CHAPTER 1.

THE IMAGO.

A. External Morphology.

It has been thought better to deal with the external characters of the imagines of one family in some detail, rather than to attempt a general and less complete study of all. The family Hemerobiidæ has been selected for this purpose mainly for two reasons : firstly, because it includes approximately half of the British species and genera of Neuroptera ; secondly, because the sclerites are for the most part well chitinized and pigmented and consequently, except in one or two regions, well defined. This account will, however, be followed by brief summaries of the more interesting features, with particular reference to the venation and genitalia, of the remaining four families.*

HEMEROBIIDÆ.

THE HEAD (Figs. 2–6).

Normally, at rest, the head is held with the face inclined steeply downwards. From above, in this position, it appears transverse, the large hemispherical

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* Reference should also be made to the following papers :

Morse (1931) has given a very complete study of the Chrysopidæ, based on *Chrysopa perla* (Linn.). This paper differs mainly from the account given here in the interpretation of the terminal abdominal segments and omits an account of the genital armature.

Tjeder (1931*a*, 1931*b*) has written two valuable papers on the abdominal structures of the Hemerobiidæ (genus *Boriomyia*) and Coniopterygidæ (genus *Coniopteryx*).

Stitz (1931) has given an account of many features of the external morphology of all the families occurring in Germany. His interpretation of the terminal abdominal structures differs in certain respects from that given in the present work, while the sclerites of the thorax have not been dealt with in detail.

Other papers dealing with particular structures will be found in the bibliography given at the end of Volume II.

compound eyes widely separated and occupying the sides of the head. Viewed from in front it is broadly ovate, the greatest width (including the compound eyes)
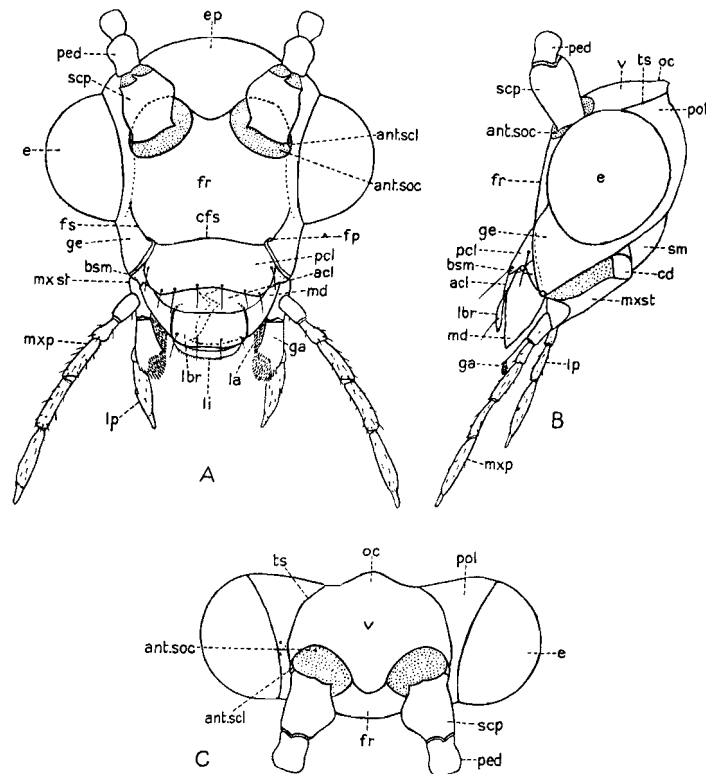

Fig. 2.—*Wesmaelius quadrifasciatus* (Reut.), ♀. A. Head viewed from front. B. Head viewed from side. C. Head viewed from above. *acl*, anteclypeus; *ant. scl*, antennary sclerite; *ant. soc*, antennary socket; *bsm*, basimandibula; *cd*, cardo; *cfs*, clypeo-frontal suture; *e*, eye; *ep*, epicranium; *fp*, frontal pit; *fr*, frons; *fs*, frontal suture; *ga*, galea; *ge*, gena; *la*, lacinia; *lbr*, labrum; *li*, ligula; *lp*, labial palpus; *md*, mandible; *mxp*, maxillary palpus; *mxst*, maxillary stipes; *oc*, occiput; *pcl*, postclypeus; *ped*, pedicel; *pol*, postocular lobe; *scp*, scape; *sm*, submentum; *ts*, temporal suture; *v*, vertex.

approximately equal to the length. From a lateral aspect it is seen to be somewhat flattened and wedge-shaped, widest towards the base between the epicranium and the gular region, and from thence it

tapers towards the apex of the mandibles. No secondary sexual characters have been found on the head in this family.

The epicranium (ep) has the vertex arched dorsally, and is not divided longitudinally by a median epicranial suture. The large median epicranial plate is separated on either side from a postocular lobe by temporal sutures (ts), which extend backwards from the margin of the antennary sockets, whilst a V-shaped suture connects the inner margins of the antennary sockets. This latter suture may possibly not be part of the true frontal suture, but may be of a secondary nature, in which case the upper part of the face is to be regarded

Fig. 3.—A. *Wesmaelius quadrifasciatus* (Reut.), ♀, labrum.
B. *Sympherobius fuscescens* (Wallengr.), ♀, labrum.

as the antefrons, whilst the portion of the head capsule behind the suture would then be the fused postfrons and vertex.

The frons (fr) occupies the upper half of the face, and is separated laterally from the genæ (ge) by the frontal sutures (fs) and anteriorly from the clypeus by the clypeo-frontal suture (cfs). Frontal pits (fp) are plainly visible at the anterior ends of the frontal sutures.

The clypeus is a well-developed transverse plate occupying the greater portion of the lower half of the face. It is divided into a large, strongly chitinized and pigmented postclypeus (pcl) and a narrow, smaller, transparent membranous anteclypeus (acl). The postclypeus is emarginate anteriorly and bears a transverse row of about six long setæ, which project forwards over the labrum. Laterally the postclypeus carries a condyle-like process, which fits into a socket (ginglymus) in the mandible.

On either side of the clypeus, behind the base of each mandible, is a small sclerite, the basimandibula (bsm).

The labrum (lbr, and Fig. 3) is a transverse sclerite, considerably narrower than the clypeus, the width approximately twice as great as the length. The lateral margins are rounded and strongly chitinized, and are produced posteriorly below the anteclypeus. The anterior margin is fringed with minute hairs, is often narrowly membranous, and may be more or less straight, slightly rounded, or slightly emarginate. In
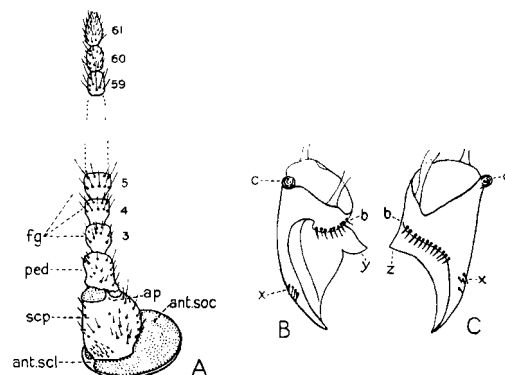

Fig. 4.—A. *Wesmaelius quadrifasciatus* (Reut.), ♀, antenna. B. *Boriomyia betulina* (Strøm), ♀, left mandible. C. Right mandible of same. *ant. scl*, antennary sclerite; *ant. soc*, antennary socket; *ap*, articulatory process; *b*, brustia; *c*, condyle; *fg*, flagellum; *ped*, pedicel; *scp*, scape; *x*, bristles; *y* and *z*, inner teeth; 3–61, segments of flagellum.

Sympherobius the chitinized part of the labrum is deeply excavate anteriorly (Fig. 3B). The upper surface carries a number of scattered hairs of varying lengths, and about half-way between the posterior and anterior margins a transverse row of four or more long, forwardly projecting setæ. In some genera the smaller setæ are arranged as a more or less transverse series behind the longer setæ. One or two groups of minute sensory organs are borne on the lower surface.

There is no suture separating the postgena from the gena.

The mandibles (md, and Fig. 4B, C) are well developed

and strongly chitinized structures adapted for cutting and crushing. They are somewhat of a triangular pyramidal form, the outer surfaces convex, the inner concave. The inner margins bear a strong projection, but that of the left mandible (Fig. 4B, y) is much more prominent and tooth-like than that of the right (Fig. 4C, z). Above the base of each of these projections is a row of short stout setæ (b), while more apically, on the outer surface of each mandible, is a small group of fine bristles (x). Apically both mandibles are acute. In
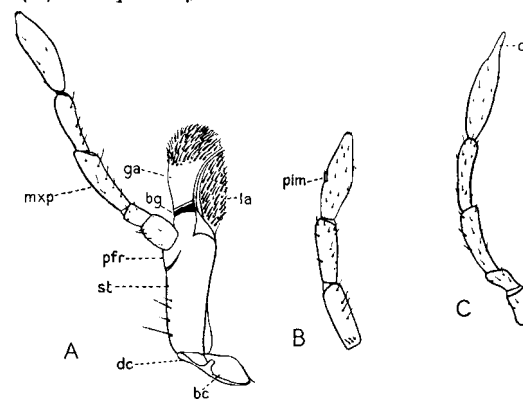

Fig. 5.—A. *Drepanepteryx phalænoides* (Linn.), ♂, maxilla. B. Labial palpus of same. C. *Boriomyia betulina* (Strøm), ♀, maxillary palpus. *bc*, basicardo; *bg*, basigalea; *dc*, disticardo; *ga*, galea; *la*, lacinia; *mxp*, maxillary palpus; *o*, "false apical segment" of maxillary palpus; *pfr*, palpifer; *plm*, palpimacula; *st*, stipes.

addition to the articulatory ginglymus to which reference has already been made, each mandible possesses a prominent condyle (c) which fits into a socket in the margin of the postgena.

Each maxilla (Fig. 5A) consists of cardo, stipes, galea, lacinia and a five-segmented palpus. The cardo is divided into two parts, a basi- (bc) and disticardo (dc), the latter carrying an articulatory condyle. The stipes (st) is a larger elongate plate, at the latero-distal end of which is the palpifer (pfr), bearing the palpus (mxp). The first four segments of the palpus are cylindrical, and of these the basal two are short and subequal in

length. The third and fourth are also subequal, but are much more elongate. The fifth segment is the longest, being from one and a quarter to one and three-quarter times the length of the fourth ; it is fusiform in shape, and in the genera *Megalomus, Hemerobius, Boriomyia, Wesmaelius* and *Sympherobius* has the apical portion rather abruptly tapered and apparently separated off as a small sixth segment (Fig. 5c, o). The separation of this apical portion, however, does not
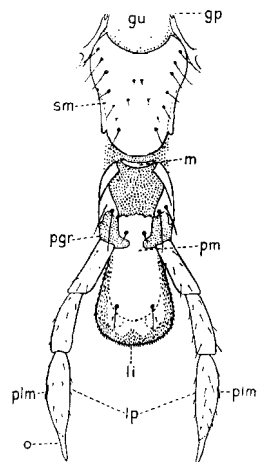

FIG. 6.—*Wesmaelius quadrifasciatus* (Reut.), ♀, labium from below. *gp*, gular pit ; *gu*, gular region ; *li*, ligula ; *lp*, labial palpi ; *m*, mentum ; *o*, "false apical segment" of labial palpus ; *pgr*, palpiger ; *plm*, palpimacula ; *pm*, prementum ; *sm*, submentum.

appear to be complete, and there is no indication of it in *Drepanepteryx* and *Micromus* (Fig. 5A).

The galea (ga) is composed of two parts, a small heavily chitinized basigalea (bg) and a much larger distigalea which is more chitinized basally than elsewhere. The lacinia (la) is likewise divided into a basal and distal portion. The distigalea and distilacinia are densely clothed with stiff hairs.

The labium (Fig. 6) consists of submentum, mentum, prementum and ligula, and carries a pair of three-segmented palpi. The submentum (sm) is by far the

largest plate and bears on its surface a number of setæ. Viewed from below it has the outline of a pear, the anterior portion being the narrowed end ; the basal margin, however, is concave. The lateral margins are curled over dorsally and are rather heavily pigmented. Separated from the anterior margin of the submentum by a membranous area is the mentum (m), which consists of a narrow, transverse median sclerite, and antero-laterad to this is a pair of curved sclerites which probably belongs to the mentum. The prementum (pm) is somewhat variable in form, but usually consists of a median chitinized expanded area between the palpigers (pgr), a considerably constricted part between the bases of the first segment of the palpi and an expanded area again in the large distal lobe of the labium. The ligula (li) is the broad and somewhat membranous portion of the distal lobe surrounding the anterior expansion of the prementum. The distal labial lobe is always broader apically than basally.

The two basal segments of the labial palpi. (lp) are elongate-cylindrical and of approximately equal length. The third segment is the longest, is fusiform in shape, and has on its outer surface a sensory area, which carries a few bristles closely appressed to the surface (plm) ; this sensory area has been called the palpimacula (Crampton, 1921). In those genera in which a slender apical sub-segment is present as part of the fifth segment of the maxillary palpi, a similar subsegment is also present on the third segment of the labial palpi (Fig. 6, o).

The gular region (Fig. 6, gu) is membranous and un-pigmented.

The compound eyes (Fig. 2, e) are large and hemi-spherical, widely separated and placed laterally on either side of the epicranium. They are usually dark in colour with a greenish or copper-coloured reflection. Ocelli are absent in this family.

The antennæ (Fig. 4A) are slender, moniliform, setose appendages arising from large, rounded membranous sockets just internal to the compound eyes. They are

articulated to a single antennary sclerite (ant. scl) projecting from the margin of the sockets on the side nearest the eye. The length of the antennæ varies somewhat : in *Drepanepteryx* it is less than half the length of the forewing, in *Psectra* it is slightly longer than the forewing, whilst in *Boriomyia*, *Hemerobius* *Micromus*, etc., it is more than half, but less than the whole, wing length. The number of segments is also variable and cannot be used for specific determination, as it is not constant in any one species and may even differ in the two appendages of an individual ; in the British genera the number varies from about forty-five in *Psectra* to between sixty and seventy in *Wesmaelius*, etc.

The antennæ are divisible into three regions—the first segment or scape (scp), the second or pedicel (ped), the remainder forming the flagellum (fg). The scape is distinctly larger than the other segments, and is usually somewhat flattened dorso-ventrally and dilated internally. In *Psectra* it is particularly well developed, forming a stout cylindrical segment twice as long as broad. Near the base of the scape is frequently a group of minute setæ, whilst longer setæ are scattered over the surface. There is an apical process (ap) articulating with the pedicel. The pedicel is much smaller and is constricted near the middle. The segments of the flagellum vary slightly in shape at different points, being often more transverse and conical in the basal region, and more elongate and oval towards the apex. The distal segment is elongate-ovate, its apex pointed. The pedicel and flagellum are rather densely clothed with setæ, those of the segments of the flagellum exhibiting a tendency to be arranged in two transverse rows.

THE THORAX (Figs. 7-9).

The thorax consists of three well-defined segments, the prothorax being the smallest and the mesothorax the largest.

The prothorax is joined to the head by a membranous neck, which contains three pairs of cervical sclerites. Of these the two latero-dorsal sclerites (ldc) are small and weakly chitinized, and lie just before the anterior margin of the pronotum. Ventrad of these are two
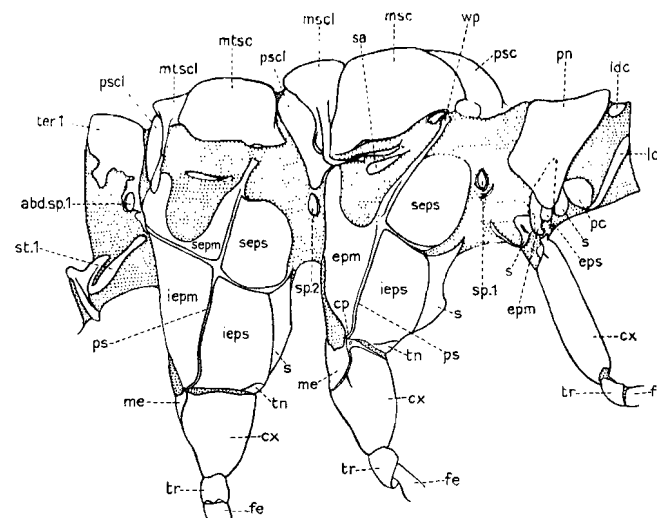

FIG. 7.—*Boriomyia betulina* (Strøm), thorax and first abdominal segment (lateral view ; membranous parts shaded). *abd. sp.* 1, spiracle of first abdominal segment ; *cp*, coxal process ; *cx*, coxa vera ; *epm*, epimeron ; *eps*, episternum ; *fe*, femur ; *iepm*, infra-epimeron ; *ieps*, infra-episternum ; *lc*, latero-cervical sclerite ; *ldc*, latero-dorsal sclerite of cervix ; *me*, meron ; *msc*, mesoscutum ; *mscl*, mesoscutellum ; *mtsc*, metascutum ; *mtscl*, metascutellum ; *pc*, postcervical ; *pn*, pronotum ; *ps*, pleural suture ; *psc*, pre-scutum ; *pscl*, postscutellum ; *s*, sternum ; *sa*, subalare ; *sepm*, supra-epimeron ; *seps*, supra-episternum ; *sp.* 1 and *sp.* 2, thoracic spiracles ; *st.* 1, sternite of first abdominal segment ; *ter.* 1, tergite of same ; *tn*, trochantin ; *tr*, trochanter ; *wp*, pleural wing process.

elongate, strut-like latero-cervical sclerites (lc) which run obliquely forwards and upwards from the region of the lateral lobes of the pronotum and articulate anteriorly with the head. The third pair consists of two post-cervicals (pc) very closely attached to the latero-cervicals and situated partly under the pronotum.

The pronotum (pn) is a fairly large, transverse, and

usually saddle-shaped plate reaching well down the sides and overlapping the post-cervicals and pleurites. In many genera the lateral margins project outwards as a prominent round and convex lobe on each side and these lobes are usually pale in colour and bear many long setæ; in *Drepanepteryx*, however, the lateral margins are not lobed. The dorsal region may have one or more transverse depressions, and the anterior margin is usually raised. In *Psectra* two depressions from either side run to the centre of the notum, dividing it into four raised lobes. The pleurites are reduced and are closely united to form a single plate, the upper
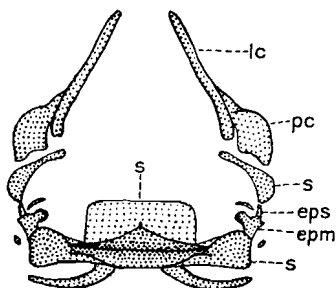

FIG. 8.—*Boriomyia betulina* (Strøm), sclerites of prothorax from below (pronotum and latero-dorsal sclerite of cervix omitted). *epm*, epimeron; *eps*, episternum; *lc*, latero-cervical sclerite; *pc*, postcervical; *s*, sternum.

half of which lies under the lateral lobe of the pronotum; the suture dividing the plate into an episternum and epimeron can, however, be traced, and the epimeron is produced downwards into a rounded process, which articulates with the coxa. Just below the ventral margin of the episternum lies a very small sclerite, which is possibly to be regarded as the trochantin. The sternum (Fig. 7, s; Fig. 8, s) is for the most part membranous. The main chitinized portion lies between the widely spaced coxæ and forms a transverse sclerite, which is very deeply convex below. From it, posteriorly, project two strongly curved divergent struts. Two other sternal plates are situated between the posterior margins of the post-cervicals and the anterior margin

of the episternum, whilst a second very small pair lies just behind the lower portion of the posterior margin of the epimeron.

The mesonotum is divided into four distinct parts: prescutum, scutum, scutellum and postscutellum. These are separated by depressed sutures and the sclerites are dorsally convex, giving a lobed appearance to the tergum. The prescutum (psc) is a fairly large triangular plate divided into two well-defined halves by a longitudinal median suture. The scutum (msc), the largest of the dorsal plates, forms a transverse sclerite much
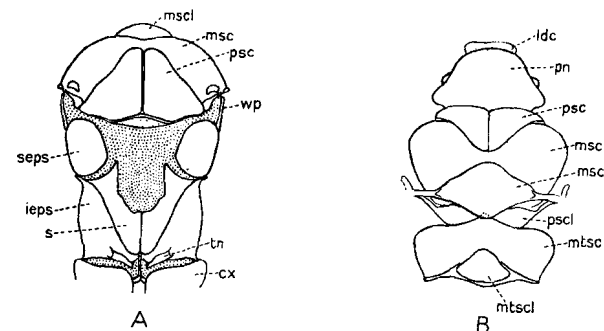

FIG. 9.—*Boriomyia betulina* (Strøm). A. Mesothorax from before (prothorax removed; membranous parts shaded). B. Thorax from above. Lettering as in Fig. 7.

constricted mid-dorsally, and expanded laterally into two rounded convex lobes. The postscutellum (pscl) is a convex and almost vertical plate lying behind the scutellum and shows longitudinal division into two halves. In *Drepanepteryx* the separation of the scutum is complete, and two distinct latero-dorsal lobes are formed. The scutellum (mscl) is an undivided, transverse, somewhat diamond-shaped sclerite.

The pleuron of the mesothorax is a well-chitinized area divided into two main regions, the episternum and epimeron, by a conspicuous pleural suture (ps) running in an almost straight line from the pleural wing process (wp) to the pleural coxal process (cp). The episternum is subdivided into two sclerites, a smaller

rounded supra-episternum (seps) and a larger, more or less rectangular infra-episternum (ieps). Antero-ventrally the latter sclerite carries a small, elongate, closely attached trochantin (tn). The epimeron is a large, elongate plate tapering as it approaches the coxa. The dorsal margin of its upper portion appears to be very broadly and deeply excavated below the wing base due to the fact that this region is largely membranous; only the anterior, lower and posterior parts are well chitinized. In the upper portion of this membranous area lies the largest of the sclerites associated with the wing base, the subalar plate (sa).

The chitinized portion of the mesosternum (Fig. 9A, s) forms a large plate across the lower anterior part of the segment; laterally it is bounded by the anterior margin of the infra-episternum, dorsally by the antero-ventral margin of the supra-episternum. It is divided into left and right halves by a median longitudinal suture, and the dorsal margin is very deeply excavated. Viewed laterally the sternum is seen to project in front of the infra-episternum (Fig. 7, s).

The structure of the metathorax is very similar to that of the mesothorax, and it is necessary to call attention only to the more striking differences. Viewed from above (Fig. 9B) the notum is seen to be composed of two main parts, a large transverse scutum (mtsc) more or less narrowed mid-dorsally and a much smaller, somewhat triangular scutellum (mtscl). The post-scutellum (Fig. 7, pscl) lies almost hidden behind the scutellum. The pleuron shows four distinct large sclerites, the epimeron being separated into a supra- and infra-epimeron (Fig. 7).

There are two pairs of thoracic spiracles. The anterior pair (Fig. 7, sp. 1) belong to the mesothorax and are situated in the membranous region in front of the supra-episternum. The posterior, metathoracic pair (sp. 2) occur in the membrane between the supra-episternum of the metathorax and the supra-epimeron of the mesothorax.

THE LEGS (Fig. 10).

The legs are well developed, the hind pair being longer than the other two pairs, which are more or less equal in length. All are densely clothed with hairs, which are particularly long and outstanding on the fore coxae. The fore coxae are widely separated, while on the meso- and metathoracic segments the coxae are closely approximated and almost touch.
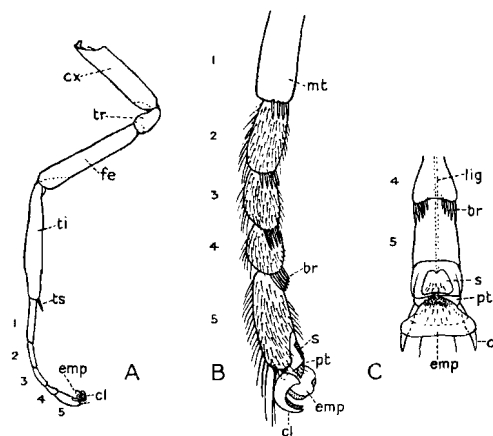

FIG. 10.—A. *Boriomyia betulina* (Strøm), ♀, prothoracic leg (lateral view; hairs omitted). B. *Drepanepteryx phalœnoides* (Linn.), ♂, tarsus of prothoracic leg (lateral view). C. Fourth and fifth segments of same (ventral view). *br*, apical comb of bristles; *cl*, claws; *emp*, empodium; *fe*, femur; *lig*, ligament; *mt*, metatarsus; *pt*, pretarsus; *s*, sole; *tr*, trochanter; *ts*, tibial spur; 1–5, tarsal segments.

The fore coxae (cx) are long, cylindrical and free, the meron being represented by a very small marginal piece at the extreme base. On the meso- and metathoracic legs (Fig. 7) this segment is much stouter, has the form of a truncated cone, is more closely associated with the main body of the thorax, and is clearly divided into a smaller basal meron (me) and a larger anterior coxa vera. The mesothoracic coxae are larger than those of the metathorax. The trochanter of each leg is a short undivided segment (tr).

The femora (fe) are elongate and cylindrical. The tibiæ (ti) are elongate, constricted at each end and usually slightly compressed and broadened about the middle ; the fore and intermediate tibiæ are about as long as the femora of their respective legs, but the posterior tibiæ are much longer, being about one and a half times the length of the femora. All tibiæ carry posterior apical spurs (ts), one on the prothoracic legs, two on each of the others.

The tarsus is divided into five segments, of which the first is the longest, the fourth the shortest. The fifth segment is stout and bears two strongly curved simple claws (cl), and between these, ventrally, is a large, broad, pad-like empodium (emp) furnished with fine short hairs. Above the empodium and between the bases of the claws is a heavily sclerotized triangular structure with excised sides, and in the membrane above this at the apex of the segment are two closely-set long setæ, which project distad over and beyond the empodium and are probably tactile in nature. The pretarsus (pt) consists of two narrow, transverse wedge-shaped sclerites, the widened ends just behind the bases of the claws, the narrowed ends almost meeting mid-ventrally. On the ventral surface basad to the pretarsus is a membranous area in which is embedded a chitinized quadrangular plate, the sole (s) ; the basal margin of the sole is deeply emarginate, and its surface towards the distal margin is set with short stiff hairs. The ventral distal margins of the tarsal segments are furnished with a number of very stout stiff bristles ; these are well seen in *Drepanepteryx*, in which genus they are arranged in two transverse comb-like rows (Fig. 10B, C, br). They appear to be mainly used for cleaning the antennæ and palpi.

THE WINGS (Figs. 11, 12).

The great majority of Hemerobiidæ possess two pairs of membranous wings of sub-equal size and similar form, although in certain genera the hindwings become

rudimentary and may even disappear. The wings are held very steeply and roof-like over the body, the costal margins almost touching the surface on which the insect rests, the inner margins meeting over the dorsum of the abdomen.
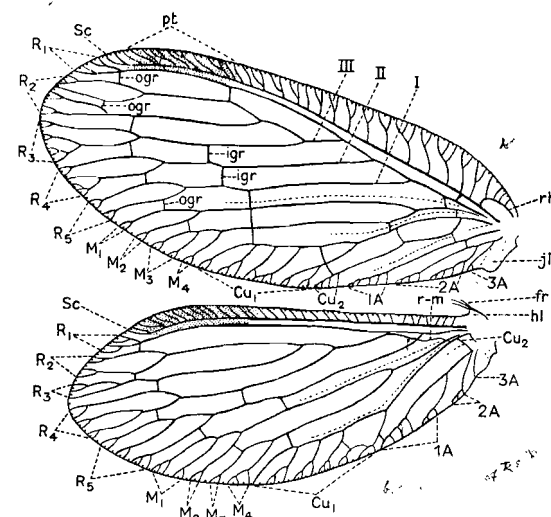

Fig. 11.—*Hemerobius humulinus* Linn., venation. *fr*, frenulum ; *hl*, humeral lobe ; *igr*, inner gradate cross-veins ; *jl*, jugal lobe ; *ogr*, outer gradate cross-veins ; *pt*, pterostigma ; *rhv*, recurrent humeral veinlet ; I–III, branches of Rs.

Forewing.

The costal area is broad towards the base, remarkably so in certain genera (*e. g. Megalomus* and *Drepanepteryx*), and is crossed by numerous veinlets. The basal or humeral costal veinlet may meet the costa at some distance from the base (*Psectra*, Fig. 63 ; *Eumicromus*, *Micromus*, Pl. XII), or may curve basad and run into the base of the costa, enclosing, with the base of the subcosta a small oval cell (*e. g. Hemerobius*, Fig. 11). In the latter case the veinlet is known as the recurrent humeral veinlet (Fig. 11, rhv) ; four to eight branches connect it to the costa. Towards the apex of the costal area the veinlets usually become very oblique and are

placed closely together. In this region there is a tendency for the membrane to thicken and become pigmented, and correlated with this is a partial absorption of the veinlets—a process that has been termed aphantoneurism (Tillyard, 1918–19); thus in many genera a more or less distinct pterostigma is formed (Fig. 11, pt). In *Drepanepteryx* the costal veinlets are connected by a longitudinal series (not two series, as stated by McLachlan, 1868) of accessory cross-veins, and occasionally one or two similar but isolated cross-veins occur in other genera.

The subcosta (Sc) is a strong vein meeting the costa before the apex of the wing ; Sc_2 is not present. The subcostal area is always narrow, and in most genera is crossed by a basal cross-vein and one or two in the pterostigmatic region ; in *Psectra*, *Drepanepteryx* and *Megalomus* there are additional intermediate cross-veins.

An important feature of the venation of the forewing in Hemerobiidæ is the fusion of R_1 and Rs, so that the branches of the latter appear to arise from R_1 (Fig. 11, I, II, III). These branches are usually, but wrongly, called radial sectors ; they will be referred to here as branches of Rs, the basal one being considered the first. In *Hemerobius* and *Boriomyia* Rs is normally three-branched, in *Psectra* and certain species of *Sympherobius* it is two-branched, in *Megalomus* there are six or seven branches, and in *Drepanepteryx* ten or more. Comstock (1918) raised a new family Sympherobiidæ to include the genera *Sympherobius*, *Psectra*, *Annandalia* and *Notiobiella*, based on the supposed separation of R_{2+3} from the remainder of the radial sector and its separate attachment to R_1. He does not appear to have been aware of the three-branched condition of Rs in *Sympherobius*, and it seems a much more reasonable view to suppose that a two-branched Rs arose from one with three branches by the migration of the base of the second branch (R_4) towards, and its final fusion with, the base of the first branch. It is to be noted that in *Psectra* (Fig. 63) and those species of *Sympherobius* with two

branches to Rs, the vein here called R_4 arises near the base of the first branch. In the Australian genus *Carobius* a two-branched Rs appears to have arisen by a similar fusion of the base of R_{2+3} with R_4, and I possess specimens of *Hemerobius* and *Boriomyia* in which this occurs abnormally. There thus appears no reason to consider the condition of Rs in *Sympherobius* and *Psectra* as fundamentally different from that of *Hemerobius*. The many-branched condition in *Megalomus* and *Drepanepteryx* appears to be the result of a complete fusion of R_1 and Rs and a splitting back of the distal forks.

The base of M lies under that of R, so that there frequently appears to be fusion in this region ; there is, however, no actual fusion as stated by Tillyard (1916b). M has occasionally been mistaken as a branch of Rs, but the two veins may readily be separated by a fold in the membrane between them (indicated in Figs. 11 and 63 by a dotted line). In most genera M_{1+2} and M_{3+4} separate in the basal half of the wing, and divide again towards the margin of the wing ; in *Drepanepteryx*, however, the four main branches of M are given off fairly close to the base of the wing.

In all genera the two main branches of Cu are present, the fork-point being near the base. Cu_1 is continuous with the stem and is pectinately branched. Cu_2, at its base, usually bends down sharply towards 1A and then continues almost to the inner margin before branching ; in *Drepanepteryx*, however, it gives off a succession of accessory branches to the hind margin, while in *Megalomus* it bifurcates before the middle.

Three anal veins are present. 1A and 2A are frequently forked and show much marginal twigging, the formation of accessory branches being most highly developed in *Drepanepteryx*. The most simple condition of the anal veins is found in *Psectra* (Fig. 63), each vein having only one marginal fork.

True cross-veins in this family are comparatively few. Mention has already been made of those in the

costal and subcostal areas. One or two basal or sub-basal cross-veins are present between all the main veins, except that 2A and 3A are sometimes not so connected. Taxonomically the most important of these cross-veins is that between R and M. It is necessary, however, to call attention to a certain degree of variability in its position relative to the origin of the first branch of Rs. Banks (1905) restricted the genus *Hemerobius* to include only those species in which this cross-vein connects the stems of R and M, and from the remaining species of the old genus erected two new genera, *Sympherobius* and *Boriomyia*, in both of which he states that the cross-vein connects the " first radial sector " (first branch of Rs) to M. His division of the old genus is sound, but it has been found that certain undoubted *Hemerobius* species (*H. pini*, *H. atrifrons* and *H. contumax*) frequently have the cross-vein at, or just beyond, the origin of the first branch of Rs. In no case, however, does the cross-vein reach M_{1+2} in *Hemerobius*, while in *Sympherobius* and *Boriomyia*, and, indeed, in all other British genera, it is always well out on the first branch of Rs and at or beyond the first fork of M.

In certain genera (*e. g. Hemerobius*, *Boriomyia* and *Wesmaelius*) a short, oblique series of cross-veins usually runs from Cu_1 towards the middle of the inner margin of the wing. These cross-veins vary in number, direction and position, and may even be absent in species normally possessing them.

In all genera one or more series of cross-veins known as the gradate cross-veins are present (Fig. 11, igr, ogr). They run obliquely across the wing, usually in its distal half, and more or less parallel with the outer margin. In *Psectra* (Fig. 63) one series is present; in *Hemerobius* and most other genera there are two, known as the inner (igr) and outer (ogr) gradate series, while in *Drepanepteryx* and certain exotic genera a third series occurs in the basal half of the wing. The number of cross-veins in these series has been much

used in generic and specific descriptions, but it must be pointed out that this is a much more variable character than is generally thought. It is, therefore, unsafe to attempt to separate species and closely related genera on the number of cross-veins in any one of the gradate series.

Hindwing.

The costal area is always narrow, and is crossed by numerous closely placed veinlets which are rarely forked except in the pterostigmatic region. The humeral veinlet is never recurrent. The pterostigma is frequently more clearly defined than in the forewing.

The subcosta (Sc) is the stoutest vein in the wing, and is often noticeably thickened near the base. The subcostal area is very narrow; it may be crossed by one or more cross-veins in the pterostigmatic region, but the number is variable among the individuals of a species and they are quite frequently absent.

Rs leaves R_1 near the base of the wing and in most genera bifurcates almost at once, the upper branch being R_{2+3+4}, the lower R_5. In *Hemerobius* the basal portion of the upper branch bends strongly upwards towards R_1, and is either connected to it by a very short cross-vein (the second false origin of Rs of Tillyard, 1916b), or is actually fused to it for a short distance, thus forming either a small quadrilateral or a triangular cell. In other genera this approach to or fusion with R_1 is less marked, while in *Boriomyia* the basal portion of Rs distinctly diverges from R_1, the basal cross-vein, when present, connecting the stem of Rs to R_1. Occasionally two basal cross-veins are present, but the number of these cross-veins is rather variable, and is neither a safe generic nor specific character. All four branches of Rs are present, and accessory branches are sometimes found (*e. g. Drepanepteryx*), although they are never developed to the same extent as in the forewing.

M is four-branched as in the forewing, but in *Micromus variegatus* M_{3+4} is free only at its base, the remainder being fused with Cu_1. Very characteristic of all Hemerobiidæ is a weak, longitudinally-placed basal cross-vein connecting the stem of M to R_5, or to the stem of Rs. This cross-vein (Fig. 11, r–m) was at one time considered as the base of Rs, but Comstock (1918) has shown its true nature.

In the majority of genera Cu_2 is absent, or its base very weakly represented as a line of slight thickening near the base of the wing. It must, therefore, be noted that the branch given off from Cu just beyond the first fork of M belongs to Cu_1 and is not Cu_2. Cu_2 is, however, present in *Megalomus* and *Drepanepteryx*, although even in these genera it is very weakly formed. A study of *Drepanepteryx* appears to show that in genera in which Cu_2 is practically absent it forms the upper half of the basal cross-vein connecting Cu and 1A.

Three anal veins are present, 1A being usually much branched, and at its apex connected to the first branch of Cu_1 (or in *Megalomus* and *Drepanepteryx* to Cu_2) by fusion of the marginal twigging.

Cross-veins are always less numerous than in the forewing. There is usually an outer gradate series (*e. g.* in *Hemerobius, Boriomyia*, etc.), but in *Sympherobius* this is either reduced to one or two cross-veins (*S. fuscescens*) or is completely absent. In *Drepanepteryx* there is also a complete inner gradate series ; in *Micromus* this series is represented by three to five cross-veins, while in most genera the usual number is two. As in the case of the forewing the number of gradate cross-veins is variable, and cannot be safely used for the separation of species and closely related genera.

Reduction of the Hindwing.

In the genus *Psectra*, of which only one species appears to exist, an extraordinary dimorphism in wing

development has arisen, one form having four fully developed wings, the other, a micropterous form, having the hindwings so rudimentary as to resemble small scale-like appendages (Fig. 63). This dimorphism has frequently been regarded as sexual, although there has not been complete unanimity of opinion as to which form is female and which male : thus Hagen (1866) and McLachlan (1868) have held the view that the male has rudimentary wings, while Banks (1905) considered this form to be the female. Mjöberg (1909*a*) obtained a number of both micropterous and macropterous specimens from Finland and Sweden, and made a superficial examination of the external structures at the apex of the abdomen, and came to the conclusion that a reduction of the hindwing may occur in either sex. Of the six known British specimens, two have been examined by Killington and Kimmins (1932), dissection being made of the genitalia : both were micropterous males, and in these, two simple veins exist in the hindwing (not one as stated by McLachlan, 1868).

Correlated with this peculiarity is a modification of the forewing, the membrane being thicker than is normal for the family, while the whole wing is slightly convex above. It is interesting to note that the modification of both pairs of wings, as seen in *Psectra*, is carried still further in two genera, *Pseudopsectra* and *Nesothauma*, described by Perkins (1899) from Hawaiian material : in *Pseudopsectra lobipennis* Perk. the hindwings are minute in both sexes and the forewings very short, rounded apically, strongly convex above, coriaceous and opaque ; in *Nesothauma haleakalæ* Perk. the hindwings have completely disappeared and the forewings are very small, their surface strongly convex and their texture approaches that of the elytron of a Coleopterous insect.

Coupling Apparatus (Fig. 12A).

This consists of a slightly convex jugal lobe (jl) at the base of the inner margin of the forewing, and of a

slightly concave and somewhat triangular humeral lobe (hl) carrying a frenulum (fr) of several stiff bristles at the base of the costal margin of the hindwing. This apparatus occurs in all British genera, even in a reduced form in *Psectra*.
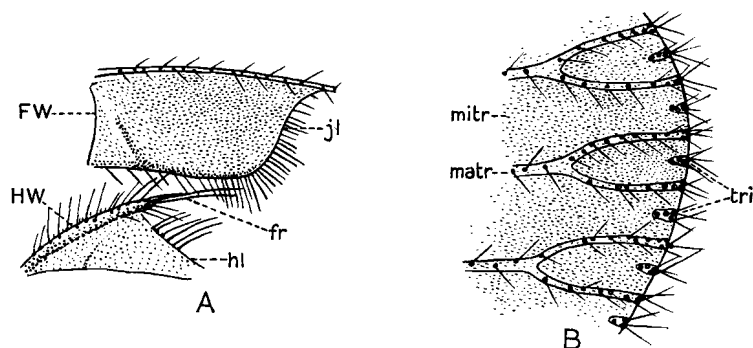

Fig. 12.—A. *Boriomyia betulina* (Strøm), coupling apparatus of wings. B. *Hemerobius humulinus* Linn., portion of apex of forewing, to show trichiation and trichosors. *fr*, frenulum; *FW*, forewing; *hl*, humeral lobe; *HW*, hindwing; *jl*, jugal lobe; *matr*, macrotrichia; *mitr*, microtrichia; *tri*, trichosors.

Trichiation (Fig. 12B).

Both microtrichia (mitr) and macrotrichia (matr) are present on the wings of Hemerobiidæ. Microtrichia densely cover the whole wing surface, but macrotrichia are found only on the longitudinal veins, costal veinlets and along the wing margins.

Marginal Thickenings (Fig. 12B, tri).

All the margins of both pairs of wings bear small setigerous swellings, the marginal " dots and dashes " of Comstock (1918), between the tips of the veins and veinlets. For these I propose the name " trichosors ". Each trichosor consists of a thickening of the membrane upon which stand several macrotrichia. Along the apical portion of the margin they are somewhat elongate in form, but towards the bases of the inner and costal

margins they gradually become shorter and smaller. They occur in a number of other Neuropterous families, although not in all.

THE ABDOMEN.

The abdomen of both sexes (Figs. 13-18) is composed of ten segments, each of the first eight bearing a pair of spiracles. The first segment is short, and except for narrow chitinized lateral strips the sternite is membranous; the spiracles of this segment are situated anteriorly, close to the metathorax, and are larger than those of the following seven segments. The second to the seventh segments in the female and the second to the eighth in the male are normally developed, with
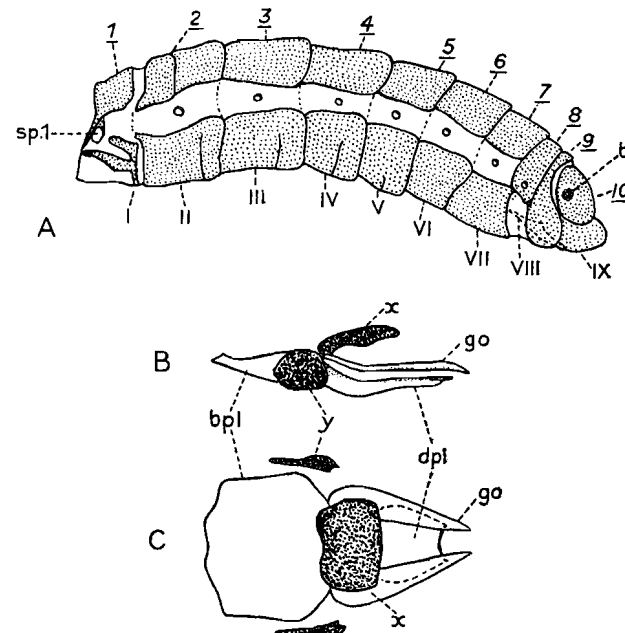

Fig. 13.—*Boriomyia betulina* (Strøm), ♀. A. Abdomen (lateral view; sclerites shaded). B. Eighth sternite (lateral view). C. The same (dorsal view). *bpl*, basal portion of eighth sternite; *dpl*, distal portion of same; *go*, gonapophyses; *sp. 1*, spiracle of first segment; *tr*, trichobothria; 1-10, tergites; I-IX, sternites.

clearly defined and well chitinized tergites and sternites that are similar in form in both sexes ; the remaining segments are specialized in varying degrees and show sexual dimorphism. Transverse secondary sutures are present on some, or all, of the tergites and sternites of the second to the sixth segments, and those of the second segment are usually so complete as to give a false impression of two segments ; on the other segments the secondary sutures vary in their stage of development, usually becoming shorter and weaker towards the sixth segment. It will be convenient to deal with the anal segments of the two sexes separately.

The Male (Figs. 14–16).

The tergite of the ninth segment (Fig. 14A, 9) varies considerably in form in the different genera. Dorsally it is always shorter than that of the eighth segment, and this shortening may be carried so far that there is a complete break, the tergite being separated into two latero-dorsal plates (*Micromus*, Fig. 15A). In *Sympherobius*, on the other hand, with the shortening of the tergite there has developed a mid-dorsal longitudinal line of thickening which is continued laterally along the anterior and posterior margins. Laterally the tergite extends well down the sides, frequently expanding in its lower parts. This expansion may consist of nothing more than a slight broadening (*Boriomyia*, Fig. 14), a much more pronounced anterior and posterior extension (*Micromus*, Fig. 15A), or may develop into a narrow elongate, acute process curving under and projecting beyond the tenth tergite (*Psectra*, Fig. 64A).

The ninth sternite (Figs. 14–16, IX) also shows considerable variation in the different genera, and even in the different species of a genus. Usually it is short, distally rounded and ventrally convex. Chitinization and pigmentation are sometimes incomplete, and this is carried furthest in *Boriomyia* and *Wesmaelius* (Fig. 14C). The highest degree of specialization is reached
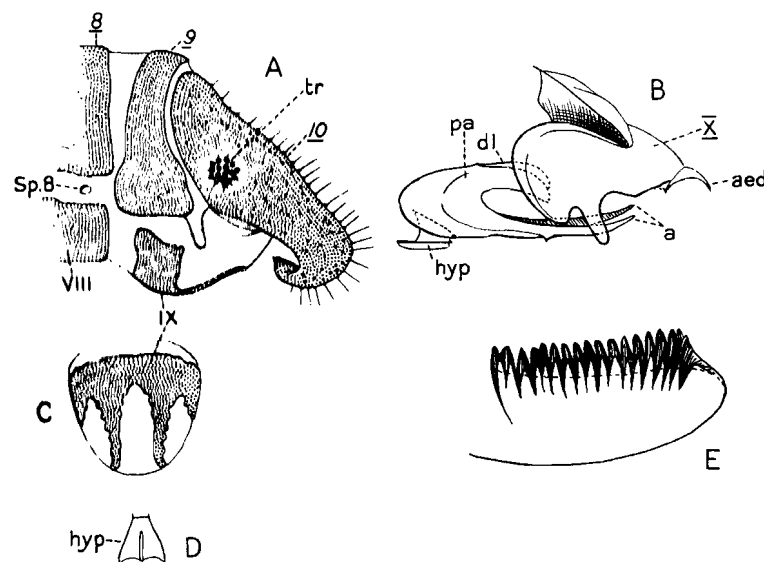
FIG. 14.—*Boriomyia betulina* (Strøm), ♂. A. Apex of abdomen (lateral view ; sclerites shaded). B. Internal genital armature and tenth sternite (dorso-lateral view). C. Ninth sternite (ventral view). D. Hypandrium (ventral view). E. Apical teeth on anal plate (tenth tergite). *a*, apices of parameres ; *aed*, aedeagus ; *dl*, dorsal lobe of paramere ; *hyp*, hypandrium ; *pa*, parameres ; *sp*. 8, spiracle of eighth segment ; *tr*, trichobothria ; 8–10, tergites ; VIII–X, sternites.
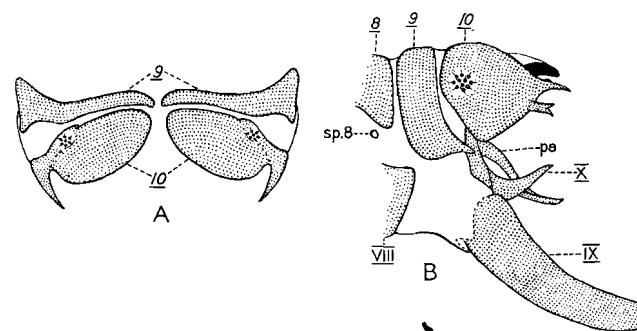

FIG. 15.—*Micromus variegatus* (Fabr.), ♂, ninth and tenth tergites of abdomen (dorsal view ; under pressure). B. *Sympherobius fuscescens* (Wallengr.), ♂, apex of abdomen (lateral view). Lettering as in Fig. 14.

in *Sympherobius*, where the sternite is produced into an elongate, hollow, finger-like process projecting beyond the apex of the tenth tergite, the maximum development being reached in *S. fuscescens* (Fig. 15B, IX).

Of the tenth segment, the tergite (Figs. 14–16, *10*) in all genera is divided longitudinally into two large latero-dorsal plates, referred to by Withycombe (1923*a*) as " paraprocts ", and by other writers as " superior appendages ". As paraprocts should be associated with the tenth sternite, and the plates are not true appendages,
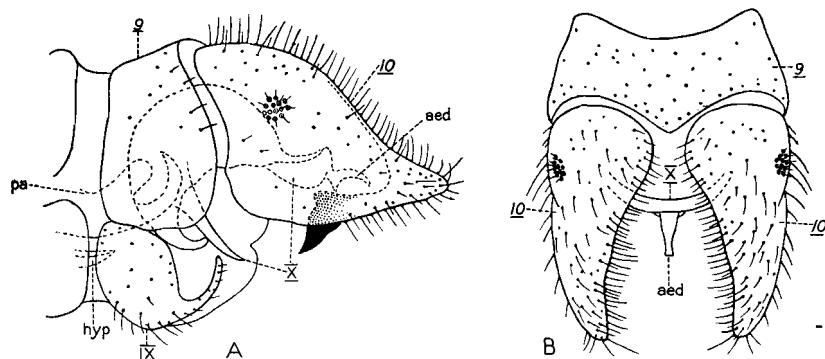

FIG. 16.—*Wesmaelius concinnus* (Steph.), ♂. A. Apex of abdomen (lateral view). B. The same (dorsal view). Lettering as in Fig. 14.

both terms are here rejected and the term " anal plates " substituted. The anus opens in the membrane between the plates. Each anal plate has the outer surface convex and clothed with long setæ, while the apex may be set with one or two comb-like rows of minute but strongly chitinized teeth (Fig. 14E). At the lower basal angle is a weakly chitinized area devoid of setæ, and furnished only with microtrichia. Above this is a circular, lightly pigmented area, in which stands a flattened dome-like structure bearing a closely set group of short, stiff, sensory bristles, the trichobothria (Fig. 14A, tr). Examined under a high power each bristle is seen to originate in a raised tubercle in the

centre of a pit, the fluted sculpture of the walls of which presents a remarkably flower-like appearance (Fig. 17). In *Psectra* there are only six or seven sensory bristles grouped together, in *Drepanepteryx* over fifty, while in *Hemerobius*, *Boriomyia*, etc., the number varies between ten and twenty. In closely allied species, however, the arrangement and number of the bristles must be regarded as unstable and of little or
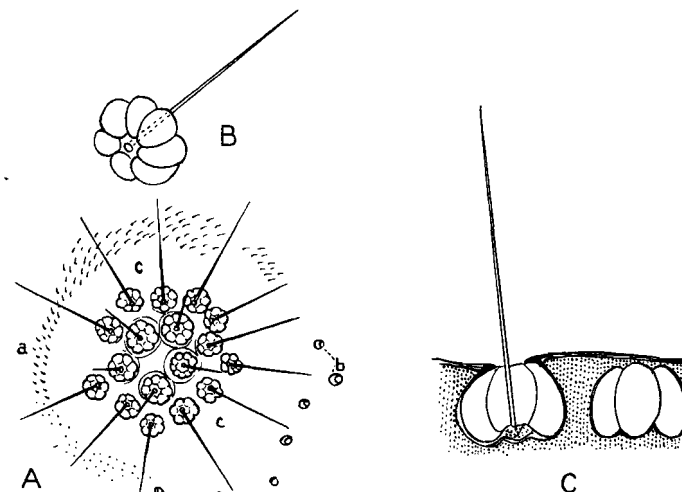

FIG. 17.—*Boriomyia betulina* (Strøm), trichobothria. A. Group of trichobothria on anal plate (tenth tergite). B. A single bristle, more enlarged (viewed obliquely from below). C. Section of cuticle to pass through two trichobothria. *a*, microtrichia; *b*, bases of macrotrichia; *c*, clear space surrounding the trichobothria.

no value in systematic work. Similar hairs have been described in spiders (Dahl, 1883), in Thysanura (Silvestri, 1905), in Orthoptera (Berlese, 1909), in the Myriopoda (Hansen, 1917), in Hemiptera (Tullgren, 1919) and in Psocoptera (Lundblad, 1925) ; they are considered to be auditory in function.

The anal plates show varied and striking modifications of form, especially at their distal extremities, and provide excellent characters in almost every case for the separation of species.

The internal armature consists of a dorsal and two ventral structures which, except in the case of the hypandrium, afford characters of good taxonomic value (Fig. 14B).

The dorsal structure lies between the anal plates with its basal parts usually beneath the ninth tergite. Although differing much in its details, the main form of this structure is very similar in all genera, and shows two lateral wing-like plates, connected postero-dorsally by a transverse arch (Fig. 14B, X). Basally the wings are often thin and very transparent, whilst towards the upper and distal margins they are strengthened by irregular chitinous ridges. Distal processes usually project from the hind margins of the wings and arch. From a study of the male abdominal structures in other families I feel convinced that the wings and arch represent the basal portion of the tenth sternite, and it appears probable that the median distal process (aed), single or paired, attached to the lower margin of the arch should be regarded as the aedeagus, the latter having become secondarily fused to the tenth sternite. The genital armature of the males of other families will be dealt with later in this chapter, but it may be well at this stage to refer to the tenth sternite and aedeagus (where present) in the Osmylidæ, Sisyridæ and Coniopterygidæ. In the Osmylidæ (Fig. 28) there is no internal dorsally arched structure of the type seen in the Hemerobiidæ and no aedeagus. There is, however, a well developed and definite tenth sternite (Fig. 28, X) in the normal ventral position. In the Sisyridæ (Figs. 32, 61, 62), in which family there is also no aedeagus, the tenth sternite occupies a more dorsal position, and has become secondarily divided into a basal, transverse, dorsally arched plate (Xa) and a pair of large, distal, clasping processes (Xb). It seems probable that a similar line of specialization has been carried still further in the Hemerobiidæ, and that the distal portion of the tenth sternite has completely disappeared, whilst the basal arched portion has

become more complex. Clasping structures in the Hemerobiidæ have then developed from the tenth tergite instead of from the sternite as in the Sisyridæ. In the Coniopterygidæ the tenth sternite has become highly specialized and there is considerable variation in its form. In two Continental species, *Coniopteryx tullgreni* Tjed. and *C. esben-peterseni* Tjed., the tenth sternite forms a transverse arched plate as in the Hemerobiidæ, but in the three British species of *Coniopteryx* it has become divided into two processes (called by Tjeder, 1931b, the paraprocts) lying latero-ventrally below the anus (Fig. 23A, X). In at least some species of *Coniopteryx* (*e. g. C. tineiformis* and *C. borealis*) a chitinized and pigmented true aedeagus (the penis, Tjeder, 1931) occupies the same position as the median distal process attached to the tenth sternite in most Hemerobiidæ, although, as in the Chrysopidæ, it has not become fused to the sternite.

The two ventral structures of the internal genital armature are associated with the ninth sternite, above which they lie. Basally there is a small, weakly chitinized and transparent hypandrium (Fig. 14B, hyp ; D) formed by the fusion of the lateral gonapophyses. This is very constant in form throughout the Hemerobiidæ ; it is always a very thin plate, along the median longitudinal axis deeply keeled below, the sides curved steeply upwards and then turned over at the margins ; viewed from above it is triangular in form with the apex excised, whilst in a lateral view it somewhat resembles the stem of a boat. Above the hypandrium and between the wings of the tenth sternite are the parameres (Fig 14B, pa), which may be separate (*Hemerobius*), fused basally (*Micromus*), or completely fused into a single plate (*Psectra*).

The Female.

The eighth segment of the female differs from that of the male in the considerable lateral development of the tergite and the great reduction in the size of the

sternite (Fig. 13). The lower margins of the tergite reach well down the sides of the body, and the eighth pair of spiracles open in its lateral surfaces. The sternite is reduced to a small subgenital plate, and has moved caudad to lie between the lower margins of the ninth tergite and the bases of the lobes of the ninth sternite (Figs. 13A, 18A, VIII). It may consist of a narrow, elongate, dorsally concave plate (e. g. *Drepanepteryx*), or may show a much more complex structure, as in *Boriomyia*. In *B. betulina* (Fig. 13B, c), for example, the main part of the structure is a thin plate with a broad, dorsally concave and somewhat quadrangular basal portion (bpl), and a narrower, tapered, dorsally concave distal portion (dpl), with emarginate apex. Above the lateral margins of this distal part and attached to it basally are the two elongate, acute anterior gonapophyses (go), which are rather firmly fastened by membrane to the inner bases of the lobes of the ninth sternite. In addition to these structures are three small darkly pigmented pieces of irregular shape, one (x) placed dorsally over the centre of the plate, the other two at the sides and just basad to the first (y).

The tergite of the ninth segment is even more extended ventrally than the eighth, and the lower margins frequently almost meet on the ventral surface (Fig. 13A, 9). Above, it is usually much shortened, and in *Micromus* is separated mid-dorsally as in the male. Occasionally the region of greatest constriction is latero-dorsal and a break in the chitinization may occur here (e. g. *Psectra diptera*, Fig. 64), in which case the lower detached portion may easily be mistaken for the ninth sternite. The lower lateral portions usually expand posteriorly, and in some genera (e. g. *Sympherobius*) this expansion is carried beyond the apex of the tenth tergite (Fig. 18B). With the lateral development of the tergite there has been a backward movement of the ninth sternite (Fig. 13A, IX) which has come to lie below the tenth tergite and to extend somewhat beyond it. It is divided into two latero-ventral

lobes, the outer surfaces of which are pigmented, well chitinized and clothed with long setæ, while the inner are swollen, soft and membranous. Tjeder (1931a) suggests that these lobes are probably to be regarded as the coxites (lateral gonapophyses). During oviposition eggs are passed between the two lobes, leaving the abdomen at their apices ; they thus form a kind of ovipositor. This ovipositor-like form of the ninth sternite is best developed in *Wesmaelius*, in which genus the lobes are very long (Fig. 18A, IX) and enable the female to place the eggs well down in crevices of bark, or between the scales at the base of the leaves of
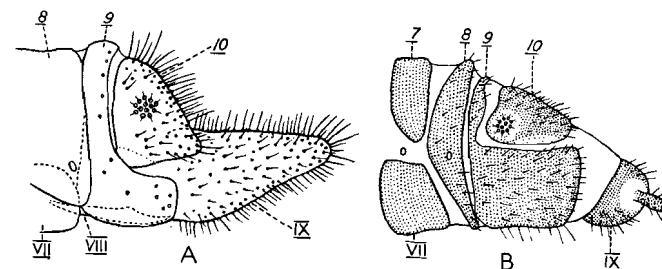

FIG. 18.—*Wesmaelius quadrifasciatus* (Reut.), ♀, apex of abdomen (lateral view). B. *Sympherobius fuscescens* (Wallengr.), ♀, apex of abdomen (lateral view). p, papilliform process of ninth sternite.

conifers. In the two widely separated genera *Megalomus* and *Sympherobius* each lobe bears a circular unpigmented area, from the centre of which projects a blackish, hollow, papilliform process clothed with setæ (Fig. 18B, p) ; these probably function as tactile organs during oviposition.

The tenth segment is represented only by the tergite, which is divided into two latero-dorsal anal plates, each furnished with a circular group of trichobothria (Fig. 13A, 10). The plates are much more generalized in form than in the male, and consequently do not offer the same striking taxonomic characters.

In spite of the more uniform nature of the structures at the apex of the female abdomen, the general neglect of these in descriptive work is not warranted. Both

the ninth and tenth segments frequently possess good generic characters; while, curiously enough, they sometimes offer appreciable specific differences in the case of pairs or groups of species otherwise difficult to separate. This latter point is well illustrated by the females of *Hemerobius humulinus* and *H. lutescens*, and in the difficult genus *Boriomyia*.

CONIOPTERYGIDÆ.

THE HEAD.

The head capsule is very strongly chitinized and darkly pigmented and the sutures clearly defined. There is no median epicranial suture, but well-marked temporal sutures run from the eye sockets to the
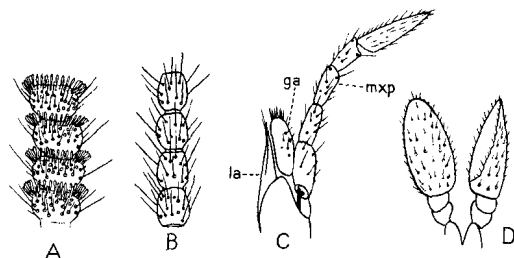

Fig. 19.—A. *Coniopteryx tineiformis* Curt., ♂, four antennal segments to show scale-hairs. B. *C. tineiformis*, ♀, four antennal segments. C. *Conwentzia psociformis* (Curt.), ♂, portion of maxilla. D. *C. psociformis*, ♂, labial palpi. *ga*, galea; *la*, lacinia; *mxp*, maxillary palpus.

posterior margin of the head and cut off postocular lobes. Wax glands are present on the epicranium. There appears to be no suture between the gena and postgena. The compound eyes are well developed. but not so prominent as in the Hemerobiidæ and other families. The antennæ are short and moniliform, the scape being swollen. The number of segments has been much used in taxonomic work, but unfortunately shows considerable variation within a species. In the genus *Coniopteryx* the antennæ show marked secondary

sexual characters: many of the segments of the flagellum in the males are shorter than wide and carry at their distal margin scale-like hairs, whilst in the females these segments are longer than wide and are furnished only with ordinary hairs (Fig. 19A and B). The labial palpi are borne on well developed palpigers which have the appearance of basal segments; the two basal segments are small and short, the distal one large, considerably expanded and somewhat depressed (Fig. 19D). In the sub-family Aleuropteryginæ the galea is three-segmented. The submentum is a very strongly chitinized and pigmented plate.

THE THORAX.

The structure of the thorax does not call for special comment. The segments are similar in their detailed structure to those of the Hemerobiidæ, but the pro-thorax and metathorax are relatively smaller and the mesothorax larger. Wax glands are present as on other parts of the body.

THE LEGS (Fig. 20).

The coxæ of the anterior legs, although longer and more cylindrical than those of the other legs, are relatively much shorter and stouter than in other families. The metatarsus of all legs is slender and cylindrical, and at least equal in length to the remaining four segments together; the second, third and fourth segments are very short, the fourth being flattened and concave above and slightly cordate in a dorsal view; the fifth is short, slender and somewhat cylindrical, and bears two slender curved claws which have a small tooth-like ventral projection near their base. There appear to be slight differences in the form of the femur, and of the arrangement of its setæ, in the anterior legs of the males of the different species in the genus *Coniopteryx*, but these differences are difficult
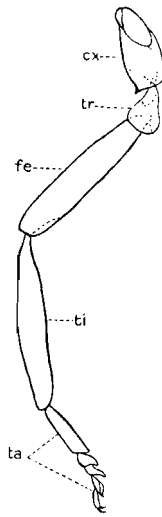
Fig. 20.—*Conwentzia psociformis* (Curt.), ♀, prothoracic leg.   *cx*, coxa ;
        fe, femur ;   *ta*, tarsus ;   *ti*, tibia ;   *tr*, trochanter.

to appreciate. The tarsal ratio of the hind legs has also been used for separating species, but there is some variation in this respect, and it is not a sound character for determining closely allied species.

THE WINGS (Figs. 21, 22).

The wings of the Coniopterygidæ differ from those of other families mainly in their reduced venation : at the most only one or two weak veinlets are present in the basal region of the costal area, cross-veins are very few, and there are no accessory branches to the longitudinal veins. The wings are covered soon after emergence with a waxy secretion exuded from hypodermal glands on the body (see p. 78).

Two or three facts of particular interest have been brought to light by Withycombe (1922*d*) in a study of the pupal tracheation (Fig. 22), the most important of which is the bifurcation of the subcosta. He has shown that the apparent cross-vein between Sc and R_1 in the imaginal wing is in reality the basal portion

of Sc_2, and that the apparent terminal portion of R_1 is the continuation of Sc_2 after it has reached R_1. A further point of interest is the apparent crossing of R and M in the basal region of the forewing. An
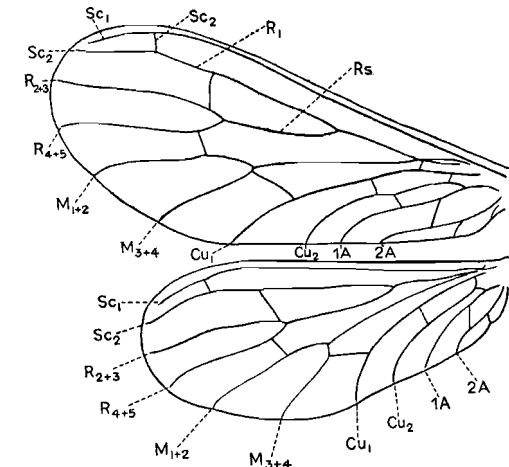

Fig. 21.—*Semidalis aleyrodiformis* (Steph.), venation.   (Coniopterygidæ).
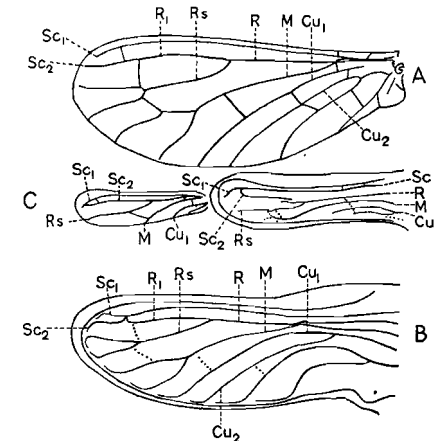

Fig. 22.—*Conwentzia psociformis* (Curt.), venation.   A. Forewing of imago.   B. Forewing of pupa.   C. Hindwing of imago.   D. Hindwing of pupa.   (Coniopterygidæ.)   (After Withycombe, 1922, *Entomologist*, **55** : 224–225.)

examination of the pupal wing shows that there is no actual crossing; the two veins are seen to approach one another and to come almost into contact, but at this point they once more separate.

In one genus (*Conwentzia*; Fig. 22) the hindwings are much reduced in both sexes, but there is no thickening of the membrane or other modification of the forewing as in the case of *Psectra* in the Hemerobiidæ. In the pupal hindwing of *Conwentzia*, Sc_2 is seen to take a rather different course from that followed in the forewing: after crossing the subcostal area it returns for some distance towards the base of the wing, whilst R_1 is either absent, or very short and weakly developed.

The membrane of the wings is densely covered with microtrichia, and the longitudinal veins carry a few macrotrichia. The margins are fringed in most genera with very short macrotrichia, with slightly longer hairs at intervals arising from tuberculate bases; the latter may, perhaps, be regarded as a very simple form of trichosor. In certain exotic genera the marginal hairs are considerably longer. The coupling apparatus is very reduced in this family.

THE ABDOMEN (*Coniopteryx*).

The abdomen is ten-segmented and not strongly chitinized except for certain plates at the apex in the male. Apart from weak chitinization the first eight segments are of the normal form found in Neuroptera; spiracles are present on each of these segments. The ninth sternite and the tenth segment in both sexes are considerably modified. The following account of the terminal segments is based on the genus *Coniopteryx*, the most important genus in this country.

The Male (Fig. 23).

The ninth sternite carries at its distal end a large, deeply pigmented and strongly chitinized plate, the

hypandrium (A, hyp; B), formed by the fusion of the coxites of the ninth segment. The posterior margin of the hypandrium shows a median and two lateral incisions, and the shape of these and of the processes to which they give rise provides excellent characters for specific determination.
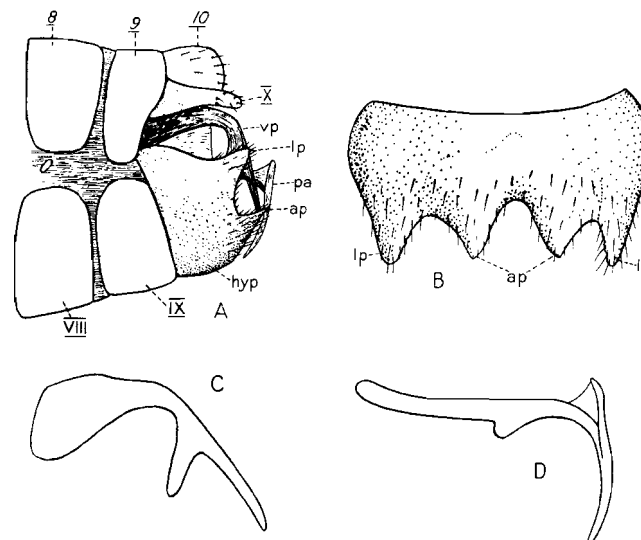

Fig. 23.—*Coniopteryx pygmaea* Enderl., ♂. A. Apex of abdomen (lateral view). B. Hypandrium (ventral view). C. Ventral process of tenth sternite (lateral view). D. Paramere (lateral view). (Coniopterygidæ.) *ap*, apical processes of hypandrium; *hyp*, hypandrium; *lp*, lateral processes of hypandrium; *pa*, paramere; *vp*, ventral process of tenth sternite; 8-10, tergites; VIII-X, sternites. (D. E. Kimmins, *del.*)

The tenth tergite is small, weakly chitinized and scarcely pigmented. It is divided into two latero-dorsal plates (A, *10*) sparingly clothed with hairs. I have been unable to discover any trichobothria on these lobes in any Coniopterygid species.

In the three British species of *Coniopteryx* the tenth sternite is divided into two lateral, backwardly directed, pigmented and chitinized processes (X), to which

Tjeder (1931b) has applied the term "paraprocts". They appear, however, to be homologous with the dorsally arched tenth sternite in the Hemerobiidæ, and in certain species (e. g. C. tullgreni Tjed. and C. esben-peterseni Tjed.), not yet discovered in Britain, these processes are fused to form a single plate. Ventrally, from the base of the tenth sternite arise a pair of chitinized and pigmented processes (A, vp ; c), each of which in the British species is bent strongly downwards and forked. Tjeder (1931b) suggests that these structures may have developed from cerci.

The internal genital armature consists of two pairs of structures, the parameres and the sclerites forming the ædeagus. The parameres (A, pa ; D) are usually elongate rods of peculiar form, and are either actually united one to another or connected only by membrane and muscles. The ædeagus, consisting of two smaller chitinized and pigmented rods, lies between the apices of the parameres ; no trace of an ædeagus has yet been found in C. pygmœa.

The tenth sternite and internal genital armature provide good specific characters.

The Female (Fig. 24).

In the female the eighth segment shows no particular specialization such as is found in other families : the tergite is similar to those of the preceding segments, and the sternite is well developed and apparently without gonapophyses. The eighth pair of spiracles open in the pleural membrane.

The ninth tergite is very short and transverse, runs well down the sides, and is more heavily pigmented than that of the eighth and tenth segment. The ninth sternite is a small and highly specialized structure. At its distal end are the lateral pair of gonapophyses, which expand into rounded and pigmented processes set with stiff hairs. At its basal end arises a single

chitinous and pigmented plate which, as Tjeder (1931b) suggests, may represent either the anterior or posterior gonapophyses, or even the spermatheca ; its form is different in the various species.
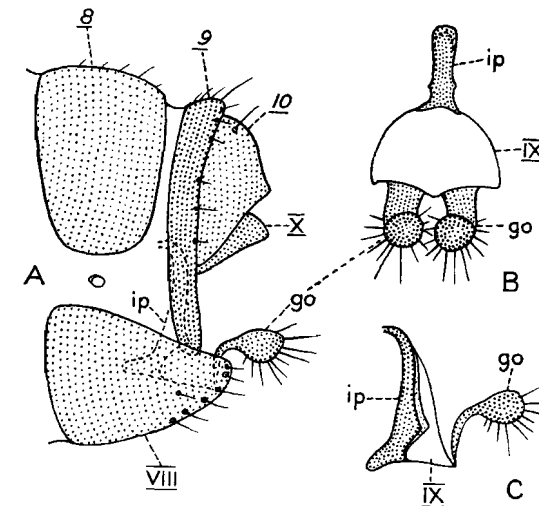

FIG. 24.—Coniopteryx pygmaea Enderl., ♀. A. Apex of abdomen (lateral view). B. Ninth sternite (posterior and slightly dorsal view). C. Ninth sternite (lateral view). (Coniopterygidæ.) go, gonapophyses ; ip, internal plate at base of ninth sternite ; 8–10, tergites ; VIII–X, sternites.

OSMYLIDÆ (Osmylus).

THE HEAD.

The epicranium has the vertex very convex. Anteriorly, just behind the antennæ, are three conspicuous ocelli, closely placed together to form a triangle ; these organs are absent in all other families. A weak and indistinct median epicranial suture is present running from the posterior margin to a point between the two posterior ocelli. Temporal sutures run from the posterior margin of the head to the middle of the hind margin of the compound eyes and cut off on either

side a rather convex postocular lobe. There is no suture present between the compound eyes as in the Hemerobiidæ. The eye sockets are relatively small, their diameter being rather less than the distance between the two eyes. The frontal pits are very conspicuous, and from each a short frontal suture leads to the middle of the anterior margin of the antennal sockets. The labrum is very transverse and slightly emarginate.
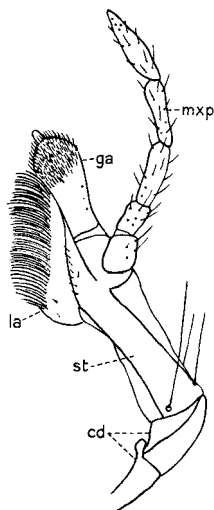

FIG. 25.—*Osmylus fulvicephalus* (Scop.), maxilla. *cd*, cardo ; *ga*, galea ; *la*, lacinia ; *mxp*, palpus ; *st*, stipes.

The gena and postgena are distinctly separated by a longitudinal suture.

The mandibles are large and acute, and bear on their inner margin a double-toothed process. As in the Hemerobiidæ, they are somewhat dissimilar, and the left mandible possesses a sub-apical tooth which is absent on the right one.

The maxillæ (Fig. 25) are well developed, the galea and lacinia showing distinct basal and distal parts. At the apex of the galea is a small papilliform process. The ligula is bilobed.

THE THORAX.

This does not call for special comment. All three segments are well developed. The prothorax, as usual, is the smallest segment ; it is longer than wide, and only about half the width of the meso- and metathorax. The scutum of each of the latter segments is very constricted mid-dorsally, but not completely divided.

THE LEGS.

The tibiæ, including those of the forelegs, are armed with two apical spurs, which are peculiar in being densely clothed with short stiff hairs. The tarsal claws differ from those of other groups in bearing ventrally a row of strong teeth (Fig. 26B). Perhaps
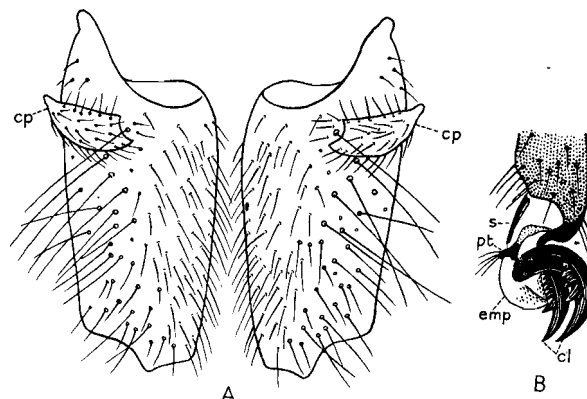

FIG. 26.—*Osmylus fulvicephalus* (Scop.), ♀. A. Fore coxæ (from before. B. Apex of fifth tarsal segment. *cl*, claws ; *cp*, coxal projection ; *emp*, empodium ; *pt*, pretarsus ; *s*, sole.

the most interesting structure, however, is that found anteriorly near the base of each fore coxa of the female. This is a curious outwardly curved process, clothed with hairs and ending in a teat-like projection (Fig. 26A). During the preliminary stages of copulation, either the right or the left process is seized by the mandibles of the male, apparently to give him a secure grip of the female.

THE WINGS (Fig. 27).

The wings in this family are large, more or less falcate, show a very dense venation and frequently possess a conspicuous colour pattern.

The costal area is broad, especially in the forewing, and is crossed by numerous parallel veinlets of which many are forked. The humeral veinlet is simple and not recurved. Occasionally certain veinlets are connected by cross-veins. Sc and R_1 are very closely
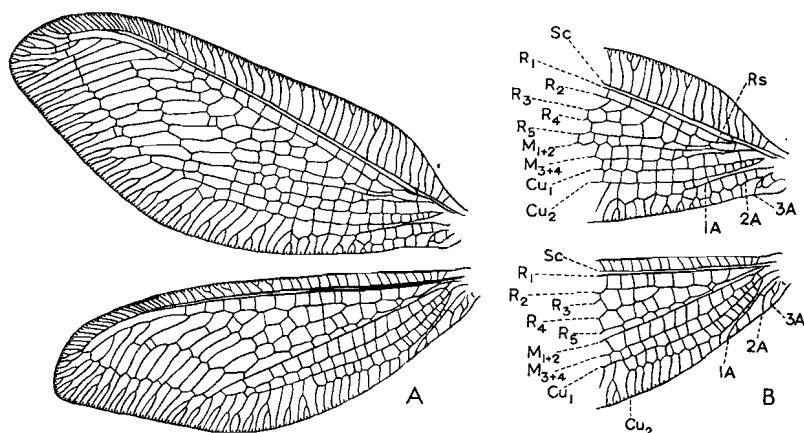

FIG. 27.—*Osmylus fulvicephalus* (Scop.), venation. A. Wings. B. Bases of same. (Osmylidæ.)

parallel and coalesce near the apex of the wing. Rs leaves the radius near the base of the wing and gives rise to numerous accessory branches. The media branches near the base of the wing, M_{1+2} and M_{3+4} running parallel to one another for a considerable distance before giving rise to further branches. The cubitus forks near the base of the wing, both Cu_1 and Cu_2 being well developed and giving off many accessory branches to the inner margin. The anal veins are also much branched. Most of the longitudinal veins give rise to marginal forks. Cross-veins are numerous, particularly in the basal two-thirds of the wings. In

the subcostal area, however, only one cross-vein is present near the base of the wing, and occasionally one or two near the apex, whilst the outer part of the wings is largely clear of cross-veins except for the well-marked gradate series.

Macrotrichia and microtrichia occur on the costal veinlets, longitudinal veins, cross-veins and margins. Microtrichia are present on the wing membrane, but are more numerous in the neighbourhood of the veins and in the pigmented areas; elsewhere they occur very sparingly. Trichosors are found on all margins, except towards the base of the costal and inner margins. The coupling apparatus is extremely rudimentary.

THE ABDOMEN.

The Male (Fig. 28).

The abdomen is ten-segmented, with well-developed tergites and sternites. Spiracles are present on the first eight segments.

The largest tergite is the eighth, which covers a pair of large eversible scent-glands (see p. 78); the sternite of this segment is less than half the length of the tergite. The ninth tergite is very short and transverse, and is raised latero-dorsally to form a pair of very prominent humps; the sternite is a large, undivided, transverse plate. The tenth tergite is almost completely divided mid-dorsally to form two latero-dorsal plates (anal plates). These are somewhat triangular in a lateral view, more deeply pigmented distally than elsewhere, and each carries, towards its base, a rather large, prominent, pale, dome-like swelling provided with about forty trichobothria. The tenth sternite is large and curiously modified. It is deeply and broadly excised in its distal region to form two large, slightly divergent, bilobed and sac-like protuberances. Dorsally, just before the base of the upper lobe of each protuberance, is a small, deeply pigmented, dome-like

prominence (Fig. 28A, B, Xc), to which reference will again be made in dealing with the tenth sternite in the Sisyridæ. The sternite, as a whole, bears a striking resemblance to a molar tooth with four
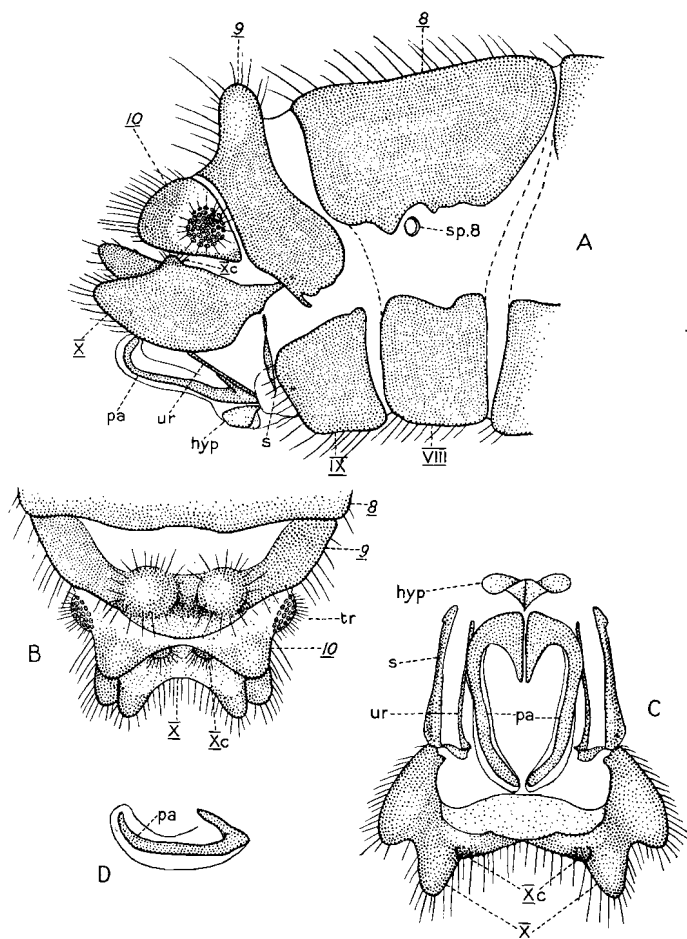

FIG. 28.—*Osmylus fulvicephalus* (Scop.), ♂. A. Apex of abdomen (lateral view). B. The same (dorsal view). C. Tenth sternite and internal armature (dorsal view; tenth sternite pushed slightly ventrad). D. Paramere. (Osmylidæ.) *hyp*, hypandrium; *pa*, paramere; *s*, strut; *sp.* 8, spiracle of eighth abdominal segment; *tr*, trichobothria; *ur*, chitinous ridge in membrane between ninth and tenth sternites; 8–10, tergites; VIII–X, sternites.

prominent cusps. On either side of the sternite, near its base, is a narrow, vertically placed chitinous strut (s), the upper end of which fits into a small, strongly chitinized notch or socket in the ventral margin of the outer wall of the sternite.

The genitalia consist of a hypandrium and a pair of parameres and lie below the tenth sternite (Fig. 28A, C). The parameres (pa) are slender sinuous rods, each within a transparent membranous sac. Distally and basally they are curved inwards and upwards so that their bases lie almost in contact and their apices are close one to another; the basal portion of each is recurved, and forms a large hook-like process directed back towards the distal end. The hypandrium (hyp) lies below the bases of the parameres and is a thin, slightly pigmented, keeled plate, the two wings of which are somewhat twisted. The two chitinized rods, labelled (ur) in Fig. 28A, C, I believe to be only chitinized thickenings in the membrane connecting sternites 9 and 10.

The Female (Fig. 29).

The first seven segments are normal. As in the male, the eighth tergite is the largest plate on the abdomen. Its basal margin shows a very strongly chitinized ridge, and is produced downwards on each side to reach the upper margin of the seventh sternite at its posterior end. The eighth pair of spiracles open laterally in this tergite. The eighth sternite is very reduced, and consists of a narrow, transverse ventral strip which is abruptly expanded at each extremity (Fig. 29B); the reduction, however, is not carried to the same extremity as in the Hemerobiidæ, neither can I find any trace of the gonapophyses of this sternite. The ninth tergite is short and transverse, and is produced well down the sides, almost reaching the ventral surface of the abdomen. Its lateral surfaces are divided into a

larger anterior part and a much smaller posterior part by a strongly thickened chitinous ridge which is produced below to form an acute process articulating with the valves of the ninth sternite. The latter are two closely connected elongate structures, bearing at
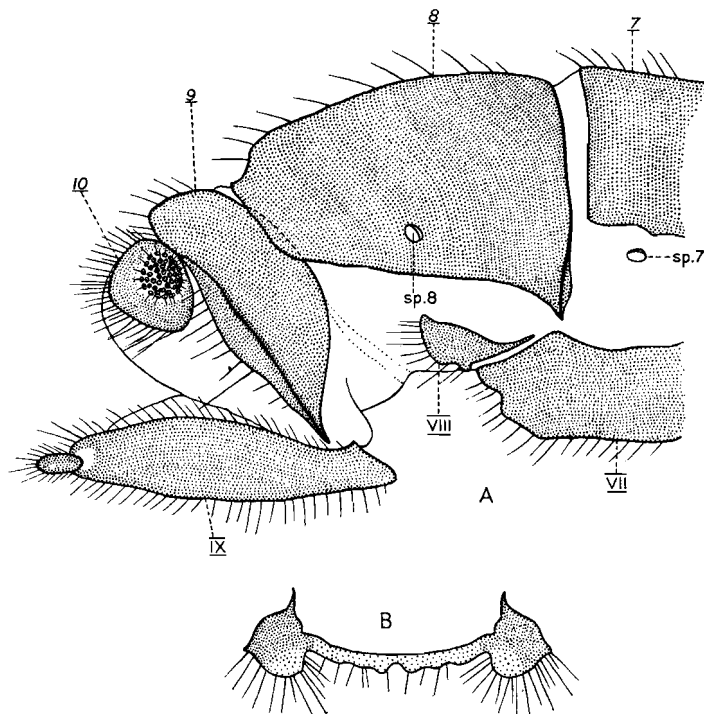

FIG. 29.—*Osmylus fulvicephalus* (Scop.), ♀. A. Apex of abdomen (lateral view). B. Eighth sternite (ventral view). (Osmylidæ.) *sp.* 7 and *sp.* 8, spiracles of seventh and eighth segments of abdomen; 7–10, tergites; VII–IX, sternites.

their apices a small oval process, and are used by the female during copulation to lever the large white spermatophore which is produced by the male. The tenth tergite resembles that of the male, and is divided into two anal plates each bearing a dome-like prominence with numerous trichobothria. The tenth sternite, as in other families, is missing.

SISYRIDÆ (*Sisyra*).

THE HEAD.

A distinct median epicranial suture runs from the posterior margin of the head, but terminates in the middle of the epicranium. Temporal sutures, one on either side of the epicranium, connect the middle of the hind margin of the compound eyes with the posterior
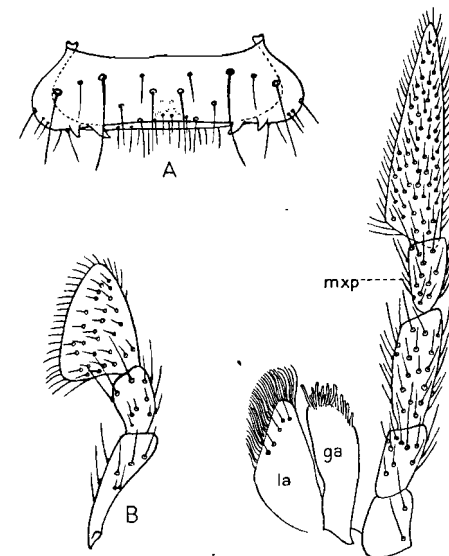

FIG. 30.—*Sisyra fuscata* (Fabr.), ♂. A. Labrum. B. Labial palpus. C. Portion of maxilla. *ga*, galea; *la*, lacinia; *mxp*, palpus.

margin of the head. I can find no trace of a suture connecting the eye-sockets. The post-gena is fused with the gena. The labrum (Fig. 30A) is, as usual, a transverse plate, but is peculiar in possessing tooth-like projections from each side of the anterior margin. There is a pair of well-developed acutely pointed mandibles, their inner margin bearing an additional tooth, whilst the left mandible possesses a sub-apical tooth which is absent on the right one.

THE THORAX.

The pronotum is transverse, and shows a median longitudinal line of division running from the posterior almost to the anterior margin.

In the mesothorax the mesoscutum is very large, and is completely divided into two very convex lateral lobes. There has been a corresponding reduction of the prescutum, which has practically disappeared. The mesoscutellum and postscutellum are, however, well developed, the latter, as usual, forming a posterior vertical wall which is not easily seen in a dorsal view. Apart from size, the metanotum is similar to the mesonotum.

THE LEGS.

The legs are very similar to those of the Hemerobiidæ. The tarsal claws are long, slender, curved and simple.

THE WINGS (Fig. 31).

The costal area of both pairs of wings is relatively narrow. It is crossed by a number of veinlets which are usually simple, although an occasional forked veinlet occurs, and the humeral veinlet is neither recurrent nor branched. A peculiarity of certain of the veinlets in the forewing is the presence of a small, basally directed projection.

Sc and R_1 meet near the apex of the wing as in the Osmylidæ. Rs leaves the radius near the base of the wing and is four-branched, R_5 in the forewing branching off much nearer to the fork-point of R_1 and Rs than in the hindwing. The branches of both the radius and the media have marginal forks. The cubitus is forked and both Cu_1 and Cu_2 are well developed, the former giving off a number of branches to the inner margin. Cross-veins are few and specialized.

The membrane and veins are densely covered with microtrichia, and the costal veinlets, longitudinal veins

and margins are clothed with macrotrichia. Trichosors are present on the outer margin and at the distal end of the inner margin.
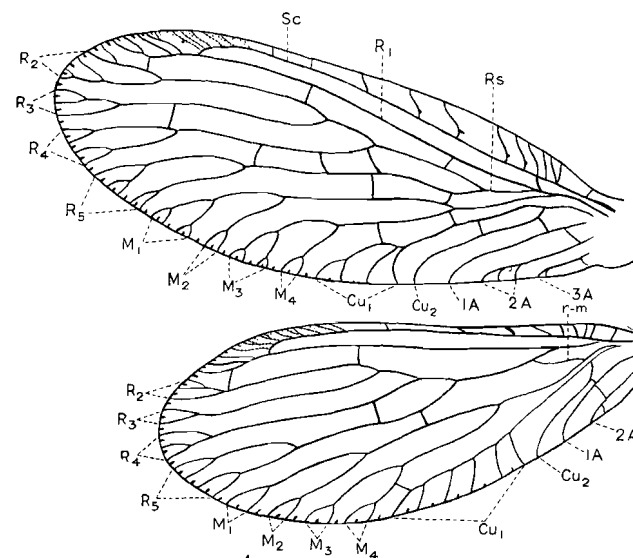

FIG. 31.—*Sisyra dalii* McLach., venation. (Sisyridæ.)

The coupling apparatus consists of a small jugal lobe on the forewing and an ill-developed humeral lobe carrying a frenulum of two stiff bristles on the hindwing.

THE ABDOMEN.

The Male (Figs. 32, 33).

The segments of the abdomen are raised convexly above and below, and the first eight segments carry very reduced tergites and short transverse sternites furnished with a few long outstanding setæ; the eighth tergite is divided into two small latero-dorsal plates. Spiracles open in the pleural membrane of the first eight segments.

On the ninth segment the tergite is also divided into two parts, and these have moved more laterally than

those of the eighth, and have come to lie beneath the lateral margins of the tenth tergite. As will be seen presently, this lateral and ventral movement of the plates of the ninth tergite has been carried much further in the female. The ninth sternite is a rather large undivided plate.

The tenth tergite is not divided into latero-dorsal plates as in the Hemerobiidæ and Osmylidæ, but forms a transverse, band-like sclerite carrying on each side a small number (two to six or seven) of trichobothria.
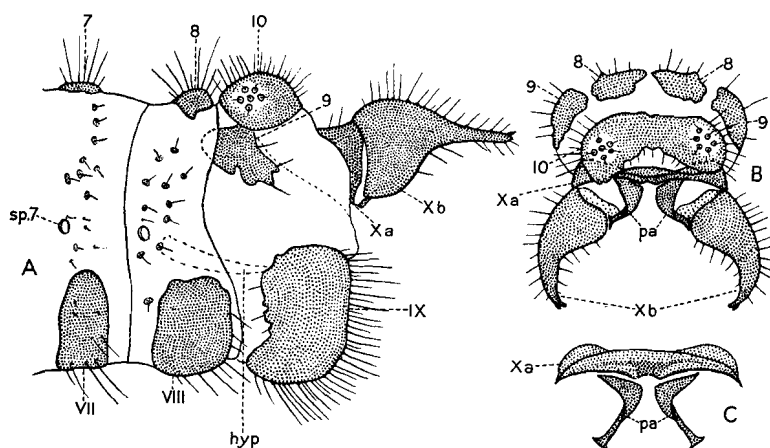

Fig. 32.—*Sisyra fuscata* (Fabr.), ♂. A. Apex of abdomen (lateral view). B. The same (dorsal view). C. Tenth sternite (basal portion) and parameres (dorsal view, slightly from behind). (Sisyridæ.) *hyp*, hypandrium ; *pa*, parameres ; *sp*. 7, spiracle of seventh abdominal segment ; 7–10, tergites ; VII–X, sternites.

The tenth sternite is very curiously modified and has moved towards the dorsal side of the abdomen ; it is of particular interest in showing how the peculiar form of tenth sternite in the Hemerobiidæ and Chrysopidæ has probably arisen. In *Sisyra* it has become divided into a basal, transverse, dorsally arched plate (Xa), and a pair of distal clasping processes (Xb). The anus opens in the membrane between the basal plate and the tenth tergite, so that the former is undoubtedly not a tergite as suggested by Stitz (1931). It appears

probable that the form of tenth sternite found in *Sisyra* has developed from a sternite similar to that of *Osmylus* by a transverse division occurring along the dotted line shown in Fig. 33, the inner lobes (Fig. 33, Xb) being then modified to form claspers. Further weight is given to this suggestion by the presence, above the base of each clasper, in *S. dalii* and *S. terminalis* of a small raised plate (Figs. 61, 62, Xc), which may correspond to the raised process in *Osmylus* (Fig. 33, Xc).

The claspers (Xb) provide good characters for specific determination, and are armed with one or more distal tooth-like projections and, in some species (*e. g. S. terminalis*), with long, seta-like processes.
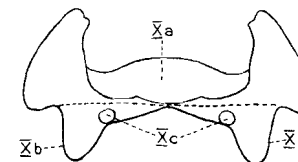

'Fig. 33.—*Osmylus fulvicephalus* (Scop.), ♂, tenth sternite (dorsal view). Dotted line indicates probable line of division leading to the form of tenth sternite found in *Sisyra*. (See also Figs. 28 and 62.)

The internal genital armature is reduced (Fig. 32B, C), and no ædeagus is present. Two chitinous rods (Fig. 32B, pa ; C, pa) run posteriorly from below the basal plate (Xa) of the tenth sternite and diverge towards the bases of the claspers ; these are probably to be regarded as the parameres. A thin, transparent, keel-shaped hypandrium (Fig. 32A, hyp), resembling that of the Hemerobiidæ, lies above the eighth sternite.

The Female (Fig. 34).

The first seven segments are similar to those of the male, but the eighth shows considerable modification. There is a complete break in the eighth tergite mid-dorsally, and the two separated lateral portions run to

the ventral surface of the abdomen and fuse mid-ventrally ; thus the tergite has the appearance of a sternite. The eighth pair of spiracles open laterally in this tergite. The eighth sternite is a minute plate lying below the genital opening and behind the tergite ; it bears two very small, elongate, lateral, backwardly directed processes (gonapophyses ; Fig. 34B, go), and is homologous with the similar plate found in females of the Hemerobiidæ.
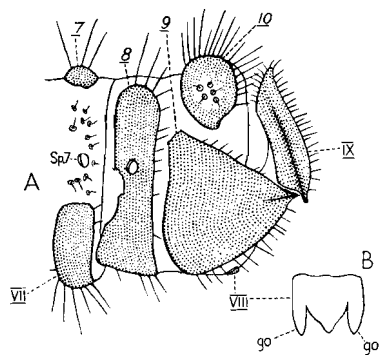

Fig. 34.—*Sisyra fuscata* (Fabr.), ♀. A. Apex of abdomen (lateral view). B. Eighth sternite (ventral view). (Sisyridæ.) *go*, gonapophyses ; *sp.* 7, spiracle of seventh abdominal segment ; 7–10, tergites ; VII–IX, sternites.

The ninth segment also shows peculiar modification, and its tergite and sternite have moved from their original positions. As in the male, the tergite (Fig. 34A, *9*) is divided into two plates, but in the female these are large and lie latero-ventrally below the tenth tergite. Posteriorly they show a short thickened ridge which projects as an acute process articulating with two elongate, upturned valves (A, IX) formed from the ninth sternite. A comparison of the ninth tergites and sternites of *Osmylus* and *Sisyra* provides an interesting clue to the true nature of these plates in the latter genus.

The tenth tergite is similar to that of the male and is not divided into latero-dorsal plates ; a small group of trichobothria are situated on either side.

CHRYSOPIDÆ (*Chrysopa*).

THE HEAD.

The vertex is raised, but flattened above, and frequently somewhat triangular in form. There is no median epicranial suture, and no suture between the eye sockets. The gena and postgena are fused. The eyes are large, prominent and hemispherical, and are green in colour with golden and reddish reflections. Ocelli are absent. The antennæ are long and filiform. The basal segment is swollen and usually but little longer than broad, although it may be considerably lengthened (*e. g.* in *C. vittata*) ; it is clothed with scattered hairs, of which a number near the base are much shorter than elsewhere. The segments of the flagellum are cylindrical and longer than wide ; each carries four transverse rows of setæ. The galea and lacinia are broadly oval and show distinct basal and distal regions. At the apex of the galea is a small somewhat cylindrical process, similar to that found in Osmylidæ. The mandibles are large and acute, in some species symmetrical (*e. g. C. flava*) ; in others (*e. g. C. perla*) the left mandible has a more prominent and tooth-like projection from the inner margin than the right one.

THE THORAX.

The pronotum varies somewhat in form in the different species, but is usually about as wide as the head (excluding the eyes). On the mesothorax the prescutum is well developed and is divided longitudinally into two halves by a median suture, and the mesoscutum is constricted in the middle to form two almost separated lobes. The metascutum is also constricted, but not to the same extent.

THE LEGS.

The legs are well developed, the posterior pair being longer than the middle and anterior pairs. The tarsal claws may be either simple (e. g. C. phyllochroma), or expanded basally into a broad, flattened, tooth-like projection (e. g. C. septempunctata) (Fig. 35).

Fig. 35.—A. Chrysopa phyllochroma Wesm., tarsal claws (imago).
B. C. septempunctata Wesm., the same.

THE WINGS (Fig. 36).

The wings are large, and possess a complex venation which can be understood only by a study of the pupal tracheation.

The costal area is fairly broad in the forewing, narrower in the hindwing, and is crossed by a number of simple and more or less parallel veinlets. Whilst the humeral veinlet is usually directed obliquely towards the base of the wing, it is not recurrent, and it is never branched as in the Hemerobiidæ.

Reference should now be made to the diagrammatic representation of the pupal tracheation shown in Fig. 36B. It will be seen that Sc terminates, not near the apex of the wing, but at the proximal end of the pterostigma ; the apparent continuation of Sc through the pterostigma and the apparent veinlets which run to the costal margin in this region are formed by branches from R_1. About twelve branches are given off posteriorly from Rs, and it will be seen that bent portions of a number of these branches help to form, in the imaginal wing, a conspicuously straight vein to which the name " pseudo-media " (with the notation M^1) has been applied by Tillyard (1916a). The pupal
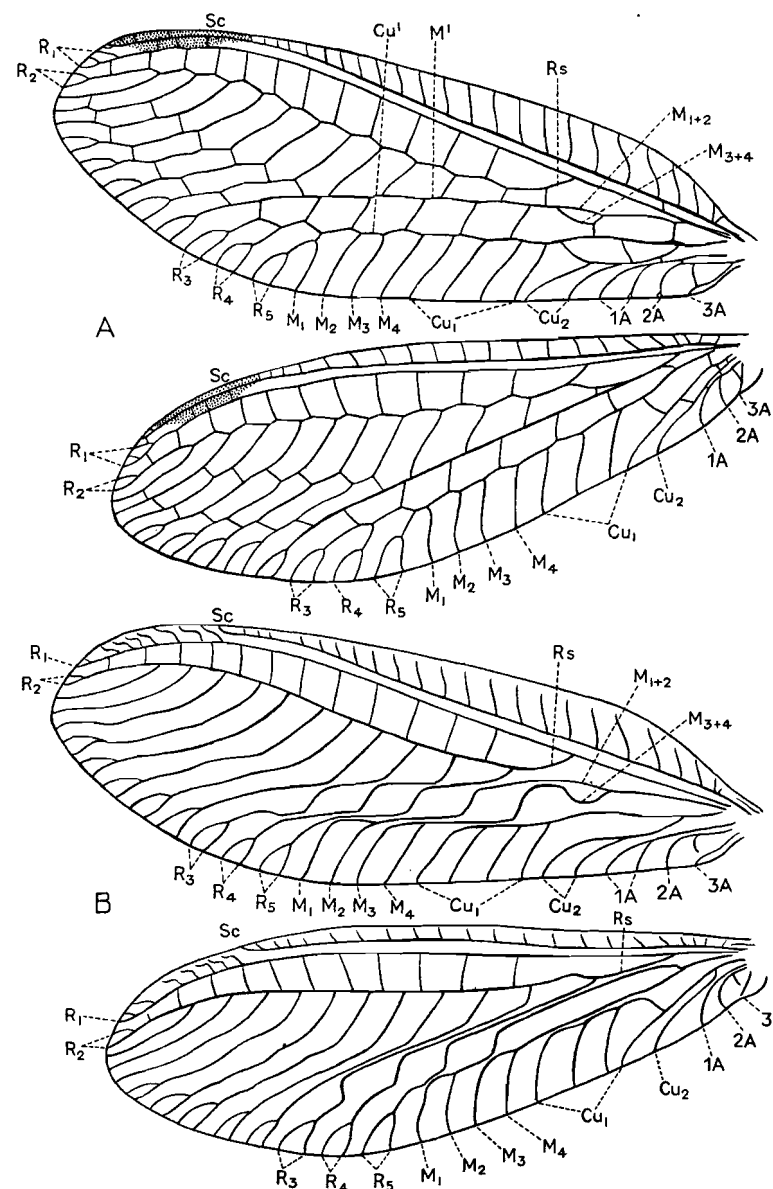
Fig. 36.—Chrysopa carnea Steph., venation. A. Imaginal wings. B. Pupal tracheation (diagrammatic). (Chrysopidæ.)

wing also shows that M branches a short distance from the base of the wing, and that the basal portion of M_{3+4}, in the forewing, forms a loop before fusing with M_{1+2}, thus cutting off a small cell (the third cubital cell of McLachlan, 1868 ; the first intra-median cell of Tillyard, 1916a). Further, it will be seen that in both fore- and hindwing a second composite vein, the pseudo-cubitus (Cu^1) is formed by portions of a number of the branches of Rs, by the branches of M and by Cu_1. The pseudo-cubitus follows a more zigzag course than the pseudo-media. Cu_2 is present in both wings, and does not form part of the pseudo-cubitus. There are three anal veins : 3A is simple, and 1A and 2A branched, the proximal branch of 2A joining 3A and having the appearance of a cross-vein.

When dealing with the imaginal wing, the veins can be correctly identified by first finding Cu_2, which is forked in the forewing and simple in the hindwing. This is followed by four branches belonging to Cu_1 (Tillyard, 1916a, shows only three branches to Cu_1), and these again are followed by the four veins M_4, M_3, M_2 and M_1.

The most important cross-veins to be noted are those connecting R_1 and Rs, and those between the branches of Rs forming, in the British genera of the Chrysopidæ, two gradate series.

Macrotrichia are present on the veins, cross-veins and margins, but trichosors are absent and no micro-trichia occur on the wing membrane. There is a very simple and reduced form of coupling apparatus.

THE ABDOMEN (*C. perla*).

The Male (Fig. 37).

The abdomen is less strongly chitinized than in the Hemerobiidæ and presents peculiar difficulties on account of the apparent absence of the ninth tergite. Immediately behind the eighth tergite is a transverse

plate bearing latero-dorsally, on each side, a slightly raised circular area carrying between twenty and thirty
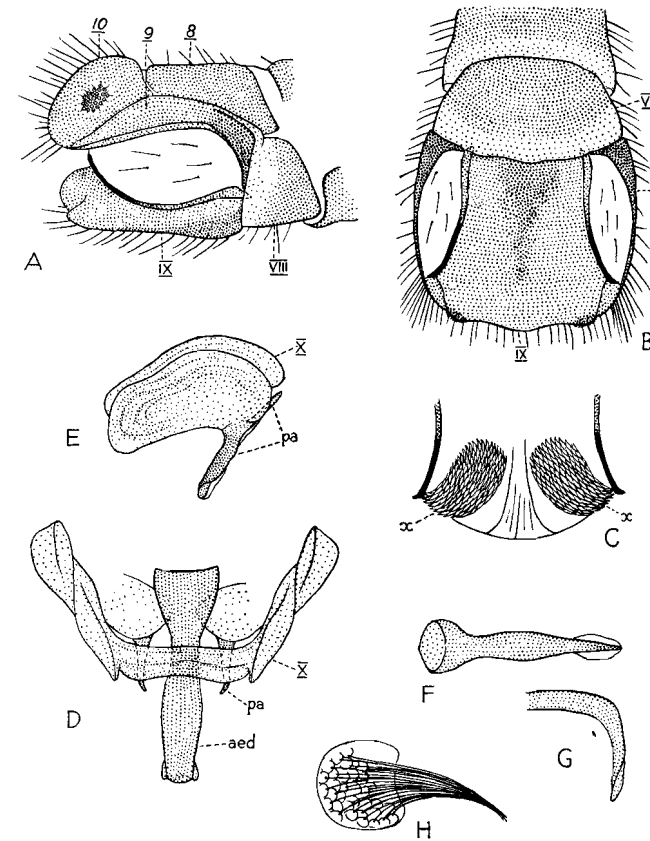

Fig. 37.—*Chrysopa perla* (Linn.), ♂. A. Apex of abdomen (lateral view). B. Apex of abdomen (ventral view). C. Apex of ninth sternite (dorsal view). D. Tenth sternite and internal genital armature. E. Tenth sternite and paramere (lateral view). F. Ædeagus (ventral view). G. Apex of ædeagus (lateral view). H. Membranous sac with tuft of setæ (? scent gland) associated with tenth sternite. (Chrysopidæ.) *aed*, ædeagus; *pa*, paramere; *x*, areas with scale-like teeth ; 8–10, tergites ; VIII–X, sternites.

trichobothria. This plate has been called the ninth tergite by Stitz (1931) and Morse (1931), both of whom regard the abdomen as only nine-segmented. In view

of the fact that the terminal plate bears the trichobothria, it should, however, be regarded as the tenth tergite, which is the trichobothria-carrying tergite in all other families. Below the ventral margins of the eighth and tenth tergites are elongate chitinized plates (A, 9), with their basal ends bent downwards just distad of the short eighth sternite, and these plates, one on each side of the abdomen, I believe to represent the ninth tergite. A similar modified tergite has been found in all species of *Chrysopa* which I have examined. Thus the abdomen in the Chrysopidæ is ten-segmented as in other families, and the trichobothria occupy their normal position on the tenth tergite.

The ninth sternite, called by Stitz (1931) and others the subgenital plate, is a large plate the form of which provides a good character for specific determination. In *C. perla* it forms a broad, ventrally convex structure, the upturned lateral margins being strengthened by a thickened and strongly chitinized rim. Between this rim and the lower margin of the ninth tergite is an oval more or less membranous area, furnished sparingly with setæ. Posteriorly the ninth sternite is more membranous and curls over dorsally, the dorsal wall thus formed showing two areas which are densely covered with overlapping scale-like teeth (c, *x*).

The tenth sternite (D, E, X) is internal and very similar to that of the Hemerobiidæ ; it is an arched structure with two lateral, transparent, expanded winglike plates. Attached closely to the underside of the tenth sternite are the parameres (pa), whilst an elongate chitinous ædeagus (æd) lies in a median position between the parameres. The hypandrium is very small and transparent. The tenth sternite, ædeagus and parameres provide valuable taxonomic characters.

Attached to the tenth sternite by membrane is a pair of membranous sacs, from the inner surfaces of which arise a number of long setæ (H). The bases of the setæ are swollen, whilst the setæ themselves lie

together to form a projecting tuft from the opening of each sac. The function of these structures is unknown, but they are possibly scent-glands.

The Female (Fig. 38).

The eighth tergite is much shorter than that of the preceding segments, with the exception of the first. The eighth sternite is reduced to a small, rather transparent plate (A, VIII ; B) lying at the distal end of the
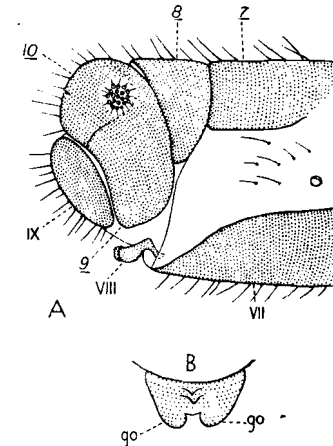

Fig. 38.—*Chrysopa perla* (Linn.), ♀. A. Apex of abdomen (lateral view). B. Eighth sternite (ventral view). (Chrysopidæ.) *go*, gonapophyses ; 7–10, tergites ; VII–IX, sternites.

seventh sternite, its posterior end bearing two lateral processes (gonapophyses). The ninth and tenth tergites are so closely united that it is difficult to find a line of separation between the two. Stitz (1931), in figuring the abdomen of *C. perla*, shows no suture, and, in fact, calls the whole structure the ninth tergite. Morse (1931), in a paper on the same species, figures a distinct lateral line of demarcation, but considers that this indicates a secondary division of the ninth tergite into an upper and lower region. The " upper region " carries, on each side, a group of trichobothria, and must, therefore, be considered as the tenth tergite.

Preparations of the abdomen of *C. perla* and of certain other species (*e. g. C. ventralis*) show an indistinct but unquestionable suture running just below and cephalad of the trichobothria, and I consider this to be the original suture separating the ninth and tenth tergites, although it seems to be disappearing in the Chrysopidæ. Viewed dorsally, the tenth tergite is seen to have its posterior margin excised, but, as in the male, there is no complete division into latero-dorsal anal plates. The ninth sternite is composed of two separate latero-ventral valves.

B. Internal Morphology.

The very brief account of the digestive, reproductive and central nervous systems which follows is based mainly on *Hemerobius*, although reference will be made to other groups.*

DIGESTIVE SYSTEM (Fig. 39).

The food of the imago consists of both solid and fluid matter, and well-developed mandibles are provided for tearing and crushing the more resistant parts of the prey. As might be expected, the alimentary canal of the imago differs somewhat from that of the larva (in which stage the mouth-parts are suctorial and the food wholly fluid) : the mouth is now open for the intake of food, a gizzard and food reservoir are present and the hind intestine is open for the passage of waste substances.

From the mouth cavity the pharynx runs parallel to the anterior wall of the head to about the level of the middle of the frons. It is surrounded by circular muscles and there are a few longitudinal muscles, whilst, in addition to these, other muscles run from

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* The accounts of the internal morphology given by Withycombe (1925*a*) and Stitz (1931) should also be consulted. Other papers dealing with the internal anatomy are given in the bibliography in Volume II.

the upper and lower walls to the walls of the head and to the tentorium. There is thus formed a pharyngeal pump which is very similar to that of the larva.

Two pairs of salivary glands are present. Of these, the small mandibular glands are placed laterally within the head, and each consists of an irregularly shaped group of secretory cells and a reservoir. The secretory cells are somewhat columnar in form, and surround a chamber which communicates by means of a very short duct to the reservoir. From the reservoir a duct leads to the base of the mandible, where it opens. The second pair of glands are recurved, tubular struc-
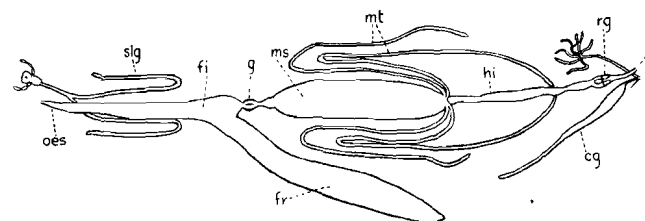

FIG. 39.—*Hemerobius humulinus* Linn., ♀, alimentary canal (four of six looped Malpighian tubes omitted). *a*, anus; *cg*, cement gland; *fi*, fore intestine; *fr*, food reservoir; *g*, gizzard; *hi*, hind intestine; *ms*, mesenteron; *mt*, Malpighian tubes; *oes*, œsophagus; *rg*, rectal glands; *slg*, salivary gland. (After Withycombe, 1923, *Trans. Ent. Soc. Lond.*, **1922** : pl. 39, fig. 6.)

tures and lie mainly within the prothorax, one on either side of the œsophagus. The secretory portions of the glands run back from just behind the head to the posterior part of the prothorax. At this point the glands curve ventrally and then forwards and run into the head, where they unite to form a common duct opening between the hypopharynx and the labium. Various modifications of these glands are found in different families, and several have been figured and discussed by Withycombe (1923*b*, 1925*a*). There is some variation of form even within a single species, and Withycombe (1925*a*) states that he has seen a three-branched salivary gland in *Hemerobius stigma*, in which species it is normally simple.

From the pharynx the œsophagus runs back under the supra-œsophageal ganglion and above the body of the tentorium, dilating slightly as it passes through the thorax. In the first and second abdominal segments it dilates considerably, and passes into a large dorsal food reservoir occupying about half of the length of the abdomen. The walls of the œsophagus consist of very thin epithelium, with an extremely delicate chitinous lining, and are surrounded by circular muscles; there are also very delicate longitudinal muscles. The circular muscles of the œsophagus act in such a way that wave-like contractions pass backwards, and food is forced into the food reservoir. In the food reservoir the action of the circular muscles is reversed, the waves of contraction passing forwards and pushing the food into the gizzard, which opens ventrally at the anterior end of the reservoir. The passage of the food into the gizzard is further aided by chitinous partitions which project from between the epithelial cells of the walls of the reservoir.

The gizzard is a funnel-shaped structure situated ventrally in the third abdominal segment. From its thickened, chitinized anterior margin long spines project inwards, whilst internally its walls bear six prominent chitinized ridges set with backwardly directed spines; other chitinized spines and folds occur between these ridges. Externally the walls are well provided with circular muscles and there are also some longitudinal muscles. The narrowed end of the gizzard projects into the mesenteron to form an œsophageal valve.

The mesenteron is a large sac within which, usually for the whole of its length, is a membranous tube, the peritrophic membrane. This is continuous with the chitinous intima of the gizzard, so that the food does not come into direct contact with the enteric epithelium. The epithelial cells are columnar, and rest upon a scarcely visible basement membrane. Circular muscles do not appear to be present, but there are a few longitudinal muscles.

From the anterior end of the hind intestine eight colourless Malpighian tubes are given off. These run forwards to about the second or third abdominal segments and are then recurrent, and six have their distal extremities loosely attached to the hind-intestine just before the rectum. In the Osmylidæ and Sisyridæ the recurrent portion of the Malpighian tubes are brown, while in the Coniopterygidæ there are normally only six tubes, of which four are distally attached to the hind intestine. It should also be mentioned that in all families there is occasional variation in the number of these tubes.

The hind intestine has a similar structure to the œsophagus. Its epithelium is thin and is surrounded by circular muscles. Where the rectum dilates, the epithelium becomes even thinner and there is an outer layer of circular and longitudinal muscles. There are six hemispherical rectal " glands ". The posterior portion of the rectum is narrow, and the anus opens in the membrane between the latero-dorsal lobes (anal plates) of the tenth tergite.

REPRODUCTIVE SYSTEM.

The Male.

The testes are separate in both Hemerobiidæ and Chrysopidæ and are situated dorsally about the middle of the abdomen. Each is enclosed in a yellow or yellowish-brown scrotum. In some species of Chrysopidæ (*e. g. Chrysopa carnea, C. flavifrons*, etc.) they are spirally twisted. In Osmylidæ and Sisyridæ they are fused within a common scrotum. The vasa deferentia may leave the testes from either the anterior or posterior end. They then pass, one on either side of the alimentary canal, to the vesiculæ seminales, which lie ventrally in the posterior third of the abdomen. The vesiculæ seminales are large bodies of complex structure, divided longitudinally in the middle. Their walls are composed largely of columnar cells, which secrete an

albuminous substance around the masses of spermatozoa to form spermatophores. An unpaired ductus ejaculatorius is given off posteriorly from the vesiculæ seminales. The reproductive system in the Coniopterygidæ is peculiar in many respects. According to Withycombe (1925a) the testes have ceased to function when the imaginal stage is reached, and the vesiculæ seminales are represented only by a ventral, oval, single-chambered receptacle, filled with spermatozoa. There is no secretion of albuminous matter to form spermatophores. A wide ductus ejaculatorius, surrounded by circular muscles, leads posteriorly to the penis.

The Female.

The ovaries reach forward to the first abdominal segment, or (Coniopterygidæ) to the metathorax, and lie one on each side of the alimentary canal. Each ovary consists of about ten polytrophic ovarioles, but the number is somewhat variable, and there may be as few as eight or as many as twelve. Two short oviducts from the posterior ends of the ovaries join to form a common oviduct and vagina. The spermatheca lies over the oviduct and is unpaired, usually oval or spherical, pigmented and chitinized. A narrow duct runs from it posteriorly to the vagina. Paired accessory glands, opening into the base of the oviduct, are frequently present ; in *Nathanica* they are large spindle-shaped structures with a long, slender terminal diverticulum ; in *Hemerobius* they are smaller and more or less globular. A second pair of glands, the cement glands, is always present, and of these one only is fully developed and active, the other usually small. As in the case of the accessory glands at the base of the oviduct, they vary in size and form in the different families. In *Sisyra* the secretory gland is an elongate-oval sac, and the short duct leading from it into the chamber at the posterior end of the vagina is slightly dilated ; in Hemerobiidæ it is tubular, with terminal

diverticula, whilst in Chrysopidæ it consists of a simple sac (*C. carnea*), or of a sac surrounded by numerous diverticula (*C. perla*, etc.). The secretion from these glands is colourless and viscid, and serves to fasten the egg to the object on which it is laid, and in the case of Chrysopidæ also forms the long supporting stalk on which the egg is raised. In the Sisyridæ the secretion is spun out more finely as silken threads which are used to construct a web over the batches of eggs.

NERVOUS SYSTEM.

The central nervous system of the imago consists of a brain or supra-œsophageal ganglion, a sub-œsophageal ganglion, three thoracic and usually seven abdominal ganglia.

The supra-œsophageal ganglion lies above the body of the tentorium and the alimentary canal in the dorsal part of the head, and innervates the eyes, antennæ and labrum. It shows distinct division into neuro-meres. Two para-œsophageal connectives pass from it, one on either side of the œsophagus, to the sub-œsophageal ganglion, which gives off paired nerves to the mandibles, maxillæ and labium.

In the abdomen there is commonly one ganglion less than in the larva. Thus in *Hemerobius* and *Chrysopa* there are usually seven, the seventh and eighth ganglia of the larva having become fused, while in Coniopterygidæ two small ganglia take the place of three in the larva.

GLANDS.

In addition to the glands already mentioned, there are several of special interest to which reference must now be made.

Stink glands occur in the Chrysopidæ. They are saccular in form and are situated in the anterior part of the prothorax, where they open laterally under the margin of the pronotum. A large quantity of very

offensive smelling, pale yellowish fluid is secreted by these glands in certain species, sometimes to such an extent that the head is covered with it. They are undoubtedly of protective value against insectivorous vertebrates. The histology of the glands has been described by Sulc (1914) and Stitz (1931).

Wax glands are present only in the Coniopterygidæ, and consist of modified hypodermal cells. Externally they appear as minute circular openings in the integument (Fig. 40B). They are situated in definite areas, mainly on the abdomen, but also on the thorax, the dorsum of the head and elsewhere. On the abdomen
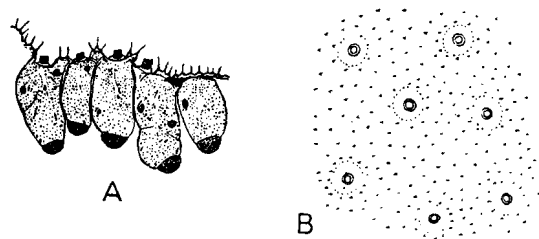

FIG. 40.—*Conwentzia psociformis* (Curt.), wax glands of imago. A. Longitudinal section. B. Surface view. (Fig. A, after Withycombe, 1925, *Trans. Ent. Soc. Lond.*, **1924** : pl. 44, fig. 37.)

the areas occur dorso-laterally and ventro-laterally on most of the segments. Their structure has been described by Withycombe (1925a). Each gland consists of a group of three or four cells, at the internal end of which is a small deeply staining cap cell (Fig. 40A). Within the larger cells are ill-defined ducteoles leading into the main duct of the gland, and this communicates to the exterior through a small papilla set in a concavity of the integument. Secretion commences soon after the emergence of the imago, and the wax is rubbed off the body and distributed over the wings by means of the hind femora.

Scent glands are found in the abdomen of the male of *Osmylus*, and lie, one on each side of the middle line, close under the eighth tergite and reaching into

the posterior end of the seventh segment. Each is a large, darkly pigmented sac, well provided with tracheal branches and densely clothed internally with bristles. The sacs open dorso-laterally between the eighth and ninth tergites, and from each a whitish eversible scent gland is protruded when the male is " calling " the female. The curious courtship in this species is described in Chapter 5.

Paired, evaginable ventral sacs are present on the abdomen in the sub-family Aleuropteryginæ (Coniopterygidæ). These have not been investigated. Withycombe (1925a) suggests that they may be repugnatorial glands.