritta*, *etc*., (Figs. 93, Plate XVI, 114,. Plate XVIII), or bent at base only as in *Pipiza* spp., (Fig. 35, Plate. XII) or bent to the left at base as in *Chilosia* (Figs. 28, 29, 30, Plate XII). Frequently instead of being cylindrical, it is compressed as in *Milesia*, *Callicera*, *Temnostoma*, *Bachyopa*, *Asemosyrphus* and *Mallota posticata;* sometimes distinctly sword-shaped as in *Melanostoma* and *Cnemodon* spp. It tapers more or less evenly from apex towards the base in *Helophilus* spp. (Fig. 83, Plate XVI). It is commonly expanded at its base as in species of *Chrysogaster*, *Criorhina*, *Triodonta*, *Mesogramma*, *Tropidia*, *Syritta*, and *Asemosyrphus* (Figs. 37, 47, Plate X; 70, Plate XIV), rarely about the middle, as in *Sericomyia* and *Sphegina* sp. (Fig. 76, Plate XIV) and almost always more or less so at its apex in adaptation to the chitinous box. This latter expansion may be noted, for example, in *Paragus*, *Platychirus*, *Allograpta*, *Brachyopa*, *Somula*, *Milesia*, *etc*. (Figs. 5, Plate X; 25, Plate XI, 67, Plate XV; 114, Plate XVIII). Sometimes the expansion has associated spurs or thorns, as in *Pipiza* spp., or it may be flattened and tongue-like, projecting cephalad as in *Syrphus*, *Eristalis* and *Chrysotoxum*, or such tongue may project caudad from the apex as in *Sphaerophoria* and *Sphegina* spp.; or it may be a flattened transverse plate. In a number of cases there are sharp thin keels or ridges running lengthwise of the apodeme probably of use for the attachment of muscles. Such keels may extend full length or over only a part of base, apex or middle. Such a keel is found on the caudal side of the apodeme in *Didea fasciata fuscipes*, and in *Pipiza* spp. (Fig. 25, Plate XI), while a similar ridge occurs on the cephalic face in *Eupeodes volucris* and *Syrphus* spp.

I have not found it in the paired condition in this family, although it is forked near the apex in Rhingia (Fig. 32, Plate XII) and from about the middle, distad, in *Paragus tibialis* (Fig. 11, Plate X); while in *Teuchocnemis* it is forked at the base. In *Pterallastes thoracicus* (Fig. 97, Plate XIX) it is triradiate toward the base, the median ray shorter, and standing more cephalad, the lateral rays extending caudad. In *Sphegina petiolata* (Fig. 75, Plate XIV) it is also split into three forks toward the base, but all three of these forks stand in the median sagittal plane. Rarely the sustentacular apodeme appears to be wanting as in *Microdon*.

(f). The Ejaculatory Sac is an expansion of the efferent ejaculatory duct at its proximal end. It often takes the form of a bottle or flask and in almost every case has attached to it at its proximal end (the bottom of the flask) a chitinous rod or sclerite which may be called *the ejaculatory apodeme.*

(g). The Ejaculatory Apodeme is often a complicated mechanism and it presents interesting variations that will well reward a complete exposition by some careful investigator. The typical condition of this sclerite appears to be an umbrella or toad-stool shaped piece which attaches to the bottom of the flask-like ejaculatory sac by the end of its handle (base of its stipe) while from the circumference of the base of the flask to the margin of the umbrella or pileus extend numerous delicate muscle fibers. The contraction of these fibers forces the piston-like part of the apodeme (the handle of the umbrella or the stipe of the toad-stool, as one pleases to think of it) into the bottom of the sac, collapsing the latter and expelling its contents with force. Such an umbrella-like arrangement is found in species of the following genera: *Paragus* (Fig. 11, Plate X), *Chrysogaster* (Figs. 36, 37, 41, 47, Plate X), *Calliproobola, Xylota, Spilomyia, Pterallastes, Brachypalpus* and *Temnostoma.*

A somewhat similar mechanism, but with the basal expansion of the apodeme small and knob-like or globular instead of umbrella-like, is found in *Sphegina* (Figs. 75, 76, Plate XIV), *Sericomyia, Hammerschmidtia, Brachyopa. Condidea lata* shows a rather larger basal expansion intermediate between the above and the umbrella-like form. In *Tropidia* and *Xylota* spp., one finds a very gradual and slight enlargement basad. A small curved rod with moderate *distal* expansion either gradual or abrupt, occurs in *Platychirus* spp., *Melanostoma* spp., *Chrysotoxum, Syrphus, Xanthogramma, Blera, Baccha.* In *Blera scitula* the rod is unusually long. A small curved rod without either a basal or distal expansion occurs in some species of *Pipiza, Chilosia, Mesogramma, Psilota buccata* (Fig. 33, Plate XII), *Helophilus* spp., *Cynorhina.*

In *Helophilus* spp., *Microdon* spp., *Eumerus strigatus* and *Somula decora* there is a large sub-triangular, flat sclerite with the apex adjoining the ejaculatory sac. In *Temnostoma, Ceriodes* and *Microdon* it is very large, with a short cylindrical handle and a broad, flat, somewhat fan-shaped basal blade. In *Mixogaster breviventris* it is similar with a longer handle and a spade-like blade with sharp shoulders and sides flaring out to a greater width at the base than next the handle.

In *Syritta pipiens* I find a flat, broom-like sclerite not unlike that in some of the species mentioned above; but at the point where the cylindrical "handle" terminates is a transverse piece composed of a median rounded expansion and two wings, the whole very similar in appearance to the head of a thumb screw.

The most elaborately developed ejaculatory apparatus yet noted is that in *Didea fasciata fuscipes.* The apodeme is broom- or spade-like, with a handle not a fourth as long as the expanded part, the latter with rounded shoulders, parallel sides and broader than long; its area nearly as great as that of the tenth tergite. The ejaculatory sac appears to enclose a chitinized bow or curved bar which expands Y-shaped at each end, at which points many muscles attach. The short handle of the apodeme attaches to the membranous sac opposite the middle of the bow.

I have not found the ejaculatory apodeme in certain species of *Sphegina*, *Sphaerophoria*, *Teuchocnemus*, nor in *Eupeodes volucris*.

B. THE PERIPHERAL SYSTEM OF THE PENIS.

(h). THE PENIS SHEATH is usually a heavily chitinized, truncated cone, cylinder or tube, attenuated distad. It has an especially heavy, basal rim, by which it is articulated and rotated. The rim is usually longer cephalo-caudad than in transverse diameter, the cephalic half of the rim almost always about semi-circular, but the caudal part becomes variously angulated against the base of the tenth sternite and the sides likewise swollen or angulated, or with apophyses to the basal corners of the tenth tergite. In some genera the caudal part is bent into quite another plane than the cephalic part. In many of the *Milesinæ* the basal part of the sheath is larger and globose on the cephalic face, the apical part more nearly cylindrical. (Note Figures 3, Plate XV; 83, 89, Plate XVI; 102 to 107, Plate XVII; 112, 115, 119 and 120, Plate XVIII).

The penis sheath is most often smooth and glabrous. But in certain genera it is highly specialized both in vestiture and by keels, tubercles and furrows of various kinds. In most species of *Temnostoma* there is an area of long delicate hairs on each side near the base. In *Criorhina* and *Milesia* there is often a diffused vestiture on the cephalic face of the penis sheath. In *Helophilus* spp. (Figs. 83, 85, 89, Plate XVI), *Tropidia albistylum* (Fig. 91) and certain species of *Xylota* (Fig. 107, Plate XVII) we note long or short heavy hairs, bent basad in such a way as to suggest a tenaceous value, in addition to others scattered promiscuously over the cephalic face of the penis that are more erect and delicate.

Irregularities of the surface of the penis sheath are often in the form of transverse, more or less parallel corrugations on its cephalic face, as illustrated in Figures 91, Plate XVI; 102, 103, 123 and 128, Plate XVII; 115, Plate XVIII. They are peculiarly unsymmetrical in *Somula decora* (Fig. 120). Tubercles of various kinds occur—symmetrical (Figs. 111, 127) or unsymmetrical (Fig. 72, *e*, Plate XIV), large (Fig. 113) or small (Fig. 86, Plate XVI); usually on the cephalic face but rarely on the caudal face as in *Pipiza pisticoides* (Figs. 19, 20, *h*, Plate XI), where an extremely thin keel runs lengthwise on the caudal face and in *Eupeodes volucris* where we note characteristic ribbed ridges at the caudo-lateral corners (Figs. 134, *c*, Plate XIX).

Berlese in describing *Eristalis tenax*, divides the sheath into "two canals (epiphallus and hypophallus)" separated by a longitudinal line on each side and supposedly representing respectively the contribution made to this complex appendage by segments eight and nine. I do not believe that these parts have any morphological significance. The line is, I think, only a reinforced line along which the chitin is heavier. It is not at all constant in the various species. Similar reinforced lines run in various directions across or along the sheath. Note *Sphegina petiolata* (Fig. 75, *x*, Plate XIV), *Criorhina nigripes*, *umbratilis* and *verbosa* (Fig. 111, *d*, Plate XVIII), *Mallota posticata*, *M. sackeni*, *Blera badia* (Fig. 116, Plate XVIII), *Merodon equestris*, *Somula decora* (Fig. 120, Plate XVIII), *Brachyopa notata*, etc. The penis sheath is typically emarginated at the apex on both cephalic and caudal faces, between which at each side project the so-called lateral arms or wings of the sheath, bearing the inferior and superior lobes at their apices.

(i). The Cephalic Emargination takes a great variety of forms and often shows a specific character. It is most often narrowly or broadly U or V shaped (Figs. 3, Plate XV; 5, 38, Plate X; 20, Plate XI; 35, Plate XII; 50, Plate XIII; 76, Plate XIV; 87, Plate XVI). In *Paragus bicolor* (Figs. 5 and 6, Plate X) the penis sheath about its margin is ornamented with many close-standing short spines.

(j). The Lingula. The cephalic emargination may be partly filled by a projection from the sheath that I have called *the lingula* which is also very variable and so of value in specific determination as in *Syrphus* spp., *Blera confusa*, *Milesia virginiensis*, *Xylota curvipes*, etc. (Note Figures 47, 48, Plate X; 52, 53, 54, 55, 56, Plate XIII; 86, Plate XVI; 96, Plate XIX). It stands between the inferior lobes as a tongue-like, unpaired, emarginated or paired extension of the penis sheath on the middle line. It may be forked at apex or modified into an apical scoop-shaped notch that may stand in direct opposition to the termination of the ejaculatory duct or, when the latter is elongate, surround and support its base. It is highly developed in *Paragus* (Figs. 5, 6, 11, Plate X). The lingula may in a series of species become so large as to nearly fill the cephalic emargination and since it is often emarginated at its own apex, there are cases where it is difficult to decide whether the apex should be called a lingula or simply the cephalic emargination. (Note *Paragus bicolor*, Figures 5, 6, Plate X).

The emargination on the caudal face of the penis is much less varied in character and, on this account and because of the difficulty of exposing it, has little taxonomic value.

In a few genera, notably *Microdon*, *Mixogaster* and *Triodonta*, (Figs. 129 and 133, Plate XIX) the penis sheath is completely interrupted on the caudal face, except for a very slight basal rim, and the margins are infolded or rolled entad and free-standing. This is apparently a highly specialized and not a primitive condition.

The penis-sheath usually bears at its apex certain specializations which may take the form of definitely articulated appendages, or which may be simply prolongations of the sheath, itself, without an articulation. Because of the similarity in function and often in appearance and the practical difficulty of telling whether there is an articulation in many cases, I have called both kinds of processes *lobes*—superior lobes when they are disto-caudal in position, inferior lobes when disto-cephalic in position.

Both pairs are present in *Hammerschmidtia ferruginea*, *Brachyopa notata*, *Chilosia* spp., (Figs. 27, 30. Plate XII) *Rhingia nasica* (Fig. 32, Plate XII). In *Microdon* and *Mixogaster*, there are neither inferior nor superior lobes (Figs. 129, 130 and 133, Plate XIX).

(k). THE SUPERIOR LOBES are usually larger than the inferior ones and when only one pair is present it is usually clearly the inferior lobes which are wanting. In *Chilosia*, however, the superior lobes are regularly smaller (Figs. 27 to 30, Plate XII). Like the styles these lobes are subject to the greatest modification of shape, size and vestiture. There appears to be considerable correlation between their development and the simplicity of the styles: that is, the more complicated and efficient the styles the less developed are the penis lobes (note *Calliprobola*, *Sphærophoria*, *Eupeodes*, *Sphegina*, *Xylota*, *Criorhina*); and when the styles are simple the penis lobes are often highly developed (*e. g.*, *Chilosia*, *Paragus*, *Rhingia*). Their more typical form appears to be a compressed, ovate, erect lobe, standing parallel to the sagittal plane and attenuated somewhat distad, (Note Figs. 19, 25, Plate XI; 46, 49, 50, Plate XIII). But from this shape we find the greatest variation, which can best be appreciated by a reference to the accompanying figures. Frequently they are more cylindrical and erect (Figs. 4, Plate XV; 34, Plate XII; and 87, Plate XVI) and may be enlarged distad (Figs. 36 and 37*e*, Plate X) or much pointed distad (Fig. 113, Plate XVIII) or incurved toward each other (Fig. 83, Plate XVI) enhancing their prehensile value; sometimes with serrations, (Fig. 40, Plate X). Frequently these serrations take the form of a definite ctenidium as shown in Figures 30, 32, Plate XII; 91, 93, Plate XVI; 107, 123, Plate XVII; 111 to 113, Plate XVIII. Many species have poorly differentiated, shapeless or irregular superior lobes very difficult to describe (Note Figures 96, 100, Plate XIX; 102, 104, 127, Plate XVII; 115, 118, Plate XVIII; 86, 89, Plate XVI). They are not infrequently bare but often have developed hairs, bristles, spines, serrations, claws or lamellæ. They are peculiarly drooping behind the penis in *Paragus* (Figs. 6, 9, Plate X) and in *Sphærophoria* (Figs. 1, 60, 63, Plate XV).

(l). THE INFERIOR LOBES arise at the cephalo-lateral corners of the apex of the penis-sheath. They are generally smaller than the superior lobes. They appear to be best developed in *Paragus*, (Figs. 5, 6, 11, Plate X), *Chrysogaster*, (Figs. 36 to 39), *Chilosia* (Figs. 27 to 30, Plate XII), and *Pipiza*, (Figs. 18, 19, 21, 23, 25, 26, Plate XI), and *Blera* (Figs. 115, 117, Plate XVIII). They are often more or less horn-like, though not infrequently simple lamellæ-like projections of the corners of the penis-sheath.

ASYMMETRY.

Typically, the asymmetry in this family is very strictly confined to the last segment of the preabdomen and the segments of the post-abdomen, cephalad of the tenth. But in many species this tendency has spread also to the tenth urite and to the genital appendages. When unsymmetrical it is almost always the left side or the left appendage that is shortened or toward which the parts are bent. Most often the cerci and styles are affected while the penis and its parts remain perfectly symmetrical; not infrequently both the former and latter take part in the asymmetry and in other cases, curiously enough, the penis and its appendages are unsymmetrical, while the styles and cerci are not or but slightly so. All kinds of combinations occur as the following examples will show. The cerci alone are unsymmetrical in *Microdon* spp. (Fig. 129, Plate XIX). The styles alone in *Blera scitula*, *Hammerschmidtia ferruginea* and *Ceria signifera*. The superior lobes only in *Mesogramma subannulata*. The inferior lobes only in *Chilosia* spp. (Figs. 27 to 29, Plate XII). The internal lobes only in *Mesogramma parvula*. The ejaculatory process alone in *Baccha* spp. The sustentacular apodeme alone in *Chilosia cyanea* (Fig. 30, Plate XII). The cerci and styles both are slightly unsymmetrical in *Crioprora cyanella*, (Fig. 118, Plate XVIII), *Blera badia*, (Fig. 116, Plate XVIII) and *Chrysogaster pulchella* (Fig. 37, Plate X). The cerci slightly and the styles very much distorted in *Sericomyia* (Figs. 108, 109, Plate XVII), *Criorhina verbosa*, *Xylota* spp. (Figs. 104 to 107, Plate XVII) and *Hammerschmidtia*. The cerci are very unsymmetrically placed and the styles only slightly affected in *Xylota curvipes* and *flavitibia*. Both cerci and styles are much affected in *Calliprobola* (Figs. 3, Plate XV; 102 and 103, Plate XVII). The cerci, styles and superior lobes are all unsymmetrical in *Chrysogaster* sp. (Figs. 40 to 42, Plate X), and *Temnostoma venusta* and *bombylans*. The cerci, styles and ejaculatory hood in *Xylota ejuncida* and *obscura* (Fig. 107, Plate XVII), *Condidea lata* and *Teuchnocnemis* (Figs. 96 and 98 to 100, Plate XIX). The cerci, styles, superior and inferior lobes of *Pterallastes thoracicus* (Figs. 97, 101, Plate XIX). The cerci, styles, ejaculatory hood and superior lobes of *Xylota subfasciata* (Fig. 105, Plate XVII). The most unsymmetrical parts that I have seen are those of a species of *Sphegina*, in which practically every part is unsymmetrical, and most of them very highly so—cerci, styles, superior, inferior and internal lobes, penis sheath, ejaculatory hood and ejaculatory process.

FUNCTIONS.

The organs described above (the postabdomen and its appendages) appear to have evolved in correlation with several different functions, in the probable order of their importance as follows:

1. Introducing the germ cells to the vagina of the female.
2. Clasping or holding the female during mating.
3. Mechanical protection of the parts.
4. Sensation.

It is surprising to note the variety of structures utilized in what one would suppose to be the very homogeneous operation of introducing the spermatozoa to the vagina. In many cases there is simply a larger or smaller aperature on the face of the ejaculatory hood or chitinous box near the apex of the penis. In other genera and species we find this aperature elevated to the end of a long or short, heavy or slender, cylindrical or clavate or tapering, and membranous or highly chitinized tubule, the so-called ejaculatory process. The termination of such ejaculatory apparatus may be in an inflatable membrane, or between spinose or serrated lips or a simple aperature of varied size and shape. Even in the species of the same genus these organs may vary tremendously (cf. *Xylota bicolor* and *Xylota vecors*, for example). (See also under ejaculatory process, above). It will be very surprising if these structures are not found to have correlated peculiarities in the females.

The necessity of clasping and holding the female during mating has been most fruitful in producing variations of the appendages. The cerci alone appear not to have taken part in this variation except in rare cases. The styles have developed the greatest variety of structures for the clasping function. Not only does the shape of the parts vary, but they are greatly enhanced in efficiency by the specialization of the vestiture, especially over their mesal faces, toward the apex. This begins as a stiffening of the hairs, accompanied by shortening; the culmination of the process results in very heavy, sharp or dull pegs, sometimes scarcely longer than their diameter. Frequently the styles are bilobed and either caudal or cephalic lobe may be of most value as a clasping organ. Besides the vestiture one or other of the lobes frequently develops a tooth or claw or finger, of endlessly-varied shape. Rarely the inflexed sides of the tenth tergite are prolonged into processes, evidently of use in this connection (*Volucella*, *Microdon*). Again as in *Tropidia* and *Sphegina*, there are processes or bristles on the fifth sternite, which assist in grasping the abdomen of the female. Various parts of the penis-sheath, its lobes and appendages have been adapted for prehension. The most important of them are the superior lobes, and the inferior lobes; but in many species the internal lobes connected with the elaboration of the ejaculatory hood are especially important in this respect. Even the ejaculatory hood itself is sometimes adapted for grasping and the various bristles and keels or processes of the penis-sheath, described in the above pages, doubtless often have a prehensile value.

For the mechanical protection of the parts, the heavily chitinized sternites and tergites of the postabdomen, especially nine and ten, are well adapted. Of even greater importance is the introversion of the base of the postabdomen between the terminal sternite and tergite of the preabdomen, to form a genital pouch. (See above). Contributing toward the investment of the delicate appendages are also the downbent sides of the terminal tergite of the preabdomen (the fifth or sixth) and the basal segments of the postabdomen on the left.

The only organs which would appear from gross dissection to have a sensory function are the cerci. The fact that they are, I believe, without exception wholly or partly exposed even when the other parts are all well retracted beneath heavy protecting sclerites, and the nature of the hairs on their exposed surfaces, which are long and arise generally from quite conspicuous rings, seem to point to them as the "antennæ" of the postabdomen; in this family, probably exclusively tactile.

TAXONOMIC VALUE OF THE GENITALIA.

A character to be really satisfactory for taxonomic purposes must meet several requirements. First and most important, it must be constant intraspecifically; or, if it vary, at least its variations in a given species must not overlap the development of the structure in the related species. Second, it must show great variation interspecifically, the greater the better. The number of species is so great in the class Insecta, that a really intricate structure is demanded if we are to find characters for all sufficientlly different to permit of recognizable description. Third, the character should be one that is readily available.

It is axiomatic that all parts of living organisms vary. But it appears that in the cases where they have been carefully tested for variability, the genitalia show a constancy greater than that of almost any other external part of the insect, possibly because they have assumed a position whereby they are practically internal and so protected from the stimulus of the external environment. I have not examined them by the hundreds or thousands, but in several common species of different genera, I have mounted from a dozen to twenty individuals, collected from points as remote as Mississippi, British Columbia, North Carolina, California, Minnesota, Maine, Ohio, Montana, Arizona, Michigan and Colorado. While occasionally one may find a slight variation in the number of hairs or bristles on a given part or a slight variation in the shape of a margin, they are always so remarkably similar that any one would place them together without the least hesitancy.

In regard to variation between species I do not believe any group of structures will be found, that so admirably fulfills this requirement. Nature seems to have run wild in developing many of the structures one finds in the terminal, abdominal appendages of insects.

In regard to the availability of the characters of the genitalia, it must be admitted that this is the chief, if not indeed the only, real objection to their use in taxonomy. The parts are in this family completely retracted except during mating. Undoubtedly the preliminary preparation, such as relaxing and clearing in potash, that is required will at once limit the number of students who will make use of these characters. But it is hardly complimentary to entomological perseverance, if we allow difficulties of this nature to be an ultimate bar to the utilization of the greatest single group of taxonomic characters that insects possess. The further hopeful feature is that, when these parts have been carefully worked out for a group, subsequent students will often be able to make use of the characters, without clearing, by simply comparing the opaque parts of the fresh or relaxed specimen.

It may be objected that the process of removing the genitalia mutilates the specimen. But if the specimen is fresh or well-relaxed and one uses moderate care, the removal of the modified terminal segments is not a matter of any seriousness. All the parts generally used in taxonomy are left intact; and a specimen with the mounted genitalia unmistakably associated with it is in my opinion not damaged but greatly enhanced in value.

Another criticism of the genitalic method is that, in the process of mounting, especially in treating with caustic potash, the parts are likely to be variously distorted and so lead to serious taxonomic errors. This criticism should be anticipated in every investigation and any possible variable effect of the method of preparation checked by examining the parts before clearing and by preparing in several different ways. It would seem that the fact that numerous mounts made at different times and by varying methods are identical to the most minute detail, is sufficient answer to this criticism, so far as the Syrphidæ are concerned. In fact the parts herein considered are almost all heavily chitinized and not likely to be distorted either by clearing or by the pressure of the cover glass. Of course one would not derive taxonomic characters from such parts as the delicate, inflatable membrane terminating the ejaculatory duct in *Sphærophoria*, for example.

One matter of genuine difficulty is that it is often hard to define the characters that give to these parts a peculiar and easily recognizable *facies*. The appendages are generally very irregular figures of three dimensions; and in the more complex forms nothing short of a figure of the parts in two or more aspects, together with a careful description is adequate to convey a real impression of their makeup. But however difficult the interpretation of these parts may be they have the essential points of intraspecific constancy and interspecific variability to a degree hardly equaled by any other set of organs.

A point of great value in the use of these structures is their usefulness in the case of mutilated specimens. Alcoholic, rubbed, or broken specimens are often wholly unintelligible from the standpoint of the characters generally employed. The genitalia, however (protected within the hard, enveloping sclerites of the abdomen), are apt to be the last parts to be injured. Interesting and valuable applications of this knowledge will at once occur to every one; as in the examination of the contents of avian or amphibian stomachs, or the elucidation of valuable, but poorly-preserved, type specimens or others of historic value.

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EXPLANATION OF PLATES.

ABBREVIATIONS AND GLOSSARY.

Except in Figures A to H, Roman numerals are used to indicate the successive urites, both for the tergites and for the sternites.

Caud. Int. L.	*Caudal internal lobes.*
C. Emarg.	*Cercal emargination,* the emargination at apex of tergite ten, into which the cerci are received to a varying degree.
Ceph. E.	*Cephalic emargination,* an emargination on the cephalic face of the penis sheath near the apex.
Ceph. Int. L.	*Cephalic internal lobe.*
Cer.	*Cercus.*
C. B.	*Chitinous box,* a chitinous mass at the apex of the penis through which the ejaculatory duct may pass and to which are articulated or joined the ejaculatory hood, the ejaculatory process and the internal lobes.
Ejac. Apod.	*Ejaculatory apodeme,* a chitinization attached to the ejaculatory sac.
Ejac. Dct.	*Efferent ejaculatory duct.*
Ejac. Hd.	*Ejaculatory hood,* a projection from the chitinizations surrounding the ejaculatory duct which stands caudad of the ejaculatory duct on the median line.
Ejac. Pr.	*Ejaculatory process,* a prolongation from the chitinous box. which surrounds the ejaculatory duct in cases where the orifice of the duct is elevated above the chitinous box.
Ejac. Sac.	*Ejaculatory sac.*
G. P.	*Genital pouch,* a depression near the apex of the venter of the abdomen, into which the penis, styles, etc., are received when not in use.
Inf. Lob.	*Inferior lobe,* the more cephalic of two pairs of lobes or appendages arising from the apex of the penis sheath.
Int. Lob.	*Internal lobe,* one of two pairs of lobes or appendages associated with the chitinous box or with other chitinizations about the ejaculatory duct.
Lingula	A median tongue-like process from the apex of the penis sheath on its cephalic face.
L. Caud. Int. L.	*Left caudal internal lobe.*
L. Cer.	*Left cercus.*
L. Inf. Lob.	*Left inferior lobe.*
L. S.	*Spiracle* of the left side.
L. Sup. Lob.	*Left superior lobe.*
Postabdomen	The caudal four or five urites of the abdomen that have been greatly modified in conformity with the genital appendages.
Post-anal Hood	A median ornamental expansion standing caudad of the anus and between the styles.
Preabdomen	The unmodified, four or five urites of the cephalic part of the abdomen.
R. Caud. Int. L.	*Right caudal internal lobe.*
R. Cer.	*Right cercus.*
R. Ceph. Int. L.	*Right cephalic internal lobe.*
R. Inf. Lob.	*Right inferior lobe.*
R. S.	*Spiracle* of the right side.
R. Sty.	*Right style.*
R. Sup. Lob.	*Right superior lobe.*
S.	*Sternite.*
Sc.	*Scutellum.*
Stern.	*Sternite.*
Sty.	*Style.*

Sup. Lob.......... *Superior lobe,* the more caudal of two pairs of lobes or appendages arising from the apex of the penis sheath.
Sust. Apod........ *Sustentacular apodeme,* an internal, chitinous rod lying along the axis of the penis.
T................. *Tergite,* the tergum of an abdominal segment.
Terg.............. *Tergite.*
U................. *Urite,* an abdominal segment.
Sternal Cornua..... A pair of processes standing caudad of the anus and mediad of the styles.
Sup. Lob.......... *Superior lobe,* the more caudal of two pairs of lobes or appendages arising from the apex of the penis sheath.

Other legends are explained in connection with the several Figures. The number preceded by * in the explanation of the Figures is the serial number of the specimen from which the illustration was made.

PLATE IX.

Fig. A. Dorsal view of abdomen of *Chilosia* sp., with the genitalia in the retracted position.
Fig. B. The same in ventral view.
Fig. C. Tip of abdomen of *Temnostoma* sp., with the genitalia in the retracted position. Dorsal view.
Fig. D. The same in ventral view.
Fig. E. Tip of abdomen of *Microdon* sp., with the genitalia in the retracted position. Dorsal view.
Fig. F. Tip of abdomen of *Syrphus arcuatus,* with the genitalia in the retracted position. Ventral view.
Fig. G. The same in dorsal view.
Fig. H. Tip of abdomen of *Chrysotoxum* sp., in ventral view, showing the genitalia in the retracted position.
Fig. I. The same in dorsal view.
Fig. K. Dorsal view of abdomen of *Mesogramma geminata,* with the genitalia partly exposed.
Fig. L. Tip of abdomen of the same more enlarged and in ventral view.
Fig. M. Tip of abdomen of *Eristalis* sp. from the right side, with the genitalia and postabdomen extended to show especially the course of the right lateral conjunctiva and the position of the spiracles.
Fig. N. Tip of abdomen of *Eristalis* sp. from the left side, with the postabdomen and genitalia extended to show the course of the left lateral conjunctiva and the position of the spiracles.
Fig. O. A diagrammatic representation of the various parts represented in the male genitalia of the Syrphidæ, dextro-cephalic view; *A*, cephalic margin of the style; *B*, caudal margin of the style.

PLATE X.

Fig. 5. *Paragus bicolor;* ventro-cephalic view of genitalia (*132). *a*, apophysis from penis sheath to base of superior lobes, equivalent to the lateral wings of the penis sheath in other genera; *b* and *c* caudal and cephalic lateral horns, respectively, of penis sheath at each side.
Fig. 6. The same in lateral view. Captions as in Figure 5. The short, slender spine from the apex of the sustentacular apodeme is shown in black between the base of the cephalic horn of penis sheath (*c*) and the base of the inferior lobes.
Fig. 9. *Paragus quadrifasciatus,* disto-lateral view of genitalia (*183). *b*, the two teeth from the apex of the sustentacular apodeme.
Fig. 10. The same in distal view. *b*, the more caudal of the two teeth from the sustentacular apodeme.
Fig. 11. *Paragus tibialis,* ventro-cephalic view of genitalia (*175).

Fig. 36. *Chrysogaster pulchella;* caudo-lateral view of genitalia (*131). *a*, thorn on inferior lobe a little laterad of the cephalic margin; *c*, thorn on cephalic margin of inferior lobe at point of fusion of the two lamellæ; *d*, tooth on the mesal lamella of inferior lobe; *e*, the deer's-head-like, disto-caudal termination of the superior lobe.

Fig. 37. The same in cephalo-lateral aspect; *a*, *c*, and *e* as in Figure 36; *b*, thumb-like projection at disto-caudal angle of inferior lobe; *f*, the joint of basal rim of penis at the point of articulation with the tenth tergite; *g*, caudo-basal continuation of the inferior lobe to the penis rim; *h*, slender apophysis of left side of penis rim to base of tenth sternite.

Fig. 38. *Chrysogaster parva;* genitalia (*254) from the right side. *a* and *b*, bispurred, disto-caudal termination of the inferior lobe; *c*, more cephalic, apical finger of superior lobe; *d* and *e*, the two spurs at the apex of the more caudal finger of the superior lobe; *f*, the "breast" of the bird-head-like ejaculatory hood.

Fig. 39. The same, in caudo-distal aspect. Captions as in Figure 38.

Fig. 40. *Chrysogaster* sp.; ventro-cephalic view of genitalia (*253).

Fig. 41. The same, in cephalo-lateral aspect. *a*, basal offset of style.

Fig. 42. A disto-caudal view of cerci and styles. Captions as in Figure 41.

Fig. 47. *Chrysogaster nigrovittata;* genitalia (*162) in cephalic aspect. *d*, opening of the ejaculatory duct; *f*, serrate flaps, overhanging the opening of the ejaculatory duct.

Fig. 48. The same, from the right side. *a*, emargination of the tenth tergite at base of style.

PLATE XI.

Fig. 12. *Pipiza nigribarba;* cephalic view of styles, post-anal hood and apex of penis (*200). *d*, the termination of the ejaculatory duct. The heavy bristles shown on the left style arise on the caudal face of the style and their bases should not be shown in this view nor in Figure 14.

Fig. 13. The same, in distal aspect. *a*, the sclerites communicating between the styles, the tenth sternite and the post-anal hood. The post-anal hood is shown in caudal aspect between the styles and the parts marked *a*, at each side, and the cerci and apex of the penis at the ends.

Fig. 14. The same, in cephalic aspect; with the penis displaced cephalad, showing the tenth sternite and cephalic aspect of the post-anal hood. *a*, as in Figure 13; *b*, pilose side walls of post-anal hood; *c*, the free-standing base of the post-anal hood.

Fig. 15. *Pipiza pisticoides;* disto-cephalic view of the post-anal hood and left style (*135). *a*, the distal, upturned end of the post-anal hood; *b*, semi-globular, spinose crown of the post-anal hood, one of the best characteristics of the species; *c*, squarish prominence of the caudal face of post-anal hood; *d*, the free-standing basal prolongations of the membranes on the cephalic face of hood; *e*, the apophysis-like rod from caudal face of the hood to the tenth sternite and styles, and forming the entire support of the hood; *f*, the double, drooping, median keel of cephalic face of hood; *g*, angular apophysis near base of style.

Fig. 16. The same, in dorso-caudal aspect. Captions as in Figure 15.

Fig. 17. *Pipiza pulchella;* dorso-caudal view of the genitalia (*134); the penis shown in cephalo-lateral aspect. *a*, chitinous box at apex of sustentacular apodeme; *c*, cephalic ramus of the inferior lobes; *d*, ear-like flaps at apex of post-anal hood. APOD is an error for SUST. APOD.

Fig. 18. The same in cephalo-lateral view; the penis in about a distal view. Captions as in Figure 17.

Fig. 19. *Pipiza pisticoides;* genitalia from the right side; the right style removed to expose the post-anal hood. Captions *a* to *g* as in Figure 15; *h*, sharp, median keel on caudal face of penis; *i*, short spur from apex of sustentacular apodeme.

Fig. 20. The same in cephalo-lateral aspect. Captions as in Figures 15 and 19.

Fig. 21. *Pipiza australis;* ventro-cephalic view of genitalia (*223).

Fig. 22. *Pipiza calcarata;* dorsal view of apices of cerci and arms of tergite ten; the styles and post-anal hood seen in caudal aspect (*138). *a*, the upturned distal end of the hood; *b*, the concave side walls of the hood; their cephalic margins, after a sharp turn caudad, fuse just above the letter *c*, in the Figure; *d*, chitinized supporting bow of the side walls *b; e*, pilose convexity on the apophyses from base of hood, connecting with base of the style and the apex of the tenth sternite on each side and constituting the only supports of the hood; *k*, distal arms of the tenth sternite.

Fig. 23. The same; genitalia in side view. *f*, the free-standing, basal extensions of the setose membrane (*g*, Figure 24); *g*, the baso-cephalic continuation of the framework margining the upturned part of the hood. Other captions as in Figure 22.

Fig. 24. The same; ventro-cephalic view of genitalia. *g*, setose membrane stretching across the cephalic face of the hood; *i*, tendon-like rod from base of hood into the tenth segment; *m*, aperature to the inside of the hood. Other captions as in Figures 22 and 23.

Fig. 25. *Pipiza (Heringia) heringi;* ventro-cephalic view of genitalia (*198).

Plate XII.

Fig. 27. *Chilosia similis;* ventro-cephalic view of genitalia (*387 and 412). *b*, cephalo-lateral keel of styles; *c*, caudo-lateral keel of styles.

Fig. 28. *Chilosia tristis;* ventro-cephalic view of genitalia (*370). *a*, the caudal excavation on blade of left inferior lobe. Other captions as in Figure 27.

Fig. 29. *Chilosia pallipes;* ventro-cephalic view of genitalia (*415). Captions as in Figure 27.

Fig. 30. *Chilosia cyanea;* ventro-cephalic view of genitalia (*402).

Fig. 31. *Rhingia nasica;* distal view of genitalia (*320). The right style omitted to expose the penis lobes.

Fig. 32. The same, in cephalic view. Right half of urite ten and right style omitted. *a*, swollen lateral portion of basal rim of penis.

Fig. 33. *Psilota buccata;* genitalia (*140) in ventro-cephalic view. *A*, median ramus of left style; *B*, lateral ramus of right style.

Fig. 34. The same, more enlarged and in cephalo-lateral aspect. *A*, as in Figure 33; *B*, lateral ramus of left style; *a*, apophysis from the right side of basal rim of penis to the tenth sternite; *b*, thickened lateral margins of tenth sternite; *c*, median split in the tenth sternite; *d*, the less chitinized median portion of the tenth sternite; *e*, catenulated area of superior lobe.

Fig. 35. *Pipiza femoralis;* cephalo-lateral view of genitalia (*137). *a*, tongue-like extension from basal rim of penis to the base of tenth sternite; *b*, palmate lobe at cephalo-distal angle of superior lobe; *c*, prominent teeth at caudo-distal corners of superior lobes; *d*, boot-like apophysis from base of right superior lobe to the chitinous box at apex of sustentacular apodeme; *e*, lateral emargination of apex of penis sheath; *f*, cephalo-lateral arms or wings of penis-sheath.

Plate XIII.

Fig. 43. *Mesogramma geminata;* dorso-distal view of genitalia and tenth tergite. (*233).

Fig. 44. The same, in cephalo-ventral aspect (*232).

Fig. 45. *Mesogramma polita;* ventro-cephalic aspect of genitalia (*321).

Fig. 46. The same, from the right side.

Fig. 49. *Didea laxa;* lateral view of genitalia (*154).

Fig. 50. The same, in cephalic aspect.

Fig. 51. *Didea fasciata fuscipes*, caudo-distal view of genitalia (*204). *a*, central lobe of trituberculate ejaculatory hood; *bb*, earlike tuberosities of ejaculatory hood; *cc*, the overhanging flaps of the collar-like, chitinous box; *d*, the opening of the ejaculatory duct or ejaculatory process.

Fig. 52. *Syrphus arcuatus;* ventro-lateral view of genitalia (*210). *b*, spurs at cephalic ends of collar-like chitinous box.

Fig. 53. *Syrphus xanthostomus;* lateral view of genitalia (*201). *b*, spurs at cephalic ends of collar-like chitinous box; *c*, apical tongue of sustentacular apodome.

Fig. 54. *Syrphus knabi;* disto-ventral view of genitalia (*205). *b* and *c*, as in Figure 53; *a*, the cephalic keel of sustentacular apodome.

Fig. 55. The same, in lateral view. Captions as in Fig. 54.

Fig. 56. *Syrphus amalopis;* lateral view of genitalia (*209). *a*, erect chitinous box.

Fig. 57. *Xanthogramma tenuis* Osburn (=Syrphus oronoensis Mtclf.) disto-lateral view of genitalia (*208).

Fig. 58. *Chrysotoxum derivatum;* caudo-distal view of genitalia (*201).

Fig. 59. *Chrysotoxum pubescens;* caudo-distal view of genitalia (*202).

Plate XIV.

Fig. 69A. *Sphegina lobata;* dorsal view of preabdomen, the genital appendages seen in their cephalic aspect. The course of the left longitudinal tracheal trunk is shown from spiracle 5 to spiracle 8.

Fig. 69B. *Sphegina lobata;* ventral view of preabdomen, the genital appendages seen from their caudal aspect (*18). *a*, ejaculatory hood; *b*, apex of ejaculatory process; *c*, superior lobes; *d*, slightly thickened, apical rim of penis-sheath; *e*, chitinous box; *f*, caudal ramus of right style; *s*, point of fusion of ejaculatory process to ejaculatory hood; *t*, tongue-like caudal projection from between the bases of the internal lobes.

Fig. 70. The same, genitalia from the right side. Captions as in Figure 69, except *e*, the internal lobes arising from the chitinous box; *v*, angle of sustentacular apodome, beyond which it widens, in cephalic aspect.

Fig. 71. *Sphegina* sp.; dorsal view of terminal segments of the postabdomen, showing the caudal aspect of the appendages (*222). *a*, the cephalic ramus of the right style.

Fig. 72. The same, genitalia from the left side. *aa*, cephalic rami of the styles, offset mesad from the base of the caudal ramus as shown to the right of the letter *c; bb*, the lever-like arms of the tenth sternite, which operate between penis rim and apices of cephalic rami of the styles; *e*, basal swelling of the cephalic face of the penis sheath.

Fig. 73. *Sphegina petiolata;* ventral view of preabdomen, the genital appendages shown from their caudal and distal sides, (*17 and 170). *a*, an anomalous, caudal lobe of the penis-sheath; *c*, the acute, cephalo-distal angle of the superior lobe; *o*, the membranous lobe projecting from under the fifth sternite.

Fig. 74. The same, in disto-lateral view. *s*, caudo-internal lobe of right side, seen through the lateral wing of the penis-sheath; *k*, chitinous arm reinforcing the bonnet of the ejaculatory hood; *o*, caudo-distal angles of superior lobes. Other captions as in Figure 73.

Fig. 75. Ventro-cephalic view of the same. *b*, rudimentary inferior lobes?; *d*, the termination of the ejaculatory duct; *f*, the open cephalic face of the ejaculatory hood; *s*, transverse septum between cephalic face of ejaculatory hood and opening of ejaculatory duct; *m*, cephalic ray of sustentacular apodome; *n*, median or principal ray of sustentacular apodeme; *x*, a reinforced line across the cephalic face of the penis-sheath. (other captious as in Fig. 73).

Fig. 76. *Sphegina rufiventris;* cephalo-lateral view of genitalia (*4, 5, 7); *a*, the cephalic emargination of the penis-sheath; *c*, bonnet-like hood overhanging the ejaculatory process.

Fig. 77. The same; a ventral view of the apex of the preabdomen showing the genitalia in distal view (*168); *a* and *c* as in Figure 76; *b*, interlocking tubercles on the mesal face of the superior lobes; *d*, notch in caudal margin of sternite five above which is shown the group of characteristic heavy black spiny hairs.

Fig. 78. *Sphegina* sp. (*24). Ventral view of sternite five, the genitalic appendages seen in their caudal aspect; *a*, the caudal ramus of the right style.

Fig. 79. The same, right style more enlarged.

Fig. 80. *Sphegina* sp. (*23). Ventral view of sternite five, the appendages seen in caudal aspect.

Fig. 81. *Sphegina infuscata;* cephalo-lateral view of the genitalia (*169). *s*, peculiar larynx-like ring or shelf at apex of sustentacular apodeme.

Fig. 82. The same, in disto-caudal view (*19).

PLATE XV.

Fig. 1. *Sphaerophoria* sp.; male genitalia (*38) in ventro-lateral aspect, slightly exposed; *a*, an apophysis from tergite ten to the penis rim; *b*, finger-like projection at cephalo-distal corner of style; *c*, sharp tooth terminating the submarginal keel of the style; *d*, the submarginal keel; *e*, a sclerite almost completely separated from tergite ten, at its baso-lateral corners.

Fig. 65. *Sphaerophoria scripta;* cephalo-lateral aspect of genitalia (*173).

Fig. 64. *Sphaerophoria* sp.; genitalia (*263), in cephalo-lateral aspect.

Fig. 62. *Sphaerophoria sulphuripes;* genitalia (*142) in cephalic aspect.

Fig. 63. The same; in lateral view.

Fig. 66. *Sphaerophoria menthastri;* genitalia (*257), cephalo-lateral view of styles.

Fig. 60. *Sphaerophoria* sp.; lateral view of genitalia (*149).

Fig. 61. The same; in cephalic aspect.

Fig. 67. *Sphaerophoria micrura;* cephalic view of genitalia (*145).

Fig. 68. The same; in caudo-lateral aspect, showing also the terminal urites.

Fig. 4. *Xylota bicolor;* cephalo-lateral view of genitalia (*277). See also Fig. 110, Plate XVII.

Fig. 2. *Chrysogaster* sp.; caudal view of genitalia (*292); *a*, cephalic margin of superior lobe.

Fig. 3. *Calliprobola crawfordi;* cephalic aspect of genitalia (*285).

PLATE XVI.

Fig. 83. *Helophilus similis;* ventro-cephalic view of genitalia (*245). *a* and *b* mark the caudal and cephalic lobes respectively of the style in this and following Figures.

Fig. 84. The same, side view of cercus and style.

Fig. 85. *Helophilus obsoletus;* ventro-cephalic view of genitalia (*249), the left style omitted.

Fig. 86. *Helophilus bilinearis;* ventro-cephalic view of genitalia (*243); left style in part omitted.

Fig. 87. *Helophilus latifrons;* ventro-cephalic view of genitalia (*246); right style omitted.

Fig. 88. The same, side view of style and cercus.

Fig. 89. *Helophilus lunulatus;* ventro-cephalic view of genitalia (*244).

Fig. 90. *Helophilus* sp.; lateral view of genitalia (*242).

Fig. 91. *Tropidia albistylum*, ventro-cephalic view of genitalia (*256); *a*, basal lobe on cephalic side of caudal lobe of style; *b*, cephalic lobe of style.

Fig. 92. The same, lateral view of cercus and style, showing the outline of the several lobes. Captions as in Figure 91.

Fig. 93. *Tropidia quadrata;* ventro-cephalic view of genitalia (*288). Captions as in Figure 91. APOD is an error for SUST. APOD.

Fig. 94. *Helophilus modestus* (=*Tropidia cooleyi* Seemans, cotype) lateral view of genitalia (*270).

Fig. 95. *Tropidia quadrata;* lateral view of the apex of preabdomen and genitalia to show especially the specialization of sternite five.

Plate XVII.

Fig. 102. *Calliprobola aldrichi;* ventro-cephalic aspect of genitalia (*284).

Fig. 103. *Calliprobola pulcher;* ventro-cephalic aspect of genitalia (*283).

Fig. 104. *Xylota vecors;* ventro-cephalic view of genitalia (*281); *d*, erect caudal lobe of the style; *a*, cephalic lobe of the style.

Fig. 105. *Xylota subfasciata;* ventro-cephalic view of the genitalia (*276); *a*, chitinous box. Other captions as in Figure 104.

Fig. 106. *Xylota chalybea*, ventro-cephalic view of the genitalia (*278); *a*, hook or claw of left internal lobe. Other captions as in Figure 104.

Fig. 107. *Xylota obscura;* ventro-cephalic view of the genitalia (*282); *f*, chitinous box, homologous to that shown at *a*, in Figure 105. Other captions as in Figure 104.

Fig. 108. *Sericomyia militaris;* cephalic view of genitalia (*224). *a*, the small bonnet of the ejaculatory hood. On the right of the letter *a*, is shown the right cercus; while at either side of the bonnet is the erect internal lobe. Between the inferior lobes is the lingula.

Fig. 109. The same, from the left side.

Fig. 110. *Xylota bicolor;* lateral view of genitalia (*277). Compare Plate XVI, Figure 4. Captions as in Figure 104.

Fig. 122. *Spilomyia interrupta;* ventro-cephalic view of genitalia (*255); *a*, caudal lobe of style; *b*, cephalic lobe of style.

Fig. 123. *Temnostoma venusta;* ventro-cephalic view of genitalia (*295). *d*, caudal lobe of style; *e*, cephalic lobe of style.

Fig. 124. *Spilomyia longicornis;* lateral view of right style (*229). Captions as in Figure 122.

Fig. 125. *Spilomyia quadrifasciata;* lateral view of right style (*228). Captions as in Figure 122.

Fig. 126. *Spilomyia fusca;* genitalia (*227) from the right side. Captions as in Figure 122.

Fig. 127. The same, in ventro-cephalic view. Captions as in Figure 122.

Fig. 128. *Temnostoma aequalis;* ventro-cephalic view of genitalia (*294). *k*, baso-mesal keel of superior lobe. Other captions as in Figure 123.

Plate XVIII.

Fig. 111. *Criorrhina nigripes;* ventro-cephalic view of genitalia (*310). *a*, caudal lobe of right style; *b*, cephalic lobe of style; *c*, mesal, thumb-like process from caudal lobe of style; *d*, median pair of keels on penis-sheath; *e*, lateral pair of keels on penis-sheath; *x*, characteristic ctenidium of superior lobes.

Fig. 112. *Criorrhina* sp. (*312); ventro-cephalic view of genitalia. Captions as in Figure 111.

Fig. 113. *Criorrhina* sp. (*313); ventro-cephalic view of genitalia. Captions as in Figure 111.

Fig. 114. *Blera scitula;* cephalic view of left style and penis (*311); *f*, distal cap or pileus of superior lobe.

Fig. 115. *Blera notata;* cephalic view of genital appendages (*324), the right style omitted; *a*, erect caudal lobe of style; *b*, cephalic lobe of style; *c*, baso-cephalic thumb or process from caudal lobe of style; *e*, emargination between caudal and cephalic lobes of style; *k*, lateral keel of lingula.

Fig. 116. *Blera badia;* ventro-cephalic view of genitalia (*301). Captions as in Figure 115.

Fig. 117. The same, apex of penis more enlarged. *k*, basal, elevated, continuation of lingula; *o*, lyre-like excavation of base of lingula; *m*, *n*, *p*, the three points of the left superior lobe.

Fig. 118. *Crioprora cyanella;* (*315), ventro-cephalic view of genitalia. *a,* cephalic claw from left superior lobe; *b,* termination of ejaculatory duct; *c,* right internal lobe; *d,* chitinous box; *e,* apical lobe of ejaculatory hood; *f,* caudal lobe of right style; *g,* cephalic lobe of right style. The vestiture of styles and lobe is not shown.

Fig. 119. *Milesia virginiensis;* ventro-cephalic view of genitalia (*319). *a,* thinly chitinized, apical portion of the superior lobe.

Fig. 120. *Somula decora;* cephalic view of left style and penis (*306). *a,* erect, caudal lobe of style; *c,* the baso-lateral prolongation to the tenth tergite; *b, b,* cephalic lobe of style which approaches the one of the right style, caudad of the penis; *k,* sinuate keel at sides of penis-sheath to basal prominence above articulation of tergite ten (*d*).

PLATE XIX.

Fig. 96. *Teuchocnemis litturatus;* distal view of genitalia (*238). *a,* apical hook of styles; *b,* keel on lateral face of styles; *c,* cephalic lobe of styles.

Fig. 97. *Pterallastes thoracious;* ventro-cephalic view of genitalia (*241). *a,* blunt, median thumb of inferior lobe; *b,* lateral finger of inferior lobe; *c,* lingula with a small V-shaped notch at apex; just above the notch is seen the small aperture of the ejaculatory duct; *e,* caudo-distal hooks of superior lobes; *f,* cephalo-distal hooks of superior lobes; *g,* swollen basal plate, forming baso-cephalic part of superior lobes.

Fig. 98. *Teuchocnemis litturatus;* left style in lateral view. Captions as in Figure 96.

Fig. 99. The same, right style in lateral view. Captions as in Figure 96.

Fig. 100. The same, genitalia in cephalic aspect; *d,* termination of ejaculatory duct. Other captions as in Figure 96.

Fig. 101. *Pterallastes thoracicus;* genitalia from the right side. *d,* small thorn at base of superior lobes.

Fig. 129. *Microdon tristis;* ventro-lateral view of genitalia (*423). *a, a,* caudal part of basal rim of penis; *b,* infolded caudal margins of the penis sheath, which is not continuous on the caudal surface; *c,* hairy prominence on lateral margin of tenth sternite; *d,* caudal lobe of style; *e,* cephalic lobe of style.

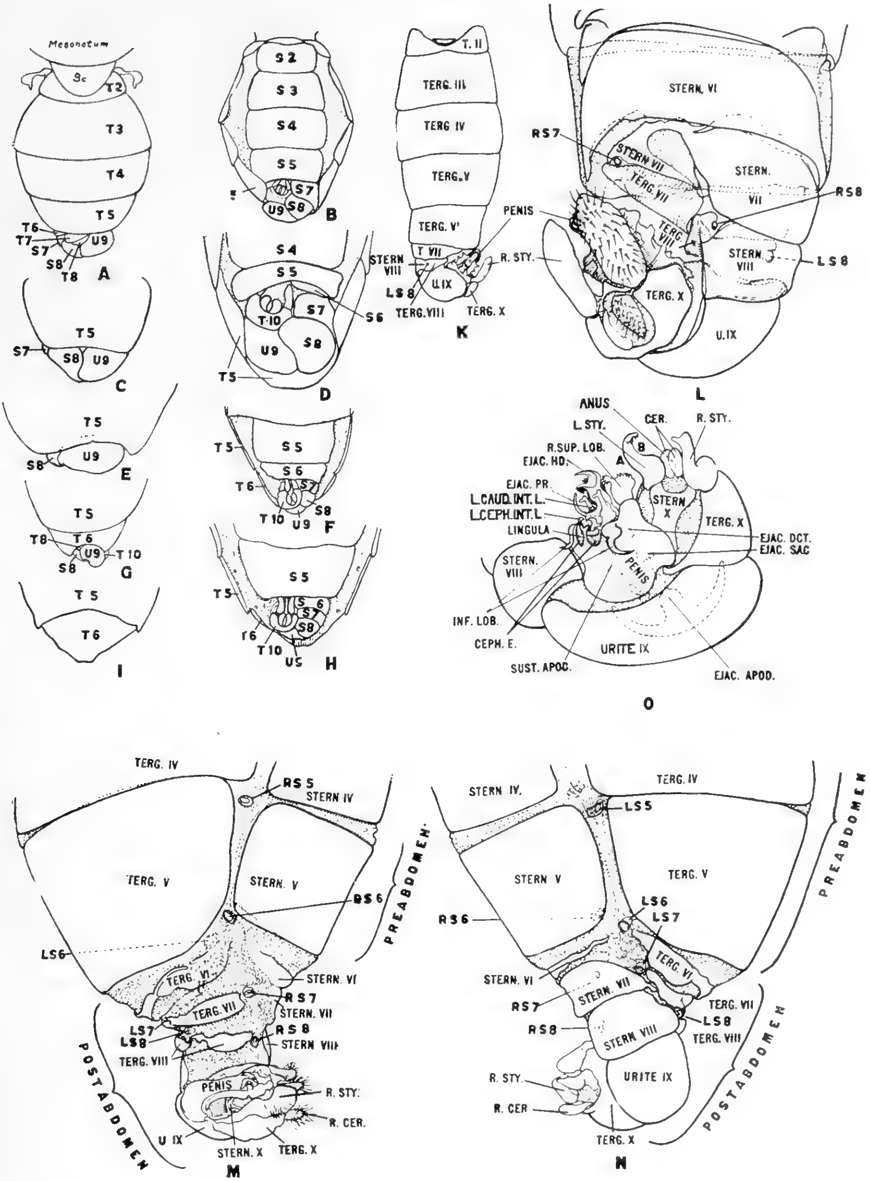
Fig. 130. *Microdon fuscipennis;* ventro-cephalic view of genitalia (*423). *f,* hairy concavity on lateral surface of tenth tergite. Other captions as in Figure 129.

Fig. 131. *Ceriodes tridens;* ventro-cephalic view of genitalia (*317).

Fig. 132. *Ceriodes abbreviata;* ventro-cephalic view of genitalia (*316).

Fig. 133. *Mixogaster breviventris;* ventro-cephalic view of genitalia (*159).

Fig. 134. *Eupeodes volucris;* ventro-lateral view of posabtdomen and genitalia (*153). The penis has been separated along the line *b* from the mesal margins of segments VI, VII and VIII; *a,* disto-ventral projection of slender basal part of tenth tergite; *b,* left side of basal rim of penis; *c,* horny disto-lateral keel of penis-sheath; *d,* cephalic face of penis-sheath; *e,* caudal face of penis-sheath; *f,* depression of sternite vi, to form a shallow genital pouch.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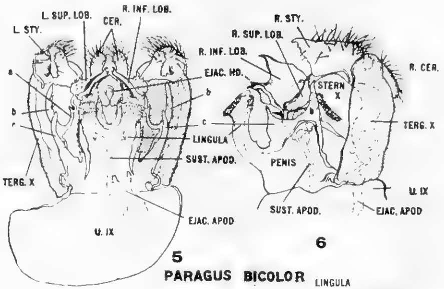

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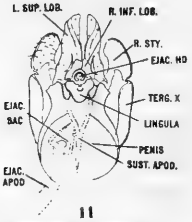

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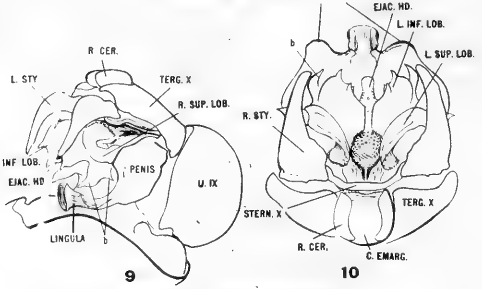

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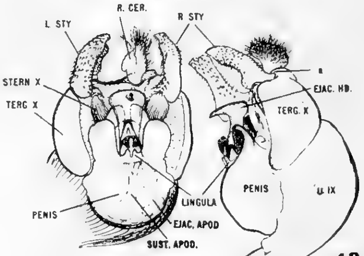

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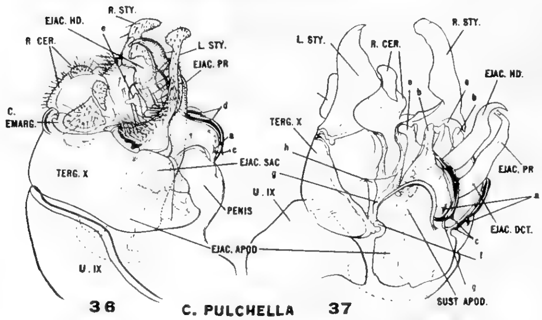

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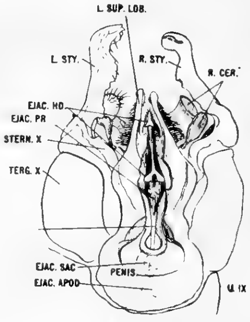

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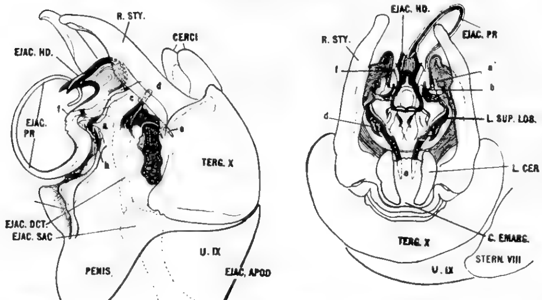

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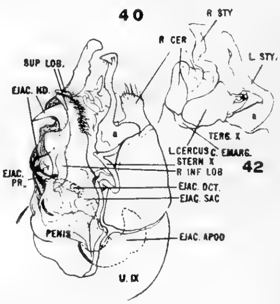

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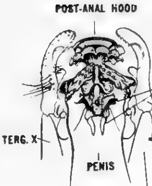

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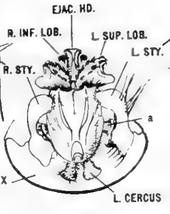

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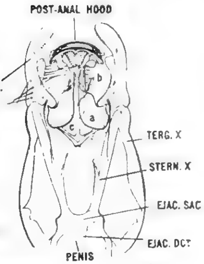

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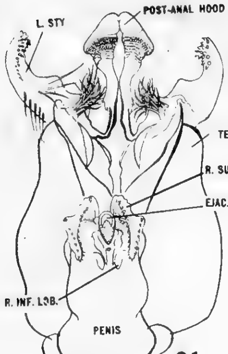

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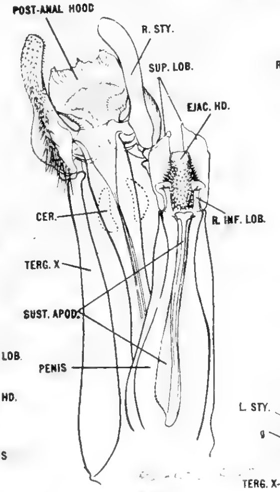

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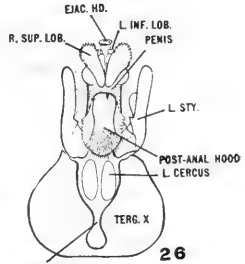

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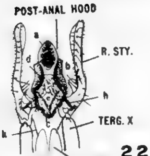

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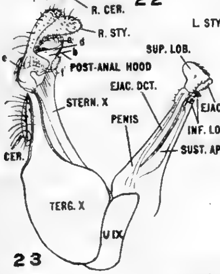

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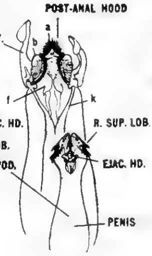

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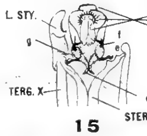

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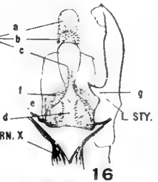

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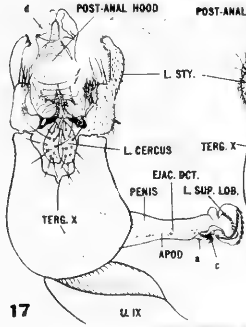

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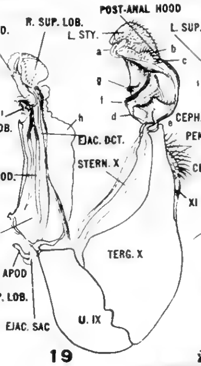

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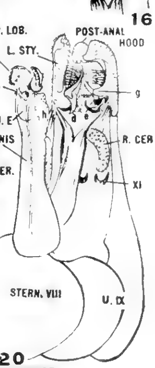

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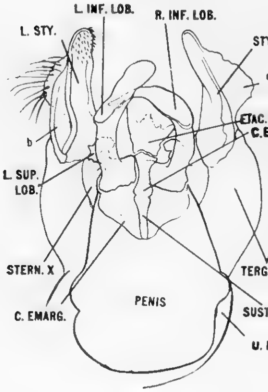

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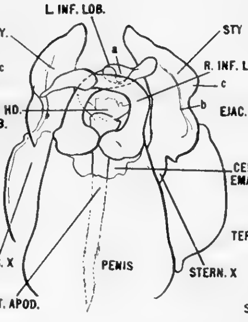

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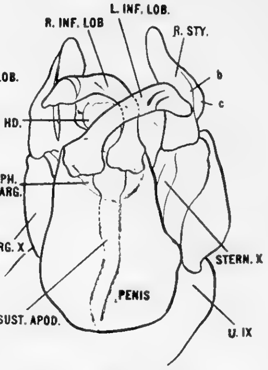

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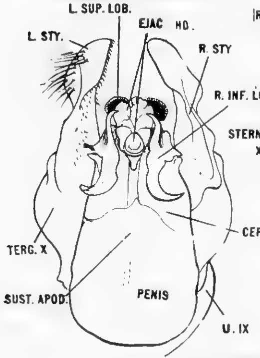

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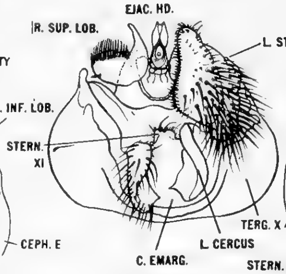

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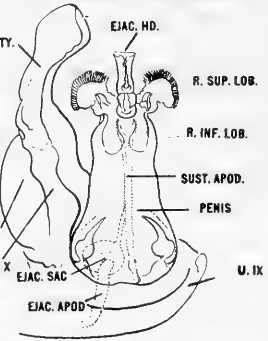

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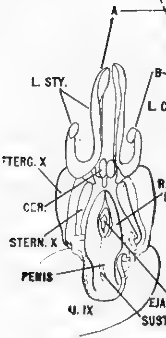

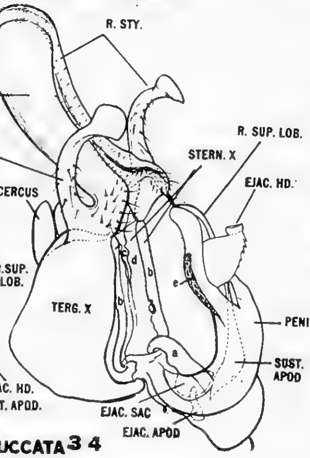

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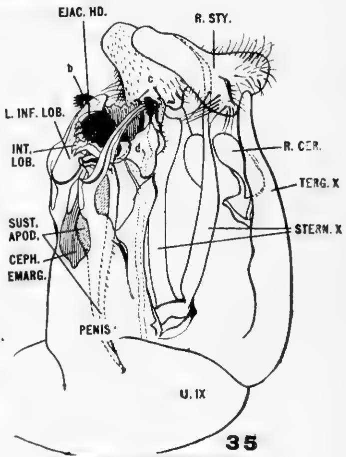

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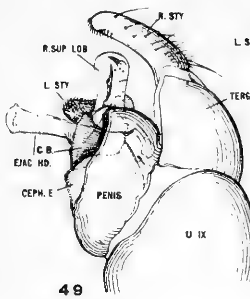

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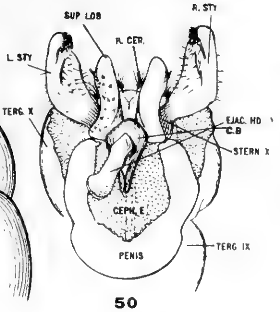

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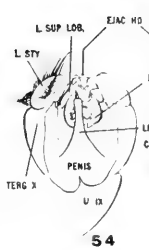

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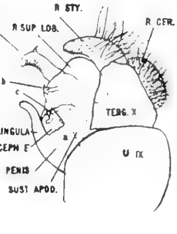

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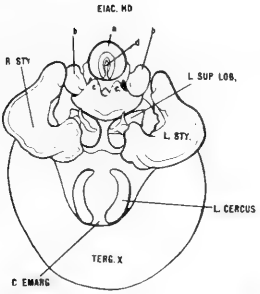

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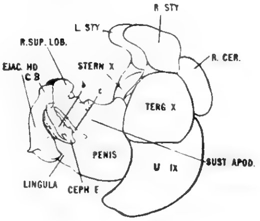

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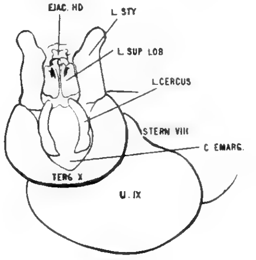

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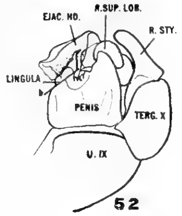

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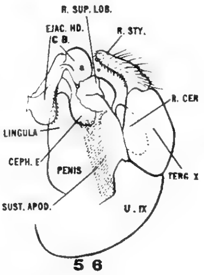

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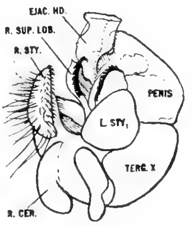

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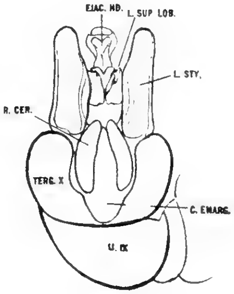

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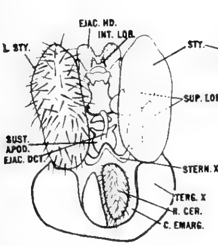

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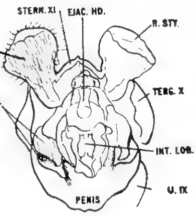

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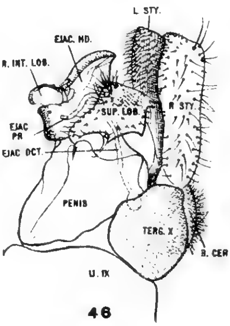

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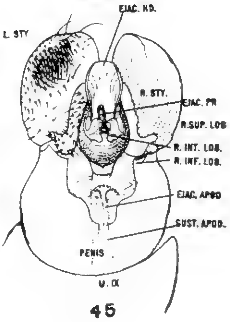

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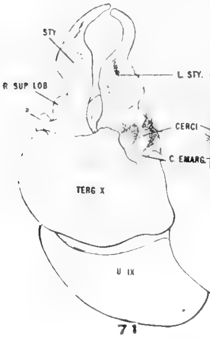

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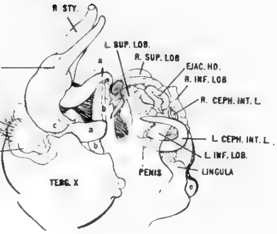

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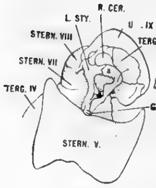

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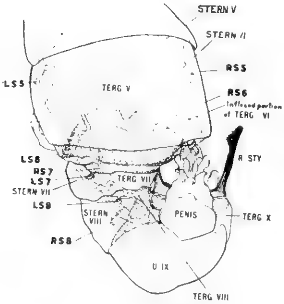

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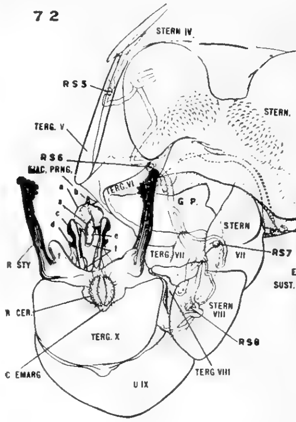

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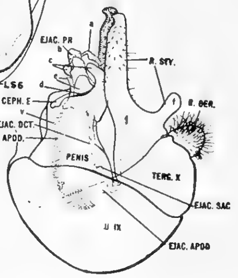

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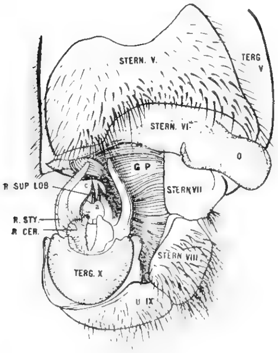

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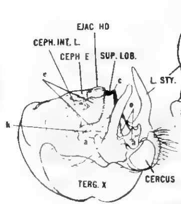

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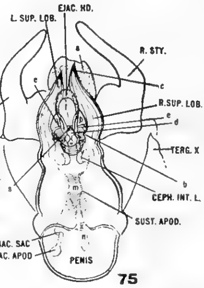

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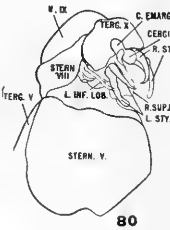

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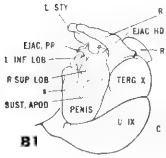

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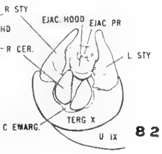

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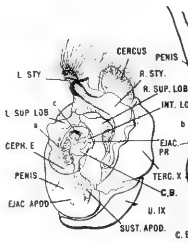

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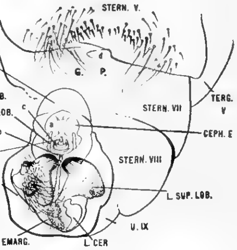

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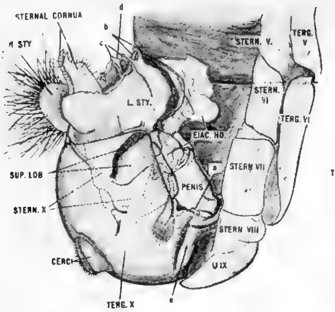

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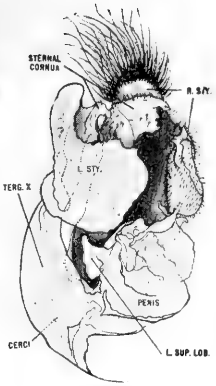

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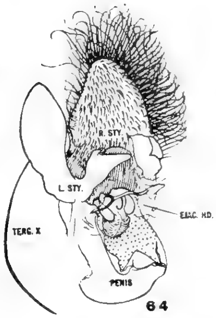

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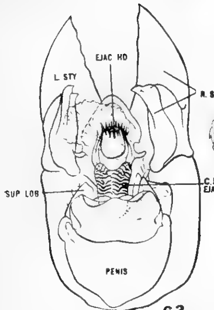

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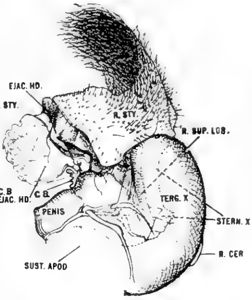

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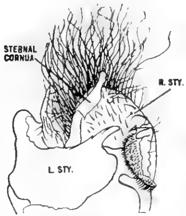

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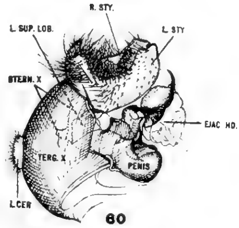

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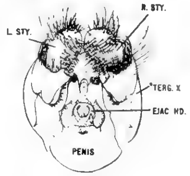

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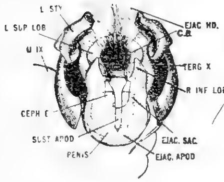

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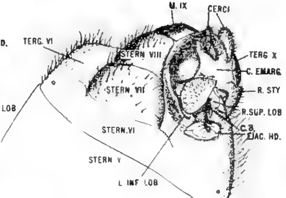

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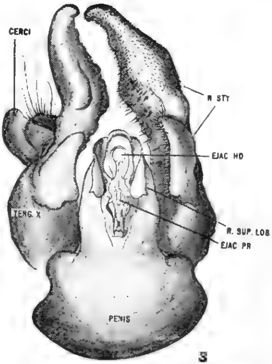

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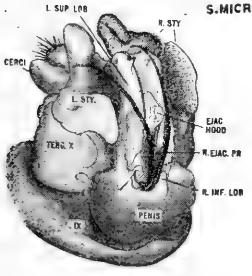

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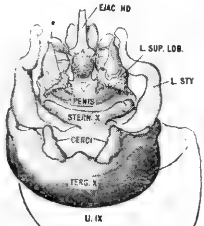

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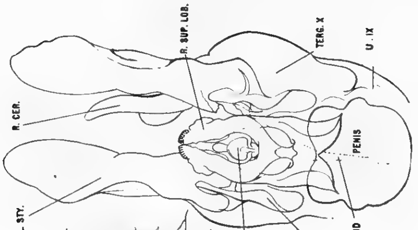

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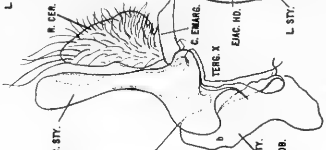

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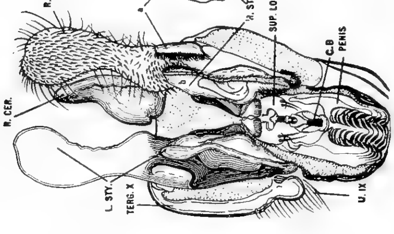

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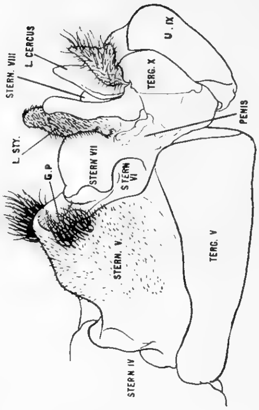

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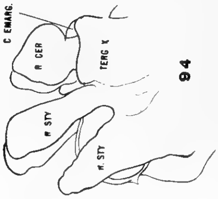

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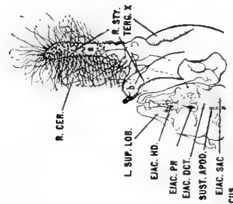

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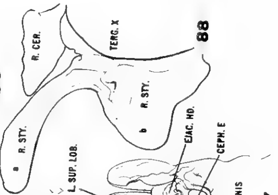

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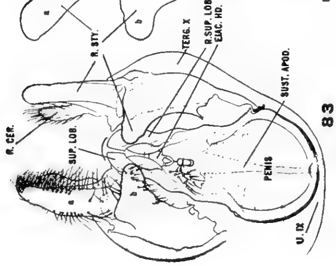

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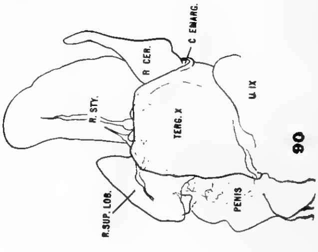

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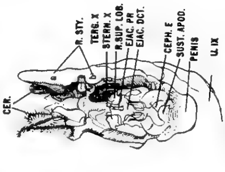

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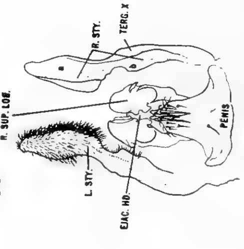

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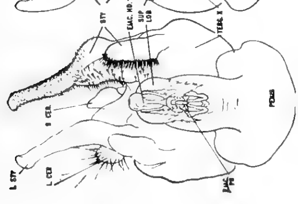

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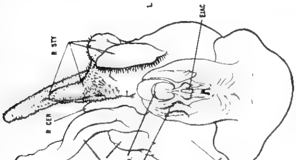

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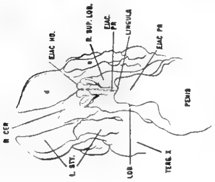

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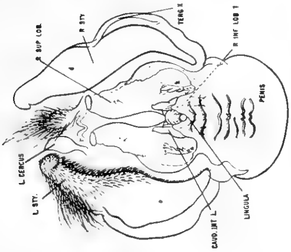

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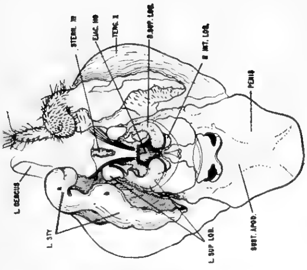

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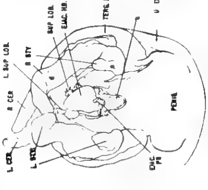

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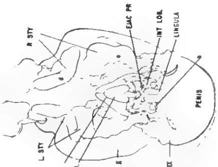

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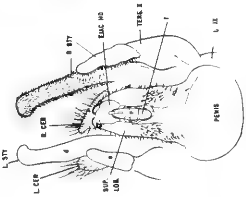

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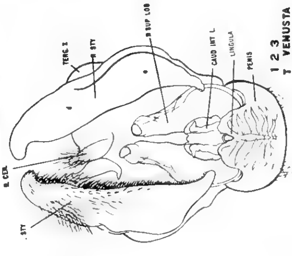

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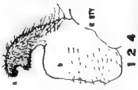

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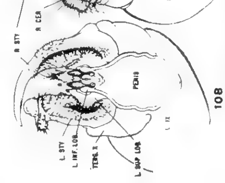

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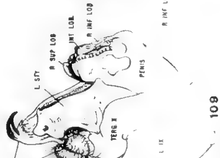

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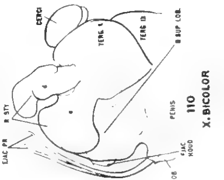

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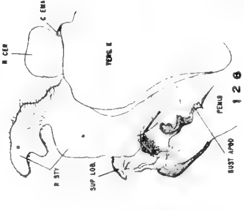

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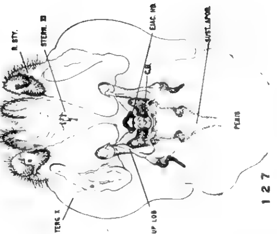

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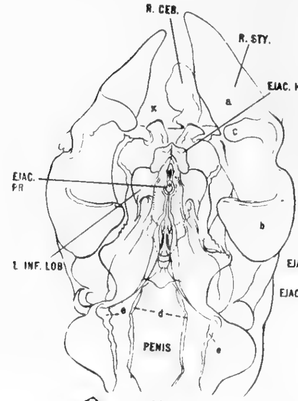

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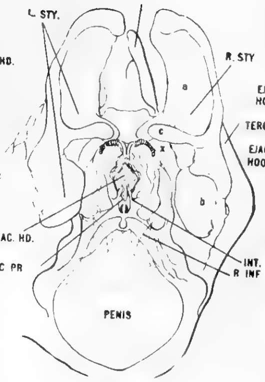

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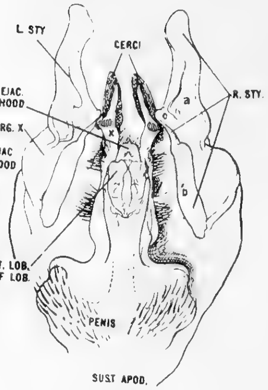

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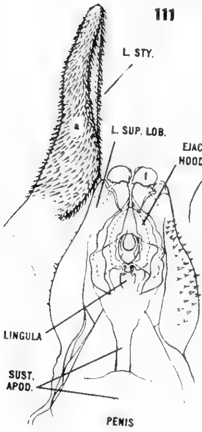

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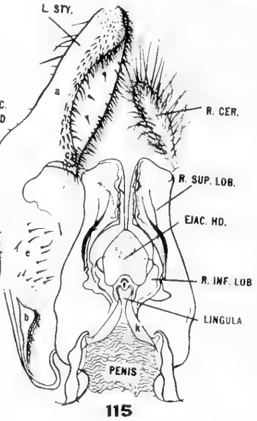

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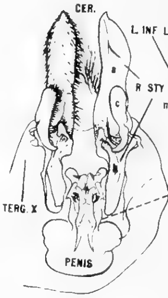

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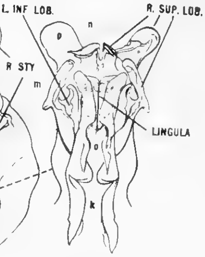

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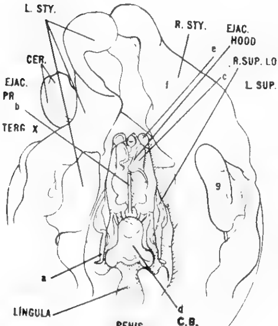

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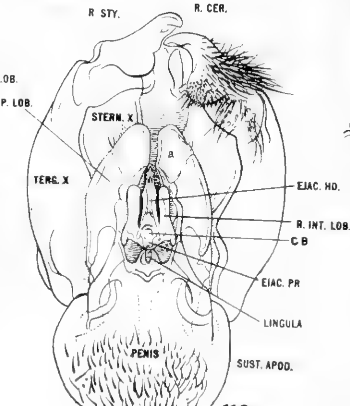

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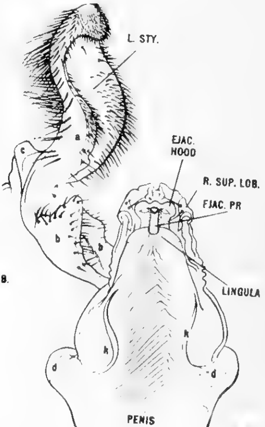

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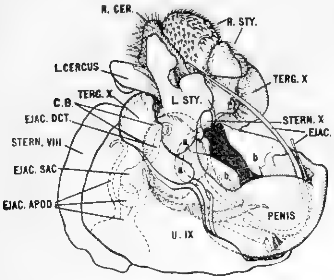

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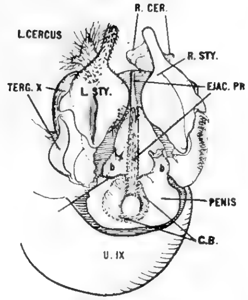

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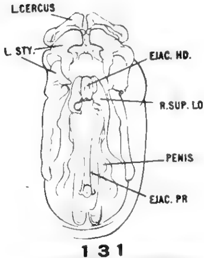

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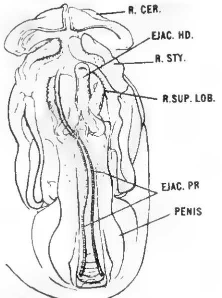

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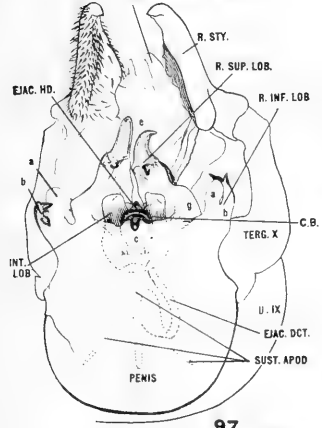

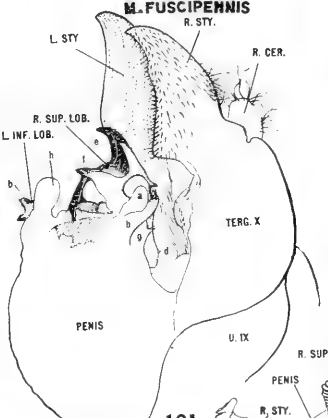

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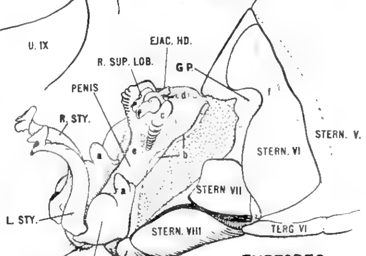

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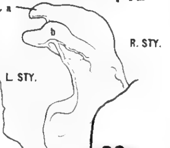

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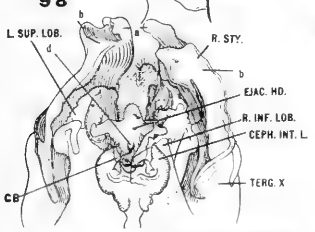

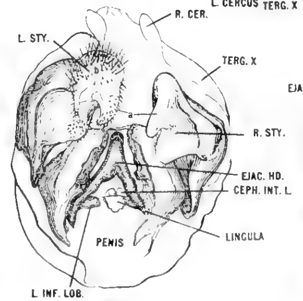

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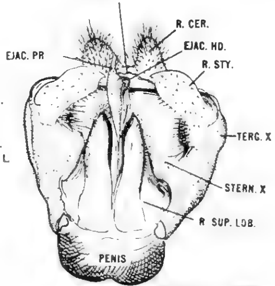

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C. L. Metcalf.

A METHOD FOR STUDYING THE HESSIAN FLY AND OTHER INSECTS.*

By James W. McColloch,
Associate Entomologist, Kansas State Agricultural Experiment Station.

The following method for conducting life history studies was developed in connection with a study of the Hessian fly (*Mayetiola destructer* Say) and since then has been used for making detailed observations on the development of several other insects attacking the stem and leaves of various cereal crops. The fact that the Hessian fly larvæ develop between the leaf sheath and the stalk often below the surface of the ground has rendered it difficult to follow the growth of this stage. It has also been hard to observe the development of the eggs and the behavior of the larvæ on the leaf.

In 1916, an attempt was made to grow the wheat plants in an artificial culture medium so that the entire plant would be exposed and accessible for observation.† Plant physiologists have long made use of water cultures in conducting experiments on the nutrient requirements of plants and other physiological relations and it seemed possible that with certain modifications this method could be extended to observations on insect life histories. In the Hessian fly investigations, the wheat was planted in soil or sand and allowed to grow to a height of two or three inches. The plants were then removed from the soil, the roots thoroughly washed to remove all soil particles, and then placed in wide-mouth bottles of 200 cc. capacity, containing about 150 cc. of the water culture (Fig. 1). One plant was placed in each bottle, the roots being immersed in the liquid and the stalk kept in position by being held lightly against one side of the neck of the bottle with a cotton stopper. The liquid

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* Contribution from the Entomological Laboratory, Kansas State Agricultural College, No. 52. This paper embodies the results of some of the investigations undertaken by the writer in the prosecution of project No. 6 of the Kansas Agricultural Experiment Station.

† The writer wishes to acknowledge his indebtedness to Mr. H. Yuasa for suggestions and aid in connection with this work.

plant food used was that known to plant physiologists as Pfeffer's solution and is prepared as follows:

Calcium nitrate	4 grams
Potassium nitrate	1 gram
Magnesium sulphate	1 "
Potassium dihydrogen phosphate	1 "
Potassium chloride	0.5 "
Ferric chloride	Trace
Distilled water	3 to 7 liters[*]

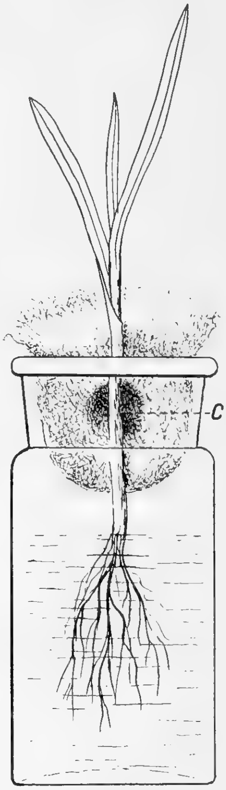

FIG. 1.

Wheat plant growing in a nutrient solution. C—Cell for confining insects on the plant.

The plants grew well in this solution, although at times some difficulty was encountered by the growth of algæ in the liquid. This was largely overcome, however, by painting the bottles black. Usually the plants lived long enough for experimental purposes without changing the liquid. When the experiments were prolonged the solution was changed as often as necessary.

By using this method, it was possible to follow the life history of the Hessian fly from oviposition to the formation of the puparium. The plants could be handled conveniently and the various stages studied with greater ease and exactness than when the plants were grown in the soil. When necessary, the plants could be removed from the bottle and placed under the binocular for close study. By carefully shaving the epidermis of the leaf sheath, it was possible to keep the larvæ under observation at all times. As the larvæ increased in size they could readily be seen through the neck of the bottle.

This method proved so successful in the Hessian fly work that it was adopted for the study of a number of other insects infesting cereal crops. Thus far the writer has grown wheat, oats, rye, barley, corn, and many of the sorghums in Pfeffer's solution in connection with studies of the chinch bug (*Blissus leucopterus* Say), green

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[*] The writer has found that five liters is best for the work under consideration.

bug (*Toxoptera graminum* Rond) and corn leaf aphis (*Aphis maidis* Fitch).

Certain modifications in the method of handling the plants were necessary for these insects. In order to confine them on the stalks of the plants, a small cell was formed in one side of the cotton stopper (Fig. 1-c). The cotton fibers served as effective barriers in holding the insects in the cell and exact data could be obtained on molting and the length of instars, and, in the case of the aphids, on the number of young produced. This method was also used to study certain phases of activity of several parasites of the Hessian fly puparium. The parasites were confined in the cells with plants containing flaxseed in their natural position and the behavior and methods of oviposition of the parasites were easily observed. In a similar manner a study was made of the chinch bug egg parasite (*Eumicrosoma benefica* Gahan). Good results were obtained in confining leaf-feeding insects on the leaves by inverting another bottle over the plant or by lowering the plant so as to bring a part of the leaf into the cell.

In conclusion, a brief summary is given of the more important advantages of this method of growing plants for life history studies.

1. By certain modifications this method may be enlarged to facilitate more extended observations on a much larger number of insects.

2. The manipulation of plants in a water culture has proved very satisfactory in growing most of the staple crops, it being easily done and facilitates handling the plants in making close observations.

3. This method is especially valuable where the work is done under constant conditions, since it eliminates the factor of variation in plant food.

4. The use of the water culture enables one to study many phenomena in the insect's life history that normally are difficult to observe and which often necessitate the destruction of the plant.

5. When plants are grown by this method, they may be removed and examined under the microscope or binocular without injury to the plant.

6. Plants are often found in the field infested with some insect which it is desirable to rear to maturity. Such plants can be removed from the soil and kept alive in a water culture until the insect matures.

7. Many points in the life economy of parasites may be studied in detail with relation to the host.

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Volume XIV DECEMBER, 1921 Number 4

RESPONSES OF THE LARGE WATER-STRIDER, GERRIS REMIGIS SAY, TO CONTACT AND LIGHT

C. F. Curtis Riley,
Department of Zoology, University of Manitoba,
Winnipeg, Manitoba, Canada.

With Twelve Figures in the Text.

CONTENTS.

I. INTRODUCTION.

Two of the most pronounced forms of behavior of many of the aquatic and semiaquatic Hexapoda are their responses to contact and to light stimuli. Study and observation of the aquatic species *Gerris remigis* Say, of the family Gerridæ, one of the common forms of aquatic Heteroptera, have demonstrated that it, also, evinces responses of this character.

Gerris remigis is a typical water-film species (Figs. 1, 11), being widely distributed in the United States on the surfaces of brooks, creeks and rivers, with currents of moderate velocity.

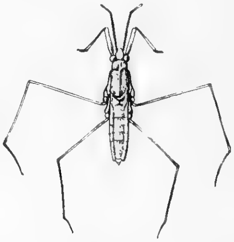

Fig. 1. The large water-strider, *Gerris remigis* Say, apterous form; a typical surface-film, stream inhabitant. Natural size. (Drawing by Beutenmüller.)

The rapidity with which it strides along the water-film, without breaking through the surface, its noticeably facile and agile movements, and the ease with which it obtains food, entangled in the surface-film, all tend to indicate the adequacy of its responses for living in a water-film habitat. Its elongated body and tapering, slender legs, spread widely apart, thus more equally distributing its weight over the water-surface, are plainly evident as this species of gerrid darts to and fro in its stream habitat. Such characteristics seem to suggest the suitableness of its bodily structure for a life on the surface of water.

II. RESPONSES TO CONTACT.

1. General Responses.

It is not uncommon for *Gerris remigis*, when striding along the surface-film to come in contact with some more or less solid body, such as a leaf, a piece of driftwood, a rock projecting above the surface of the water, the bank of the stream, or another gerrid (Figs. 2, 3, 6). Sometimes such contact does not appear to impede the movements of the insect. At other times the gerrid remains quiet for a few seconds only, while, on the other hand, there are instances when the animal keeps in contact with such surfaces for varying periods, extending from a few minutes to an hour or more. On some occasions only one leg may be in touch with the solid surface, the gerrid remaining there as if it were anchored, swaying gently with the breeze, or falling and rising with the movements of the surface of the water. Then again, one side of the body may be closely applied to some solid object, the animal staying quietly in one position, as if suddenly paralyzed. Such responses are very common in the daily life of this species and they appear to be due to its thigmotactic propensities (Figs. 2, 3).

Members of other groups of aquatic Heteroptera exhibit habitat responses to contact of a somewhat similar character to those described for *Gerris remigis*. Holmes (1907, p. 163) found that *Ranatra quadridentata* Stal, of the family Nepidæ is responsive to contact stimulation. He directs attention to the fact that:

> As a rule *Ranatra* inhabits more or less shaded retreats among submerged grass or weeds near the water's edge. It is kept in such situations, partly through the direct effect of its positive thigmotaxis, and partly because contact stimuli (as shown in a previous paper) cause it to become negatively phototactic.

According to Essenberg (1915, pp. 381-382, 383, 390), several species and genera—*Notonecta insulata* Kirby, *Notonecta undulata*, var. *charon*, *Notonecta indica*, and *Notonecta* sp.—of the family Notonectidæ are thigmotactic. She states that:

> The two pairs of forelegs are sparsely covered with hairs and are provided with claws. The latter serve for the capture of food and for attachment to the surface-film, from which they hang with their heads downward, the posterior part of the ventral surface being exposed to

the air. When in this position the fore- and middle-legs are slightly bent so that the claws are at the surface. The insects often rest at the bottom, clinging to sticks or weeds.

The contact phases of behavior of *Gerris remigis* that have been discussed are very suggestive of the responses of some other members of the Hexapoda, for example certain Agrionid nymphs, of the order Odonata, described several years ago in a paper by me (1912, pp. 274, 280), brief quotations from which follow:

> In their natural habitat, Agrionid nymphs react strongly to contact. They are found clinging tightly to the stems, branches and leaves of *Elodea* and *Ceratophyllum*. This is an indication of their decided thigmotactic proclivities. They tend to place as much as possible of the external parts of their bodies in contact with a solid surface. This is accomplished by clinging to the aquatic plants, in such a manner that the long axes of their bodies lie parallel to the long axes of the stems and the branches. The nymphs frequently assume a somewhat different position, with the long axes of their bodies rather oblique to the long axes of the stems and branches. The creatures are frequently found with their bodies closely applied to the *Elodea* and *Ceratophyllum* at the points where the branches are given off—that is, in the forks formed by the stem of the main plant and the lateral branches. They are also

Fig. 2. Detail of portion of surface of brook-pool, with current passing through it—flowing to left—along margin of forested region, near White Heath, Illinois—autumn. Five water-striders, *Gerris remigis* Say, shown on surface-film in contact with solid objects and clinging to them; indicates manner of group formation. Water-striders, about one-third natural size. (For other details, see Fig. 3.) (Photograph by Lloyde and Riley.)

found on both plants in the angles formed by the whorls of leaves arranged around the stem.

When experiments are performed with a number of individuals in the glass trough, it is found that their movements are often very much impeded. As they swim away from the source of illumination, they frequently come in contact with the sides of the vessel and with other individuals. This contact, in many instances, impedes the movement away from the light, and causes the nymphs to become practically motionless. This is the result of the contact stimulus. They usually assume a position with the long axes of their bodies parallel with each other and in close contact, although this relation may be modified considerably. Another response, which the writer designates as the "clasping response," quickly follows. The nymphs clasp each other closely around the thorax and abdomen. The preliminary contact of their bodies causes locomotion to cease, being an example of true thigmotaxis. Then as the full surface of the body of one is applied to the body of another the "clasping response" results.

Before passing from these brief references to the writings of other observers on thigmotaxis in aquatic Heteroptera and Odonata, attention well may be directed to certain observations on the Crustacea, a less specialized class than the Hexapoda. Holmes (1903), in a very valuable and suggestive paper, has pointed out that this form of response is exhibited in a high degree by certain genera and species of the order Amphipoda, belonging to the family Orchestiidæ, of the subclass Malacostraca. Certain statements of his, with respect to two species, *Orchestia agilis* and *Allorchestes littoralis*, will be given here. He (1903, pp. 194-195) remarks that:

> This instinct of *O. agilis* to get into close contact with solid objects is an expression of the strong thigmotactic tendency found among amphipods in general. It is a tendency especially marked in the aquatic representative of the Orchestiidæ, *Allorchestes littoralis*. . . . The thigmotactic reactions of amphipods keep these animals among the seaweeds and rocks where they secure protection and obtain food. The behavior of the terrestrial *O. agilis* in relation to solid objects is little modified beyond that of the aquatic species. The thigmotaxis of this form is certainly protective in function, not only by enabling the animal to escape detection by lying quiet, but by leading it into situations such as under stones or into crevices which are inaccessible to its enemies.

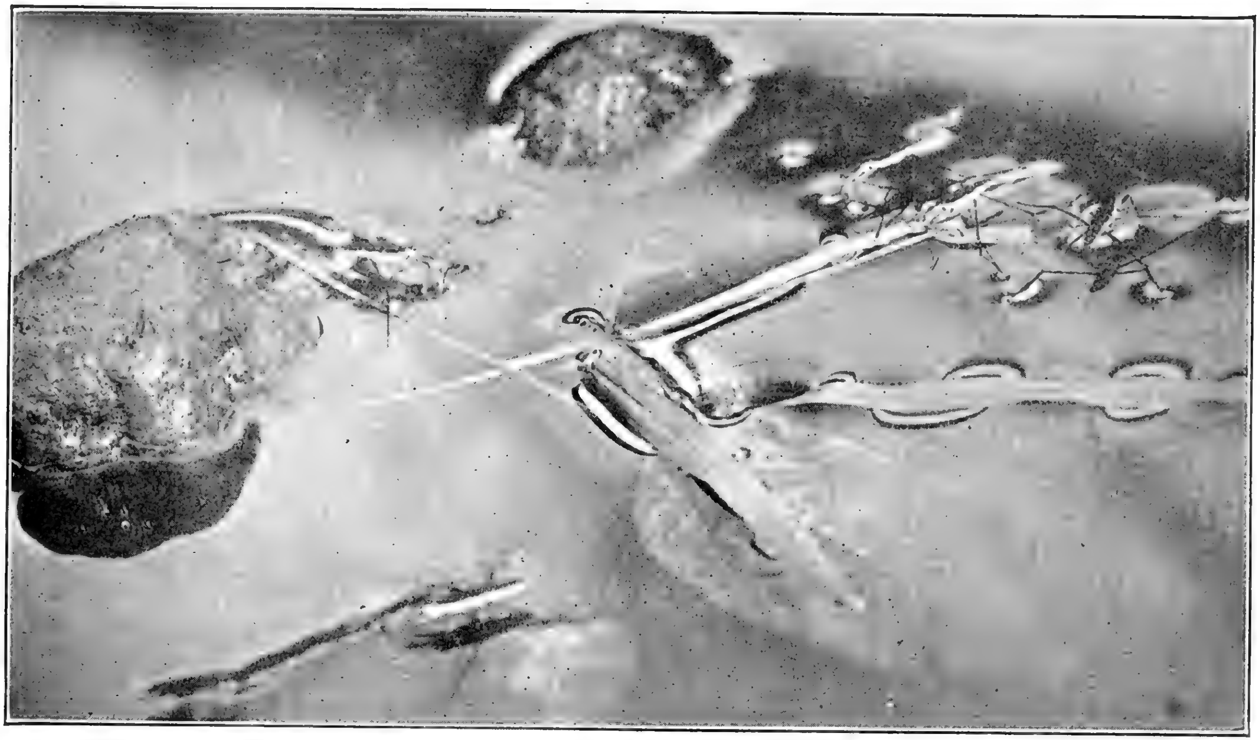

Fig. 3. Detail of portion of surface of brook pool, with current passing through it—flowing to left—along margin of forested region, near White Heath, Illinois—autumn. Five water-striders, *Gerris remigis* Say, shown on surface-film in contact with solid objects and clinging to them, indicating manner of response to contact stimuli, also showing beginning of group formation; during rain and wind storms gerrids take similar positions. Three water-striders shown in right background, with distal parts of legs clinging to aquatic vegetation, legs of each gerrid in contact with and overlapping those of the next one; one water-strider in left background close to rock, distal part of right middle leg in contact with blade of aquatic grass and distal part of right hind leg clinging to surface of rock; one water-strider in left foreground—slightly out of focus—head directed to left, right front and middle legs in contact with piece of driftwood. Water-striders about seven-tenths natural size. (Photograph by Lloyde and Riley.)

Fig. 4. Detail of Cossell Brook in Dice's Woods, a rolling, forested region—current flowing southerly, away from observer, in illustration—about one mile northwest of Charleston, Illinois—late spring. Water-striders, *Gerris remigis* Say, live on surface of such pools as indicated in foreground, frequently forming large groups on surface-film. Elms, sycamore, basswood, dogwood, hackberry, sedges, *Equisetum*, columbine, nettles, Solomon's seal, wild ginger, etc., found along the banks. (Photograph by Hankinson.)

2. VARIATION OF RESPONSES UNDER SIMILAR CONDITIONS.

The fact has been pointed out that although *Gerris remigis* responds to contact usually by a decrease or a cessation of its locomotory movements, yet the manner in which it responds, apparently, varies at different times. Similar facts have been observed when two or more gerrids, moving about on the surface-film, come in contact with each other, for under such conditions their responses also vary at different times. As they touch each other, the stimuli of contact may result in increased movement, the insects darting away from each other, in different directions, with great speed. This rapid locomotion may continue for several minutes before it subsides. At such times the behavior of the water-striders appears as if due to some strong or unpleasant stimuli. After the subsidence of the immediate effects of the stimuli, they continue their usual movements. In connection with the statement that the gerrids, after coming in contact with each other, may continue to stride about rapidly for sometime after contact has occurred, a quotation from Jennings (1906, p. 285) may be of interest. He states that:

> Often, of course, stimulation does rouse an organism to increased activity. But even in this case the activity is due to the release of internal energy. It may, therefore, continue long after the stimulation which inaugurated the release has ceased to act. Such continuance thus does not necessarily imply continued action of the stimulus. In many cases the specific stimulus to action is only the *change* of conditions.

The responses are not always as have been described, for on touching each other, the gerrids may not stride rapidly away, but, on the other hand, they may do so in a manner which is very slow and appears to be deliberate. Sometimes, when such contact occurs, while striding about on the water-surface, they pause for a few seconds and then move forward or backward again, usually the former movement taking place.

It is rather difficult to understand, at least from direct observation and without definite experimental evidence, why these water-striders should respond in different ways at different times, for careful and repeated observations in the field seem to indicate that they respond differently, even when the stimuli and the various physical conditions of the immediate environment remain unchanged. The natural assumption that occurs to the observer is that these different responses, to similar stimuli at different times, is due, probably, to the physiological conditions of the bodies of these insects varying at different times and, therefore, because of these differences in the physiological conditions, the gerrids do not respond in the same manner at all times to similar stimuli. Therefore, it may be assumed that the behavior of these animals is affected by the changes which occur within their bodies, and yet these changes can not take place unless there are either internal or external stimuli that bring about such changes. In this connection it is perhaps worth while to recall a brief statement by Mast (1911, p. 287):

> It is evident that such changes must be regulated by internal factors, that they must be due to alterations within the organism itself. As a matter of fact, all reactions are directly controlled by internal factors which are in turn influenced by external factors.

The general subject of "physiological states" in lower organisms has been elaborated by Jennings (1904, pp. 109-127), (1906, pp. 283-292).

3. Assembling of Groups.

Not infrequently, after coming in contact with objects protruding above the surface-film (Figs. 5, 6) the legs of the gerrids, and sometimes their bodies, become closely applied; there may be several individuals taking part in such responses (Figs. 2, 3). In this manner a number of water-striders may stop their locomotor movements and attach themselves to the group, until, eventually, a large aggregation is formed. As many as seventy-five to a hundred individuals have been enumerated in groups of this character. Usually such responses occur, not on those parts of the stream where the current is the swiftest, but rather on the surfaces of small pools, with gentle currents passing through them (Figs. 2, 3, 4, 5, 6). The gerrids may remain in such formations from a few minutes to an hour and a half, or for much longer periods. The general physical conditions of the environment, the season of the year, and the physiological conditions of the animals themselves, all these, seem to have a bearing on this matter. As viewed by the observer from a distance, such groups of insects appear as dark patches on the surface of the stream, rising and falling with the movements of the water. It was interesting to me to find in a paper by de la Torre-Bueno (1911), who is a very accurate observer, certain records of behavior of a similar character with respect to a member of the same family, Gerridæ, to which *Gerris remigis* belongs. He refers to *Metrobates hesperius* Uhler, of the tribe Halobatini, placed in the subfamily Gerrinæ. The following quotation is taken from his paper (1911, pp. 249-250):

> This is a species which, like most of the other members of the tribe, is lacustrine to a very great extent, and it may be seen congregated in large patches of blackness on the smooth waters of our lakes, or perhaps in the wide reaches of slow moving streams. It is a very active species. . . . It commonly occurs in the apterous, but the winged form seems not rare under favorable conditions.

Fig. 5. Detail of large pool at headwaters of small brook, with current flowing through it — looking down stream — near Syracuse, New York — spring. Hundreds of water-striders, *Gerris remigis* Say, form large groups on surface of pool (a), grouping themselves near overhanging banks, especially when wind is off shore; also found crawling onto and into the interstices of fallen, dead tree, separating pool into two parts, and forming groups near it. Both alate and apterous water-striders hibernate in interstices of overhanging shore (c) and among vegetation and dead leaves (b), in close proximity to pool. (Reproduced from the *American Naturalist*.)

In the early and late fall, there appears to be a much greater tendency for these groups of water-striders, *Gerris remigis*, to be formed than is the case during any other season of the year. Long and continued observations, extending over a number of years, seem to indicate that the gerrids are much more responsive to thigmotactic stimuli just previous to and while migrating onto the land to "seek" hibernation quarters, than they are under most other conditions.* Early in the fall, even on the open surface of the brook-pools, they appear to congregate more thickly and more compactly, although engaged in their usual normal responses. As the fall advances, these somewhat loose formations—more dense in appearance, however, than those of the early summer—are found nearer to the banks of the streams (Figs. 5, 6). In the late fall, large numbers of gerrids, frequently, are observed close to the land, to rocks rising above the water surface, to tree-roots extending into the water, to dams of driftwood, in fact in close proximity to such objects and places as afford them opportunity for contact, and onto which they can crawl from the surface-film. Sometimes, for days together, they are found in such situations, forming large aggregations, with their legs and not infrequently their bodies touching and the former even overlapping (Figs. 2, 3, 5, 6).

Curiously enough, strong air-currents and surface-breezes blowing along the surface-film—which in the next section of this paper are designated as agents that are active in the disintegration of groups—assist in the formation of clusters of gerrids. Such currents frequently move the water-striders nearer to each other, thus making the loose groups more compact. In addition to the mere drifting together of the insects, the winds act as stimuli that produce active responses on the part of the gerrids, for under such circumstances, they usually quickly stride close up against each other or against some solid object in the vicinity (Figs. 2, 3, 5, 6). Such stimuli not only invoke the usual contact responses, but they also induce clinging responses on the part of the insects as soon as they come in touch with their neighbors (Figs. 2, 3). Such behavior is especially noticeable when the water-striders are gathered along the leeward side of a brook or creek (Fig. 5). On the

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* Data are being accumulated and experiments are being conducted with the expectation of obtaining precise evidence on this subject.

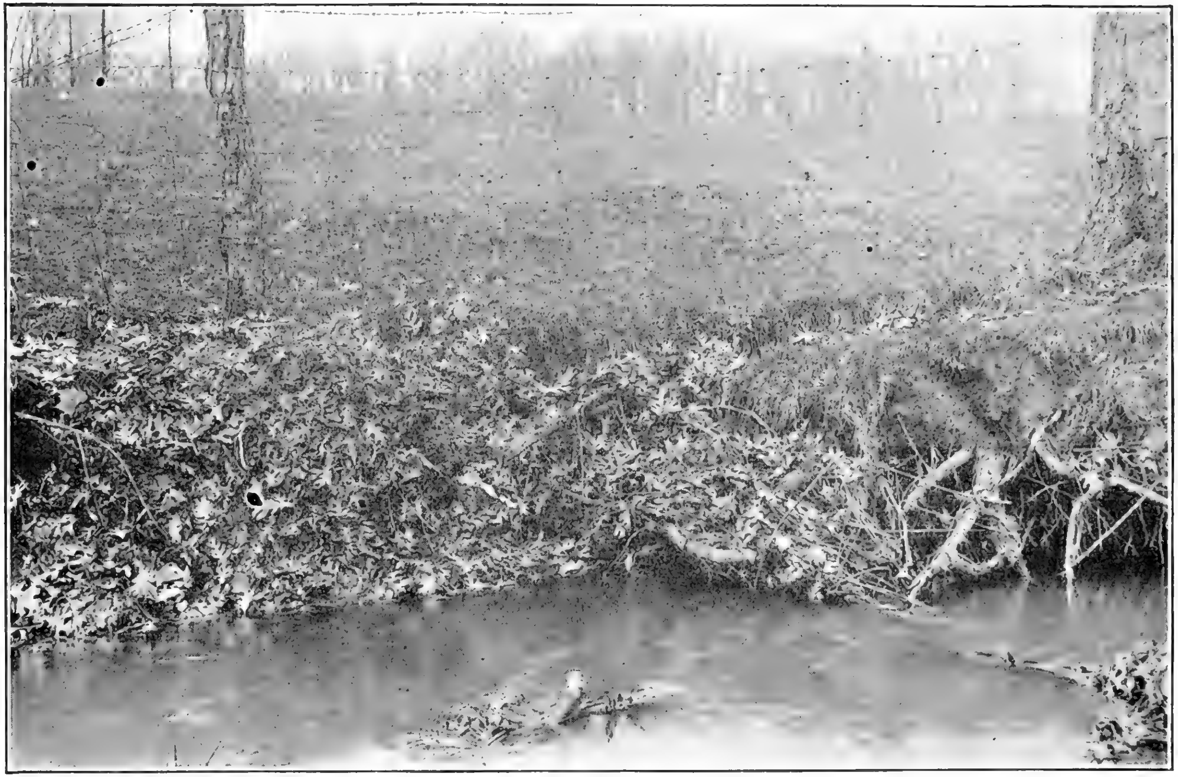

Fig. 6. Detail of bank and pool of brook—current flows to right—near White Heath, Illinois—autumn. Shows undercutting of bank, roots of tree, and clump of dead leaves—mainly oak—two to three feet in depth and six to eight feet in length; water-striders, *Gerris remigis* Say, hibernate in all three situations, frequently found in large numbers under dead leaves close to water. Gerrids often form groups, on surface-film, composed of large numbers of individuals, in contact with driftwood and dead leaves shown in center and right foreground. (Photograph by Lloyde and Riley.)

surface of a large pool (Fig. 5), near the headwaters of a small brook, in the vicinity of Syracuse, New York, and on the water-film of pools of intermittent brooks, of permanent brooks (Fig. 6), and of creeks, in the region roundabout Urbana, Illinois, such gatherings frequently have been observed. Often they were so large and the gerrids were so numerous that two to five hundred insects could be taken in less than half an hour. It should be pointed out that the best and most satisfactory evidence, for the general facts stated above, concerning the formation of groups, has been obtained in the fall. The "habit" of this species of forming groups was pointed out by me (1912, p. 281), several years ago in the following statement:

> This tendency to cluster together frequently has been observed by the writer in the case of *Gerris remigis* Say.

Other aquatic Heteroptera evince responses much like those that have been described, as Severin and Severin (1911a, pp. 100-101) have demonstrated on the part of several different species and genera. In connection with certain observations on the thigmotaxis of *Belostoma flumineum* Say, they state that:

> Again, it was not unusual to find two or more Belostomas or somewhat larger clusters clinging together at the surface or bottom of the water, a characteristic which is also noticed with *Lethocerus* (*Belostoma* aucct.) *americanum*, *Benacus griseus*, *Nepa apiculata*, *Ranatra americana*, and *Ranatra kirkaldyi*. This habit is probably a manifestation of their thigmotactic responses.

Holmes (1905, pp. 324-325) in his phototactic experiments on *Ranatra fusca*, Pal. B., of the family Nepidæ, states that:

> Efforts to go toward the light are frequently inhibited by contact stimuli. When several individuals are put into a dish of water near a window they commonly cease, after a time, to swim towards the light and form a cluster in which they lie at all possible angles to the direction of the rays.

While the experiments referred to here are related to the consideration of the subject of the inhibition of one form of response by stimuli that result in responses of another character, yet they indicate that *Ranatra fusca* also forms aggregations through the action of contact stimuli. Holmes (1905, pp. 320, 323) states that Ranatras group themselves into compact groups, in cool water, at the ends of dishes farthest from the light. In some of my own experiments (1912, pp. 279, 280), it has been observed that Agrionid nymphs, Hexapoda belonging to a totally different order, the Odonata, exhibit responses during the process of forming groups that are decidedly similar to those that have been described for *Gerris remigis*, and for that reason and also for a basis of comparison, they are mentioned here.

4. Disassociation of Groups.

It has been pointed out that water-striders gather in groups on the surfaces of streams, the legs and bodies of different individuals being in contact with each other (Figs. 2, 3). It also has been stated that these aggregations, probably, are due to the thigmotactic propensities of the animals. This thigmotaxis may be overcome, or at least it may be modified, by other stimuli, with the result that the groups of gerrids are broken up. Frequently, this occurs because of mechanical stimuli acting on them. Usually, this is brought about by the activity of certain individuals in the clusters disturbing others around them; or it may be accomplished by wind-currents, of considerable strength, blowing against the groups and thus causing some of the water-striders to disentangle themselves; while in other instances, members of the aggregations become active from the stimuli received from the agitation of the surface of the stream by water-currents. Driftwood, or a bunch of dead leaves, drifting with the current, occasionally strikes against one of these groups of gerrids and acts as the initial stimulus which results in its disintegration. Other Heteroptera exhibit similar responses, for Holmes (1905, pp. 318-325) has pointed out, in his experimental investigations on the water-scorpion, *Ranatra fusca*, that members of this species, responding to stimuli of one character, not only may have these responses modified, but also may have them inhibited through the influence of stimuli of a different character. It is interesting to notice that behavior of this general character is not limited to the Hexopoda, but that it is evinced by members of a less specialized class, the Crustacea, as Holmes (1901, p. 212) has demonstrated in his experiments on the freshwater shrimp, *Gammarus locusta*, belonging to the order Amphipoda and to the subclass Malacostraca.

Some of the gerrids in these gatherings are more active than others and thus, probably, less responsive to contact stimuli. These from time to time move their legs and bodies, in this way disturbing other water-striders next to them. Such disturbances act as mechanical stimuli on still other individuals in the groups. In this manner, whole clusters may be affected and may become disorganized, so that there is a tendency for them to disintegrate. The insects that have become the most active are most likely to leave the aggregations first. Then others in their immediate vicinity follow, so that eventually all the members of any individual aggregation free themselves from it and are found striding back and forth on the surface-film as separate units. Often the gerrids on the outside of the groups are the first to break away, but this is not always the case, for individuals crowded into the centers of the masses of water-striders have been observed to pull loose from the others in contact with them and then to stride over, or to push between, those forming the peripheral parts of the groups, until they reached the free surface-film. Generally, it appears to be more difficult for the gerrids in the centers of the clusters to free themselves, than is the case for those nearer the outer margins to do so.

With respect to the manner in which the disintegration of the aggregation of gerrids occurs, it is interesting to notice that members of a related family, Nepidæ, have been observed to evince behavior of a somewhat similar character. Holmes (1905, p. 308), writing of the responses of *Ranatra fusca*, found that individuals of this species formed groups in aquaria, and he states that:

> In this way they may lie for hours in an almost motionless state.

He (1905, p. 323) also has observed that an aggregation of this character is more likely to disintegrate as the animals exhibit more activity. Again, this writer (1905, p. 308) remarks that in these clusters, which are formed by *Ranatra fusca*, the insects

> are often so closely aggregated and so tangled together that those which are near the center of the group experience much difficulty in disengaging themselves.

Other Hexapoda display responses not dissimilar to those of *Ranatra fusca* and *Gerris remigis* in the disintegration of clusters.

Fig. 7. Detail of bunch of dead oak leaves—approximate dimensions 8 x 4 x 3 feet—on bank of brook near White Heath, Illinois—autumn. Water-striders, *Gerris remigis* Say, hibernate in large numbers under dead leaves, among tree roots—right of illustration—and in interstices of undercut bank—upper right of illustration. Leaves, forming bunches, usually in much closer contact and much more compact than indicated here and in Fig. 6. Portion of brook shown at lower right of illustration. (For other details, see Fig. 6.) (Photograph by Lloyde and Riley.)

In some of my own work (1912, pp. 283-285) on the behavior of Agrionid nymphs, of the order Odonata, it was observed that the responses exhibited, during the process of the disassociation of groups, were decidedly of a like nature to those of *Gerris remigis.* It was found that compact aggregations were formed, but that the Agrionid nymphs did not remain quiet for as long periods as either *Ranatra fusca* or *Gerris remigis* and that the breaking up of such groups was apt to occur at shorter intervals. The disassociation of these clusters resulted from mechanical stimuli and also from the activities of certain nymphs within the aggregations, although photic stimuli played a part in this process. The Agrionid nymphs in the peripheral portions of the groups were more likely to leave first, as those in the more central parts of the clusters were influenced more strongly by the contact stimuli of the individuals surrounding them, and, therefore, frequently remained more or less stationary.

5. CONTACT RESPONSES AND HIBERNATION.

During the period of hibernation, responses to contact stimuli are strongly in evidence. *Gerris remigis* begins to leave the surface-films of streams in the early autumn, continuing this migration until the late fall, and goes onto the land to "seek" winter quarters. The gerrids of this species hibernate in various situations. They have been taken from under piles of dead leaves, from interstices and deep holes in the banks of streams, from under tree-roots on the land, from under the bark in interstices of fallen dead trees, from holes in the ground under logs and driftwood, and from under piles of brush (Figs. 5, 6, 7, 8, 9, 10). They have been found, also, in such places as are mentioned by Kirkaldy (1899a, p. 151), who refers to the Gerridæ in general in the following quotation:

> As has been previously remarked, many of the Gerridæ conceal themselves—in fact "hybernate"—under moss, stones, etc., often far from water, during the winter.

However, it should be stated that, after looking through my field notes for the past few years, no records were found of *Gerris remigis* hibernating far from water (Figs. 5, 6, 7, 8, 9). Further investigation may prove that alate forms (Fig. 11) of this species sometimes hibernate in other situations than those close to their own habitats. Referring to the hibernation of *Gerris orba* Stal, a congener of *Gerris remigis*, Essenberg (1915a, p. 397) states that:

> The water-striders pass the winter as adults, hibernating under logs, rocks, rubbish, and in other sheltered places.

It is evident that these two species pass the winter in somewhat similar situations. While Hungerford (1919, p. 117) has little to say regarding the hibernation of *Gerris remigis*, the records that he does give are correct. He remarks that:

> Our large *G. remigis* winters as an adult hidden under some brush, logs or other shelter about the water.

His records are from Kansas and it is interesting to notice that he points out the fact that this species hibernates in the vicinity of its own habitat. It should be stated that *Gerris remigis* is mainly an apterous species (Fig. 1) and it is to be expected that few even of the alate forms (Fig. 11) will be found hibernating at any great distance from their aquatic habitats (Figs. 4, 5, 6, 7, 8, 9). In a paper by me (1919a, p. 484), on certain habitat responses of *Gerris remigis*, there is a brief statement of some extended observations on the hibernation of this species on and near the margin of a large pool, at the headwaters of a small, rapid stream, in the vicinity of Syracuse, New York, which is quoted here:

> They [*Gerris remigis*] undoubtedly hibernate, in large numbers, along the shores of this pool. In fact, I have found a few of them hibernating in interstices where the shore slightly overhangs the water, and also among dead leaves and other vegetation at points from a few inches to three yards away from the pool.

On several occasions, a few alate individuals (Fig. 11) have been found hibernating within three yards of the water (Fig. 5).

In all of these situations, where water-striders were found, the insects kept in close contact with their immediate surroundings and with each other. In some of these places, they have been taken in large numbers (Figs. 6, 7, 8, 9). They have been found in groups, frequently as many as fifty individuals in a cluster. Sometimes the aggregations were so large that one hundred and fifty to two hundred and fifty gerrids have been counted. Often in these winter quarters (Figs. 5, 6, 7, 8, 9, 10) they lie in close contact with each other, their bodies being closely applied. Such responses were, very probably, due to their thigmotactic propensities.

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At this point it may be mentioned that a number of other entomologists have referred to the hibernation quarters of water-striders. Among these are Uhler (1884), McCook (1907), and Kellogg (1908). From the context, it is to be inferred that all three of these writers refer to *Gerris* (=*Hygrotrechus*) *remigis*. Uhler (1884, p. 268) makes the statement that:

> These insects stow themselves away under the banks of streams, in the mud beneath leaves or rubbish, or at the bottom of water under stones and roots of trees when the autumn begins to be cold, and from thence they reappear upon the surface of the water as soon as the warm weather of spring returns.

McCook (1907, p. 265), when writing about the hibernation of water-striders, remarks that:

> When winter sets in the survivors of the season burrow into the mud, or under bunches of dead leaves and withered grass-stalks or stones or other rubbish, and there lie dormant or semidormant until spring again calls them to active life.

Kellogg (1908, p. 198), in referring to the situations in which water-striders hibernate, makes the following statement:

> In late autumn the water-striders conceal themselves in the mud beneath leaves or rubbish or at the bottom of the pool under roots or stones to hibernate, coming out again with the first warm days of spring.

I wish to state that it was a long time before I found *Gerris remigis* in a hibernating condition. Search was made in almost every conceivable situation before the hibernation quarters of this species were located. Many careful searches were conducted during a large part of one winter before any hibernating individuals were discovered, and a part of a second winter passed before they were found in numbers. For a period of years, both in the autumns and in the winters, careful observations were made of the behavior of these water-striders, not only as they migrated into places of hibernation, but also after they were settled in their winter quarters (Figs. 5, 6, 7, 8, 9, 10); and I never have found them hibernating in mud, in water, at the bottom of water, at the bottom of a pool, pond, brook, creek, or river.

During the hibernating period, the gerrids evince little movement. Within a radius of two miles of White Heath, Illinois, in the months of December and January, large numbers have been taken from holes in the banks of brooks—but not

Fig. 8. Detail of small intermittent brook—during high water, current flows southeast, in illustration to left—Brownfield Woods (elm-maple deciduous forest), about three miles northeast of Urbana, Illinois—autumn. Shows drought conditions, greater part of brook being dry, except for a few small, isolated pools, three being shown in bed of brook in foreground. Water-striders, *Gerris remigis* Say, found on this brook, pass from one pool to another, over dry bed of stream, by method of trial and error; when photograph was taken, gerrids observed only on pool next to log; ten days earlier found on all three pools. Water-striders observed leaving surface-film for hibernation quarters in interstices of undercut bank, under dead leaves, under log, in interstices of and under bark. Trees, shrubs and herbaceous vegetation shown along bank of brook. (Photograph by Chenoweth.)

in mud—from holes on the land, filled in with dead leaves and drift debris left after floods, under the roots of trees, and from under compact masses of dead leaves (Figs. 5, 6, 7, 8, 9). There would be so many of them from one location that they scarcely could be held in two cupped hands. At such times it was noticed that they were very quiet, there being hardly any movement at all on the part of the gerrids. If they were taken from their winter quarters during a thaw, there was more movement than was the case during freezing weather. Occasionally, when their hibernating quarters were uncovered, the insects were almost overlooked, because they remained so quiet and in such close contact with the substratum and with each other. There was, in addition, another fact which increased the difficulty of finding them and that was the frequent similarity in color of the background to the color of the water-striders. It has been observed by me (1912, p. 275) that certain other semiaquatic Hexapoda, Agrionid nymphs of the order Odonata, exhibit somewhat similar responses.

In general it may be stated that when hibernating water-striders were found, their bodies were closely applied to each other. Those on the periphery of the group were in close contact with their immediate physical surroundings on the one side and with the gerrids forming the inner portion of the cluster on the other side. Frequently, their legs were so inextricably entangled that on lifting up a few members of the aggregation, many others would be found clinging to them. Essenberg (1915a, p. 400) has recorded responses of a similar character with respect to a closely related species of water-strider, *Gerris orba*. In connection with certain of the statements made above, a quotation from one of my own papers (1919, pp. 402-403), on some habitat responses of *Gerris remigis*, may be of interest:

> During hibernation, there is no question about water-striders remaining quietly in one place for a long period of time. But it must be recalled that the temperature is low at such times, and that they frequently seek dry situations. . . . The positive thigmotactic responses of these gerrids have been observed frequently during periods of hibernation. At such times they formed tangled masses, which were due to the water-striders crowding closely together. These facts were recorded in my field notes as early as the winter of 1912–1913.

The different phases of behavior that have been discussed, such as crawling into the various hibernating quarters which have been enumerated, the crowding together into clusters, and the motionless state in which the gerrids lie, are due in part, if not largely, to contact responses, although there have been accumulated certain facts that seem to indicate that the crawling into winter quarters may be partially the result of a tendency toward negative phototaxis at the hibernation period. However, more evidence is needed on this point.

These gerrids seem to be responsive to contact stimuli not only during the hibernation period, but also at its inception. Apparently, both the dorsal and ventral surfaces are sensitive to contact as well as the legs and lateral sides of the body. Frequently, they have been found in piles of dead leaves (Figs. 5, 6, 7, 8, 9) with their bodies in such positions as to suggest evidence for the above statement. Their bodies were in contact with a leaf above and with a leaf below, the legs being stretched out as nearly as possible in the same plane as that of the body. The legs and bodies of the insects appeared to be rigid and they were so to the touch of the fingers. It was possible to lift the body of a gerrid by means of the posterior pair of legs, without bending them, the animal remaining perfectly stiff and motionless while this was done. All of this was very suggestive of the death-feigning response—briefly discussed later in this paper—which is induced, certainly in part, by contact stimuli. The gerrids evidently had crawled into the masses of leaves through the interstices formed between the different individual leaves (Figs. 6, 7, 8, 9). Such movements brought not only the upper surface of the body in contact with the leaf or leaves above this surface, but it also brought the lower surface of the body against the leaf or leaves below this latter surface. In many instances it was clear that the spaces between the leaves were so small that the water-striders could not have walked erect into the interstices (Figs. 6, 7, 8, 9), but must have raised their legs almost to the same plane as that of the body and almost parallel with its longitudinal axis. In fact, not infrequently, individuals have been found with their appendages exactly in the position described.

However, there is considerable positive evidence with respect to the points just discussed. On several occasions the gerrids have been observed, after they had left the surface-film, walking along in a direction more or less parallel with piles of leaves situated about a yard from the bank of the stream from which the water-striders came. They have been seen to enter such masses of leaves by way of the spaces left between the individual leaves of these bunches (Figs. 6, 7, 8, 9). Sometimes they attempted to enter the masses of leaves by means of interstices between the individual leaves so small that it was impossible for them to walk in an upright position while doing so, or even after they had entered the interstices (Figs. 6, 7, 8, 9). It should be stated that, in course of time, these large bunches of leaves become very firm and compact (Figs. 6, 7, 8, 9). It was found that the insects overcame the difficulty of entrance, in some instances at least, by pressing the proximal portions of the legs so closely against their bodies that these appendages extended laterally from them and appeared to be almost in the same plane. In other instances the legs were raised until they were almost in the same plane as the bodies of the gerrids and slightly oblique from parallel to their long axes. These water-striders have been found under the bark of fallen, dead trees (Figs. 7, 8, 9) and in their interstices (Fig. 5) in spaces so restricted, that if the animals actually had not been observed to crawl therein, it would seem rather difficult to account for their presence in such situations. Often they have been taken from under heavy logs (Fig. 7, 8, 9) and driftwood, in such places where it seemed no insect could remain without being crushed. The act of crawling into locations of the various characters that have been indicated, as well as the act of staying there quietly, seems to be partially explained at least by their thigmotactic responses. There is some evidence that these gerrids may be negatively phototactic at this season; if this proves to be true, it would have to be taken into consideration in the final summing up.

6. CONTACT RESPONSES AND DROUGHT.

Some extended observations made, during the years 1911-1913 inclusive, on *Gerris remigis*, with reference to certain habitat responses, present additional information on the behavior of this species to contact stimuli. These observations were concerned mainly with the responses of the gerrids after their stream habitat had become dry (Figs. 8, 12), during

Fig. 9. Detail of log, bank of brook, and pool of small, intermittent brook, showing drought conditions, Brownfield Woods, near Urbana, Illinois—autumn. Shows part of isolated, brook pool, which water-striders, *Gerris remigis* Say, inhabit. Gerrids observed to leave surface-film for hibernation quarters in interstices of undercut bank, under bunches of dead leaves—usually much more compact than indicated in illustration—under stones, under log, in interstices of and under its bark. (For other details, see Fig. 8.) (Photograph by Riley and Chenoweth.)

periods of severe and extended droughts. It was evident, if they reached another stream or pool, that the result was accomplished by means of trial and error. During the course of their wanderings, they frequently came in contact with various objects in their path, such as lumps of dry mud, driftwood, clumps of dead leaves, and stones (Figs. 8, 12). Often, the forward movement of the gerrids ceased at such contact. Stimuli of this character inhibited locomotion and the water-striders became stationary, their bodies being applied closely to such objects as have been enumerated. Apparently, as a result of such contact stimuli, sometimes they crawled underneath these obstructions (Figs. 8, 12). In both cases, whether their bodies were in close contact with the objects, or whether they crawled beneath them, they remained stationary for various periods of time. Frequently, these extended from a few minutes to an hour or more. Sometimes, after such inhibition of locomotor activities, there was a change in the direction of their movement, when their journey was renewed. Occasionally, they fell or jumped into large cracks which had been formed in the mud of the dry bed of the stream and they remained there during intervals of time extending from a few minutes to several hours, on one occasion at least for three hours. During such wanderings as occur after their habitats become dry (Figs. 8, 12), responses to contact appear to be a common feature of their behavior. Contact stimuli, frequently, result in inhibiting locomotor activities and cause the insects to become quiet, so that they remain motionless in one position for various periods of time.

7. CONTACT RESPONSES AND LABORATORY OBSERVATIONS.

While conducting certain experiments in the laboratory on *Gerris remigis*, some phases of the behavior of these water-striders indicated that they responded to contact stimuli. After collecting the gerrids in the field, they were placed in large, glass aquaria—dimensions 36 x 18 x 20 inches—in the laboratory. These aquaria contained a few inches of water and several large stones, the upper surfaces of which protruded an inch or so above the surface of the water. At first the insects moved about freely on the surface of the water, but, frequently, after a few minutes of time, some of them left the water-surface and climbed up onto the surfaces of the stones. Very soon the leaders were followed by others, until, eventually, the majority of the gerrids had left the water. The entire upper surfaces of the stones were covered by the water-striders, sometimes several layers in thickness, so that they presented the appearance of dark brown masses extending above the surface of the water. The insects remained motionless, with their legs and bodies entangled in clusters. If undisturbed, they often stayed in these compact groupings for hours and even for days. The solid surfaces of the stones and the contact of the bodies of the hemipterons appeared to act as stimuli, inhibiting movements and resulting in the gerrids lying motionless for long periods of time.

Many of the insects left the surface of the water and crawled up the perpendicular glass faces of the aquaria, a response probably due to gravity. However, they did not remain in such situations, for within one or two hours they were all assembled, with the exception of a few individuals that were still leaving the surface of the water, in the angles formed by the meeting of two of the glass sides of the aquaria. Frequently, in these angles, there were formed tangled masses of gerrids, extending from a point one or two inches above the water-surface to the very tops of the aquaria. Several of the aquaria had metal flanges, extending inwards, placed at right angles to the upper edges of the upright glass sides. The juxtaposition of these flanges and the perpendicular sides of the aquaria formed right angles, and, often, many of the insects were found in these angles. Pearl (1903, pp. 560-562), experimenting with planarians, applied the name goniotaxis to responses of a similar character. The gerrids climbed to the very tops of the aquaria and formed tangled groups all round their upper edges and especially in the corners formed at the meeting points of the flanges and of two upright glass surfaces. Responses of this character were first observed when conducting experiments with some half dozen gerrids in each aquarium. It was noticed that the water-striders had disappeared. After searching for them carefully, it was found that they had crawled to the tops of the aquaria and had taken up positions such as already have been described. In a number of the aquaria, stones were placed close together, but with small spaces between them. It was observed that the gerrids crowded into these openings and came to rest there, often staying in a quiescent condition for several hours and on a few occasions for several days. In these various observations, it appeared as if the angles of the aquaria and the close proximity of the stones exerted contact stimuli to which the water-striders responded by coming to rest in such positions. In situations of this character large areas of their bodies were in close application to the substrata.

Certain members of the class Crustacea, belonging to the order Amphipoda, for example some of the species of the family Orchestiidæ, evince thigmotactic responses which are very similar to those of *Gerris remigis.* Because of this similarity, attention is directed to the careful observations made by Holmes (1903, pp. 194, 195) on three species of the Amphipoda, *Orchestia agilis, Allorchestes littoralis* and *Orchestia palustris.* Brief quotations from the paper by Holmes are given here:

> *O. agilis* generally continues hopping until it alights in a place where it can readily get under some object or wedge itself between bodies, so that it secures contact on a considerable surface of its body.

Writing of *Allorchestes littoralis*, he mentions how it glides away when it is disturbed and continues his remarks as follows:

> The efforts are continued until they bring the creature into some niche or crevice where the contact sought for is obtained; then it curls up and lies quiet.

With reference to *Orchestia palustris*, Holmes states that:

> The tendency to get under or between objects is as strongly developed in this species as in *agilis*, and contact has apparently a stronger quieting effect upon it. When lying quiet *O. palustris* may be poked about more or less without being aroused from its thigmotactic lethargy.

While it is true that the observations on *Gerris remigis* were made on individuals confined in aquaria and the records of Holmes were obtained in the habitats of the Amphipods, yet the responses in the two cases were so much unlike—and similar behavior on the part of the gerrids has been observed in their own environment—that a brief comparison seemed to be desirable.

Fig. 10. Detail of log in bed of intermittent brook, Brownfield Woods, near Urbana, Illinois—autumn. Water-striders, *Gerris remigis* Say, hibernate, in large numbers, in interstices of and under bark of log, also in deep depression under leaves in foreground. (For other details, see Figs. 8, 9.) (Photograph by Riley and Chenoweth.)

8. CONTACT RESPONSES AND DEATH-FEINT.

Another form of response, related to contact, often is evinced by these gerrids and that is the death-feint. This frequently can be induced by gently stroking the dorsal sides of their bodies. Sometimes, merely touching the animals is sufficient stimulation to obtain the death-feigning response. In other instances, if they are picked up in the fingers, this response occurs. However, on other occasions, it is very difficult to elicit the death-feint and sometimes, no form of contact stimuli calls forth the response. Essenberg (1915a, pp. 399-400, 402) states that *Gerris orba*, a congener of *Gerris remigis*, feigns death, the response being very pronounced in certain individuals. The response can be elicited by contact stimuli. On arousing from the death-feint, it again can be induced by means of contact stimulation. The normal position assumed by *Gerris remigis* during the death-feint is for the body to lie flat against the substratum, where it becomes rigid. At such times the front pair of legs and antennæ are stiff and stretched forward, while the middle and hind pairs of legs also become rigid and are stretched backward. The legs assume a position as nearly as possible in the same plane as that of the body and almost parallel with its longitudinal axis. The insects remain perfectly motionless during the response and may be handled without arousing them from the death-feint. They may be lifted by the posterior pairs of legs without these being bent. At such times, the entire weight of the body is supported by these legs. Often, on arousing from the death-feint, stroking the body and other forms of contact stimuli again induces the response. On the other hand, after the death-feigning response has continued for some time, contact stimuli, frequently, arouses the animals from it, as does dropping them onto the surface-film of water.

Members of other families of aquatic Heteroptera besides Gerridæ exhibit the death-feigning response, for example, the water-scorpions, *Ranatra fusca* (Holmes, 1906), *Ranatra quadridentata* (Holmes, 1907)—both of the family Nepidæ—*Belostoma flumineum* Say and *Nepa apiculata* Uhler (Severin and Severin, 1911), the former of the family Belostomidæ and the latter of the family Nepidæ. Severin and Severin (1911a) again refer to the death-feigning instinct of *Nepa apiculata*.

It is evident, from the observations and experiments of these and other writers, that responses to contact stimuli are closely associated with the death-feint. Holmes (1906, pp. 200-201, 206, 211) has pointed out the fact that contact and stroking the bodies of Ranatras with the fingers induces the death-feint. He (1906, p. 204) records the interesting observation that when the water-scorpions arouse from the response, the death-feint again can be invoked by contact. This writer (1906, p. 201) also declares that the contact of air currents brings about the death-feigning response. According to Holmes (1907, pp. 161-163), *Ranatra quadridentata* exhibits the death-feigning response. He found that the response is not so pronounced in young Ranatras as is the case in older individuals. Contact stimulation appears to be influential in eliciting the response both in the immature and adult insects. Under certain conditions, as the water-scorpions arouse from the death-feint, it can be induced again by contact stimuli.

In the interesting monograph by Severin and Severin (1911, p. 2), the fact is pointed out that *Belostoma flumineum* feigns death "when raked or scooped out of the water." Picking it "out of the water from an aquarium," or repeated contact of the fingers to the abdomen, often elicits the death-feigning response. *Nepa apiculata* readily feigns death, while in the water, if it is touched on the dorsal side "with a pencil or other object." A similar response is obtained by removing the insect from the water by means of a pair of forceps. The result is the same, whether it is grasped by the body, the breathing tube, or the legs. It is evident, in these instances, that contact stimulation is the factor which induces the death-feint. These writers (1911, pp. 6, 7) direct attention to other examples of the influence of contact stimuli in eliciting the death-feigning response. *Nepa apiculata* will feign death when placed on its back. After arousing from the death-feint it attempts to turn over onto its ventral side and in making such an attempt the animal often falls again onto its back. The effect of the shock, in falling back again, may result in inducing the response. When righting itself, the "shock effect" of dropping onto its ventral surface is frequently sufficient to elicit the death-feint. A feigning *Belostoma flumineum* can be aroused by a breath of air blowing against it. The contact of a pair of forceps, a house-fly, or another *Belostoma*, any one of these, may stimulate the animal so that it arouses from the death-feint. Then again, this species may arouse from the feint without any visible external stimulation.

Severin and Severin (1911, pp. 8, 9) state that the legs or parts of the legs of a feigning *Nepa apiculata* may be cut off without disturbing the animal. During the death-feint, this species may be cut through the prothorax and both parts of the body will remain quiet. But a feigning insect immediately arouses when dropped onto the surface-film of water. These investigators (1911, p. 13) remark, with reference to ten individual *Nepa apiculata*, that:

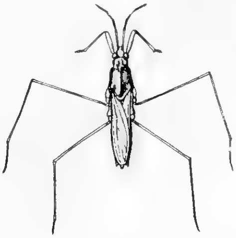

Fig. 11. The large water-strider, *Gerris remigis* Say, alate form; a typical surface-film, running water inhabitant. Natural size. (Drawing by Beutenmüller).

> Every specimen was made to feign by taking it out of the water with a pair of forceps, dropping it upon a moist blotter from a small height and turning it over and over laterally three or four times.

In another connection they (1911, p. 16) state that:

> The death feint of Belostomas often ends suddenly when the insects are thrown into water; frequently, however, the bugs bob up to the surface of the water and continue to feign there.

With reference to the death-feint of *Nepa apiculata*, mentioned by these writers (1911a, p. 100) in the second of their papers, there is the statement that:

> When raked out of the water, together with the mud and partially decayed vegetation, these insects usually feign death, in which condition they readily escape detection, as their flat bodies are effectively concealed by the black mud and decaying plant tissue.

Regarding the origin of the death-feigning response, Severin and Severin (1911, pp. 37-38) make the following statement:

Among the aquatic Hemiptera, the death feint may have arisen out of positively thigmotactic propensities which are manifested to such a marked degree by various members of the families Belostomidæ and Nepidæ. In a previous paper, attention has already been called to the fact that *Belostoma* and *Nepa* as well as other closely related aquatic Hemiptera cluster together to form groups whenever possible, which probably is a manifestation of their positively thigmotactic response. *Belostoma* will crawl, whenever possible, beneath aquatic plants or other objects and will then often assume that death-feigning attitude in which the legs are folded against the ventral surface of the body. Specimens, which had cuddled within thick masses of *Elodea* or *Ceratophyllum*, often required a considerable amount of shaking to bring them out of their inert state. *Nepa* can be caused to feign while in water by a mere contact stimulus.

The death-feigning response is a common phase of behavior among certain Crustacea, especially among members of the order Amphipoda, of the family Orchestiidæ. Holmes (1903) discovered that both *Talorchestia longicornis* and *Orchestia agilis* exhibit this response, the latter in a lesser degree. He (1903, pp. 192-193) draws attention to the fact that, in the case of *Talorchestia longicornis*, contact with the fingers and with solid objects such as sand and small stones induce the death-feint. When the bodies of these animals are surrounded with the objects mentioned, thus giving greater contact, the duration of the response is much longer than that of individuals lying on a flat surface. As members of this species arouse from the death-feint, pressure or contact cause them to resume death-feigning. Regarding *Orchestia agilis*, this observer (1903, pp. 194, 195) states that contact stimuli exercise "a sort of hypnotic effect" on it. On the other hand, contact may arouse the animal from this condition. The thigmotactic responses of *Orchestia agilis* do not appear to be so definitely of the death-feigning character as do those of *Talorchestia longicornis*.

The entire paper of Holmes (1903) is of an extremely important character. His discussion of the probable method of evolution of the death-feigning instinct and of its probable origin are both very suggestive. He (1903, p. 195) refers to another species of amphipod, *Orchestia palustris*, of the family Orchestiidæ, pointing out that, although it responds definitely to contact stimuli and lies very quiet when in contact with and between solid objects and is aroused with difficulty from "its thigmotactic lethargy," yet its response with the death-feint is less pronounced than that of *Talorchestia longicornis.* However, its thigmotactic responses are much better developed than are those of *Orchestia agilis.* Holmes (1903, pp. 195-196) states that:

> The conduct of this species [*Orchestia palustris*] is intermediate between the thigmotactic response of *agilis* and the death-feigning of *Talorchestia.* Some specimens might almost be said to possess a death-feigning instinct.

He believes that if certain of its thigmotactic responses were

> carried out in a more decided manner and persisted in longer [that they] would result in what would commonly be called feigning death.

Continuing his discussion of the probable development of thigmotaxis into the death-feigning instinct,he remarks that:

> The death-feigning instinct of *Talorchestia* is an instinct which, I believe, has its root in the thigmotactic responses common among other amphipods. One may easily conceive that by the selection generation after generation of those individuals of *O. agilis* in which the thigmotaxis is most persistent . . . a mode of behavior like the death-feigning instinct of *Talorchestia* might readily be produced.
>
> It seems not improbable that an instinct having its phyletic root in a simple thigmotactic response may in course of time come to be comparatively independent of contact stimuli. The persistence of death-feigning in *Talorchestia* depends far less upon contact than the thigmotactic reactions of the aquatic Amphipoda, although, as has been pointed out above, contact still increases the duration of the feint.

Holmes points out that eventually contact stimulation may become necessary only to initiate the death-feigning response, but may not be required for the continuation of the feint. In course of time a mere tap or jar is all that is required to bring about the response. He points out that the death-feint is generally evoked as a response to some sort of contact stimulation. These references to the work of Holmes will be closed by directing attention to one other statement recorded by this writer. He (1903, p. 193) states that:

> *Talorchestia* does not feign death upon receiving purely visual impressions; it requires contact of some sort to elicit this form of response. The same fact seems to be quite general in the death-feigning of animals, especially below the vertebrates, and it is a circumstance, I believe, of considerable significance in relation to our views of the genesis of this instinct.

Fig. 12. Detail of part of Stony Creek, a branch of Salt Fork, a tributary of Vermilion River—showing drought conditions—near Muncie, about eighteen miles east of Urbana, Illinois—late autumn. Stream flows through a forested region. Light-colored rock in bed of creek is limestone; aquatic grasses and sedges shown in partially dry bed of stream. This part of creek consists mainly, of isolated pools, with some running water flowing to right in left background; one large pool in left background, a portion of a smaller one in left foreground, and others—not clearly shown—among vegetation in bed of creek. Water-striders, *Gerris remigis* Say, live on surface of creek and pools; gerrids become trapped in pools and, as these become dry, pass overland to other pools by method of trial and error. High clay bluff in background forms north bank of creek. (Photograph by Lloyde and Riley.)

9. CONTACT RESPONSES AND RAIN STORMS.

These water-striders frequently display a form of behavior that is at least associated with the contact response. During heavy rains, it has been found, in observations of their behavior on the surfaces of brooks and creeks, that they stride along the surface-film to the shore, to rocks, to dams formed of driftwood, and also to vegetation (Figs. 2, 3). On one of the earlier occasions when responses of this character were noticed, work was being carried on along the course of a small brook, in the vicinity of White Heath, near Urbana, Illinois. A sudden thunder shower came up and it was observed, as the rain began to fall, that the gerrids quickly left the open situations on the surface of the brook. Many of them sought the windward bank of the brook, at points where it overhung the water. Here they were found close in to the shore, usually, with the middle and hind legs on one side of the body anchoring them to the solid substratum. Others "sought" the windward sides of rocks where they attached themselves in a similar manner. In a few cases, it was noticed that they climbed up the perpendicular sides of the rocks and crept into crevices. In some other instances, they crawled up onto the upper surfaces of flat stones that were just a few inches above the surface of the water. Others came in contact with aquatic and semiaquatic plants that either extended above the surface of the water, or else grew along the margins of the brook (Figs. 2, 3). In this connection it may be of interest to direct attention to a statement by Essenberg (1915a, p. 398), made with respect to *Gerris orba*, who remarks that:

> When disturbed while on the water, the insects betake themselves quickly to the land or among the weeds, and hide by clinging to the lower surface of the leaves or by lying quietly on the ground.

Near the location where my work was being done on that particular day, there was a large dam formed of driftwood, so situated that during this storm one side of it was to windward. It was found that the gerrids were congregated here by the hundreds. Many of them were on the surface-film with their middle and posterior pairs of legs of one side placed on a portion of the driftwood. Such a position anchored them from the storm and gave them security from the wind and rain. Some left the water and crawled a few inches onto the driftwood, where they were secure. Their legs were spread out and their bodies flattened against the substratum. In a number of instances, they crept into slight depressions and interstices in the driftwood and lay there motionless. It should be stated that the great majority of the gerrids did not leave the surface of the water and those that did do so occupied positions seldom more than a few inches away from it. Those individuals, that were caught by the wind and rain on the surface-film in situations considerably nearer to the leeward than to the windward side of the brook, in the main "sought" the bank on the former side. It was noticed that a larger number of these crawled from the surface-film onto some solid substratum than was the case of gerrids on the windward side of the brook. During such storms, none or only a few of the gerrids may leave the surface-film, but always they are found anchored to, or in contact with some solid object, or else on the surface of the water in some unusually well protected situation. In this connection a statement by de la Torre-Bueno (1917a, p. 296), with respect to a related species, *Gerris marginatus* Say, is of interest. He remarks that:

> Unlike its larger congener *remigis*, it is a dweller in still waters by preference. Here at times it gathers in large numbers. In strong winds it hugs the shore, particularly if it blows that way.

After the storm was over and the sun emerged, many of the water-striders promptly "sought" the surface-film and continued their usual forms of behavior. Others delayed making this movement for several minutes after the cessation of the rain. While still others were found in contact with some solid substance for a half an hour after the storm had ended. Many of those, which first moved onto the open areas of the stream, were gerrids that did not crawl upon any solid surface away from the water. The animals which crept into depressions and interstices, in the main, were the last to reach the surface-film, probably due to the fact that greater areas of their bodies were applied to the substratum and, therefore, contact stimuli influenced them more strongly than the others which did not have such large surfaces of their bodies in contact with some solid surface. Contact stimuli appear to play a considerable role in responses of the character that have been described. Certainly they seem to have a decided effect in the cessation of the locomotor activities of the water-striders. Such stimuli not only appear to exert influence in bringing the gerrids to rest against some solid object, but also in their action in keeping them there for considerable periods of time.

III. RESPONSES TO LIGHT.

1. Habitat Responses to Sunlight.

The responses of *Gerris remigis* to photic stimuli have not yet been worked out fully. Groups of these gerrids, in their habitats on the surfaces of brooks and creeks, frequently have been observed to assemble in the shade of the banks, of overhanging rocks, and of trees. These aggregations are evident especially during the heated days of summer. Such gatherings are very common on the surfaces of streams in the prairie regions of Illinois, where, during the late summer, there is often a very high temperature and glaring sunlight untempered by any wind. On cloudless days, with the temperature at 100° F., the unshaded portions of streams frequently were entirely free from water-striders, but they were found on those parts of such waters that were shaded by trees, shrubs and other vegetation. Occasionally, there were days of this character when no gerrids could be seen on the open surface of a brook, but often on reaching some situation where the water practically was concealed by overhanging willows, alders and herbaceous vegetation, it was found, when such vegetation was disturbed, that the water-striders darted out from under it in many different directions. Hungerford (1919, p. 116), writing of *Gerris remigis* in Kansas, states that:

> They are gregarious fellows, seeking a resting place in the shade of overhanging bank or bush, but taking wildly to the open when alarmed.

However, this "seeking" of shaded situations may be the result of a combination of responses to the sunlight and to the heat, or it may be entirely a response to the latter form of stimulation. Although this needs to be tested in detail experimentally,* yet certain statements by de la Torre-Bueno (1911, p. 246) seem to suggest that temperature is a factor in influencing these gerrids to congregate in shaded situations. This observer remarks that:

> It [*Gerris remigis*] is to be found most frequently on running waters, although it also frequents still, but to a less extent. . . . They con-

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* Some experimental evidence already has been obtained and further experiments are under way. It is hoped that the results obtained will be published in a later paper.

> gregate in groups in shady, slow-moving parts of streams, at the tree roots projecting from banks into the water, in the shadow of bridges, and in general in almost any place where they have some shelter from the burning rays of the summer sun.

Again referring to *Gerris remigis*, he (1917, p. 201) makes the following statement in connection with some of their habitat responses:

> These beasties are common and familiar sights to the lover of the quiet flowing waters running to the distant sea. In these haunts, in some still bay or moveless backwater, under a bridge, or in the shadow of a tree, or in the cool recesses of an overhanging bank, you may see *remigis* gathered in numbers, rowing silently about. . . . Here they rear large families and spend at ease the sultry dog-days.

2. Responses to Sunlight and Laboratory Observations.

Although the habitat responses of the gerrids, referred to in the previous section of this paper, eventually may be proved to be responses to temperature rather than to light—sunlight—nevertheless, there is some positive evidence in connection with their behavior with respect to sunlight. During the summer, numbers of *Gerris remigis* frequently have been kept in the laboratory in large aquaria, of the kind already described. On several different occasions, it was observed that when a strong beam of sunlight entered an aquarium, containing gerrids of this species, that they were found congregated at the end of the receptacle farther away from the entering beam of light. Sometimes they did not crowd to the end of the aquarium, but simply moved out of the sunlight into the more shaded parts of the vessel. One afternoon, two aquaria accidently were left on a laboratory table near a window, in such a position that they were practically parallel to each other. The aquarium next to the window was almost full of water, while the one farther away from the window contained only a few inches of water. There were gerrids in both aquaria and in each case they were congregated at the end farther from the beam of sunlight that passed through both aquaria. Such behavior suggested that the water-striders were responding to the sunlight, but there remained the possibility that the response might be due to temperature, at least on the part of the gerrids in the aquarium next to the window. However, the behavior of the insects in the farther receptacle seemed to be the result of a negative response to sunlight, for it is evident that the water in the aquarium near the window must have modified to a considerable degree the temperature of the sunlight as it passed through the farther receptacle.

3. RESPONSES TO ARTIFICIAL LIGHT OF MODERATE INTENSITY.

In order to discover whether the gerrids would respond to artificial light of a weaker intensity than sunlight, the animals were subjected to electric light. They were placed in an aquarium—all aquaria used in this work being of the dimensions previously given—with parallel glass sides and ends, containing a few inches of water. The bulb of an incandescent light was hung in front of one end of the aquarium and about four inches away from it, the illumination within the field of experimentation being approximately 44 ca. m. All experiments with artificial light were performed in a dark room.

When the light first was placed near the aquarium, the insects, about fifty of them, were found to be scattered about on the surface-film. There were movements of the antennæ, legs and bodies as soon as the animals were subjected to the influence of the light. In a few seconds, perhaps half of the gerrids so oriented themselves that their heads were directed toward the source of illumination. This placed the longitudinal axes of their bodies parallel with the sides of the aquarium and also parallel with many of the rays of light passing through the bulb. It can not be said, however, that the long axes of the bodies of the insects were definitely parallel with all the rays of light passing into the aquarium from the source of illumination. Directly after orientation, the gerrids strode along the surface-film to the end of the vessel next to the light. The majority of them remained there, with their heads pointing toward the light.

By the time that these twenty-five water-striders reached the positive end of the aquarium, all but four of the remaining gerrids were oriented, with their heads directed toward the light and the long axes of their bodies placed parallel with many of the incoming rays. They then moved over the surface-film in the direction of the source of illumination, remaining at the end of the aquarium next to the light. None of the water-striders evinced a total indifference to the light, for even those that did not stride to the positive end of the aquarium, exhibited some sort of response. In certain instances there were movements of the antennæ, of the legs, or of the bodies. In other instances two or three of these sets of movements were observed. Two out of the four gerrids oriented themselves with their heads directed toward the source of light and they moved a few inches in the direction of the positive end of the aquarium. On the part of the two remaining insects, there was no orientation with respect to the light, but there were such movements of the legs, antennæ and bodies as already have been mentioned.

When the light was placed at the opposite end of the aquarium, the resulting responses of the gerrids were similar to those that have been described. The animals oriented with their heads toward the light and moved to the end of the vessel next to the source of illumination. Many individuals strode over the surface-film to the light very rapidly, the photic stimuli, apparently, exerting its influence on them immediately. By moving the light first to one end of the aquarium and then to the other, the gerrids were made to respond by moving to that end of the receptacle where the light temporarily was placed. Such experiments were performed many times with similar results. It is evident that *Gerris remigis* responds positively to photic stimuli from an incandescent light, with a field of illumination of 44 ca. m.

It has been pointed out previously that the majority of the members of this species are apterous (Fig. 1), but that occasionally a few alate forms are found (Fig. 11). In the various experiments performed up to the present time, it has not been possible to make the gerrids leave the surface of the water and fly toward the light. However, it is probable that, under certain favorable conditions, they would do so. In a former paper by me (1920a, pp. 4-5), attention was directed to the fact that a related species, *Gerris marginatus*, has been observed to migrate by flight during moonlight nights, a probable response to photic stimuli. Drought may have some bearing on such flights, as they were noticed in an interval of extended dry weather. Attention is directed to a quotation from the paper just referred to:

> On perhaps three occasions, when droughts of this character extended into the fall, I have witnessed the flight of a few isolated specimens [of *Gerris marginatus*]. I wish to state that it was several years, after I first became interested in the family Gerridæ, before I saw a water-strider fly without some artificial stimulation. Flight occurs at dusk and during moonlight nights. This fact I observed for the first time in Illinois. Flight may take place at other times also, but it has not been seen by me.

Essenberg (1915a, p. 400) has observed the flight of another closely related species, *Gerris orba*, in response to stimuli from artificial light. She states that:

> *Gerris remigis* [orba] is positively phototactic. If it takes to its wings once in a while it always flies toward the light, producing a buzzing sound as it flies.

4. RESPONSES TO ARTIFICIAL LIGHT OF WEAKER INTENSITY.

These water-striders respond not only to the stimuli of an electric light of 44 ca. m. in the field of experimentation, but they also respond to photic stimuli from a light of much less intensity. An electric incandescent light bulb, which gave 22 ca. m. illumination in the experimental field, was hung at one end of the aquarium containing the gerrids. The general responses of the animals, with respect to the photic stimuli, were noted. When the light was flashed onto them, the majority so oriented themselves that their heads pointed toward the source of illumination and the long axes of their bodies were parallel with the sides of the aquarium and with many of the incoming rays. There were thirty water-striders in the receptacle. Twenty-two responded by striding over the surface-film to the positive end of the aquarium. Most of them congregated there, but they did not remain stationary. Some crawled up the perpendicular glass end; others remained with their heads directed toward the light; while still others moved back and forth at the lighted end of the aquarium. A number of similar experiments were performed and the results, with certain slight modifications, were much the same as those that have been described.

Although no quantitative data were obtained, the general behavior of the water-striders, with respect to the source of illumination, was very similar to that recorded in connection with their responses to the electric light of 44 ca. m. in the field of experimentation. If there was any difference of importance, it was that the gerrids appeared to respond with somewhat less promptness to the stimuli of the weaker light than they did to those of the stronger illumination. According to Essenberg (1915a, p. 400) who observed the light responses of a closely allied species, *Gerris orba*, she found that:

> It is more phototactic in strong light . . . less so in a weaker light.

5. RESPONSES TO OSCILLATING ARTIFICIAL LIGHT OF MODERATE INTENSITY.

Not only does *Gerris remigis* respond positively to a stationary electric light, but it also responds to a moving electric light. In these experiments the source of stimulation was an incandescent electric light of 44 ca. m. in the field of experimentation. The gerrids were placed on the surface-film in an aquarium of the usual kind, containing water a few inches in depth. The bulb of the electric light was hung directly in front of one end of the aquarium and made to oscillate as a pendulum, its plane of motion being parallel to the end of the receptacle.

Thirty gerrids were used in the experiments. When the light was set in motion, the majority of the insects oriented with their heads pointing in the direction of the source of illumination. Then they moved promptly across the surface-film toward the positive end of the aquarium, in much the same manner as they did with respect to the stationary light of equal intensity. While no quantitative results were obtained, it was evident that the responses of the water-striders were more prompt with regard to the oscillating light than was the case with respect to the stationary one. They seemed to orient themselves to the source of illumination and also to move toward it more readily, perhaps, than was observed to be the case in their responses to the stationary light.

After reaching a point in the aquarium approximately eight to ten inches away from the glass end, nearest the source of illumination, the majority of the water-striders changed their direction of movement. Instead of continuing in lines practically parallel to the sides of the aquarium, they assumed positions with the long axes of their bodies oblique to the longitudinal axis of the receptacle. While their heads continued to be directed toward the general source of illumination, that is, toward the end of the aquarium where the light was placed, they now strode along the surface-film in oblique directions. Some of them turned their heads to the right and others turned them to the left. The directions in which their heads were pointed apparently depended on the swinging of the light—that is to say, it depended on the point that the light had reached in its oscillation. There appeared to be a certain amount of "indecision" as to the directions that the gerrids would take in their locomotor movements. As the light swung to the right, they tended to turn to the right and often moved for a short distance in that direction; then, as the light swung back again to the left, there was a tendency for them also to move back again in that direction. Whether the gerrids moved to the left or to the right, with respect to the oscillating light—while there were some slight movements toward it—the bulb swung back toward them so quickly that, in many instances, there were not many actual locomotor movements in its direction. So that the insects, in some cases at least, remained, approximately, in the same locations, although there were certain slight changes in positions.

Some of the gerrids congregated at the end of the aquarium nearest to the oscillating light, but they were found at any point along this end. Evidently, there was not much additional stimulation, in so far as the oscillating light was concerned, for they did not stride after it, but rather they moved about anywhere close to the lighted end of the aquarium. A few remained more or less stationary with respect to locomotion, some of them being actively engaged in cleaning their legs and antennæ. Other gerrids—as they strode across the water-film from the negative toward the positive end of the aquarium—on reaching the region where their paths became oblique, due to the influence of the oscillating light, moved close up to the glass in the end of the vessel. After the light swung past them, they moved, for a very short distance, along paths parallel to the end of the aquarium, but in the direction that the light had gone. Then, as it swung back and passed them again, some oriented themselves with their heads toward the light and moved for short distances in its direction along lines parallel with the end of the aquarium. In many instances—as the light swung past the gerrids—orientation toward the source of illumination was attempted, but this was not completed before the light was well on its way back again toward them. On such occasions, the water-striders did not orient, but continued along the paths that they already had taken. It is evident, therefore, that there was a tendency for those gerrids, which had reached the glass end of the aquarium, to follow after the oscillating light and so to move, frequently for distances of one or two inches, back and forth in lines roughly parallel with the end of the aquarium.

6. RESPONSES TO OSCILLATING ARTIFICIAL LIGHT OF WEAKER INTENSITY.

Experiments were conducted with the view of discovering the character of the behavior of these water-striders when subjected to the stimuli of an oscillating artificial light of lesser intensity than 44 ca. m. in the experimental field. For this purpose, an incandescent electric light of 22 ca. m. in the field of experimentation was suspended in front of the glass end of an aquarium. Then, the light was made to oscillate as a pendulum in a plane parallel with the end of the receptacle.

There were twenty gerrids on the surface of the water. When the light first was flashed onto the insects, it appeared as if all of them responded by so orienting their bodies that the long axes were parallel with the sides of the aquarium and their heads were pointed toward the source of illumination, but this soon was observed not to be the case. Five of them did not orient in this manner and fifteen of them did assume such positions as have been mentioned. Fifteen individuals responded positively to the light by striding along the surface-film toward the source of illumination. Five of the gerrids remained behind and did not move toward the light. Two out of the five responded by turning their heads toward the positive end of the aquarium, but they did not move in the direction of the light. The other three appeared to be rather indifferent with reference to the directive influence of the photic stimuli. The fifteen water-striders which had responded by moving toward the light, assembled at the positive end of the vessel. After an interval of a few minutes, the light was removed to the opposite end of the receptacle and the gerrids responded to the photic stimulation in a similar manner as before. By placing the oscillating bulb first at one extremity of the vessel and then, after a short interval of time, at the other extremity of the aquarium, the greater number of the water-striders always moved toward the source of illumination.

As the hemipterons strode along the water-film toward the light, the long axes of their bodies were approximately parallel with the sides of the aquarium and also with many of the entering rays of light, but by no means were their bodies parallel with all the incoming rays. However, when the animals reached points roughly six or eight inches from the positive end of the aquarium, their directions of locomotion became oblique with respect to the paths that they so far had travelled. Evidently these changes of directions of movement were due to the directive influence of the swinging light as it assumed various positions along the plane of its oscillation.

The further responses of the gerrids were much like those described in the experiments with the swinging 44 ca. m. electric light. The locomotor movements, in connection with the experiments with the light of weaker intensity, in a general way, were very similar to those evinced in the experiments with the stronger light of 44 ca. m. in the field of experimentation. There was, perhaps, a little less promptness in orienting to the oscillating light and also a little less definiteness in moving toward it than was the case when the light of greater intensity was employed as the source of illumination.

7. RESPONSES TO MOVING BUT NON-OSCILLATING ARTIFICIAL LIGHT OF MODERATE INTENSITY.

It was found that the gerrids responded readily to a moving incandescent electric light that was not oscillating. The light that was employed in the experiments was approximately 44 ca. m. in the experimental field. At the beginning of the experimental work, the light was placed directly in front of the aquarium containing the water-striders and at one end. Water was poured into the vessel to a depth of about four inches.

Contact responses modified the phototaxis to some degree, due to the fact that a large number of gerrids were used in each trial, forty to be exact.

When the experiments began, the animals were scattered about at various points on the surface-film. On the light being flashed into the aquarium, those gerrids which did not have their heads directed toward the lighted end of the aquarium, with four exceptions, immediately turned until they were standing with their heads oriented toward the source of illumination and with the longitudinal axes of their bodies parallel with the long axis of the aquarium and also parallel with many of the rays emerging from the electric light bulb. The majority of them promptly strode toward the light and congregated at the positive end of the vessel. Others paused a few seconds before they moved toward the source of illumination. Seven appeared to be indifferent to the photic stimuli, in so far as locomotion toward the light was concerned. They moved about on the surface-film apparently without any reference to the source of illumination; or they remained almost stationary; or they were busy cleaning their legs and antennæ. A majority of the seven, during the locomotor movements, kept nearer to the negative than they did to the positive end of the aquarium. This suggested, perhaps, a tendency toward being negative in their responses with respect to the light. However, while conducting several other experiments, of a similar character, it was noticed that just about as many individuals were near the positive as there were near the negative end of the vessel. These experiments showed that the larger number of the insects responded positively to the light and in much the same manner as was found to be the case in many former instances.

After these preliminary trials and after similar responses to the above had been noted in a number of different trials, the gerrids were subjected to the influence of a moving light. It was moved slowly around the outside of the aquarium close to the glass sides and ends. The majority of the insects followed after the light. Some kept just behind it, or almost parallel with it—that is, opposite to the light—while others followed at a considerable distance behind the electric bulb. In a number of instances, gerrids followed the light, but kept at a distance of four to six inches behind it. However, there was very little regularity about this. In the manner described, many of the water-striders followed the light entirely around the aquarium, until the starting point was reached. There appeared to be no difference in the responses whether the light was moved round the aquarium from left to right or vice versa. When the light was moved about above the gerrids, there was a tendency for them to keep in the lighted area. In general, the water-striders displayed considerable promptness in responding to the moving light, for they followed it with great readiness.

8. RESPONSES TO MOVING BUT NON-OSCILLATING ARTIFICIAL LIGHT OF WEAKER INTENSITY.

Some experiments were performed in which a moving but non-oscillating electric light was employed, in the field of experimentation the illumination being about 22 ca. m. The responses of the gerrids were of much the same character as those that have been described in connection with their behavior toward a moving light of 44 ca. m. When the light was placed at one end of the aquarium, the insects responded by striding across the surface-film toward the source of illumination. Then the light was moved slowly around the outside of the aquarium and the gerrids responded by following after it. There were no marked differences in their behavior to light of this intensity from that which they evinced in their responses to the 44 ca. m. moving light, except that it fairly may be said that they did not respond with quite the equal readiness to the photic stimuli of weaker intensity.

9. RECORDS OF OTHER OBSERVERS ON THE PHOTOTAXIS OF GERRIDÆ AND RELATED AQUATIC HETEROPTERA.

Other observers have noticed that certain Heteroptera evince behavior of a definite character with respect to the photic stimuli of a moving light. Holmes (1905), in an excellent paper, has proved that *Ranatra fusca* exhibits decided positive phototaxis to a moving light and also to a light that often is changed in its position. He (1907, pp. 160-161) further has demonstrated that, in water, *Ranatra quadridentata* responds promptly to the change in position of the light. Individuals of this species respond to a moving light by exhibiting movements of the head toward it. *Gerris orba*, according to Essenberg (1915a, p. 402), responds quickly to a moving object or to a shadow. As early as the summer of 1911, it was observed by me (1920, p. 70) that *Gerris remigis* evinces responses to moving objects and shadows. Some years later, the behavior of this species with respect to a moving incandescent light of 44 ca. m. in the experimental field was noticed. The following quotation gives my statement:

> I observed, as early as the summer of 1911, that these water-striders [*Gerris remigis*] respond to moving objects and shadows more promptly than they do to stationary ones. In the early fall of 1918, I discovered that individuals of *Gerris remigis*, confined in an aquarium, respond definitely and in a pronounced manner to a moving incandescent electric light and also to frequent changes in the position of such a light.

It is very probable that photic responses form an important part of the general behavior of the family Gerridæ. Therefore, at this point it is, perhaps, worth while to draw attention briefly to some of the records of various writers on this group. Statements by Kirkaldy (1898, p. 110) indicate that *Gerris thoracicus* Schumn, in Hungary and *Gerris tristan* Kirk., in Ceylon are both positively phototactic at night. Weiss (1914, p. 33), in certain experiments with water-striders, *Gerris marginatus*, a species related to and frequently observed in similar situations as *Gerris remigis*, found that, when they were removed from the surface of a large pond and placed on the ground at distances of one to nine yards from their habitat, they returned to the water promptly. It is quite possible that vision was the most important factor in guiding these insects back again to the water. The pool referred to by this observer covered an area of 3,000 square feet and would therefore serve as an effective reflective surface. According to Essenberg (1915a, p. 400), *Gerris orba*, a species closely related to and sometimes mistaken for *Gerris remigis*, exhibits positive phototaxis, sometimes leaving the surface of the water and flying to the light. Several years ago, while conducting an extended series of observations and experiments on some habitat responses of *Gerris remigis*, certain phases of the behavior of this species indicated that vision played a not inconsiderable rôle. In this connection reference is suggested to some of my former papers (1919, pp. 410-414), (1919a, pp. 503-505), (1920, pp. 68-70, 71-72, 77-80), (1920a, p. 9). It was suggested by me (1919a, p. 499) that *Gerris marginatus*, another common species of water-strider, during migration by flight, probably finds bodies of water through the sense of sight. It should be remembered that the surface of water is an effective reflector, and large bodies of water, such as ponds and lakes, are likely to attract migrating gerrids.

Other aquatic bugs, besides members of the family Gerridæ, belonging to a number of different genera of the order Heteroptera, exhibit responses to photic stimuli. It is of interest to notice that behavior of this character is not limited to a few groups, but, on the other hand, shows itself in many more or less divergent forms. It is not the intention to make an exhaustive enumeration of the genera and species that evince such responses, but rather to point out that these responses are a phase of behavior that should receive consideration in the study of the bionomics of this order of the Hexapoda.

Comstock and Comstock (1895, p. 132) state that members of the family Belostomidæ respond to the stimuli from electric lights. Certain members of this group are apparently positively phototactic. From the context it is to be inferred that these observers probably refer to several genera of this family. It is well known, through the admirable investigations of Holmes (1905), that *Ranatra fusca* evinces positive phototaxis and that it is very strongly influenced by light. This paper by Holmes is an extremely suggestive and valuable one and for this reason it should be read carefully by all workers in animal behavior who are interested in the photic responses of aquatic Heteroptera. Because of its importance, certain quotations have been taken from it. Holmes (1905, p. 315) points out that:

> Light seems to dominate entirely this creature's behavior when the phototactic reactions are once started. It does not manifest any fear or awareness of any object in its environment save the light which it so strenuously seeks. Its excitement increases the longer it is operated with. . . .

Ranatra fusca does not always exhibit positive responses to light. Under certain conditions it becomes negatively phototactic. Holmes (1905, p. 317) makes the important statement that:

> The negative reaction is associated with a condition of lowered phototonus. It is rarely shown except when the animal is in a condition of comparative sluggishness. When in great excitement, when its movements take place with quickness and vigor, *Ranatra* always shows a positive reaction.

He (1905, pp. 318-325) has recorded a number of other very singular facts with respect to the negative responses to light. This water-scorpion may become negative in its behavior toward photic stimuli through the agency of contact stimulation, but, strange to relate, the negative responses also may be held in check by the latter form of stimuli. Further, negative phototaxis can be induced by long exposure to strong light. In another interesting paper, Holmes (1907, pp. 160-161) directs attention to the fact that the young of *Ranatra quadridentata* respond to light. In this connection, he states that:

> The reactions of young Ranatras to light are not nearly so vigorous and decided as those of the adult. A feeble positive phototaxis is manifested the first day after hatching and increases gradually as the insect grows older. Individuals a week old are very often found swimming on the side of the dish towards the light; if the dish is turned about they quickly swim again to the light side. When out of the water they are comparatively irresponsive to light—a fact in marked contrast to the behavior of the mature insects.

According to this writer (1907, p. 163), *Ranatra linearis*, a European species, is positively phototactic and occasionally flies to lights during the night. Cole (1907, pp. 382-383) has not only substantiated a number of the experiments of Holmes, but in addition he (1907, p. 397) has shown that *Ranatra fusca* can discriminate between two lighted areas that are of different size, although the illuminated fields are of the same intensity. His experiments evidently prove that *Ranatra fusca* also is able to form images of "considerable definiteness." De la Torre-Bueno (1914) has written a paper on phototropism, which is of value not only because of the discussions in it on the phototaxis of Heteroptera, but also because of the relations of these discussions to the light responses of aquatic Heteroptera in general.

Many of the species of the family Notonectidæ are responsive to photic stimuli as Essenberg (1915) has demonstrated. *Notonecta insulata* Kirby, *Notonecta undulata* var. charon, *Notonecta indica*, and a species that was not identified were all used, apparently, in Essenberg's experiments. Notonectas evince a strong positive phototaxis (1915, pp. 385-386) to various kinds and intensities of lights. The positive photic responses are intensified by increases in temperature and increases in light intensities (1915, pp. 387-388). A suggestive paper by Parshley (1917) is valuable because of its probable bearing on the phototaxis of aquatic Heteroptera. In one of my former papers (1919a, pp. 499-500), it has been pointed out that some of the genera in the family Belostomidæ are positively phototactic at night to electric lights—street arc lights. *Benacus griseus* and *Lethocerus americanus* have been observed in great numbers flying around electric street lights. It is very probable that other aquatic genera and species of the order Heteroptera exhibit phototactic responses. A recent paper by de la Torre-Bueno (1920)—and the references contained therein—is suggestive because of the explanations it may offer regarding light responses of certain aquatic Heteroptera.

IV. SUMMARY AND CONCLUSION.

1. Introduction.

This paper treats of some of the general responses of the large water-strider, *Gerris remigis* Say, one of the common species of aquatic Heteroptera, to contact and also to photic stimuli. According to de la Torre-Bueno (1911), its systematic position is as a member of the family Gerridæ, subfamily Gerrinæ, tribe Gerrini, and subgenus Aquarius Schell (=*Hygrotrechus* Stal).

The optimum habitat of the species is, in the main, on the water-films of permanent brooks and creeks, of medium size, with currents of moderate velocity. The structural characters of the body, as well as the general behavior of the species appear to be suited for a life in such a habitat. The species is mainly an apterous one.

2. Discussion.

Gerris remigis readily responds to contact, various objects, in its habitat, such as a piece of driftwood, a rock, a drifting leaf, and the bank of the stream serving as stimuli. Thigmotaxis is evinced by the members of this species coming to rest against such solid bodies. Contact between two individuals frequently results in a cessation of locomotion of both gerrids. Animals under the influence of contact stimulation remain stationary from a few minutes to an hour or more.

These gerrids respond to contact in a different manner on different occasions to similar stimuli, although the general conditions are not changed. When two of them come in contact with each other, they may become stationary; they may move apart slowly; or they may dart rapidly away from each other. These variations in responses probably are due to the differences in the internal conditions of the animals at different times.

Through the influence of contact, groups of various sizes are formed. The animals respond by remaining quietly on the surface-film, with their legs overlapping and their bodies closely applied to each other. These aggregations may originate near some solid object, extending above the surface of the water, or they may arise through various individuals impinging against each other. Surface breezes assist in the formation of these assemblages. The physical conditions of the environment, the physiological states of the gerrids, and the season of the year, all seem to have a bearing on this matter. Such groupings appear to be more common in the fall than is the case at any other season. They are larger and more compact at this time. The groups may consist of a few gerrids, as many as seventy-five to a hundred, or even more. Such aggregations are formed on the surfaces of pools, through which pass gentle currents, but usually they are not formed on the swiftest water, and they appear as dark patches on the surface-film. They may continue to exist from a few minutes to an hour and a half or for longer periods.

The disintegration of the groups of gerrids appear to occur mainly through the modification or inhibition of thigmotaxis by means of other stimuli. Mechanical stimulation appears to have the greatest influence in this process. This is due, frequently, to the activities of certain individuals within the groups. Their activities disturb other gerrids in the immediate vicinity and eventually result in the disassociation of the groups. Those gerrids near the peripheries of the groups generally leave first. It is usually more difficult for the individuals within the groups, near the centers, to break loose from the clusters. Very strong wind currents; agitation of the surface by means of water-currents; objects drifting with the stream, such as dead leaves and driftwood; all these seem to have much the same sort of influence in disintegrating the groups of assembled gerrids.

Responses to contact stimuli are strongly in evidence at the inception of and during the hibernation period. These gerrids hibernate in many different situations, for example, under masses of dead leaves, in holes in the banks of streams, under tree roots, under the bark of fallen dead trees, under logs and driftwood, and under piles of brush. The acts of crawling into and remaining in such places are evidently due to the contact stimuli that impinge on them at such times. They usually hibernate in large groups or clusters, sometimes as many as two hundred and fifty gerrids being found in such assemblages, although they are taken in smaller numbers. On such occasions, they are in close contact with each other, their legs and bodies being closely applied. They remain very quiet, with their bodies in close contact with the substratum. At such times, the bodies of the gerrids appear to be very sensitive to contact stimuli. They hibernate in close proximity to their own habitat.

During severe droughts, the water in the habitat of these gerrids may disappear entirely. At such times they migrate from their dry habitat, often along the beds of streams. During such migrations, they frequently come in contact with various objects, such as stones, driftwood, clumps of dead leaves, and lumps of dry mud. Their thigmotactic propensities are in evidence at such times, for contact stimuli influence the gerrids to come to rest against and underneath these objects. They also jump into cracks in the dry beds of streams. Stimulation of this sort inhibits locomotor activities, and the responses of the animals to such stimuli influence them to remain quietly in these places, with their bodies closely applied to the objects with which they are in contact. Such thigmotactic responses keep the gerrids in places of this character from a few minutes to an hour or more and even for longer periods.

In laboratory aquaria the gerrids frequently leave the surface-film and crawl onto the sides and upper surfaces of stones, extending above the surface of the water, often covering the stones several layers in thickness. They remain motionless in clusters for long periods of time. They crawl up the glass walls of the aquaria into the angles formed by the sides of the aquaria and also into the angles formed by the flanges and sides of the aquaria. They move into small spaces between stones, often staying there in a quiet condition for several days. These responses evidently are due to the thigmotactic proclivities of the gerrids. The tendency to congregate in compact masses is pronounced.

The so-called death-feigning response can be induced in these animals by means of contact stimuli. Touching their bodies or stroking them, often is sufficient stimulation to incite the response. In some instances the gerrids can not be induced to feign death through the agency of contact stimulation. The bodies are rigid and the antennæ and the legs are stiff while the response continues, the gerrids remaining motionless. At such times, contact stimuli may not arouse them from the death-feint, while on other occasions, such stimulation does so in a few seconds. Then again, there are instances, as the animals arouse from the death-feint, when the application of contact stimuli reincites the response. Vision appears to have little influence in bringing about the death-feigning response, but contact seems to be the principal factor in inducing it.

During rain and wind storms, these water-striders leave the open, exposed surfaces of streams. They are found with their bodies in close contact with solid objects, such as rocks, vegetation, banks of streams, and dams of driftwood. Usually, they are observed on the windward side of the objects that have been enumerated. If they are nearer to the leeward than to the windward side of a stream, during a wind or rain storm, they, generally, move to the former side. Frequently, they crawled from the surface-film onto these objects, many of them moving into crevices. Sometimes, they congregated by the hundred in such situations as have been mentioned, their bodies being in close contact with the substrata. Evidently, these responses are due to the thigmotactic proclivities of the animals. After the abatement of a storm, they again moved onto the surface-film. Some, promptly, "sought" the surface of the water, others after a few minutes delay, while still others did not reach the water-surface for a half an hour after the storm had ceased. Many of those that moved onto the surface-film last came from depressions and interstices in the substrata. Probably, they were influenced more strongly by contact stimuli than was the case of the other gerrids. Contact stimulation plays a definite part in such responses, exerting an influence to bring the gerrids to rest against solid bodies and also in keeping them in such situations for considerable periods of time.

Gerris remigis readily responds to photic stimuli of various intensities. Frequently, on cloudless days, at a temperature of 100° F., they are not found on the open, unshaded surfaces of streams. They congregate in the shade of the banks, rocks, trees, and other vegetation. However, this may be partially due to responses to temperature and may not be due entirely to negative responses to strong sunlight.

In laboratory aquaria, they are found to be, on certain occasions at least, negatively phototactic to sunlight. They move, either to the ends of the aquaria farthest from the beams of sunlight, or else they simply stride out of the sunlight into the more shaded regions of the aquaria.

The majority of these gerrids are positively phototactic to electric light of 44 ca. m. within the field of experimentation. In an aquarium, when fifty individuals were used, they orient with their heads pointing toward the source of illumination, thus having the longitudinal axes of their bodies parallel with many of the entering rays. Then, they stride to the positive end of the vessel. When the light is changed to the opposite end of the aquarium, the gerrids respond again by moving toward the source of illumination. All of them do not orient to the light with equal promptness. Some delay for several seconds before completing this response. None appeared to be entirely indifferent to the light. A few individuals moved only two or three inches toward the source of illumination. A few others evinced movements of the antennæ, legs and bodies. Sometimes, there were one or two alate individuals among those subjected to photic stimulation, but none of them flew toward the light.

Water-striders respond positively to the stimuli of an electric light of 22 ca. m. in the field of experimentation. Their behavior with respect to light of this intensity is much the same as that described for a light of 44 ca. m. in the field of experimentation. The chief differences of importance are that the gerrids neither orient quite so promptly to, nor do they move so readily toward the light of lesser intensity.

Gerris remigis responds positively to an oscillating electric light of 44 ca. m. in the experimental field. The light oscillated in a plane parallel to the end of the aquarium containing the gerrids. Thirty water-striders were used in the experiments, the majority of them orienting with their heads pointed toward the oscillating light and also moving promptly to the positive end of the aquarium. They appear to orient to and also to move toward the source of illumination more promptly than was the case with respect to the stationary light of a similar intensity. Before reaching the positive end of the aquarium, their path becomes oblique to the longitudinal axis of the vessel, this being due, apparently, to the oscillations of the light. On nearing the lighter end of the aquarium, there appears to be some "indecision" as to their direction of movement. There are some attempts to follow the swinging light, but, in the main, many of them make only slight changes in position, after reaching this end of the vessel. Some remain practically stationary, in so far as locomotion is concerned, being engaged in cleaning responses. Others move close to the glass end of the aquarium and attempt both to orient to and also to follow the light.

The responses of water-striders to an oscillating electric light of approximately 22 ca. m. in the field of experimentation, in general, are very similar to those described in the experiments when the stronger light was employed. Twenty gerrids were used in the experiments. Their responses to the source of illumination are positive, but there is neither quite the same promptness in orienting to, nor in moving toward the light as was the case in the experimental work with the light of greater intensity. After nearing the positive end of the aquarium, while their responses are much the same as in the former experiments, with the electric light of stronger illumination, yet in general the responses are rather less definite and precise.

A number of experiments were conducted with a moving, but non-oscillating, electric light of 44 ca. m. in the experimental field. Forty gerrids were used in the experiments and they readily move around the aquarium in which they are confined, in response to a moving light. They either follow just behind the light or else retain positions almost parallel to it. However, these positions vary, for there is not much regularity about this phase of their responses. They readily follow the light, whether it is moved around the aquarium from left to right, or vice versa. If the light is moved about above the gerrids, they tend to keep in the illuminated region. They display much promptness in their responses to the moving light and these apparently are always positive.

The gerrids respond to a moving electric light of half the intensity of the one recently mentioned. Their behavior is very similar to that described when the source of illumination is 44 ca. m. The chief difference is that the responses are not quite so prompt as in the case with the light of greater intensity.

3. Conclusion.

It is evident that responses to contact and to photic stimulation play an important rôle in the daily lives of these water-striders. Such responses appear to form very definite elements in their general behavior. Many of the normal habitat activities, undoubtedly, are due to the thigmotactic and phototactic propensities of these animals. If such forms of stimulation were eliminated from their environment, the result would be a marked modification in the whole general behavior of the species. It is not improbable that the responses of *Gerris remigis* to contact and to light stimuli may have had some influence on the development of certain of the phases of behavior discussed in this paper, perhaps in a manner somewhat analogous to that pointed out by Holmes (1903) in his discussion of the relation of thigmotaxis to the evolution of the death-feigning instinct.

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ON THE MORPHOLOGY OF THE OVIPOSITOR OF CERTAIN ANTHOMYIAN GENERA*

HUGH C. HUCKETT.

CONTENTS.

INTRODUCTION.

This difficult family of flies has caused not only the systematist but also the economic entomologist no little misapprehension due to the unsatisfactory conception of existing taxonomic characters. The generic definitions are also ambiguous and are at present undergoing a thorough revision. This is especially true of the three genera *Chortophila* Macquart, *Hylemyia* Desvoidy, and *Pegomyia* Desvoidy. The male species have been studied with a certain amount of detail and success, but the females have been neglected and owing to their peculiar characters are not capable of being classified according to male specimens. Stein (Archiv für Naturgeschichte 1914, viii: 4–55) has formulated a key for the determination of European female species and the paper has been largely used for the determination of the American species dealt with in the following pages.

The unsatisfactory nature, however, of such a position lead the writer to undertake the morphological study of the ovipositors of certain species of the above named genera in the hope that it would at least aid in determining without further doubt the identity of any female specimen.

The material for study was furnished by the Cornell University Collection, Dr. O. A. Johannsen's own collection and the author's specimens caught at Burlington, Ontario, and

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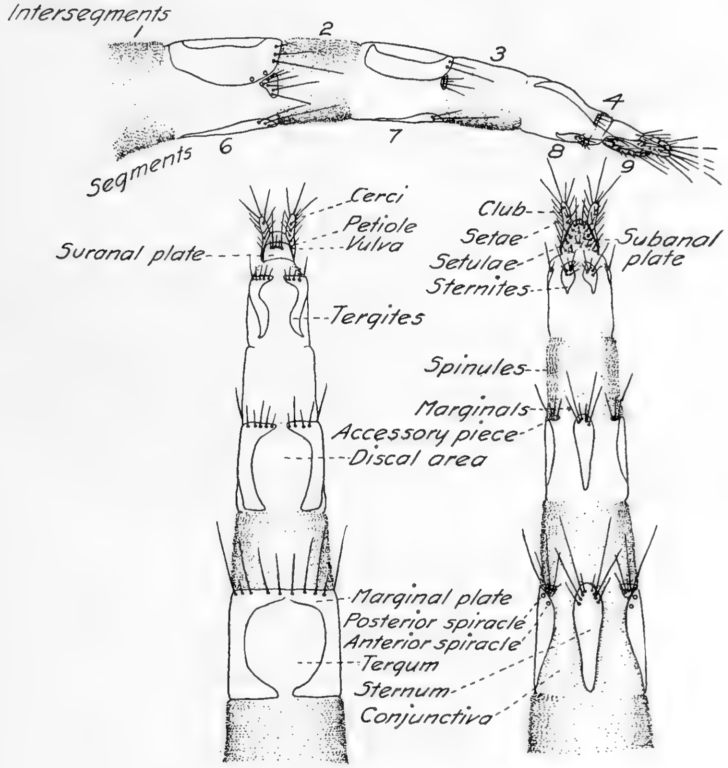
* Since this paper was prepared for publication, Malloch has introduced a new concept of the genera mentioned herewith.

around Ithaca. In the determination of specimens use has been made of Stein's keys to the females of European Anthomyidæ and the determined material in the above private collections.

The writer wishes to acknowledge the advice and help received from Dr. O. A. Johannsen in the determination of species and in the loan of the above collections without which the work would have been impossible.


OVIPOSITOR (hypothetical)
Illustrating structural terms

TECHNIQUE.

The technique was of the simplest. The abdomen was transected in the region of the third abdominal segment with dissecting scissors. The excised portion was then placed in a 10 per cent solution of potassium hydroxide and left to soak until cleared. This time varied with different specimens from four hours to six days. Prior to removing the specimen from the solution the ovipositor was distended by lightly placing a blunt dissecting needle on the exposed portion of the ninth segment and with forceps or another needle gradually drawing away the excised portion of the abdomen from the point of attachment. This pulled out the ovipositor in a telescopic manner and allowed it a better opportunity of clearing. After thoroughly washing in water the ovipositors were placed in 50 per cent alcohol and run through the successive grades to 70 per cent, at which they were preserved for drawing and examination under the low powers of the microscope. For examination under high power, slides were prepared by continuing the dehydration of the ovipositors through successive grades to absolute alcohol, thence passed through xylene, and finally mounted in 50 per cent xylene, 50 per cent Canada balsam mixture, directly under a coverslip and within an xylonite ring.

Drawings were made from the preserved specimens and prepared slides with the aid of a micrometer eye piece and squared graph paper. No attempt was made to show the relative sizes of the ovipositors, but only the proportional composition of each.

GENERAL MORPHOLOGY OF THE OVIPOSITOR.

The ovipositor represents the terminal segments of the abdomen, namely six to nine. They are modified for the purpose of conveying the egg to its destination during oviposition. On account of this peculiar function the abdominal sclerites and membranes have become altered so that they no longer resemble in general appearance the anterior segments, namely, numbers two to five, but are diminished in size to form a tubular structure, neatly telescoped within itself and which, when at rest, come to lie within the fifth abdominal segment.

Berlese (Rivista de Patologie Vegetale, 1902, ix:345-354) in his observations on the copulation of the house fly, claims that the ovipositor also functions as the active organ in securing fertilization, the male organs being the meanwhile conspicuously inactive. Since the structure of the ovipositor and the male genitalia of *Musca domestica* Linn., and the following Anthomyian flies are essentially alike, especially with regards vestiture, it is not improbable that an additional function exists here also.

The segments of the ovipositor are alternated by a well developed membrane known as the intersegments. The function of the latter is to provide a membranous sheath for the folding up of the segments and to increase the range of the ovipositor when necessary. The intersegments may be smooth, without vestiture, as in *Pegomyia affinis* Stein, *Hylemyia lipsia* Wlk., and *Chortophila longula* Fallen, or covered with minute spines, partially or wholly. These recurrent spinules are sometimes arranged in transverse striæ, or as broad, imbricated spinules in no definite order, as in *Chortophila parva* R-D. *caerulescens* Strobl. and *cinerella* Fall. These spinules, although they appear to be limited to definite areas, yet frequently are to be found on adjacent membranes and sclerites, there being no definite demarkation. The annulations of the segments can, however, be always determined.

Intersegment nine is considerably reduced in size and dissimilar in form to the three preceding membranes. It functions as an attachment for the modified ninth segment (suranal and subanal plates) to the caudal margin of the eighth segment, as well as serving in a telescopic manner for the inclusion of the ninth segment when the ovipositor is retracted. Further the ligaments of the cerci are associated with the ninth intersegment.

The segments represent chitinized areas that are unstable both in delineation and degree of chitinization. Though functioning primarily as a strengthening device for the rigidity of the ovipositor, it undergoes changes in structure to provide elasticity and collapsability. Thus the dorsal plate (tergum) is frequently composed of two lateral pieces that are more heavily chitinized caudad than cephalad, and whose margins blend imperceptably into a mid-dorsal membranous area known as the discal area, or into the lateral conjunctivæ, ventrad. Degrees of chitinization, varying from a complete dorsal encasement, as in the abdomen proper, to vestiges of chitinous thickenings in the membrane, have been found in a series of the same species. This is thought to depend upon the age of the adult, degree of development, condition of pupation, etc., so that it is deemed inadvisable to put much credence in its taxonomic value.* The caudal margin of each tergum is

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* The peculiar outline of the chitinous thickenings on segment eight in *Chortophila brassicæ* Bche, and *antiqua* Meig, have been so constant in the specimens under examination that it has been thought fit to make an exception of this case and to include this character in the key.

surrounded by a row of setæ which in most cases is limited by the extent of the chitinization. In specific cases, short, hooklike setæ or stout spines replace the normal bristles. In segment six the posterior angles of the tergum possess two spiracles, orifices of a common trachea. On account of their position they are conveniently designated as the anterior and posterior spiracles. In segment six and seven the posterior angles of the tergum may become accentuated by a thinning of the chitin across those regions and the isolation of chitinous areas bearing numerous setæ. In such cases these areas have been designated as the accessory pieces.

The ventral plate (sternum) likewise varies in degree of chitinization, though not to the extent of the tergum. In segments six and seven the sternum usually consists of a long strip of chitin that tends to become indeterminate cephalad, sometimes this plate is limited to areas adjoining the caudal margin. The setæ border the caudal margin of the sternum in a row or are separated into two lateral groups. Similarly they are too replaced by stiff stout spines in certain cases. In segment eight the sternum is divided into two chitinous halves, more or less bilaterally symmetrical and known as the sternites. In general structure they present a hingelike appearance, overlapping the junction of the fourth intersegment with the conjunctiva of the eighth segment. In *Chortophila cinerella* Fall, and *parva* R-D, the sternites attain the whole length of the segment as two narrow rods of chitin. The setæ are to be found toward the caudal extremity, scattered irregularly, among which are often two of greater size and strength.

The lateral conjunctivæ of segments six, seven and eight are situated in a similar position to that of the segments of the abdomen, i. e., it consists of that part of the less chitinized cuticula, which is found between the sternum and tergum. Similar to the intersegments the conjunctivæ may be smooth or spinulose, or partly smooth, partly spinulose. The spinules may be arranged in indefinite transverse striæ or scattered irregularly throughout the membrane. The cephalic and caudal extents of the conjunctivæ are limited by the annulations of the segments.

Segment nine is modified to form the upper and lower lips of the anus The tergum or upper lip is composed of a single chitinous piece, hemispherical or scoopshaped, which is known as the suranal plate. It bears two strong setæ and a few spine-like setulæ. The sternum or lower lip is larger usually than the suranal plate and is composed of but one chitinous piece which is spade-shaped or broadly deltoid in outline. This sclerite is known as the subanal plate. Its surface is usually spinulose, rarely glabrous, and is clothed with numerous setulæ. At the apex and along the margins are to be found two pairs of strong setæ.

The cerci* are two subcylindrical anal appendages emerging from beneath and beside the suranal plate. They are composed of a distal half, which is club-shaped or knob-like, and a proximal half, which forms a stem for attachment and is termed the petiole. Sometimes the cerci are sessile, plate-like or pubescent. The apex of each club bears one to three long setiform hairs and two or more setiferous sense organs, *hautsinnesorgane*. The latter are tubercular in form, each of which is armed with a short, sharp spine at the apex, or is large and disc-like, from the center of which emerges a fine hair-like papilla. The remaining surface of the cerci is clothed with numerous stout setulæ.

LIST OF SPECIES.

Genus Chortophila Macquart.
- C. antiqua Meigen.
- C. brassicæ Bouché.
- C. caerulescens Strobl.†
- C. candens Zetterstedt.‡
- C. cilicrura Rondani.
- C. cinerella Fallen.
- C. dissecta Meigen.†
- C. fugax Meigen.†
- C. grisella Rondani.†
- C. laevis Stein.§
- C. longula Fallen.†
- C. muscaria Meigen.
- C. nuda Strobl.†
- C. parva Desvoidy.
- C. rubivora Coquillett.
- C. substriata Stein.

Genus Hylemyia Desvoidy.
- H. aemene Walker.
- H. alcathoe Walker.
- H. coarctata Fallen.†
- H. flavicans Stein.
- H. flavipennis Fallen.†
- H. juvenilis Stein.
- H. lipsia Walker.
- H. setiventris Stein.
- H. strigosa var. nigrimana Fabricius.‡
- H. variata Fallen.

Genus Pegomyia Desvoidy.
- P. affinis Stein.
- P. calyptrata Zetterstedt.
- P. hyoscyami Panzer.
- P. trilineata Stein.
- P. trivittata Stein.
- P. unicolor Stein.
- P. winthemi Meigen.

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* The term cerci has been chosen from a number of names given by authors as least likely to produce confusion. On the other hand there appears to be little doubt but that these anal appendages are tactile and not prehensile in function and for the sake of explicitness and accuracy would better be designated as anal palpi.

† See note under Description of ovipositors.

‡ European specimens.

§ Specimen closely resembles laevis Stein.

DESCRIPTION OF OVIPOSITORS.

An asterisk qualifying the name of a species signifies that the specimen keys out to that species in Stein's key (1914) to the females of European Anthomyidæ.

GENUS **Chortophila** MACQUART.

Chortophila antiqua Meigen.

Segments and intersegments of equal length, sclerites glabrous, except the subanal plate which is spinulose. Intersegments one, two, and three spinulose, fourth smooth.

Segment VI. Tergum in structure and character similar to *cilicrura*, usually more heavily chitinized, the discal area appearing yellowish; accessory pieces present; marginals diverse, in an irregular row; spiracles approximate, barely the width of the sternum apart, in the same straight line†, posterior spiracles cephalad of the accessory pieces. Sternum somewhat pegshaped, the cephalic half narrowed to a blunt point which attains the cephalic margin; setæ grouped apart around the caudal margin; conjunctiva smooth, with chitinous thickenings.

Segment VII. The tergum similar to that of segment VI, the tergites less chitinized; accessory pieces present. Sternum lanceolate, tapering to a blunt point on the cephalic margin, flaring caudad; marginals distributed in a broad semicircle along the caudal border; conjunctiva as in segment VI.

Segment VIII. Tergum divided bilaterally, the tergites strongly chitinized along the caudal margin of the segment as in *cilicrura;* the sclerites proceed dorsocephalad as undulating plates, scarcely attaining the cephalic margin; marginals diverse, more numerous than in *cilicrura*, regular‡. Sternum composed of two ovoid sclerites, but one-half the length of the segment; setæ diverse, scattered caudad; conjunctiva smooth, studded with chitinous knobs.

Segment IX. Suranal plate scoop-shaped; setæ less than the width of the club apart; subanal plate spinulose, spade-shaped to triangular; setæ long, fine, hairlike, bounding the apical third of the sclerite, setulæ diverse; cerci glabrous, club compact, petiole short; setæ composed of one long apical and three or four shorter, besides long spinelike setulæ.

Chortophila brassicæ Bouché.

Segments and intersegments of equal length, sclerites glabrous except the subanal plate which is spinulose. Intersegments spinulose except for the fourth whose ventral surface is smooth.

Segment VI. Tergum divided bilaterally, the tergites border the caudal and cephalic margins, in the former case the sclerites tend to fuse across the mid dorsal line, ventral and dorsal margins indeterminate; discal area slightly chitinized blending imperceptibly with the

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† As opposed to oblique.

‡ Regular = In a single row.

adjoining sclerites; accessory pieces absent; marginals diverse, regular; spiracles approximate, the width of the sternum apart, oblique,† posterior spiracles cephalad of the caudal margin. Sternum lanceolate, tapering to both margins; marginals approximating, in pairs; conjunctiva smooth, ornamented with rough chitinous thickenings.

Segment VII. Similar to segment VI in structure, the tergites less extensive along the margins; discal area well marked, roughened by chitinous thickenings; marginals diverse, regular; accessory pieces absent. Sternum lanceolate, tapering cephalad, rounded caudad; marginals approximate; conjunctiva, smooth, chitinized.

Segment VIII. Tergum divided bilaterally into two irregular plates somewhat similar to those of the corresponding segment in *antiqua* except that the dorsal surface of the lateral plates becomes more markedly sinuous giving the discal area a decided constriction at the middle; marginals short, regular, with strong lateral setæ. Sternum similar in structure and character to that of *antiqua* setæ distributed over the entire surface, two strong, remainder short spinelike; conjunctiva smooth, chitinized.

Segment IX. Suranal plate scoop-shaped; setæ barely the width of the club apart, setulæ few; subanal plate spinulose, spade-shaped to conical, setæ apart, a fringe of setulæ around the margin, surface covered with short spinelike setæ; cerci smooth, petiolate, conical to subcylindrical; apicals long, setæ diverse, long, fine, more abundant than in *cilicrura* or *antiqua*, clothing the club and petiole; sense organs two, apical, papillæ short.

Chortophila cærulescens Strobl.*

Segments and intersegments of equal length, sclerites glabrous except for the subanal plate which is spinulose. Intersegments spinulose, each successive membrane from the first to the third becoming more densely spined; spinules broad at their bases giving the appearance on the third intersegment of being clothed with scales, similar to *cinerella* and *parva*.

Segment VI. Tergum composed of two lateral plates each shaped like an inverted "L," somewhat flaring along the caudal margin, tapering cephalad; accessory pieces present, distinct; marginals few, two or three, equal,‡ distributed dorsad; discal area hyaline, membranous, occupying the greater part of the tergal region; spiracles closely approximate, directly cephalad of the accessory pieces, posterior spiracles of greater diameter than the anterior and situated slightly oblique. Sternum much reduced, a small quadrangular sclerite adjacent to the caudal margin, pointed cephalad; marginals separated into two lateral groups of a few setæ each; conjunctiva smooth, hyaline.

Segment VII. Tergum composed of two narrow lateral tergites whose form is maintained undiminished to the cephalic margin, caudad the ventral borders are rounded off so that the marginal plates are lim-

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† Oblique = Spiracles placed at an angle to the longitudinal axis of the insect.

‡ Equal = The same in size and length.

ited to a short dorsal curve; accessory pieces present, distinct; marginals few, similar in distribution to segment VI; discal area hyaline. Sternum much reduced, funnel form; marginals separated into two lateral groups of a few setæ each, usually two; conjunctiva smooth, hyaline.

Segment VIII. Tergum composed of two lateral plates whose caudal expansions fuse across the mid-dorsal line and extend slightly ventrad; cephalad the tergites approximate slightly; discal area smooth, hyaline; marginals equal, regular, sparsely distributed. Sternum composed of two heavily chitinized, lanceolate plates, attaining three-quarters the length of the segment, similar to *cilicrura;* setæ few distributed on the apical area; conjunctiva smooth, hyaline.

Segment IX. Suranal plate scoop-shaped; setæ short and stout, wide apart, equal to the breadth of a club; setulæ few: subanal plate spinulose, bell-shaped; setæ limited to the apical region; setulæ numerous, equal, short and thornlike, distributed over the inner surface, the outer margin being bare; cerci glabrous, knoblike, short petiole; setæ few, sparesly distributed, apicals short, one per club; sensory organs two, contiguous, situated at the apex, domelike.

Chortophila candens Zetterstedt.†

Segments slightly longer than the intersegments, broader than long, more heavily chitinized along the cephalic than on the caudal margins; sclerites glabrous, except the subanal plate which is spinulose. Intersegments spinulose except the fourth which is smooth.

Segment VI. Tergum composed of two broad quadrangular lateral plates, dorsal and ventral borders indefinite; discal area lightly chitinized, blending imperceptibly with the lateral plates, widely separating the tergites for the most part; accessory pieces present; marginals diverse, numerous, closely distributed along the caudal margin of the segment; spiracles oblique, separated by the caudal margin of the segment, the posterior spiracles opening on the second intersegment. Sternum vasiform, heavily chitinized cephalic half, lightly chitinized caudal half; marginals approximate, bordering the caudal margin; conjunctiva spinulose.

Segment VII. Tergum similar in character and structure to segment VI, except that the spiracles and accessory pieces are absent; marginals numerous, closely distributed, discal area thinly chitinized. Sternum lanceolate, the borders indeterminate; marginals bordering the caudal margin; conjunctiva spinulose, indistinctly striated.

Segment VIII. Tergum composed of two quadrangular lateral plates, the caudal margin oblique, constricting the ventral borders to but one-half the length of the segment, cephalic margins strongly chitinized, approximating dorsad so as to enclose the discal area; discal area thinly chitinized, imperceptibly blending into the lateral plates; marginals equal, closely distributed along the caudal margin of the segment, a group of strong setæ situated at the caudo-ventral angles of the tergum. Sternum composed of two short ovoid sternites on which are distributed numerous stout heavy spines; conjunctiva smooth.

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† European specimen.

Segment IX. Suranal plate scoop-shaped, the basal angles narrowly produced ventrad; armed with four strong curved spines; subanal plate fanshaped; setæ long, hairlike; setulæ dense, fine and hairlike, at the basal angles are found a group of fine, strong bristles; cerci glabrous, modified into a pair of thin chitinous plates that border the lateral regions of the anus and closely articulate with the concave margins of the suranal plate; each is armed with two heavy upcurving apical spines in addition to numerous shorter spines of a similar nature, a few long, fine hairs on the apical region interspersed amongst the spines.

Chortophila cilicrura Rondani.

Segments and intersegments of equal length, sclerites glabrous, except the subanal plate which is spinulose. Intersegments spinulose, densely striated.

Segment VI. Tergum divided bilaterally; the caudal and cephalic boundaries of the tergites concur with the margins of the segment, the dorsal border merges into a semi-opaque discal area, which is spotted with chitinous thickenings; accessory pieces present; marginals few, diverse, regular; spiracles wider apart than the breadth of the sternum, slightly oblique, posterior spiracles bordering the caudal margin. Sternum, a narrow mid-ventral plate reaching both margins of the segment, flaring slightly caudad, tapering cephalad; marginals continued along the lateral margins; conjunctiva spinulose, densely striated.

Segment VII. Similar in structure and character to segment VI; marginal plates of the tergites somewhat constricted caudad; sternal marginals separated into two lateral groups.

Segment VIII. Tergum divided bilaterally; marginal plates strongly chitinized, which extend as lateral plates dorsocephalad thereby constricting the cephalic extent of the discal area. The latter is marked by chitinous thickenings; marginals diverse, regular. Sternum composed of two elongate sternites, but two-thirds the length of the segment; setæ spine-like, scattered about the caudal areas; conjunctiva smooth, throughout ornamented by knoblike thickenings of chitin.

Segment IX. Suranal plate scoopshaped; setæ the width of the club apart; subanal plate spinulose, spade-shaped, setæ normal;† setulæ sparsely distributed; cerci glabrous, club or cone-shaped, petiolate; setæ composed of one long apical and two shorter, besides a few setulæ scattered on the club and petiole.

Chortophila cinerella Fallen.

Segments and intersegments of equal length, sclerites glabrous except the subanal plate which is spinulose. Intersegments spinulose, covered with broad, straight spinules that give the membranes the appearance of being clothed with scales.

Segment VI. Tergum composed of two broad lateral plates, crescent-shaped, separated by a wide hyaline discal area; accessory pieces pres-

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† Normal=Setæ consisting of an apical pair approximate, and a preapical pair, wide apart, situated on the margins.

ent; marginals few; spiracles contiguous, slightly oblique, directly cephalad of the accessory pieces. Sternum reduced to two round chitinous areas that have fused and lie adjacent to the caudal margin of the segment; marginals wide apart, arranged into two groups; conjunctiva hyaline, transparent.

Segment VII. Tergum composed of two narrow chitinous strips, flaring caudad and extending the length of the segment along the subdorsal axes; discal area hyaline; accessory pieces present; marginals few and stout. Sternum, similar in structure to segment VI, pointed cephalad; marginals widely separated into two groups; conjunctiva hyaline.

Segment VIII. Tergum similar in structure to that of segment VII; the tergites broaden more noticeably caudad; marginals more numerous; discal area hyaline transparent, the sides of the segment clothed for the greater part with scalelike spinules. Sternum composed of two narrow sternites, oar-shaped, subparallel, extending along the subventral axes for the length of the segment; setæ two; conjunctiva hyaline.

Segment IX. Suranal plate hemispherical; setæ stout, setulæ few; subanal plate spinulose, spade-shaped, setæ normal; setulæ sparsely distributed; cerci small, glabrous, knoblike; setæ consist of one strong apical seta, setulæ spinelike.

Chortophila dissecta Meigen.*

Segments slightly longer than the intersegments, breadth exceeds length. Intersegments; vestiture not uniform, first intersegment spinulose, second and third the ventral surface spinulose with narrow dorsal stripes along the cephalic margins, fourth intersegment spinulose on the ventral surface, smooth dorsal region.

Segment VI. Tergum spinulose, composed of two broad enveloping plates that are linked together across the mid-dorsal line by a thinly chitinized discal area; accessory pieces present; marginals diverse, arranged in an irregular row; spiracles, the width of the accessory piece apart, oblique, posterior spiracles close to the caudal margin of the segment. Sternum spinulose, expansive, whose margins are indeterminate, gradually fading into the surrounding membrane; marginals diverse, scattered about the caudal border; conjunctiva spinulose.

Segment VII. Tergum glabrous, divided into two lateral plates, each extensively bordering the caudal margin, almost fusing across the mid-dorsal line, thence forward gradually tapering to a rounded apex, not quite reaching the cephalic margin of the segment; discal area hyaline, smooth, widely separating the tergites cephalad; accessory pieces present; marginals diverse arranged in an irregular, row. Sternum spinulose, a short, indeterminate plate; marginals in a transverse row; conjunctiva spinulose, on the mid-ventral line adjacent to the cephalic margin is found a small chitinous thickening bearing two stout spinules.

Segment VIII. Tergum glabrous, composed of two lateral pieces whose caudal margins have fused dorsad to form a marginal plate, the tergites extend dorsocephalad toward the cephalic margin, bordering a smooth, hyaline discal area; marginals diverse, in an irregular row.

Sternum glabrous, ovoid, pointed caudad; setæ diverse, few, distributed over the sclerites; conjunctiva smooth, hyaline.

Segment IX. Suranal plate glabrous, scoop-shaped; setæ approximate, less than the width of the club apart, long, exceeding by twice the length of the plate, few setulæ; subanal plate spinulose, spade-shaped; marginals long, setulæ sparsely distributed; cerci sparsely spinulose, conical to subcylindrical, petiolate, setæ consist of three long apicals and numerous bristlelike setulæ distributed on the petiole and club; sense organs, tubercular, situated laterad.

Chortophila fugax Meigen, and **substriata** Stein.*

Segments longer than the intersegments, breadth exceeds length. Intersegments spinulose.

Segment VI. Tergum glabrous, completely chitinized, encasing the whole region, ventral margins protruding; marginals few, diverse, unevenly distributed, continuing along the ventral margin; accessory pieces absent; spiracles the width of the sternum apart, oblique, posterior spiracle considerably dorsad of the anterior one, in the region of the caudal margin of segment. Sternum spinulose, spatulate, extending the length of the segment; marginals in two separate groups along the lateral margins; conjunctiva spinulose.

Segment VII. Tergum glabrous, completely chitinized as in segment VI; discal area vestigial; marginals diverse, distributed irregularly around the caudal margin; accessory pieces absent. Sternum spinulose, spatulate, thinly chitinized cephalad, marginals wide apart, grouped laterad; conjunctiva spinulose, striated.

Segment VIII. Tergum, caudal half spinulose, cephalic half glabrous, completely chitinized across the tergal region; marginals equal, irregularly distributed. Sternum spinulose, elongate; setæ sparsely distributed over the surface; conjunctiva spinulose.

Segment IX. Suranal plate spinulose, scoop-shaped, setæ very long, 2½ times the length of plate; setulæ few; subanal plate, broad, spade-shaped, spinulose; marginals short, setulæ equal, numerous; cerci spinulose, setulæ short; sense organs, two contiguous, one separate.

Chortophila grisella Rondani.*

Segments and intersegments of equal length, sclerites glabrous except the subanal plate which is spinulose. Intersegments smooth, without vestiture, in common with the segmental membranes ornamented with chitinous granulations.

Segment VI. Tergum somewhat similar in structure to *antiqua*, the lateral plates expand along the caudal and cephalic margins almost fusing across the mid-dorsal line; discal area semi-opaque, coarsely granulated; marginals short, equal, regular, terminating on either side in a strong setæ; spiracles the breadth of the sternum apart, oblique, the anterior spiracles dorsad of the posterior, the latter twice the size of the former and situated at the bases of the strong marginal setæ; accessory pieces absent. Sternum reduced to a small cordate sclerite adjacent to the caudal margin; marginals few, wide apart; conjunctiva coarsely granulated.

Segment VII. Tergum divided into two lateral plates whose caudal extremities expand to form marginal plates; discal area hyaline; marginals few, regular, with strong lateral bristles; accessory pieces absent. Sternum reduced to a small, ovoid sclerite adjacent to the caudal margin, the apices pointed, marginals wide apart, few; conjunctiva roughened.

Segment VIII. Tergum yoke or collar-shaped, the tergites ill-defined with ragged borders that blend irregularly into the less chitinized semi-opaque discal area, a distinguishable, interrupted chitinous thickening along the mid-dorsal line that merges finally with the fused caudal pieces. The caudal margin of the segment, as in *rubivora*, is only recognized by the marginals due to the fusing of the heavily knobbed chitinous area of the fourth intersegment with the tergum which obliterates any definable line; marginals equal, regular with pronounced lateral setæ. Sternum consists of two small, ovoid sclerites, tapering caudad; setæ diverse, scattered over the entire surface.

Segment IX. Suranal plate scoop-shaped, setæ approximate, strong; subanal plate spinulose, spade-shaped, setæ widely separated, hairlike, setulæ short, equal, distributed over the surface; cerci smooth, knobbed, long slender petiole; apicals long and fine, setulæ diverse, confined to the club; sense organs four.

Chortophila lævis Stein.†

Segments nearly twice the length of the preceding intersegment. Intersegments, spinulose, densely striated.

Segment VI. Tergum undivided, encasing the dorsal surface as a shield, the chitin semi-opaque and somewhat thinner toward the mid-dorsal line on which region it is lightly spined; accessory pieces absent; marginals diverse, scattered irregularly around the caudal margin, continuing cephalad in a single row along the ventral border; spiracles twice the breadth of the sternum apart, slightly oblique, the posterior spiracles on the caudal margin of the segment; area bounded by the caudo-ventral angles clothed with a few fine spinules. Sternum spinulose, club-shaped, the cephalic half but lightly chitinized; marginals distributed along the lateral borders for some distance; conjunctiva covered densely with short spinules.

Segment VII. Similar in structure to segment VI; spinules thinly distributed over the tergal and sternal surfaces; discal area almost obliterated; marginals diverse, distributed irregularly along the caudal border; accessory pieces absent. Sternum spatulate, the cephalic half attenuated and but lightly chitinized; marginals distributed along the lateral margins; conjunctiva densely spinulose, striated.

Segment VIII. Tergum composed of a fused marginal plate which extends as two lateral pieces, gradually tapering toward the cephalic margin; discal area thinly chitinized, merging imperceptibly with the chitin of the lateral plates; margins short, diverse, regular. Sternum

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† Probably a new species though closely resembling laevis.

spinulose, narrow sclerites that attain two-thirds the length of the segment; setæ few, diverse; conjunctiva, spinulose, the cephalic margin of the segment bordered by spinules throughout.

Segment IX. Suranal plate glabrous, scoop-shaped, setæ very long; subanal plate spinulose, spadelike, setæ normal, fairly long; setulæ sparsely distributed; cerci glabrous, small, knoblike, petiolate; setæ short, stout, two or three apicals on each cercus, setulæ short, bristlelike confined to the club.

Chortophila longula Fallen.*

Segments and intersegments of equal length, sclerites glabrous except the subanal plate which is spinulose, marginals of the terga equal, evenly distributed in a single row along the caudal margin of the segments. Intersegments smooth, hyaline, transparent, except the base of the first intersegment which is spinulose.

Segment VI. Tergum lightly chitinized, encasing the dorsal region as a homogeneous plate, except for the ill-defined notch-like discal area which partitions the cephalic margin; accessory pieces present; spiracles closely approximate, oblique, near to the caudal margin. Sternum lanceolate, attaining half the length of the segment; marginals few, separated into two groups; conjunctiva smooth, with slight chitinous granulations.

Segment VII. Tergum composed of a strong marginal plate, from the lateral boundaries of which extend two chitinous plates cephalad. At times there develops along the mid-dorsal line a median chitinous thickening; discal area hyaline; accessory pieces present. Sternum reduced to a short, oblong plate, about half the length of the segment; marginals few, wide apart; conjunctiva smooth, with chitinous thickenings.

Segment VIII. Tergum similar in structure to segment VII, the lateral plates slightly undulating and taper gradually toward the cephalic margin; discal area hyaline, sometimes divided by a median chitinous thickening. Sternum composed of two short tapering plates adjoining the caudal margin; setæ few; conjunctiva, smooth, hyaline.

Segment IX. Suranal plate scoop-shaped; setæ wide apart, exceeding the breadth of the club by twice; setulæ five or six, between the setæ; subanal plate spinulose, spade-shaped; setæ distributed along the margin; setulæ diverse; cerci smooth, conical, petiolate; setæ short, apicals strong; setulæ few; sense organs four, contiguous, situated towards the apex of each cercus.

Chortophila muscaria Meigen.

Segments longer than the intersegments; marginals long, diverse, scattered around the caudal margin of the segments. Intersegments spinulose, except for the dorsal region of the fourth which is reduced to a hyaline transverse strip; the remaining membranes are densely spinulose, the spinules increasing in size from the first to the third intersegment; similarly a clear membranous strip defines the caudal margins of intersegments one to three, which increases in width and proportion according to succeeding intersegments.

Segment VI. Tergum glabrous, composed of two broad lateral plates whose caudal margins approximate, almost fusing across the mid-dorsal line, dorsal and ventral borders ragged, indeterminate; discal area gradually widening cephalad, hyaline, indefinitely striated by rows of spinules; accessory pieces absent; marginals long, diverse, distributed in two irregular rows; spiracles wide apart, equalling twice the breadth of the sternum, oblique, posterior spiracles situated on the caudal margin. Sternum lanceolate, extending for three-quarters the length of the segment, spinulose posteriorly; marginals approximate, scattered, including two very long setæ; conjunctiva spinulose, spinules very small and dense, short fine spines sparsely distributed about the caudal area.

Segment VII. Tergum glabrous, somewhat similar in structure to segment VI, heavily chitinized along the lateral and caudal margins, investing a coarsely spinulated discal area; marginals diverse, distributed around the caudal margin irregularly. Sternum, lanceolate, attaining the whole length of the segment, gradually tapering to a point caudad; marginals few, including two very long setæ; conjunctiva densely spinulose, short, fine spines sparsely distributed about the caudal area.

Segment VIII. Tergum composed of a heavily chitinized, archlike plate, partially enclosing a lightly chitinized, spinulose discal area; the lateral plates spinulose cephalad, smooth throughout the caudal half; marginals numerous, short, spinelike, scattered across the marginal plate. Sternum smooth, composed of two narrow chitinous sclerites, broadened toward the cephalic margin thence gradually tapering to a fine point caudad; setæ few, one or two; conjunctiva spinulose.

Segment IX. Suranal plate triangular, equilateral, larger than the subanal plate; setæ approximate, closer together than the width of the club; subanal plate spinulose, smaller than the suranal plate; setæ arranged in a semi-circle, bordering the margin; setulæ numerous, distributed over the entire surface; cerci short, smooth, laterally compressed, sessile; setæ short and fine; apicals two; sense organs two, situated laterad.

Chortophila nuda Strobl.*

Segments and intersegments of equal length, sclerites glabrous except for the subanal plate which is spinulose. Intersegments densely spinulose, striated, except for the ventral surface of intersegment four which is smooth.

Segment VI. Tergum composed of two broad lightly chitinized lateral plates that blend gradually into the more or less constricted discal area, ventral margin defined; accessory pieces present; marginals diverse, few, evenly distributed, regular; spiracles wide apart, the breadth of the sternum, situated along the ventral margin. Sternum, elongate sclerite, rounded caudad, gradually tapering cephalad to the margin; marginals approximate, around the caudal border.

Segment VII. Tergum similar in structure to segment VI, the caudal margin somewhat constricted; accessory pieces present, distinct; marginals few; discal area membranous, hyaline. Sternum lanceolate, rounded caudad, tapering to a point cephalad, attaining the length of the segment; marginals separated into two lateral groups; conjunctiva lightly spinulose.

Segment VIII. Tergum composed of two lateral plates which flare caudad so as to envelop the margin, cephalad the plates curve dorsad, approximating at the cephalic margin; discal area with chitinous granulations, constricted cephalad; marginals equal, distributed regularly in a single row. Sternum, two small ovoid sclerites bordering the caudal margin; setæ strong, spinelike, scattered throughout; conjunctiva smooth.

Segment IX. Suranal plate scoopshaped; setæ approximate, less than the width of the club apart, setulæ few; subanal plate spadeshaped; setæ equidistant, bordering the apical margin, setulæ spinelike, distributed over the surface; cerci clubbed, petiolate, smooth; apicals two or three, setulæ long, diverse; petiole smooth; sense organs, two apical tubercles.

Chortophila parva Desvoidy.

Segments slightly longer than the intersegments, sclerites glabrous except the subanal plate which is spinulose. Intersegments spinulose, increasing in density according to successive intersegments, spinules broad at their base, not recurrent, becoming much coarser in intersegment three; structure and character very similar to *cinerella* and *cærulescens* scalelike in appearance.

Segment VI. Tergum denoted by a chitinized caudal half and a clear hyaline cephalic half, the caudal region composed of two bilaterally symmetrical plates, somewhat crescentshaped, bounding a clear hyaline discal area; accessory pieces present; marginals few, short, usually two; spiracles closely approximating, in a horizontal plane, side by side, directly cephalad of the accessory pieces. Sternum reduced to a small pear-shaped sclerite adjacent to the caudal margin; marginals separated and arranged in two lateral groups; conjunctiva smooth, hyaline.

Segment VII. Tergum composed of two chitinous rods situated subdorsad, from the caudal to the cephalic margins; at the extremities the rods tend to approximate, constricting the long hyaline discal area; accessory pieces present, distinct; marginals few, short, usually two, distributed dorsad. Sternum reduced to a small triangular sclerite adjacent to the caudal margin; marginals separated into two groups, wide apart; conjunctiva smooth, hyaline.

Segment VIII. Tergum composed of two chitinous rods, subdorsad, that expand at their caudal extremities to invest the margin of the segment, cephalad the rods approximate reaching the cephalic margin; marginals few, short, bristlelike, regular. Sternum similar in structure to the tergum, the sternites extend along the subdorsal axes, tapering to a point caudad; marginals short, bristlelike; conjunctiva hyaline, transparent, the caudal half of the lateral membranes clothed with dense, broad spinules, scalelike.

Segment IX. Suranal plate broad, scoop-shaped, setæ strong, the width of the club apart; subanal plate spinulose, broadly conical, setæ short, in a transverse row across the apical third, setulæ small, thornlike; cerci smooth, knoblike, sessile; setæ few, apicals stout, setulæ bristlelike; sense organs two, contiguous, papillæ of medium length, not domelike.

Chortophila rubivora Coquillett.

Segments and intersegments of equal length. Sclerites glabrous. Intersegments densely spinulose except the fourth which is smooth but for a few spinules along the cephalic margin of the dorsum.

Segment VI. Tergum an unevenly chitinized plate which presents two lateral thickenings and a thinly chitinized mid dorsal region; discal area indeterminate; marginals diverse, regular; spiracles closer together than the width of the sternum, oblique, posterior spiracle cephalad of the caudal margin; accessory pieces absent. Sternum broadly lanceolate, tapering at both extremities to the margins of the segment; marginals approximating, continued for a short distance along the lateral borders; conjunctiva spinulose, densely covered.

Segment VII. Tergum similar in structure to segment VI except that the chitin is thinner and tends to separate the tergum into two lateral, thickened plates; discal area vestigial; marginals diverse, somewhat irregularly arranged; accessory pieces absent. Sternum lanceolate, tapering to both margins, marginals approximate; conjunctiva spinulose.

Segment VIII. Tergum composed of two lateral chitinous plates which have fused along the caudal margin across the mid-dorsal line. Frequently a tonguelike chitinous thickening appears on the discal area which fuses caudad with the marginal plate; discal area chitinized; marginals short, spinelike, regular, denoting the fusion of the firmly chitinized fourth intersegment with the caudal margin of the segment with which it appears to form an integral part, similar in structure to *substriata*. Sternum composed of two narrow sternites that attain three-quarters the length of the segment, pointed caudad; setæ few, short, spinelike; conjunctiva spinulose.

Segment IX. Suranal plate triangular; setæ approximate, strong, the base of the plate closely coincident with the margin of the fourth intersegment; subanal plate, smooth, spadelike to conical; marginals apart, a fringe of setulæ around the apex, the surface sparsely covered with setulæ; cerci smooth, clavate, petiolate; apicals long, setulæ covering club and petiole; sense organs two, contiguous, subapical.

Genus **Hylemyia** Desvoidy.

Hylemyia æmene Walker, **flavicans** Stein and **alcathœ** Walker.

Up to the present no accountable differences are to be observed in the structure, vestiture or chætotaxy of the three above named species. The three species in common may therefore be treated under the same description.

Segments and intersegments of equal length, sclerites glabrous except the subanal plate which is spinulose. Intersegments spinulose on the ventral surface except the fourth which is smooth throughout, on the dorsal surface intersegments one, two and three spinulose along the cephalic margins and for a greater or less distance along the region of the mid-dorsal line, remaining area smooth, hyaline.

Segment VI. Tergum completely chitinized, encasing the dorsal region, cephalic border indeterminate; accessory pieces absent; marginals diverse, regular; spiracles oblique, the width of the sternum apart, posterior spiracle on the caudal margin. Sternum lanceolate to pegshaped, tapering to a blunt point on the cephalic margin, truncate caudad; marginals approximate; conjunctiva spinulose on the caudal half, smooth cephalad.

Segment VII. Tergum similar in structure to segment VI, thinly chitinized on the discal region; marginals diverse, regular. Sternum pegshaped, tapering cephalad; marginals bordering the caudal margin; conjunctiva, caudal third spinulose, remaining surface smooth.

Segment VIII. Tergum composed of two lateral plates which tend to approximate toward the cephalic margin, gradually tapering to a point, caudad the extremities flare and coincide with the margin, nearly fusing across the mid-dorsal line; discal area broad, hyaline; marginals diverse, regular. Sternum composed of two broadly ovoid sclerites that taper to a point at both ends, attaining one-half the length of the segment; setæ distributed over the surface irregularly; conjunctiva smooth.

Segment IX. Suranal plate scoop-shaped; setæ strong, approximate, setulæ strong, spinelike; subanal plate spade-shaped to conical; setæ long; setulæ beside the margins long, remainder short; cerci smooth, petiolate, club clavate to subcylindrical, clothed with long fine setulæ, apicals long and fine; sense organs apical, consist of two large membranous discs from which emerge fine hairlike papillæ, also two small spined tubercles, the former give the club a truncate or "chipped" appearance.

Hylemyia coarctata Fallen.*

Segments and intersegments of equal length, sclerites glabrous except the subanal plate which is spinulose. Intersegments spinulose on the ventral and smooth on the dorsal surfaces except for the fourth, which is smooth throughout.

Segment VI. Tergum composed of one thinly chitinized plate encasing the dorsal region, cephalic margin indeterminate; accessory pieces present; marginals few, equal, regular; spiracles the width of the sternum apart, slightly oblique, posterior spiracles situated on the accessory pieces. Sternum lanceolate, attaining the length of the segment, expanding before tapering to the cephalic margin; marginals approximating, distributed for a short distance along the lateral borders; conjunctiva spinulose.

Segment VII. Tergum similar in structure and character to segment VI, a more noticeable thinning of the chitin dorsad. Sternum with rounded caudal margin; the marginals arranged in a semi-circle around the border; conjunctiva smooth.

Segment VIII. Tergum similar in structure to *æmene*, composed of two lateral plates whose caudal extremities flare and adhere to the margin, cephalad the plates slightly approximate, tapering toward the cephalic margin; discal area hyaline, spaceous; marginals diverse, regular. Sternum composed of two broadly ovoid sclerites tapering to a point caudad, attaining one-half the length of the segment; setæ distributed over the entire surface, bristlelike; conjunctiva smooth.

Segment IX. Suranal plate scoopshaped; setæ barely the width of the club apart; setulæ few, strong; subanal plate spade-shaped; setæ regular; setulæ around the margin spinelike, remainder shorter; cerci conical to subcylindrical, clothed with fine long setulæ, apicals long and fine; sense organs consist of two large membranous discs from which emerge fine hairlike papillæ and two small tubercles, the former cause the apices of the clubs to appear chipped or notched.

Hylemyia flavipennis Fallen.*

The structure and character of the segments and intersegments are very similar to those of *coarctata*. In *flavipennis* the length of the segments and intersegments is equal to their breadth; the accessory pieces are absent, and the shape of the ventral sclerites vary slightly from that of *coarctata*. In *flavipennis* the caudal border of the sternum of the sixth segment is truncate with the marginals arranged along the caudal margin whereas in *coarctata* the caudal extremity tapers to a point with the marginals arranged laterad. The conjunctiva of the sixth segment in *flavipennis* is spinulose on the caudal third and smooth for the remaining area whereas in *coarctata* the whole surface is spinulose. The sternum of the seventh segment of *flavipennis* tapers cephalad, in *coarctata* the cephalic half of the sclerite expands before reaching the margin. Further in *flavipennis* the setæ of the suranal plate lie closer to each other.

Hylemyia juvenilis Stein.

Segments one and two slightly longer than the foregoing intersegments, segment VIII equal to intersegment three; suranal, subanal plates and cerci densely pubescent. Intersegments spinulose except the fourth which is smooth throughout.

Segment VI. Tergum glabrous, completely chitinized, shieldlike, encasing the tergal region; accessory pieces absent; marginals diverse, regular, continuing for a short distance along the ventral border; spiracles barely the width of the sternum apart, oblique, posterior spiracles cephalad of the caudal margin. Sternum spatulate or paddle-shaped, the blade covered with dense minute spines, marginals distributed along the lateral borders; conjunctiva densely spinulose.

Segment VII. Tergum similar in structure to segment VI, the chitin less dense toward the mid-dorsal region, cephalic margin ragged, incised; marginals confined to the caudal border. Sternum spatulate, unevenly chitinized, the outline at times interrupted, clothed with dense minute spines around the caudal margin; marginals even, distributed laterad; conjunctiva densely spinulose.

Segment VIII. Tergum separated by a spacious discal area into two lateral plates whose caudal extremities flare, adhering to the margin to fuse as a narrow marginal plate, cephalad the plates broaden slightly; discal area divided by a median, interrupted thickening of the chitin; marginals diverse, irregular. Sternum composed of two elongate sclerites pointed at both extremities, attaining but half the length of the segment; setæ few, distributed irregularly; conjunctiva spinulose.

Segment IX. Suranal plate scoop-shaped to hemispherical; setæ wide apart, exceeding the width of the club, setulæ few, long; subanal plate conical, pubescent; setæ long, fine, approximate, setulæ sparsely distributed over the surface; cerci slender, densely pubescent; club subcylindrical; petiole slender, longer than the club; apicals long and fine, setulæ long, few, bristlelike; sense organs consist of two tubercles.

Hylemia lipsia Walker.

Segments and intersegments of equal length, sclerites glabrous. Intersegments smooth, hyaline, transparent.

Segment VI. Tergum thinly chitinized extending from side to side as a broad plate, cephalic margin indeterminate, incised; discal area vestigial; accessory pieces large, setæ thickly distributed; spiracles approximate, oblique, cephalad of the accessory pieces. Sternum obconic, truncate caudad, pointed cephalad, attaining three quarters the length of the segment; marginals diverse, regular, distributed along the caudal margin; conjunctiva smooth, hyaline.

Segment VII. Tergum composed of two lateral chitinous plates whose extremities flare caudad to partially coincide with the margin, cephalad the plates taper, not reaching the margin; discal area spacious, hyaline; accessory pieces large, bearing numerous setæ; marginals numerous, diverse, irregular. Sternum reduced to two short chitinous strips on either side of the mid-dorsal line adjacent to the caudal margin; marginals diverse, irregular, closely distributed; conjunctiva membranous, hyaline, occupying the whole ventral area.

Segment VIII. Tergum divided into two chitinous plates, dorsocentral, that flare and fuse together along the caudal margin, cephalad the plates taper and fail to reach the margin; discal area hyaline, transparent; marginals diverse, irregular. Sternum reduced to two small ovoid sclerites adjacent to the caudal margin, pointed at both extremities; setæ few; conjunctiva smooth, hyaline.

Segment IX. Suranal plate triangular; setæ the width of the club apart; subanal plate conical, glabrous; setæ regular; setulæ few; cerci short, knobbed, sessile; apicals single, setulæ confined to the distal half.

Hylemyia setiventris Stein.

Segments and intersegments of equal length, sclerites glabrous except the subanal plate which is pubescent. Intersegments heavily spinulose except the fourth, which is smooth throughout.

Segment VI. Tergum divided by a lightly chitinized discal area into two heavily chitinized lateral plates whose caudal and cephalic extremities expand dorsad along their respective segmental margins, almost fusing across the mid-dorsal line, the plates blend imperceptibly with the discal area; accessory pieces present; marginals few, even, regular; spiracles wide apart, oblique, posterior spiracles cephalad of the accessory pieces and twice the diameter of the anterior spiracles, the latter small, situated in the conjunctiva. Sternum elongate, extending the length of the segment, tapering cephalad; marginals divided into two lateral groups; conjunctiva densely spinulose.

Segment VII. Tergum separated by a lightly chitinized discal area into two broad lateral plates that tend to approximate cephalad, the caudal extremities expanded dorsad along the margin; accessory pieces present; marginals equal, regular. Sternum lanceolate, extending for the length of the segment, tapering at both ends; marginals divided into two lateral groups; conjunctiva spinulose except for a cephalic area bordering the segmental margin.

Segment VIII. Tergum composed of two lateral rodlike chitinous plates that partially enclose a spacious, lightly chitinized discal area, the plates approximate at the cephalic margin, caudad the extremities adhere to the margin as chitinous strips, nearly fusing across the mid-dorsal line; marginals diverse, regular, terminating at both sides in a group of setæ. Sternum reduced to two, broadly ovoid sclerites adjacent to the caudal margin; setæ distributed over the entire surface; conjunctiva smooth.

Segment IX. Suranal plate scoop-shaped to hemispherical, armed with six or seven stout black spines; subanal plate spade-shaped, pubescent, setæ and setulæ long, fine, hairlike, the latter distributed densely over the surface; cerci smooth, knobbed, sessile, armed with numerous stout upcurving spines on the dorsal surface, on the ventral surface clothed with fine, hairlike setæ; sense organs consist of two tubercles, situated laterad, from which emerge two bristlelike papillæ.

Hylemyia strigosa var. **nigrimana** Fabricius.†

Ovipositor short, compact, equalling the fifth abdominal segment in length. Segments much longer than the intersegments, breadth three times the length. Intersegments spinulose except the fourth which is smooth on the ventral surface.

Segment VI. Tergum smooth, composed of a broad, bandlike discal area, lightly chitinized, separating two small quadrangular plates which are confined to the lateral margins of the segment; accessory pieces absent; marginals few, regular; spiracles large, exceeding the breadth of the sternum apart, posterior spiracles mesad of the anterior, both

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† European specimen.

situated along the ventral margin. Sternum spinulose, lanceolate, attaining the length of the segment; marginals separated into two lateral groups; conjunctiva spinulose.

Segment VII. Similar in structure to segment VI, the sternum spinulose, expanding into a broader sclerite caudad; marginals wide apart; conjunctiva spinulose.

Segment VIII. Tergum spinulose, divided by the median discal area into two broad quadrangular lateral plates; marginals diverse, irregular. Sternum spinulose, consisting of two elongate sclerites, attaining the length of the segment, tapering at both extremities; setæ few, usually two; conjunctiva smooth.

Segment IX. Suranal plate pubescent, scoop-shaped; setæ long and stout, setulæ numerous, bristlelike; subanal plate spinulose, broadly spade-shaped; setæ, three pairs on the apical third, setulæ diverse, numerous; cerci pubescent, short petiole, knobbed; apicals stout, setulæ diverse, long and stout, distributed over the distal region; sense organs consist of two spined tubercles.

Hylemyia variata Fallen.

Segments longer than the intersegments, breadth twice the length. Intersegments spinulose except the fourth which is smooth on the ventral surface. Spinules arranged in no regular striations.

Segment VI. Tergum spinulose, divided by a thinly chitinized median strip into two quadrangular plates which encase the sides of the segment, dorsal and ventral borders ragged; accessory pieces absent; marginals equal, even, regular; spiracles barely the breadth of the sternum apart, oblique, posterior spiracles situated cephalad of the caudal margin. Sternum spinulose, attaining the length of the segment, broadly expanding caudad, tapering to a blunt point cephalad; marginals widely separated into two lateral groups; conjunctiva densely spinulose.

Segment VII. Similar in structure and character to segment VI. The tergum divided by a more pronounced median discal area into two lateral quadrangular plates, the latter are not so extensive as in segment VI. Sternum tapering more decidedly to a point, scarcely attaining the caudal margin.

Segment VIII. Tergum divided by a broadly expanding discal area into two broad, lateral, heavily chitinized plates, the latter expanded caudad, adhering to the margin and almost fusing across the mid-dorsal line; marginals few, equal, regular; the region along the caudal margin and projecting for some distance onto the discal area densely spinulose. Sternum glabrous, composed of two small elongate to oval sclerites, adjacent to the caudal margin; setæ distributed irregularly; conjunctiva smooth.

Segment IX. Suranal plate pubescent, hemispherical, setæ approximate long; subanal plate spinulose, spade-shaped, setæ and setulæ nearly equal, few and sparsely distributed over the surface; cerci pubescent, knobbed, short petiole; apicals long and stout, setulæ distributed over the club; sense organs apical, consisting of two spined tubercles.

Genus **Pegomyia** Desvoidy.

Pegomyia affinis Stein.

Segments slightly longer than the intersegments except segment and intersegment eight which are foreshortened, sclerites glabrous. Intersegments smooth, hyaline, transparent.

Segment VI. Tergum thinly chitinized, covering the entire dorsal region, margins indeterminate; accessory pieces present; marginals diverse, slightly irregular; spiracles approximate, oblique, cephalad of the accessory pieces. Sternum lanceolate, extending for the entire length of the segment, expanding slightly caudad; marginals distributed laterad; conjunctiva smooth, hyaline.

Segment VII. Tergum divided by a hyaline discal area into two lateral pieces which extend from margin to margin as more or less uniform plates; accessory pieces large, distinct; marginals diverse, irregular. Sternum spatulate, the caudal extremity flaring, truncate; marginals approximate, distributed in a semi-circle around the margin; conjunctiva smooth, hyaline.

Segment VIII. Tergum reduced in size to form a lightly chitinized, archlike plate, the margins indeterminate, blending imperceptibly with the discal area. Sternum consists of two small elongate sclerites one-half the length of the segment; setæ few, distributed on the caudal third; conjunctiva smooth.

Segment IX. Suranal plate triangular to conical; setæ short, approximate, less than the width of the club apart; subanal plate broadly spade-shaped; setæ irregular, approximate; setulæ absent; cerci smooth, small, knobbed, sessile; apicals short, stout; setulæ distributed on the distal portion of the club.

Pegomyia calpytrata Zetterstedt.

Ovipositor short, compact, slightly longer than the fifth abdominal segment, spinulose throughout, segments longer than the intersegments, breadth twice the length. Intersegments reduced to narrow transverse membranes.

Segment VI. Tergum completely chitinized encasing the entire tergal region, posterior angles produced ventrad to embrace the sides of the segment; marginals few, one or two; accessory pieces present, distinct; spiracles in the same plane, not oblique, wide apart, posterior spiracles situated on the caudal margin of segment. Sternum consists of an oblong sclerite, truncate at both extremities, extending the entire length of the segment, the posterior region densely covered with black, short spines, which continue sparsely along the lateral borders; conjunctiva spinulose.

Segment VII. Tergum similar in structure to segment VI; marginals diverse, regular, confined to the caudal margin of the posterior angles of the tergum; accessory pieces absent. Sternum broadly conical, the apex reaching the cephalic margin, posterior half densely clothed with black, short spines, hooked at the tip; conjunctiva spinulose.

Segment VIII. Tergum reduced to two subtriangular tergites whose posterior angles are produced ventrad and dorsad, coinciding with the caudal margin, cephalad the apices reach the cephalic margin; discal area membranous, widely separating the tergites and occupying the entire dorsal region; marginals diverse, irregular. Sternum reduced to two small triangular sclerites adjoining the cephalic margin; setæ short, fine; conjunctiva spinulose.

Segment IX. Suranal plate broad, scoop-shaped, apex rounded; setæ wide apart, equal to the breadth of the club, setulæ numerous, strong; subanal plate broadly spade-shaped; setæ stout, distributed apically and at the basal angles; setulæ short, surrounding a spinulose discal area; cerci spinulose, ovoid, sessile; apicals single; setulæ few, confined to the distal region of the club; sensory organs, small, apical.

Pegomyia hyoscyami Panzer.

Ovipositor short, compressed, slightly longer than the fifth abdominal segment, spinulose except for the cephalic margin of the sternites; the latter longer than the intersegments, breadth twice length. Intersegments reduced to narrow transverse membranes.

Segments VI. Tergal region occupied by a spacious discal area, extending from side to side, margin to margin; bounded laterally by angular chitinous plates that project ventrad; accessory pieces absent; marginals diverse, irregular; spiracles wide apart, in the same plane, posterior spiracles situated caudad of the margin, in the membrane of the second intersegment. Sternum consists of a broad plate, similar to that of the fifth abdominal segment, posterior angles rounded, anterior angles square, the entire surface except along the cephalic margin covered with diverse setæ, cephalic margin glabrous; conjunctiva reduced to narrow articulating membranes between the sternum and tergum.

Segment VII. Tergum similar to segment VI in appearance, the tergites confined to the caudo-ventral regions of the dorsum, tapering cephalad and dorsad, the ventral margins anastamose with the borders of the sternum, appearing to form a continuous sclerite with the sternum, the dorsal margin glabrous, the remaining surface sparsely covered with diverse setæ. Sternum cordate, humped anteriorly, occupying nearly the whole sternal region, lateral borders anastamose with the ventral margin of the tergites, cephalic margin glabrous, the remaining surface covered with setæ; conjunctiva reduced to the cephalic margin, and is confluent with the tergal membrane.

Segment VIII. Tergum composed of a transverse chitinous plate, completely encasing the tergal region, spinulose except for a hemispherical area along the cephalic margin; marginals irregular, distributed along the caudal margin and about the ventral region. Sternum composed of three chitinous sclerites; two lateral hemispherical sclerites, approximating toward the caudal margin, gradually diverging cephalad; into the angular space thus formed fits the triangular apex of the median anterior sclerite, the latter continues cephalad as a narrow plate, surpassing the cephalic margin and dissecting the third intersegment into two lateral regions; the sclerites are spinulose except for the dorsal area of each lateral plate and the anterior portion of the median sclerite, included amongst the spinules are a few short setæ; conjunctiva reduced to narrow articulating membranes between the sternites and the tergites.

Segment IX. Suranal plate broad, transverse; setæ long, wide apart; setulæ scattered; subanal plate spade-shaped; setæ distributed apically, setulæ distributed over the entire surface; cerci spinulose, knobbed, sessile; apicals strong; setulæ short, fine, distributed on the distal region of the club.

Pegomyia trilineata Stein.

Segments longer than the intersegments. Sclerites glabrous except the sternum and accessory pieces of the sixth segment which are partly spinulose, and the subanal plate which is wholly spinulose. Intersegments smooth, hyaline.

Segment VI. Tergum lightly chitinized, with thicker areas along the caudal, cephalic and lateral margins. These plates blend imperceptibly into a large semi-translucent discal area. Marginals short, diverse, more or less regular; accessory pieces present, partly spinulose; spiracles oblique, adjoining the accessory pieces. Sternum spatulate, cephalic half but faintly chitinized, at the tip of which is a pair of sensory organs, caudal half spinulose, hexagonal in outline; marginals in two lateral groups; conjuctiva spinulose on the caudal half, hyaline and smooth cephalad.

Segment VII. Tergum divided into two lateral plates that fuse across the caudal margin; discal area large, semi-translucent, confining the plates to the lateral margins of the segment; marginals as in segment VI; accessory pieces present. Sternum spatulate, glabrous, with but a few if any spinules; marginals and sense organs as in segment VI; conjunctiva smooth, hyaline, with a very few spinules along the caudal margin.

Segment VIII. Tergum completely and heavily chitinized, encasing the dorsal region, cephalic margin emarginate, a short chitinous tooth at the caudal end of the middorsal line; marginals short, diverse, irregular. Sternum composed of two strongly chitinized, elongate plates reaching three-quarters the length of the segment; setæ short, confined to the caudal third of the sternites; conjunctiva, smooth, semi-opaque.

Segment IX. Suranal plate scoop-shaped, setæ short, approximate; subanal plate spade-shaped, setæ normal, setulæ long around the caudal margin, short and thornlike on the plate; cerci glabrous, subcylindrical, petiolate, apicals one per club, setulæ short, distributed on the club and petiole, at the apex of the former are two strikingly recurrent setulæ.

Pegomyia trivittata Stein.

Segments longer than the intersegments. Sclerites glabrous except the sternum of the seventh segment which bears numerous stout, short spines. Intersegments heterogeneous; the first smooth on the dorsal surface, on the ventral surface spinulose throughout the cephalic half, smooth caudad; second intersegment spinulose, densely so along the cephalic margin of the dorsal surface, very lightly for the remaining region, on the ventral surface spinulose along the cephalic margin and for a short distance caudad along the midventral line, the remaining region smooth. Intersegment three spinulose on both surfaces except for a posterior margin of smooth hyaline membrane. Intersegment four smooth throughout.

Segment VI. Tergum thinly chitinized, completely encasing the dorsal region, cephalic margin ragged; accessory pieces present clothed, with numerous setæ; marginals diverse, distributed closely together and irregularly; spiracles approximate, oblique, cephalad of the accessory pieces. Sternum reduced to two spherical chitinous areas adjacent to the caudal margin; marginals diverse scattered over the entire surface; conjunctiva adjoining the sternites densely spinulose, remainder smooth.

Segment VII. Tergum similar in structure to segment VI except that the chitin along the mid-dorsal line is much thinner, dividing the tergum into lateral plates; accessory pieces present; the marginal region and the accessory pieces possess numerous short, stout, spines amongst which are scattered a few longer bristles. Sternum reduced to two ovoid chitinous pieces adjacent to the caudal margin, which are covered throughout their entire area with numerous short, stout, spines; marginals few, usually two; conjunctiva densely spinulose between the tergum and sternites and for a short distance cephalad, remaining region smooth.

Segment VIII. Tergum divided by a spacious hyaline discal area into two lateral plates which taper gradually to the cephalic margin; marginals surplanted by a row of stiff, short, spines. Sternum composed of two elongate sclerites attaining one-half the length of the segment, the apical third armed with stout, short spinules; conjunctiva spinulose along the caudal margin, smooth for the remaining region.

Segment IX. Suranal plate subtriangular, setæ approximate; subanal plate broadly spade-shaped, setæ regular, setulæ sparsely distributed over the surface; cerci, small, knobbed, smooth, sessile; apicals short and stout, setulæ confined to the club; sense organs tubercular, with sharp apical spines.

Pegomyia unicolor Stein.

Segments longer than the intersegments, sclerites glabrous on the dorsal surface, spinulose on the ventral, lightly chitinized throughout, armed with bunches of stout spines. Intersegments smooth, hyaline.

Segment VI. Tergum lightly chitinized, hyaline, slightly thickened around the caudal margin; accessory pieces present, armed with numerous stiff bristles; marginals stout, equal, regular, usually eight in number, distributed dorsad; spiracles the width of the sternum apart, oblique, orifices surrounded by a broad brim or margin, situated in the conjunctival membrane. Sternum short, conical, attaining one-third the length of the segment, sparsely covered with spinules; marginals approximate, in a semi-circle around the margin; conjunctiva smooth, hyaline, the caudal border with a few stout setæ.

Segment VII. Tergum lightly chitinized, the sides and the caudal margin slightly thickened into two faintly perceptible lateral plates which are separated by a hyaline, transparent discal area; accessory pieces present, armed with stiff, stout bristles. Sternum densely spinulose, reduced to a short transverse sclerite adjacent to the caudal margin; marginals scattered; conjunctiva smooth, constricted at the caudal limits by the accessory pieces.

Segment VIII. Tergum composed of two lateral plates, broadly separated throughout by a spaceous hyaline discal area, the caudal region characterized by a tuft of dense short hair, the caudal margins of the tergites are armed with a few stout stiff bristles. Sternum densely spinulose, composed of two somewhat raised sclerites adjacent to the caudal margin and nearly fusing across the mid ventral line, the outer halves of each sternite bear numerous stiff setæ; conjunctiva smooth for the greater part, sparsely spinulose along the caudal margin.

Segment IX. Suranal plate scoop-shaped; setæ approximate, short, stout; setulæ few; subanal plate spinulose, conical; setulæ few; subanal plate spinulose, conical; setæ apical; setulæ long, spinelike, sparsely distributed over the distal half; cerci small, subcylindrical; apicals short and stout; setulæ few, stout, confined to the club; sensory organs tubercular, spined, scattered over the club.

Pegomyia winthemi Meigen.

Segments slightly longer than the intersegments, sclerites glabrous except the sternum of segment eight which is pubescent and the subanal plate which possesses a few scattered spinules. Intersegment one spinulose throughout; the second spinulose along the cephalic region and for a short distance caudad along the mid dorsal and mid-ventral lines, the remaining surfaces smooth; intersegment three smooth on the dorsal surface with a narrow strip of spinules along the cephalic margin, densely spinulose for three-quarters the length of the ventral surface, the caudal margin smooth, hyaline; fourth intersegment spinulose throughout.

Segment VI. Tergum completely but thinly chitinized, encasing the entire tergal region; accessory pieces absent; marginals diverse regular; spiracles situated close together, oblique, less than the width of the sternum apart. Sternum lanceolate, attaining the length of the segment, apex rounded caudad; marginals approximate, divided into two groups; conjunctiva spinulose for the caudal third, smooth for the remainder of the surface.

Segment VII. Tergum composed of two broad lateral plates whose caudal extremities fuse across the mid-dorsal line, cephalad the chitinization is well maintained; discal area hyaline; marginals diverse, irregular. Sternum reduced to a short lanceolate sclerite attaining one-half the length of the segment, pointed caudad, tapering cephalad; marginals preapical, in two groups; conjunctiva spinulose for the caudal third, smooth for the remaining surface.

Segment VIII. Tergum composed of two lateral plates whose caudal extremities develop dorsad to fuse across the mid-dorsal line, cephalad the plates taper and tend to approximate; discal area hyaline; marginals equal, regular. Sternum composed of two ovoid sclerites with the apices prolonged to a point, attaining one-half the length of the segment; setæ few, one or two, the surface densely pubescent; conjunctiva smooth, hyaline, fringed with pubescense at the caudal margin.

Segment IX. Suranal plate scoop-shaped; setæ wide apart, exceeding the width of the club; setulæ few; subanal plate sparsely spinulose, spade-shaped to conical; setæ regular, strong, bristlelike, setulæ short, scattered over the entire surface; cerci glabrous, knobbed, shortly petiolate; apicals and setulæ similar in size and length, stout, bristlelike, distributed over the club and petiole; sense organs consist of three spined tubercles situated laterad.

KEY.*

(Exclusive of *Pegomyia* Desv.)

A. Cerci pubescent or spinulose.
  B. Conjunctiva of segment VII smooth
    C. Suranal plate pubescent, cerci pubescent, intersegment 3 spinulose.
      D. Sternites of segment VIII spinulose, attaining almost to the cephalic margin......................*strigosa var. nigrimana* Fabr.
      DD. Sternites of segment VIII glabrous, confined to caudal region. *variata* Fall.
    CC. Suranal plate glabrous, cerci slightly spinulose, intersegment 3 spinulose on the ventral surface, smooth on the dorsal region........ *dissecta* Meig.
  BB. Conjunctiva of segment VIII spinulose.
    C. Segment VIII with sternites spinulose, tergum partly spinulose. *fugax* Meig. *substriata* Stein.
    CC. Segment VIII with sternites and tergites glabrous.....*juvenilis* Stein.
AA. Cerci glabrous, suranal plate glabrous.
  B. Cerci armed with upcurving stout spines.
    C. Sternites of segment VIII armed with upright, stout spines, suranal plate with 4 large hooks, cerci clothed with but few setæ, *candens* Zett.
    CC. Sternites of segment VIII clothed with setæ, suranal plate armed with numerous short hooks, cerci with conspicuous apical tufts of setæ...*setiventris* Stein.
  BB. Cerci clothed with setæ.
    C. Subanal plate glabrous, subtriangular.
      D. Subanal plate setulose, sternites of segment VIII attaining the length of the segment, conjunctiva spinulose........*rubivora* Coq.
      DD. Subanal plate with but one or two setulæ at most, sternites of segment VIII small, adjacent to the caudal margin, conjunctiva smooth, hyaline............................*lipsia* Wlk.

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* For the sake of feasibility the characters have been restricted to the distal end of the ovipositor, with the exception of one couplet.

CC. Subanal plate spinulose, spade-shaped.

D. Segment VIII with marginals scattered, discal area spinulose, sternites thin, chitinous strips attaining the cephalic margin, *muscaria* Meig.

DD. Segment VIII with marginals bordering the caudal margin, discal area smooth, sternites flaring caudad.

E. Sternites of segment VIII equal in length to the tergites.

F. Suranal plate scoop-shaped.......................... *parva* R. D.

FF. Suranal plate hemispherical........................ *cinerella* Fll.

EE. Sternites of segment VIII shorter than the tergites, failing to attain the cephalic margin.

F. Third intersegment smooth, sense organs 4.

G. Intersegment 4 heavily chitinized, fused to the margin of segment VIII, membranes covered with chitinous granulations...................................... *grisella* Rond.

GG. Intersegment 4 hyaline, transparent, membranes thin, delicate...................................... *longula* Fll.

FF. Third intersegment smooth on the dorsal surface, spinulose on the ventral surface.

G. Setæ of the suranal plate approximate, closer together than the width of club, accessory pieces absent on segments VI and VII..................... *flavipennis* Stein.

GG. Setæ of the suranal plate the width of the club apart, accessory pieces present on segments VI and VII, *coarctata* Fll.

FFF. Third intersegment partly smooth, partly spinulose on the dorsal surface, spinulose on the ventral surface... *aemene* Wlk.
alcathoe Wlk.
flavicans Stein.

FFFF. Third intersegment spinulose.

G. Spinules broad, imbricated, scale-like...... *caerulescens* Strobl.

GG. Spinules fine, recurrent, hooklike.

H. Conjunctiva of segment VIII spinulose......... *laevis* Stein.

HH. Conjunctiva of segment VIII smooth.

I. Tergites of segment VIII undulating.

J. Cerci short, compact, petiole short, intersegment 4 smooth, tergites slightly undulating... *antiqua* Meig.

JJ. Cerci elongate, subcylindrical, petiole slender, intersegment 4 spinulose on the dorsal surface, tergites markedly undulating................ *brassicæ* Bouché.

II. Tergites of segment VIII straight, approximating.

J. Sternites of segment VIII short, ventral surface of intersegment 4 smooth................. *nuda* Strobl.

JJ. Sternites of segment VIII elongate, attaining two-thirds to three-fourths the length of segment, ventral surface of intersegment 4 spinulose, *cilicrura* Rond.

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EXPLANATION OF PLATES.*

Plate XX.

Fig. 1. Chortophila dissecta Meig.
Fig. 2. Chortophila longula Fall.
Fig. 3. Chortophila candens Zett.
Fig. 4. Chortophila cilicrura Rond.

Plate XXI.

Fig. 5. Chortophila antiqua Meig.
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Fig. 9. Chortophila parva R-D.
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Fig. 17. Hylemyia variata Fall.
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Fig. 25. Pegomyia affinis Stein.
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Fig. 28. Pegomyia trivittata Stein.

Plate XXVII.

Fig. 29. Pegomyia hyoscyami Panz.
Fig. 30. Hylemyia strigosa var. nigrimana Fabr.

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* Each Figure is represented by two drawings, of which the left hand one denotes the dorsal aspect, the right hand one the ventral aspect of the ovipositor.

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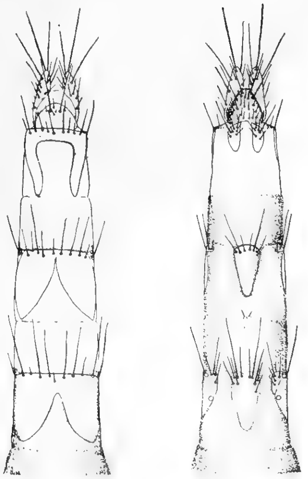

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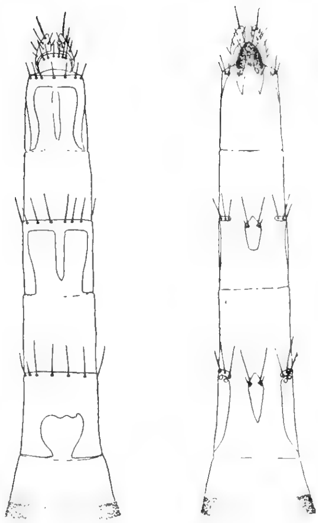

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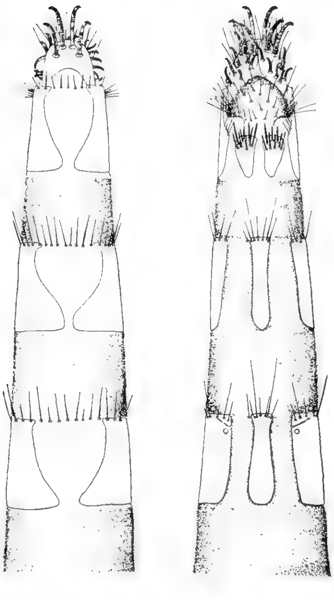

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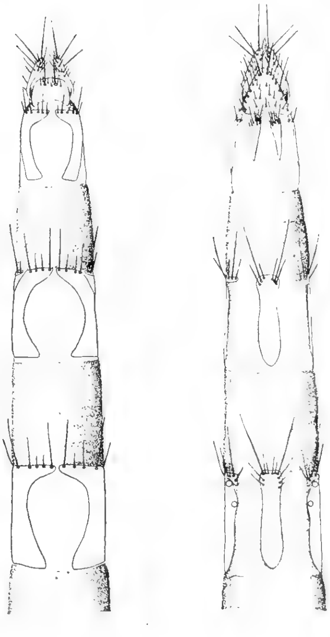

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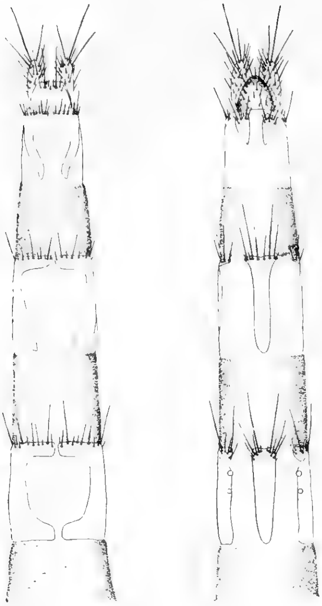

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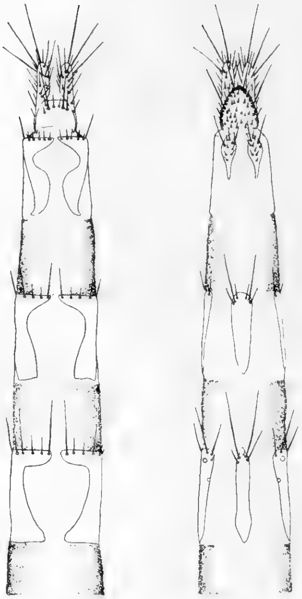

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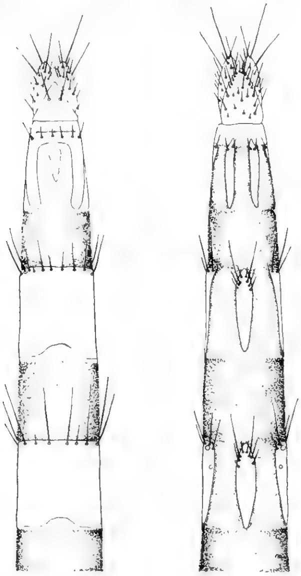

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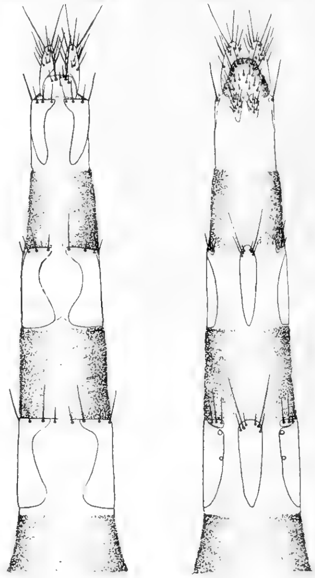

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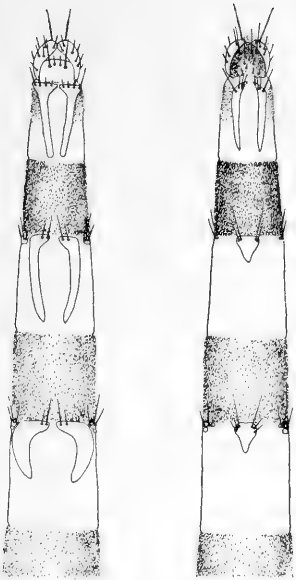

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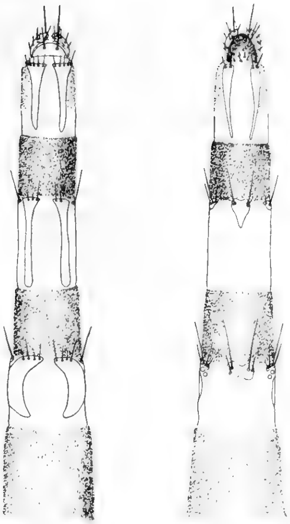

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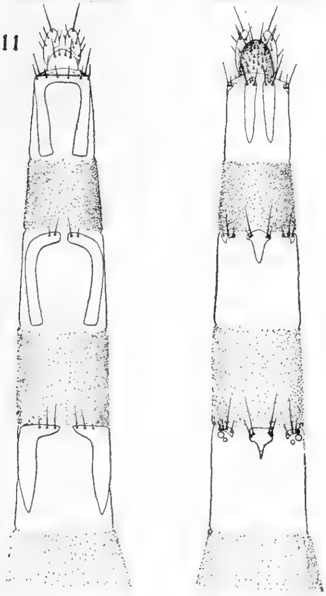

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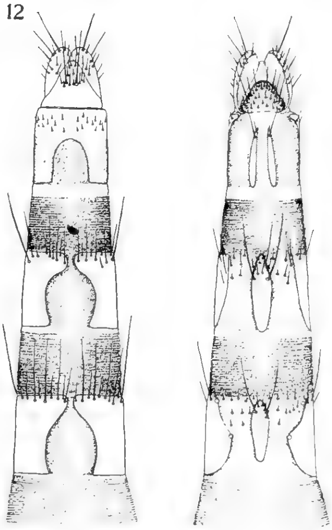

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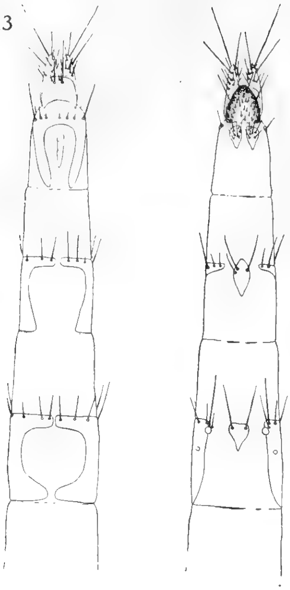

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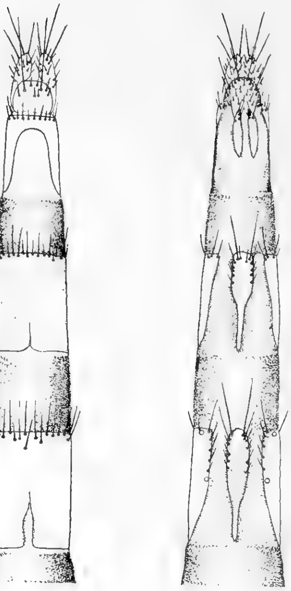

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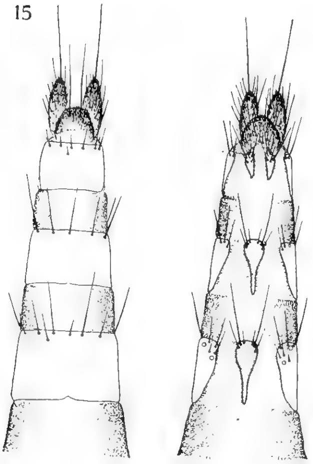

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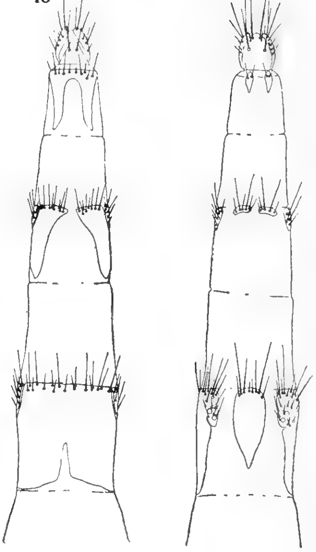

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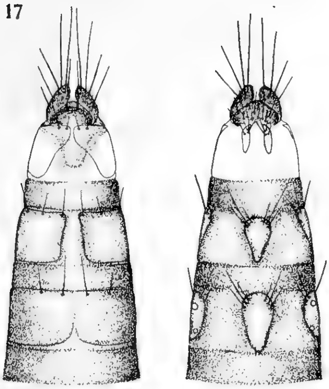

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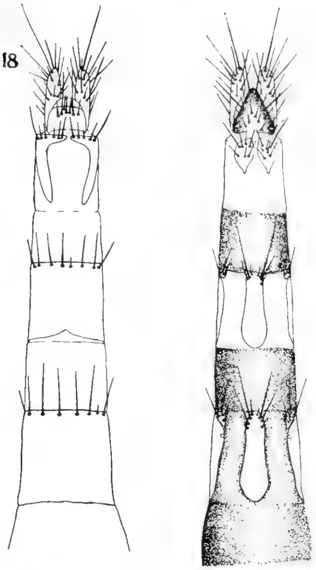

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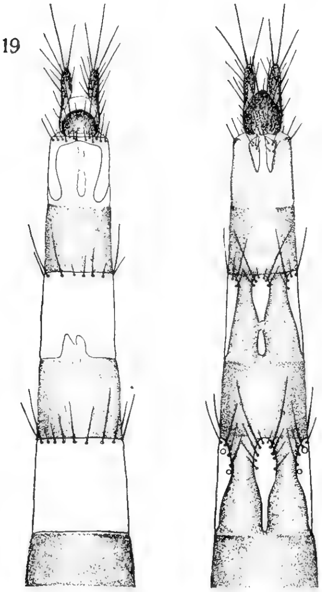

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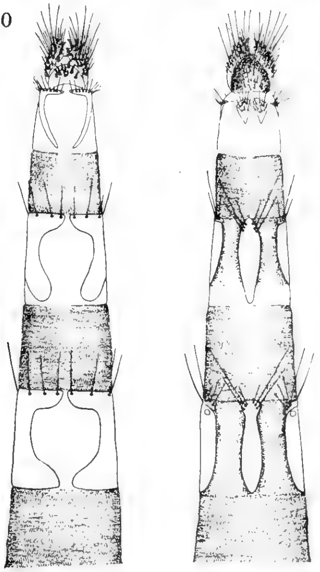

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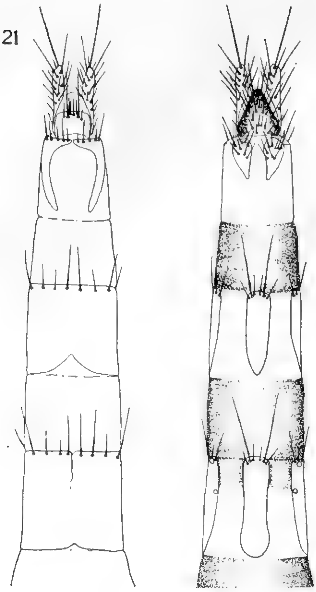

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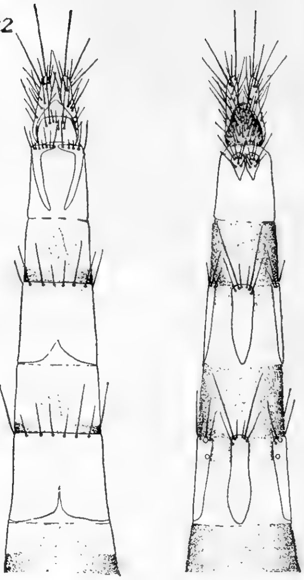

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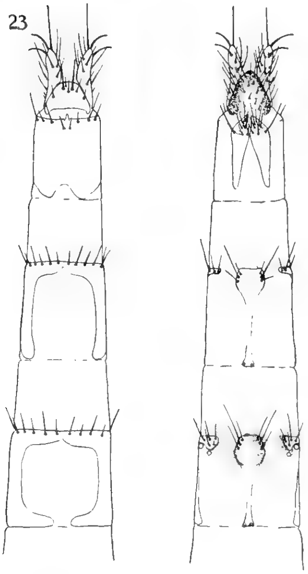

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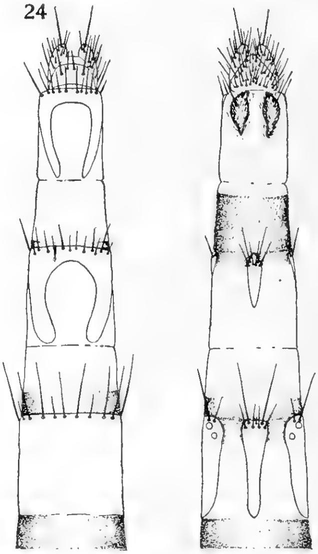

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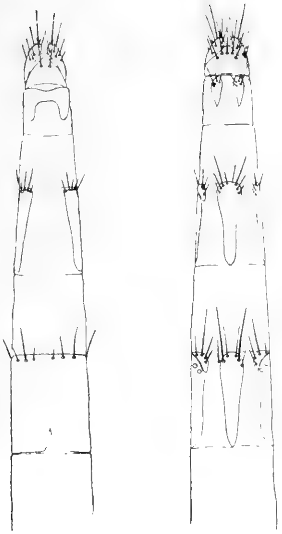

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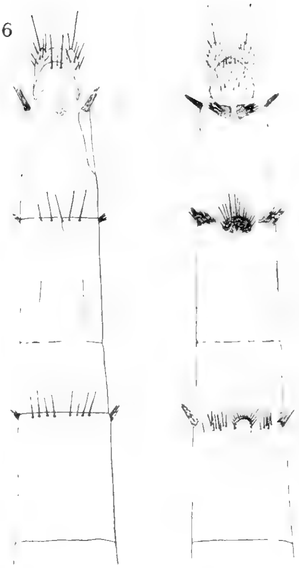

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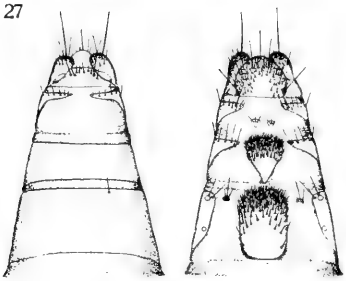

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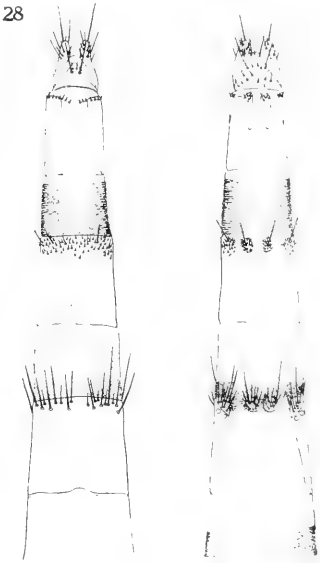

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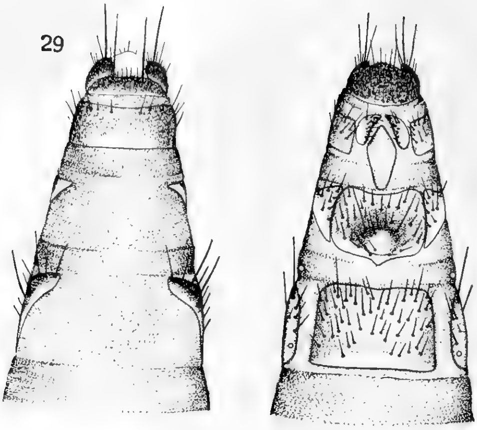

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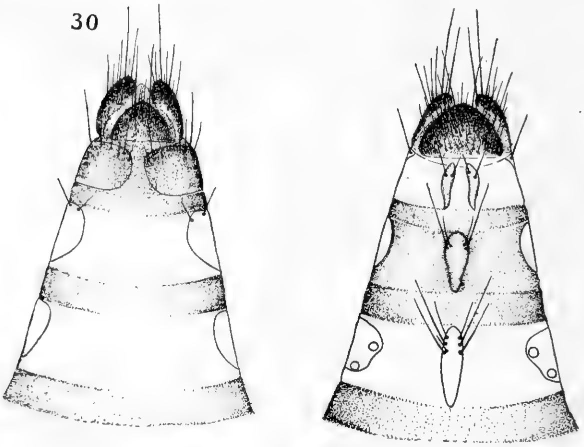

H. C. Huckett

SOME NEW SPECIES OF TEXAS TACHINIDAE (DIPTERA)

By H. J. Reinhard,
Entomologist, Texas Experiment Station, College Station, Texas.

This paper includes the descriptions of six new species of Tachinidæ. Most of these were collected in the vicinity of College Station. The accompanying drawings were prepared by the writer to supplement the descriptions and assist in the recognition of the proposed new species. All type specimens are for the time being retained in the writer's collection. Grateful acknowledgment is here made to Dr. Herbert Osborn for helpful suggestions and to W. R. Walton for supplying important references.

Ernestia frioensis n. sp.

Male.—General color gray. Eyes distinctly hairy. Head slightly broader than thorax, diameter at the vibrissæ nearly as long as at base of antennæ. Front at narrowest point as wide as either eye. Frontal bristles in two rows, descending to the base of third antennal joint; the three posterior bristles in each row robust, and directed posteriorly. Genæ, facial depression and sides of face gray pollinose. The pollen on sides of the front, ocellar triangle, and upper portion of the posterior orbits tinged lightly with yellow. Frontal vitta entire, rather broad, opaque, black. Ocellar bristles robust, directed obliquely forward. Numerous long bristly hairs on ocellar triangle, and on front between the eyes and frontal rows, and extending downward below the lowest frontals to almost the middle of the face. Antennæ nearly as long as the face, first two joints yellow, third joint black, the latter nearly four times as long as second joint. Arista slender, a little longer than third antennal joint, microscopically pubescent, thickened on basal half, penultimate joint not longer than broad. Facial depression rather deep, distinctly carinate; ridges diverging but little below, bristly on lowest one-fourth. Sides of face on lower half bare, at narrowest point one-half as wide as the facial depression.* Vibrissæ inserted on a level with front border of oral margin. Proboscis short and fleshy; labella large. Palpi rather long, but little thickened distally, yellow. Cheeks covered on lower two-thirds with bristly hairs, one-half as broad as

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* According to Coquillett's key—Rev. of Tach. p. 36, the genus *Ernestia* (Panzeria) is characterized by having the sides of the face at the narrowest part, less than one-third as wide as the median depression. A series of specimens of *Ernestia radicum* Fabr. from Ohio, New Mexico, and Kansas, all show the width of face one-third or more, as wide as the facial depression.

eye-height. Thorax gray pollinose marked with five black vittæ, the median one narrow in front of suture. Four postsutural and three sternopleural macrochaetæ. Scutellum pollinose like thorax, yellow at apex, bearing three pairs of long marginal macrochaetæ and a shorter cruciate apical pair. Abdomen conical, gray pollinose on last three segments, with dark reflecting spots on dorsum, sides of second segment faintly yellow. First segment black, with a pair of weak dorsal and lateral marginal bristles. These bristles on the second segment are more robust, and it also bears a pair of discals. Third segment with a pair of discals and a marginal row, the fourth with a row of both discals and marginals. Wings hyaline, veins yellowish. First posterior cell open, terminating far before extreme wing tip. Third vein with two to four bristles at base. Fourth vein arcuate beyond bend, not appendiculate. Calypteres white. Legs black, knees yellowish. Middle tibia with a single stout bristle on front side near the middle, hind tibia subciliate. Front pulvilli nearly as long as last two tarsal joints.

Habitat.—Frio County, Texas. Described from two male specimens collected by the author May 4, 1920, from the blossoms of *Acacia berlandieri*, Benth.

In general appearance this fly is not so robust and more densely pollinose than *E. radicum* Fabr. It is separable from that species by the narrower and much longer third antennal segment. The front tarsi of the female is not dilated, and the last abdominal segment is black. It differs from Coquillett's *penitalis* by having yellow palpi, three pairs of long marginal scutellar macrochaetæ and four postsuturals.

Pseudochaeta antennalis n. sp.

Length 7 mm. Eyes sparsely hairy. Genæ, facial depression, sides of face, front, and posterior orbits silvery white pollinose. Front at vertex as wide as either eye, vitta entire, narrow, widening slightly at the base of antennæ, opaque, velvety-black. Two pairs of orbital bristles, ocellars absent, one posteriorly directed bristle on each side of front outside of frontal row, situated about midway between the lower ocellus and the posterior pair of orbital bristles; post ocellars well developed. Frontals in two rows, descending to base of third antennal segment; front, including ocellar triangle, with many long erect hairs. Antennæ five-sixths as long as face, third joint twice the length of second, black, except first joint, apex of second and base of third, which are yellowish. Arista long, slender, thickened on basal half, penultimate joint as broad as long. Facial depression large and rather flat; ridges strongly diverging downward, bristly on lowest one-fifth. Sides of face narrow and bare. Cheeks slightly over one-fifth the eye-height, with a row of robust macrochaetæ along oral margin, and numerous long hairs. Vibrissæ inserted on a level with the front edge of the oral margin. Proboscis short and fleshy, labella large. Palpi yellow. Thorax with five black vittæ on the dorsum, gray pollinose.

Four postsutural and four sternopleural macrochaetæ. Scutellum concolorous with thorax, bearing four pairs of long marginal macrochaetæ, the posterior pair reaching base of the third abdominal segment, also a shorter apical and discal pair, directed almost horizontally backward, the former is cruciate. Abdomen gray pollinose on bases of last three segments, narrow apical borders shining black, first segment black, subshining, with no macrochaetæ, sides of segments two and three faintly yellow, second with a pair of dorsal and lateral marginal macrochaetæ, third with a marginal row, fourth with an irregular row of discals and a row of marginals. Wings hyaline. Third vein with a single bristle at the base. First posterior cell widely open, terminating far before wing tip. Bend of fourth vein decidedly angulated, forming a right angle for some distance before it bends posteriorly, destitute of an appendage. Calypteres white. Legs black, middle tibia with three bristles on front side near the middle, hind tibia evenly ciliate outwardly.

Habitat.—College Station, Texas. Described from two female specimens collected by the author October 6, 1917, and September 18, 1920.

This fly is very closely allied to Coquillett's species *pyralidis* but differs from the description of that form as follows: Third antennal joint twice the length of second; facial ridges bristly on lowest one-fifth. Scutellum with four pairs of long marginal macrochaetæ. Cheeks equal one-fifth the eye-height. The four sternopleural macrochaetæ will serve to separate it from *P. argentifrons* Coq.

Exorista loxostegeæ n. sp.

Length 4.5 to 6 mm., rather compact, black, thorax and abdomen gray pollinose, sub-shining.

Female.—Head slightly wider than thorax. Front at vertex as wide as either eye; sides cinereous pollinose, vitta one-third width of front, black, opaque; two pairs of orbital bristles, ocellars present, directed obliquely forward; frontal bristles in two rows, descending slightly below base of arista. Antennæ almost as long as face, second joint fuscous, one-fifth the length of third joint, the latter black, covered lightly with gray pubescence; arista microscopically pubescent, thickened on basal half, penultimate joint as broad as long. Facial depression, sides of face, and cheeks cinereous pollinose on a fuscous ground. Facial ridges bristly on little less than lower half; vibrissæ situated on level with front border of oral margin. Palpi black, sometimes yellowish at tips, proboscis short, fleshy, labella large, yellow. Eyes distinctly hairy. Dorsum of thorax with five black vittæ, the inner pair ending midway between the suture and base of scutellum, the median vitta linear in front of suture, almost as wide as outer pair post-suturally. Four postsuturals. Sternopleural macrochaetæ variable, usually four, sometimes with five or six on either side. Scutellum black, sometimes faintly yellow on apex, three pairs of marginal macrochaetæ, an apical pair directed almost vertically, and a pair of discals directed posteriorly. Abdomen short, ovate, first segment black, sub-shining, second segment sometimes with brown spot on sides. All segments except the first with discal macrochaetæ, pollinose at base, and dark reflecting spots on the dorsum. Wings hyaline, faintly yellow at base, all veins yellowish. Third vein with one to three bristles at the base. First posterior cell open, ending well before wing tip. Legs black, middle tibia bearing a single stout macrochaeta on the front side near the middle. Hind tibia ciliate.

Male.—Similar to female, differing as follows: Front slightly narrower, no orbital bristles, facial ridges usually bristly on at least the lower half, third joint of antennæ seven times length of second. Front pulvilli as long as last tarsal joint.

Habitat.—College Station, Texas. Described from 10 female and 14 male specimens, reared from *Loxostege similalis* Gn., by the author, June, 1920.

This species is readily referable to the genus *Exorista*. According to Coquillett's table—Revis. Tachinid, p. 92—it runs out under caption 2, where no provision is made for forms with four or more macochaetæ. In general appearance it somewhat resembles *futilis* O. S., but differs essentially from this and its other congeners by the presence of discal macrochaetæ and four sternopleurals.

Houghia baccharis n. sp.

Female.—Black, gray pollinose. Front at vertex one and one-fourth times as wide as either eye, white pollinose, frontal bristles in two rows, descending to the base of the third antennal joint, two pairs of orbital bristles, vertical and ocellar bristles robust, the latter directed obliquely forward. Frontal vitta rather narrow, opaque, dark-brown, extending from base of antennæ to ocelli where it is divided and extends on either side to the vertex. Facial depression shallow and large, not carinate, white pollinose. Antennæ as long as face, first two joints and base of third yellow, third joint nearly four times as long as second; arista black, microscopically pubescent, thickened on basal half, penultimate joint twice as long as wide. Sides of the face bare, narrow, concolorous with facial depression; facial ridges diverging below, with a few bristles above the vibrissæ. The latter on a level with oral margin, the front border of which is projecting; proboscis ridged, shining, black, labella fleshy, yellow; palpi normal, yellow, with only a few short bristles. Cheeks white pollinose, with short bristles and stout macrochaetæ, along oral margin; width about one-fifth the eye-height. Eyes bare. Thorax gray pollinose, marked with four narrow black vittæ on dorsal surface, the outer pair widening in front of suture. Four postsutural and four sternopleural macrochaetæ. Scutellum black, yellow at the apex, gray pollinose except along the base; three pairs of robust marginal macrochaetæ and a smaller apical pair; dorsal surface covered with short erect spines; abdomen somewhat conical, convex on dorsal surface, first segment black, sides yellowish, second and third white pollinose on basal half, shining apically, sides tinged with bronze; second segment with a pair of dorsal and lateral marginal bristles, third with a row of marginals; fourth segment white pollinose on base, on apical half shining reddish-yellow, a row of discal macrochaetæ and thickly covered with short spines on the apex. Wings hyaline, slightly yellowish at base, first vein with stout bristles near the base, bare on the apical three-fourths, second vein bristly nearly to small crossvein. First posterior cell widely open, terminating before the extreme wing tip. Calypteres white. Legs black, bristly, hind tibia not ciliate, middle tibia with three or four bristles on the front side near the middle. Length 7 mm.

Habitat.—College Station, Texas. Described from a single female specimen collected by the author July 7, 1919, on the blossoms of *Baccharis halimifolia* L.

This species agrees well with Coquillett's description of *H. setipennis*. It differs from that species, which is the genotype, as follows: Proboscis more elongate and slender; last abdominal segment rufous; four sternopleural macrochaetæ; and the middle tibia with three or four macrochaetæ on the front side near the middle.

Blepharipeza pollinosa n. sp.

Length 6 mm. Black, gray pollinose. Head wider than thorax.

Female.—Eyes with minute sparse hairs. Sides of front, upper portion of posterior orbits, and ocellar triangle golden pollinose. Front at vertex one and one-fourth times as wide as either eye, vitta about one-third width of front, opaque, reddish-brown. Two pairs of orbital bristles, ocellars directed obliquely forward. Frontal bristles in two rows extending from the vertex to base of third antennal segment, several stout bristles and more numerous shorter erect hairs between frontal row and eye. Antennæ five-sixths the length of face, third joint four times as long as second, black, second yellow at apex, first fuscous. Arista moderately long, microscopically pubescent, thickened on basal three-fourths, penultimate joint not longer than wide. Facial depression, cheeks, and sides of face fuscous, white pollinose; the latter with a few short bristles in the middle, at narrowest point less than one-third the width of facial depression; ridges strongly diverging below with three or four bristles above vibrissæ, which are inserted on a level with the oral margin. Proboscis fleshy, short, labella large, yellowish; palpi normal, yellow. Cheeks moderately bristly, one-fifth as wide as the eye-height. Thorax gray pollinose, with four black vittæ on dorsum, the outer pair interrupted at the suture forming a triangular spot in front. Three postsutural and three sternopleural macrochaetæ. Scutellum black, gray pollinose, with three pairs of long marginal, and a shorter cruciate apical pair of macrochaetæ. Abdomen short, ovate, all except first segment entirely gray pollinose, with dark reflecting spots on dorsum; thickly covered with suberect spines. First and second segments with a pair of dorsal and lateral marginal macrochaetæ, third with a marginal row, fourth segment covered with irregular rows of macrochaetæ. Wings hyaline. Costal spine minute. Third vein with two bristles at base. First posterior cell narrowly open, ending shortly before wing tip. Fourth vein beyond bend nearly straight, without a stump or fold. Hind crossvein nearly straight, the posterior end at less than one-third the distance from bend to small crossvein. Calypteres white, bordered with faint yellow. Legs black, hind tibia evenly ciliate outwardly, middle tibia with a single stout macrochaeta on the front side near the middle.

Male.—Differs from female as follows: Front narrower, at vertex as wide as either eye, no orbital bristles, front pulvilli as long as the tarsal joint, hind crossvein S shaped and posterior end at one-third the distance from bend to small crossvein.

Habitat.—College Station, Texas. Described from one female specimen (the type), collected May 25, 1920, and one male specimen collected June 12, 1919, by the author.

This species runs to *Blepharipeza*, according to Coquillett's key—Revis. Tachinid, p. 35. Superficially it is strikingly unlike any species of this genus which the writer has seen. It is smaller, more densely pollinose, and the bristles of the scutellum and abdomen are weaker and less numerous. In the absence of sufficient comparative material it seems desirable to provisionally place the species in *Blepharipeza*, until reliable characters are obtained which will justify the erection of a new genus for the reception of this species.

Chaetoplagia modesta n. sp.

Female.—Black, silvery pollinose, head obtusely conical. Front at vertex one and one-half times as wide as either eye, white pollinose, two rows of frontal bristles extending almost to base of third antennal segment, directed inward and converging towards base of antennæ; an irregular row of weaker bristles and numerous hairs between the frontal row and eye. Two pairs orbital bristles present; ocellar bristles diverging strongly and directed forward. Facial depression narrow and deep, ridges nearly parallel, with three or four bristles at base above vibrissæ. Antennæ nearly as long as face, black except second joint, which is brownish-yellow, length of third joint about seven times the second; arista short, bare, black, thickened on basal two-thirds, penultimate joint slightly longer than wide. Sides of face silvery white pollinose, with a row of ventrally directed macrochaetæ on each side. The facial bristles begin as short hairs on a level with insertion of the arista, and become more robust and longer towards the lower corner of the eye; numerous short hairs between the facial row and the eye.

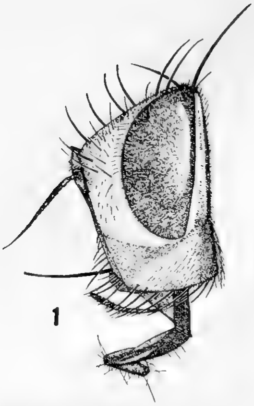
Vibrissæ cruciate, situated on level with oral margin; proboscis moderately long, palpi black. Cheeks white pollinose, covered with black hairs, width about one-seventh the eye-height. Eyes bare. Thorax black, white pollinose, marked with four black vittæ. Three postsutural and two sternopleural macrochaetæ. Scutellum black, white pollinose on apical half, with three pairs of long marginal macrochaetæ. Abdomen ovate, first segment shining black, segments two, three, and four white pollinose on basal three-fourths, distal portions of each shining black. First segment destitute of dorsal or lateral marginal macrochaetæ, fourth with a marginal row of five, no discal macrochaetæ. Wings hyaline, veins yellow, costal spine minute, first vein bristly except at the base and apex, second vein bristly nearly to the small crossvein. First posterior cell open, terminating far before the extreme wing tip. Bend of fourth vein distinctly angulated, bearing a long appendage. Posterior end of hind crossvein nearer bend of the fourth than to small crossvein. Calypteres white, legs black, moderately bristly, hind tibia outwardly ciliate, middle tibia with one bristle on the front side near the middle. Length 7 mm.

Habitat.—College Station, Texas. Described from a single female specimen collected by the author July 19, 1918.

This little fly differs markedly from Coquillett's genotype *atripennis*, which heretofore has been the only representative of this genus reported from our fauna. Coquillett's form is black, almost destitute of pollen, and sub-shining, with clouded or smoky wings. This species is smaller and covered with silvery white pollen. The wings are hyaline. It differs from Tothill's *asiatica*, described from India, Bull. Ent. Resch. Vol. IX, part 1, May, 1918—by the short second aristal segment; two sternopleural macrochaetæ; black palpi; and the bristles on the third longitudinal vein extending hardly to the small crossvein.

EXPLANATION OF PLATE XXVIII.

Fig. 1. Lateral view of head of *Ernestia frioensis.*
Fig. 2. Right wing of *Ernestia frioensis.*
Fig. 3. Lateral view of head of *Pseudochaeta antennalis.*
Fig. 4. Right wing of *Pseudochaeta antennalis.*
Fig. 5. Lateral view of head of *Houghia baccharis.*
Fig. 6. Right wing of *Houghia baccharis.*
Fig. 7. Lateral view of head of *Blepharipeza pollinosa.*
Fig. 8. Right wing of *Blepharipeza pollinosa.*
Fig. 9. Lateral view of head of *Chaetoplagia modesta.*
Fig. 10. Right wing of *Chaetoplagia modesta.*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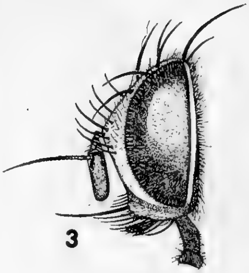
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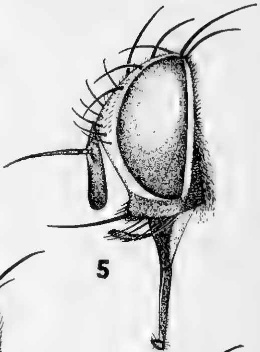
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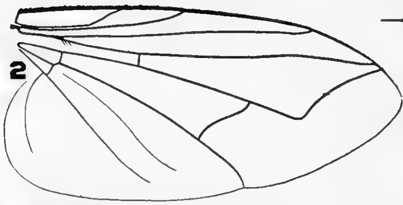
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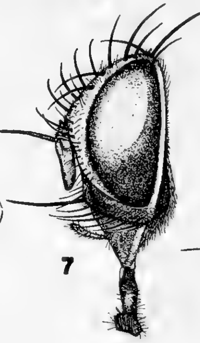
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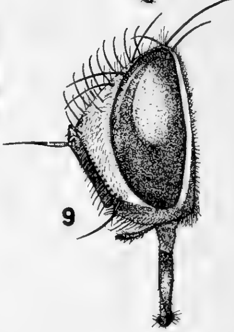
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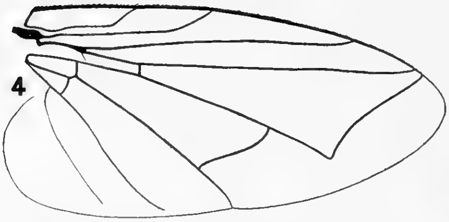
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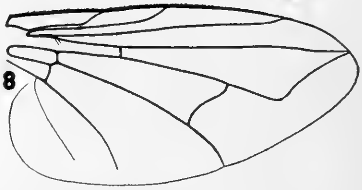
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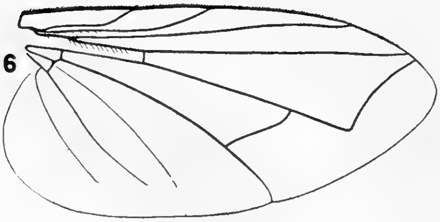
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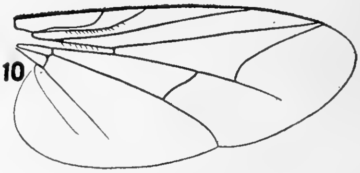
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H. J. Reinhard.

OBSERVATIONS ON THE STRUCTURE OF THE ORACERATUBAE AND SOME NEW LEPIDOSAPHINE SCALES (HEMIPTERA)*

By Gladys Hoke,
Como, Mississippi.

An oraceratuba is the opening of a ceratuba to the exterior. So far as I have been able to ascertain an oraceratuba is regarded as an opening having a diameter approximating the diameter of the ceratuba. The attached end of the ceratuba is usually heavily chitinized in the altaceratubæ, though in the brevaceratubæ an excess of chitinization is seldom present. Attached to the edge of the ceratuba and stretched across the end is a thin membrane with a slit in the center, which may be opened or closed to allow the wax to be extruded or retained in the ceratuba. This opening in the membrane which closes the ceratuba is the oraceratuba. The edge of the membrane around the oraceratuba is slightly chitinized. Figure 1 is an altaceratuba of *Lepidosophes pinnaeformis* with the oraceratuba open. Figure 8 is a large brevaceratuba of *Scobinaspis dentata.* with the oraceratuba closed.

The ceratubæ of the tribes Parlatoriini, Diaspidini and Aspidiotini are closed in the same fashion as those of the Lepidosaphini. It is very probable that the ceratubæ of the Fioriniini and the Leucaspidini are closed by a similar membrane.

The presence of a membrane which closes the attached end of the ceratubæ—hitherto regarded as open—and the presence in the membrane of an aperture which may be opened and closed seems to confirm MacGillivray's suggestion in The Coccidæ that the ceratubæ function as reservoirs for the storage of the wax secreted by the wax-cell which is attached to the end of the bulla, and which is formed into threads as it passes through the aperture.

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* Contributions from the Entomological Laboratories of the University of Illinois, No. 66.

As all Lepidosaphine scales are usually thought of and described as having plates simple or rarely furcate it is interesting to find two species, *Lepidosaphes camelliæ* and *Mytiella sexspina*, with plates which are distinctly pectinate. The plates of the median incisura are pectinate on both the lateral and the mesal edge about midway between the proximal and the distal end. More or less variation is found in the number of the projections on each side and some variation in the length of the projections. Usually the greatest number of projections in sexspina are on the lateral edge while on the mesal edge frequently only one pectination is evident (Fig. 12c). The lamaceratubæ are long and slender. Those opening in the plates of the median and second incisuræ are approximately the same length, while those of the plates of the third incisuræ are slightly longer. The entire plate with its lamaceratuba is illustrated in Figure 12c. Only the proximal portions of the lamaceratuba are shown in Figure 12a and 12b. The pectinate projections of the mesal plates of each second (Fig. 12b) and third incisura (Fig. 12a) are always on the lateral margin of the plate. There are usually three or more distinct dentate projections on the mesal plate of each of the third incisura. The plates of camelliæ are of the same general type as in sexspina, but the mesal edge of the plates of the median incisura usually has the greatest number of projections, while on the lateral edge frequently only one pectination is evident. (Fig. 4).

The first preabdominal segment of dentata bears a number of small plates or bracteæ on each lateral aspect (Fig. 6). These bracteæ vary in shape and a paraceratuba opens at its distal end. These bracteæ with their paraceratubæ are greatly enlarged in Figure 9, which also shows a ceratuba which is usually found associated with the plates, but which opens flush with the surface of the cuticle instead of through a bractea.

The lateral aspects of the preabdominal segment of sexspina bear a number of ceratubæ varying in size. These are shown in Figure 11. Ceratubæ of still smaller size are located on the ventral aspect of the cephalic portion of the head of *Scobinaspis dentata* (Fig. 7). The antennæ, setæ and the tooth-like projections on the ventral aspect of the head are also shown in Figure 7.

The scales described at this time were collected in Mississippi, from the central part of the state to the gulf coast. Each species is found in both sections and it is very probable that they are generally distributed throughout the state. *Mytiella sexspina* also occurs in Florida.

Lepidosaphes camelliæ n. sp. (Figs. 2, 3 and 4).

Scale of Female.—Color pale brown, broadest at posterior end, at broadest portion usually three-eighths as broad as long, straight or curved, usually straight when not crowded; ventral scale white, median portion usually adhering to host-plant.

Scale of Male.—Similar to that of female, though smaller and darker, sides more nearly parallel; exuvia and posterior hinged portion each occupying one-fourth of total length of scale.

Adult Female.—Body usually twice as long as broad, broadest through preabdominal segments; brevaceratubæ numerous along lateral portion of preabdominal segments and along lateral margin of metathorax and caudal portion of lateral margin of mesothorax, extending mesad from margin as far as metaspinacles; mesothoracic spiracerores 0–5, metaspiracerores wanting; lateral margin of last three preabdominal segments with bracteæ, fifth segment with two or occasionally with three, fourth and third with 2 to 5, those of the third usually not well developed.

Pygidium.—Lobes in two pairs, second pair deeply incised; median pair entire, rounded at distal end with slight indication of notch on each edge near proximal end, as broad as long; second pair of lobes with mesal lobelet distinctly longer and broader than lateral; each lobelet entire, rounded at distal end, lateral margins longer than mesal; plates arranged 2–2–2–2–2, those of third incisure longest and largest, those in incisura as long or longer than lobes, those of median incisura latapectinate, with teeth more numerous on mesal margin, median plate of second and third incisuræ unipectinate on lateral margin, median plate of second incisura occasionally appears to be latipectinate, lateral plate of second and third incisuræ swollen at proximal end, apparently never pectinate, plates of second incisura slightly smaller and shorter than those of median incisura, those of lateris never pectinate; genacerores 3–6(6–11)4–9, mesogenarerores arranged in a single row, pregenacerores usually 7–8 and often in two rows, postgenacerores usually 7–8 and generally arranged in a compact group more or less circular in outline rather than in rows; altaceratubae arranged 1–2–2–1, a small ceratuba, one-half to three-fourths as large as altaceratubæ, cephalad of lobelets of second pair of lobes; brevaceratubæ arranged in three rows, those of third row usually consisting of four equidistant oraceratubæ, occasionally apparently arranged in two groups of two each, rarely only three in third row, cephalic one usually cephalad of caudal margin of pregenacerores, two median mesad of postgenacerores, fourth and fifth rows arranged in two groups, lateral group 1–2, mesal group 1–4, or 0–4 in fourth row; anus usually thirteen times its own width from distal end of lobes; vulva between postgenacerores; incisuræ slight, median usually wider than width of a median lobe.

Host.—*Camellia japonica;* Mississippi; Big Point, June 29, 1917, (R. L. Eberhard); June 25, 1918, (J. C. Roberts); Laurel Hill, October 19, 1918, (J. S. McGhee); Magnolia, September 1, 1920, (Mrs. W. M. Lampton); Moss Point, December 27, 1918, (Mrs. G. B. Bowen); South Pascagoula, January 1921, (R. P. Barnhart, E. K. Bynum); Woodville, 1920, (J. C. Hamilton).

These insects apparently seek the protection of the under surface of the leaves, though frequently they are very numerous on the upper surface.

Lepidosaphes camelliæ differs from *euryæ* in having the plates of the third incisuræ well developed, never smaller than the other plates and usually much longer and larger.

Scobinaspis dentata n. sp. (Figs. 5, 6, 7, 8, 9).

Scale of Female.—Color dull white, with yellowish-green tinge, long, four to eight times as long as broad; second exuvia often occupying one-half of entire length of scale.

Scale of Male.—Similar to that of female, but shorter and broader in proportion.

Adult Female.—Body long, usually four times as long as broad, in living specimens portion of body caudad of rostrum almost cylindrical, ventral surface slightly flattened, portion of body cephalad of rostrum thinner, due to a deep concavity on ventral surface; single row of small tooth-like projections on the ventral surface between antennæ and cephalic margin of head, and a heavily chitinized thorn-like projection on each lateral margin between antenna and tentorium, rarely more than one; antennæ with two large setæ and a small one, large setæ sometimes branched; rostrum and rostralis dark; margin of pygidium dark; mesospiracerores 1–2; preabdominal segments and lateral portion of metathorax with numerous brevaceratubæ, lateral margins of preabdominal segments with bracteæ, segments five and four usually with two each, segment three with 3–4, and segment two with several small incompletely developed bracteæ.

Pygidium.—Lobes in two pairs, with second pair deeply incised; median lobes large, as broad as long, distal half subtriangular distal end bluntly rounded, margins slightly crenulate; second pair of lobes consisting of two distinct slender lobelets, mesal longer and wider, both lobelets together narrower than a median lobe, each lobelet with slight notch on lateral margin; plates arranged 2–1–1–1–1, apparently never pectinate; genacerores 2–4(6–8) 4–5; altaceratubæ arranged 1–2–2–1, very short and broad, almost as broad as long, opening in latadentes, those of second incisuræ largest; brevaceratubæ numerous, three large ones just cephalad of median and second incisuræ approximating size of altaceratubæ, laterals two or three times their own length from margin, median nearer margin, small brevaceratubæ apparently not arranged in distinct rows; anus usually not over eight times its own width from distal end of lobes; vulva between postgenacerores; incisuræ slight, second almost as wide as median.

Host.—Maple (Acer), leaves; Vicksburg, Mississippi, April 1920, (Luther Brown); black haw (*Bumelia lanuginosa*), leaves, Cat Island, off gulfcoast, Mississippi, September 8, 1920, (R. P. Barnhart).

The scales are usually found along the sides of the veins or in the depressions at the forks of the veins, especially near the petiole of the leaf.

The striking differences between this scale and *Scobinaspis serrifrons* is the greater proportional length of the scale, which is white in contrast to the shorter reddish-brown scale of *serrifrons;* and the same difference in the length of the body which has only a few dentate projections on the ventral surface of the head and with no projections on the cephalic margin.

Mytiella sexspina n. sp. (Figs. 10, 11, 12, 13).

Scale of Female.—Color brown, long, length usually more than four times breadth; straight or curved, according to crowded conditions of specimens, ventral scale white, very prominent along sides of scale but retracted a short distance within margin, adhering to dorsal scale when insect is removed from plant, if many eggs have been deposited, usually divided, otherwise generally intact on meson.

Scale of Male.—Similar to that of female, but only about one-half as long.

Adult Female.—Body usually three and one-half times as long as broad, with a distinct constriction between mesothorax and metathorax and between metathorax and abdomen; five distinct preabdominal segments; mesothorax, metathorax and first abdominal segment more heavily chitinized than remaining segments; coria of thorax and preabdomen distinct and not heavily chitinized; brevaceratubæ numerous, on lateral margins extend mesad on ventral aspect along unacoria; mesothoracic spiracerores 2–4, metaspiracerores wanting; cephalic end of each lateral margin of each of last three preabdominal segments with a small heavily chitinized thorn or tooth-like projection; fifth preabdominal segment with two bracteæ, occasionally three, fourth with two, and third with three or four short, stout ones, these latter may be wanting.

Pygidium.—Lobes in two pairs, second pair deeply incised, median pair of lobes rounded at distal end, mesal margin with two slight notches, lateral margin apparently always with a single notch, second pair of lobes with mesal lobelet about twice as wide as lateral lobelet and longer with slight notch on each side, lateral lobelet entire, rounded at distal end; plates arranged 2–2–2–2–2, plates of median incisuræ with short dentate projections on each side, usually located near middle of their length, plates of second incisuræ with similar short dentate projections on lateral margin only, median plate of third incisuræ with similar dentate projections, lateral plate without projections, plates of lateris without projections; genacerores 2–6 (4–9) 4–6; altaceratubæ arranged 1–2–2–1, at least three times as long as broad, brevaceratubæ not more than twice as long as broad, in three rows, those of third row consisting of one group of 3–5, fourth row divided into two groups, with three or four in lateral group and usually about six in mesal, fifth consisting of two widely separated groups of about three each; anus small, about eighteen times its own width from distal end of lobes, near a line drawn through lateral angles of fourth preabdominal segment; vulva always nearer anus than distal end of lobes, usually on a line drawn through caudal end of third row of brevaceratubæ; incisuræ slight, almost filled by plates, an incisura-like indentation cephalad of second pair of lobes; setæ arranged as shown in Figure.

Host.—Citrus, leaves and twigs; Logtown, Mississippi, August 22, 1916, (E. C. Lindsey); Satsuma oranges, Fort Pierce, Florida, January 7, 1920; (the writer); *Euonymus japonica*, leaves and twigs; Laurel, Mississippi, August, 1920, (H. L. Dozier, L. E. Miles, R. C. Price, J. V. Vernon); Yazoo City, Mississippi, February, 1921, (R. N. Lobdell, G. D. Dorroh).

Mytiella sexspina differs from *carinata* in having a thorn-like projection on the cephalic end of each lateral margin of the last three preabdominal segments and in having two well developed plates in each second incisura.

EXPLANATION OF PLATE XXIX.

Lepidosaphes pinnaeformis Bouche.

1. Altaceratuba with oraceratuba open.

Lepidosaphes camelliæ n. sp.

2. Body of adult female.
3. Pygidium of adult female.
4. Sinistral plate of median incisura.

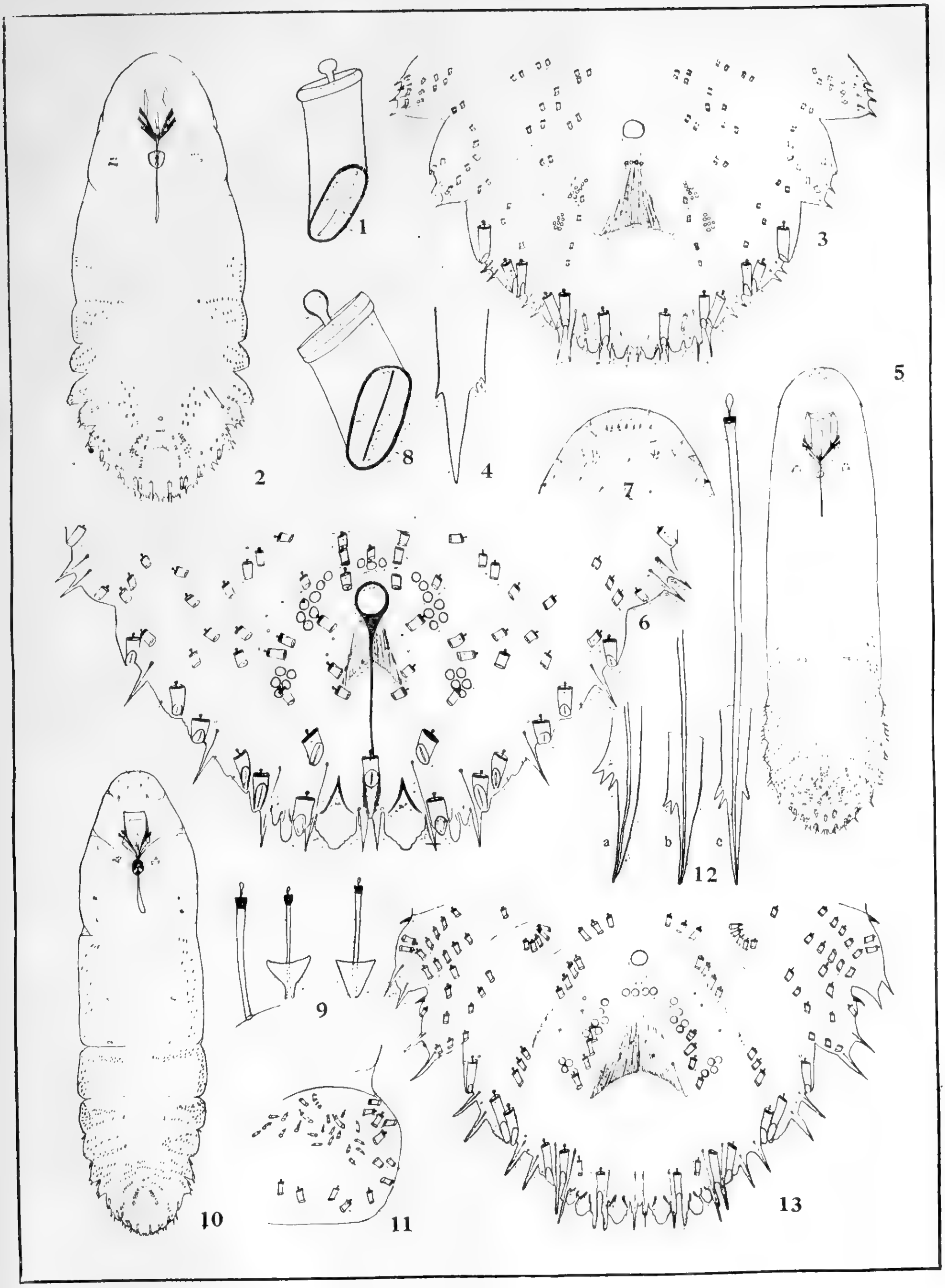
Scobinaspis dentata n. sp.

5. Body of adult female.
6. Pygidium of adult female.
7. Ventral aspect of cephalic portion of head, with dentate projections.
8. Large brevaceratuba with oraceratuba closed.
9. Ceratuba and paraceratuba from lateral portion of first preabdominal segment.

Mytiella sexspina n. sp.

10. Body of adult female.
11. CeratubZ from lateral edge of second preabdominal segment.

12a. Mesal plate of third incisura.
12b. Mesal plate of second incisura.
12c. Sinistral plate of median incisura.
13. Pygidium of adult female.



Gladys Hoke.

THE SMALL PRIMARIES OF LEPIDOPTEROUS LARVAE.

Wm. T. M. Forbes.

Attention has been called in the June number of the Annals to certain minute setæ which occur in all the known Lepidopterous larvæ, but which are inconspicuous save in a few cases, and have not been used in purely systematic work. The following references to papers where they are mentioned and figured may be of use. They appear to be strangely fated, having received no less than four different nomenclatures, besides a fifth which was never published, and so may be ignored.

I believe they were discovered by Charles B. Simpson, working in the Entomological Laboratory of Cornell University, and are described and figured in his manuscript thesis deposited here in 1899. His work called my attention to them, and I designated them by numbers similar to those assigned by Dyar to the larger setæ, in my dissertation published in the Annals in 1910. They are mentioned there only incidentally as they proved of no apparent taxonomic value. Fracker mentions and figures them in his thesis (Illinois Biological Monographs, Vol. 2, No. 1, p. 33, etc.) giving them new designations. Tsou (Trans. Am. Micr. Soc. 33, 223, 1914) discusses the thorax subdorsal group in detail; and I again mention and figure the setæ in Hepialus (Journ. N. Y. Ent. Soc. 24, 137-142, 1916). Finally actual priority of publication appears to belong to Quail and Bacot in *Notes on Cossidæ*, with its appended footnote, published in the *Entomologist*, Vol. 37, p. 93, in 1904; where they are mentioned and figured, though not given a name. There are certainly other references, but only these are now at hand.

The names which these setæ have received may be tabulated as follows:

	Thorax.					Abdomen			Thorax and Abdomen
Forbes.......	xa	xb	xc	xd	(1)	(2)	x	iiia	ix
Fracker......	gam'a	do	do	do	tau	—	gam'a	epsi'n	omega
Tsou.........	A1a	A1b	A2a	A2b	P1	—	A1	A2	P4
Garman......	A	B	D	E	F	C	B	iiia	G

NOTES.

(1) I seem to have overlooked this seta.

(2) This seta is not generally present, though apparently a regular feature of the Cossidæ; I omitted it from discussion, regarding it as a subprimary.

Postscript—Professor Comstock has called my attention to two recent papers by A. Schierbeek (Proc. Koninkl. Akad. v. Wetensch te Amsterdam 19, 1, 1916; and Onderzoekinzen verricht in het zool. Lab. der Rijksuniv. Groningen, VI, 1917). His account is confused, but ix and Fracker's *tau* (propedalis), and iiia (prostigmalis) are identifiable.

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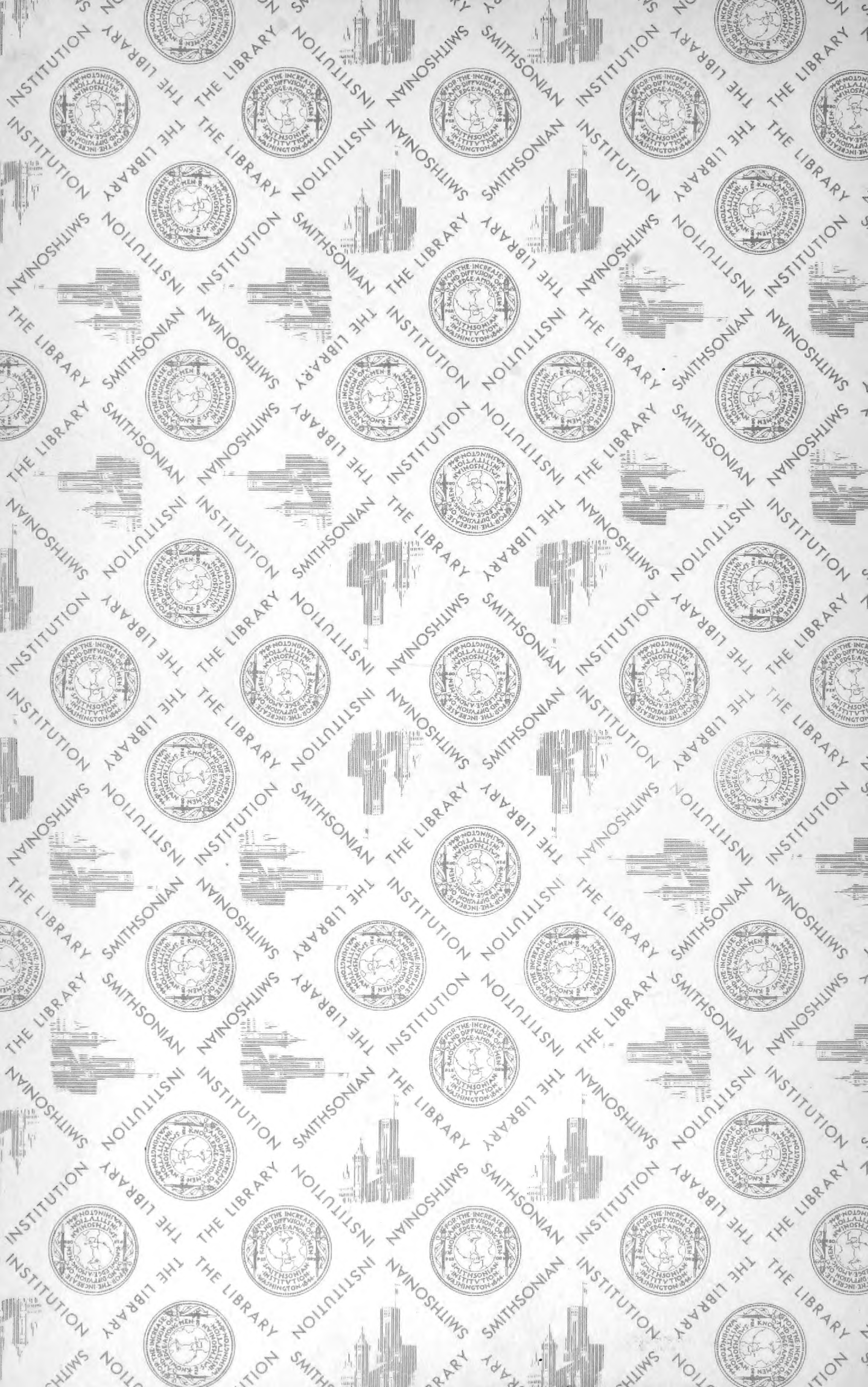
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