

On the Morphology of the Larva of *Dorcus parallelopi pedus*, L. (Coleoptera).
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(With 7 Text-figures.)

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CONTENTS.

	Page
I. Introduction and General Features	93
II. External Structure.	94
(a) Head	94
(b) Thorax	100
(c) Abdomen	100
(d) Spiracles	102
III. Internal Structure	102
(a) Digestive System	102
(b) Nervous System	105
IV. Concluding Remarks	108
V. Literature	108

I. INTRODUCTION AND GENERAL FEATURES.

The present paper is intended as a contribution towards a more complete understanding of the morphology of characteristic types of Coleopterous larvæ. Access to abundant living material of the larva of the Lucanid beetle *Dorcus parallelopi pedus* afforded opportunity to make as complete a study as possible of its internal and external structure, which was carried out under the direction of Dr. A. D. Imms. Brief accounts of the external structure of the larva of *Dorcus* will be found in the works of Bree (1833), Ratzeburg (1837), Mulsant (1842), Dufour (1842), Perris (1877), and others, but the most complete description is that of Schiödte (1873). Since the work of the latter authority is over fifty years old, it is naturally somewhat out of date with respect to modern conceptions of morphology, and it makes no reference to internal structure.

The larva of *Dorcus parallelopi pedus* is of the typical Lucanid type, and is somewhat soft, fleshy, elongate in form, almost semicircular in section with flattened underside. It is usually bent in a curve and very often with the last three or four abdominal segments completely turned forward on the ventral side. The head is flexed downwards with its posterior edge covered by the fleshy anterior edge of the prothorax. Its colour is yellowish brown with

darker clypeus, labrum, and jet-black mandibles; on its dorsal surface the Y-shaped epicranial suture appears whitish. There are no eyes. The body is divided into three thoracic and ten abdominal segments. When fully grown the larva is of large size, about 35 mm. long; the sides nearly parallel from the prothorax to the eighth abdominal segment, whence it gradually tapers towards tip of abdomen. The maximum width occurs at the third or fourth abdominal segment, being about one-fourth the length of the body; the maximum depth is at the eighth segment. The body is nearly pure white, deepening posteriorly to a dark grey or brownish tint, due to the dark colour of the viscera appearing through the transparent cuticle; anteriorly on each side of the prothorax there is a narrow yellowish-brown chitinized plate which is dorso-ventrally directed. The thoracic segments are smaller than those of the abdomen, and each is provided with a pair of well-developed five-jointed legs. The abdominal segments are subequal in length dorsally, the first being the shortest and the penultimate one the longest. The cuticle of the first six abdominal segments is thickly beset dorsally with small denticles. The hindmost segment is somewhat conical in shape, and is provided on each side of the anal slit with a well-defined oval area.

II. EXTERNAL STRUCTURE.

(a) *Head.*

Head-capsule (fig. 1).—Semicircular with the anterior margin somewhat concave, narrower than prothorax; its breadth related to the length about as 1.45 : 1, widest at about third the length from base of antenna. Surface finely reticulate under high-power magnification. The number and arrangement of setæ as shown in fig. 1 is characteristic: in addition to these, numerous shorter setæ are present but are not constant in number and position, and for that reason have not been depicted in the figure. Occipital foramen in middle of ventral surface of head-capsule; circular, slightly shorter in diameter than the length of head-capsule. The frons (F, fig. 1) is subtriangular, with a distinct dark median line extending forward from the posterior angle to about third its length; wider than long, with maximum width related to maximum length as 3 : 2; about two-thirds the length of head-capsule and widest anteriorly. Anterior margin is thickened and deeply pigmented at postero-lateral angles of clypeus.

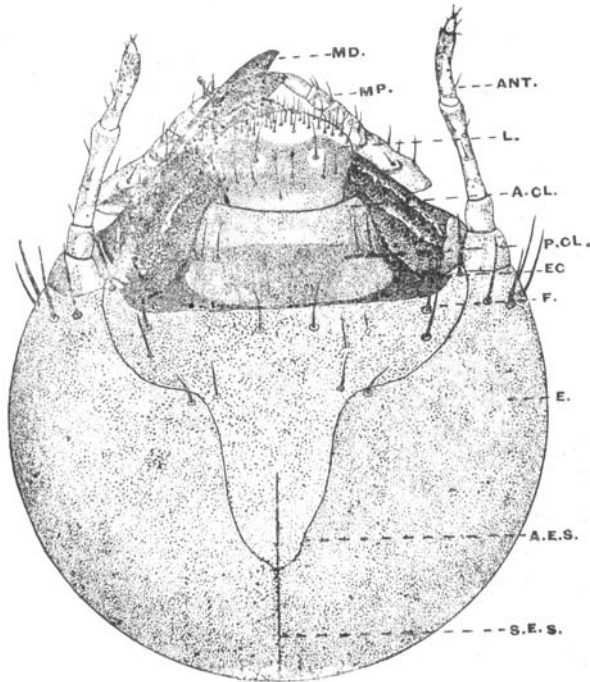
Epicranium (fig. 1, E.) divided posteriorly by the mid-epicranial suture (S.E.S.) and anteriorly separated from the frons by the arms of the epicranial suture (A.E.S.). The mid-epicranial suture about one-third the length of head-capsule and extending forward beyond the junction of the sutural arms into the frontal region. Corresponding with mid-epicranial suture is an internal ridge for muscle-attachments.

Clypeus (fig. 1) is well developed, trapezoidal, distinctly separated from frons, broad at base, the sides narrowed to the apical angles; maximum length

related to maximum width about as 1 to 2.5. *Post-clypeus* (P.C.L.) more strongly chitinized and pigmented than ante-clypeus (A.C.L.); near anterior margin of post-clypeus there is a transverse lateral series of three setæ on each side, the outermost seta being much shorter than the other two.

Labrum (fig. 1, L.) is well developed, movable, sub-rectangular, with anterior margin convex and somewhat obtusely produced; anterior angles rounded, sides narrowing toward the base; total length a little longer than that of the whole clypeus; greatest length related to greatest width as 2 to 1.6. Dorsal

FIG. 1.

Dorsal aspect of head of larva, $\times 12$.

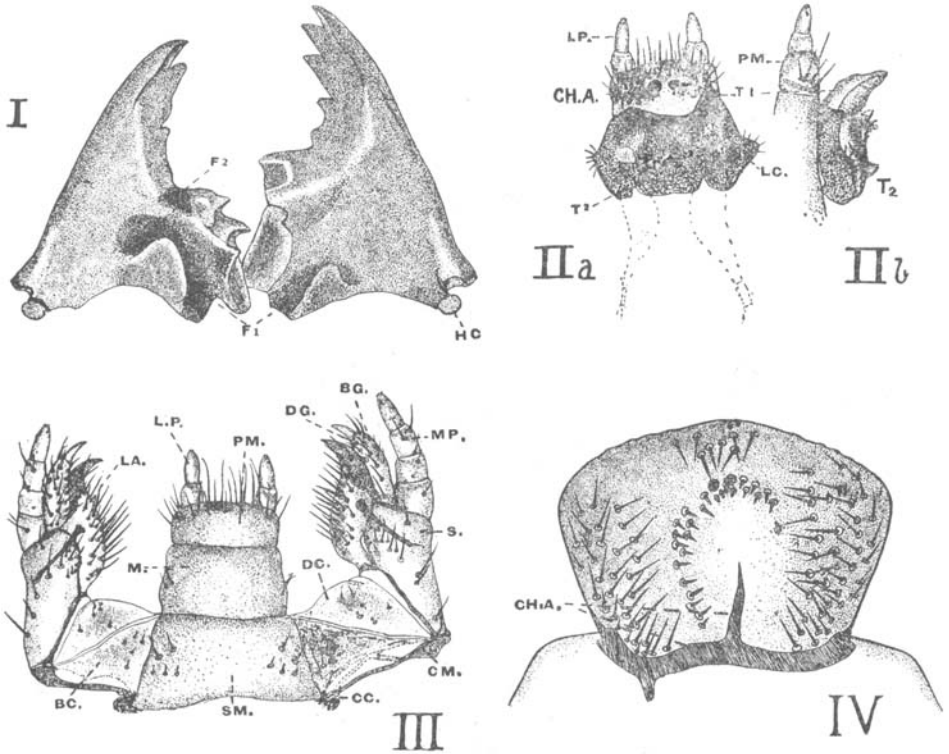
A.C.L., anteclypeus; A.E.S., arms of epicranial suture; ANT., antenna; E., epicranium; EC., epicondyle of mandible; F., frons; L., labrum; MD., mandible; MP., maxillary palp; P.C.L., post-clypeus; S.E.S., median epicranial suture.

surface lighter-coloured anteriorly, where it is thickly beset with short stout setæ; a pair of long dorsal setæ and a variable number (about 7) of short posterior setæ are present.

Antenna (fig. 1, ANT.) well developed, almost as long as mandible, four-jointed, borne on a large conical basal membranous cone; basal joint cylindrical, about one-sixth the length of entire antenna; prebasal joint cylindrical, about

two and a half times the length of the basal joint ; subapical joint shorter than prebasal joint, being about four-fifths its length, slightly flattened laterally and produced anteriorly on its ventral side into a small accessory process of somewhat conical shape ; apical joint small, about one-fourth the length of

FIG. 2.



Details of mouth-parts.

I. Mandibles, ventral aspect, $\times 15$. II *a*. Labium and hypopharynx, dorsal aspect, and II *b*. Left ventro-lateral aspect of same, $\times 15$. III. Maxillae and labium, ventral aspect, $\times 15$. IV. Epipharynx, $\times 32$.

BC., basicardo; BG., basigalea; CC., condyle of cardo; CH.A., chitinized area; CM., cardomarginal; DC., disticardo; DG., distigalea; F₁, F₂, fossæ; HC., hypocondyle; LA., lacinia; LC., lateral condyle; L.P., labial palp; M., mentum; MP., maxillary palp; PM., prementum; S., stipes; T₁, T₂, dorsal and ventral teeth of hypopharyngeal sclerite.

subapical joint, with its maximum diameter related to its length about as 1 to 1.5. All the joints with scattered conical rounded cup-like papillæ, but the latter are more numerous on subapical joint where they nearly all bear

a minute stout seta. Basal joint anteriorly with a single seta ; prebasal joint with about eight setæ ; subapical joint with three near base ; apical joint with three near the middle and two at apex arising from a membranous area, the latter also with two or three peg-like projections or papillæ.

The *Epipharynx* (fig. 2, IV) is membranous forming the under surface or palatal lining of the clypeus and labrum, merging posteriorly into the wall of the pharynx. It is strengthened by a narrow, strong, transverse band of chitin corresponding to or slightly behind the clypeo-labral suture ; a median prolongation extends forward some distance from the transverse chitinized band (CH.A.). The sides of the epipharynx beneath the labrum are clothed with long stiff setæ extending roughly in four irregular rows parallel with its lateral margin. In the middle region there is a shallow depression fringed on its right lateral border and anteriorly by a single row of stout, short, and somewhat blunt setæ, which are inwardly directed ; these setæ are absent on the left margin. This asymmetrical arrangement of spines is probably associated with the structural differences of the two mandibles. Anteriorly the outer series is interrupted by two somewhat rounded, heavily chitinized, raised areas which appeared, in many larvæ dissected, to be guarded in front by a group of about eight long stiff setæ, near anterior margin of the epipharynx. On the surface of each area are two pit-like depressions. Immediately behind these chitinized areas are four very short, stout, peg-like setæ arising from cup-shaped bases.

The *mandibles* (fig. 2, I) are strong and robust, with shiny black cutting and crushing edges. Each mandible is worked by two powerful muscles, an extensor attached to the dorso-lateral surface of the mandible and a retractor to the inner surface. The retractor is far the stronger of the two. Each mandible articulates ventrally with the hypostoma by means of a condyle (HC.) on its latero-ventral surface. Dorsally the mandible bears a condyle (fig. 1, EC.) which articulates with the frons close to the postero-lateral angles of the clypeus. Each mandible is about three-fourths the length of the head-capsule and bears a longitudinal series of three latero-dorsal setæ (fig. 1, MD.). The general form of both mandibles is triangular, but their inner cutting-edges differ (fig. 2, I). On its inner surface the right mandible is produced into two and the left into three well-developed apical teeth ; below the middle both carry a short blunt tooth ; the left mandible also carries a small conical tubercle near the junction of the scissorial with the molar region ; the latter regions of the right mandible are separated by a shallow groove or fossa (F_2) for articulation with the dorsal tooth of the hypopharyngeal sclerite (fig. 2, II, T₁). The molar region of each mandible bears ventrally a well-developed process bounding a fossa (fig. 2, I, F₁) which receives a corresponding process of the hypopharyngeal sclerite.

The *Maxillæ* (fig. 2, III) are completely developed, with the full number of elements present. The maxillary palp (M.P.) is 4-jointed with the basal joint short and broad and about same length as the apical joint ; prebasal joint

narrower, two-thirds the length of the basal joint, and bearing a rounded puncture below the middle on the ventral face; subapical joint about three-fourths the length of apical joint and on its ventral face, slightly anterior to inner border of lateral seta, are two rounded punctures; apical joint conical, about two and a half times longer than wide, with a few scattered punctures, finely papillose at the tip and with a very minute spine-like process near apex on inner border of ventral face. The *lacinia* (*la.*) is about the same length as the palpus—blade-like, armed with rows of strong setae on its inner border and distally produced into a strong chitinized tooth. The *galea* is somewhat lacinia-like in shape, divided into a large basal segment (BG.) and a distal claw-like projection (DG.) which probably correspond with *basigalea* and *distigalea* respectively of Crampton (1923). The galea is about three-fourths the length of palpi, with its basal segment armed with stiff setae and the distal claw half the length of the apical joint of the palp.

The *cardo* is rather large, subquadrate, and separated distally from the stipes and proximally from the submentum by fine sutures. It is divided into two triangular sclerites, viz., a basal element (BC.) connected with the submentum and a distal element (DC.) connected with the stipes. Both areas are but slightly chitinized except for a narrow region (CM.) on the posterior border of the basal sclerite. These regions of the cardo are probably homologous respectively with the *basicardo*, *disticardo*, and *cardo-marginal* of Crampton (1923). The cardo articulates by means of a condyle (CC.) with the posterior angle of submentum. The *stipes* (S.) is about the same length, but narrower than the cardo, and is hinged to the latter. It overlaps the lacinia ventrally, and basally it is strengthened by a narrow, strongly chitinized, and pigmented region. Dorsally it is provided with an elongated tubercle, and one large seta slightly anterior to the latter. On the ventral side it is provided with setae as shown in fig. 2, III, S.

The *labium* (fig. 2, III) is composed of a well-defined submentum, mentum, prementum, and palpi. The *submentum* (SM.) is trapezoidal, broadest posteriorly, twice as wide as long and articulated laterally with the cardo. The *mentum* (M.) is smaller than the submentum, with its side-margins free, about one-third wider than long and bears the prementum on its anterior margin. The *prementum* (PM.) is transversely rectangular in shape, with the anterior angles rounded; its length in proportion to length of mentum as 3 is to 5; the anterior margin is almost straight and provided with closely-set large setae. The *labial palpi* (L.P.) are well developed and two-jointed; the proximal joint is thick and rounded, with few punctures; the distal joint more elongated and slender, about one and a half times the length of basal joint, twice as long as thick, with few scattered rounded punctures and several small papillae at its apex.

The *hypopharynx* is membranous and united with the pharyngeal surface of the labium. Beneath the mentum and distal margin of the submentum it is produced into strongly chitinized plate, or *hypopharyngeal sclerite*.

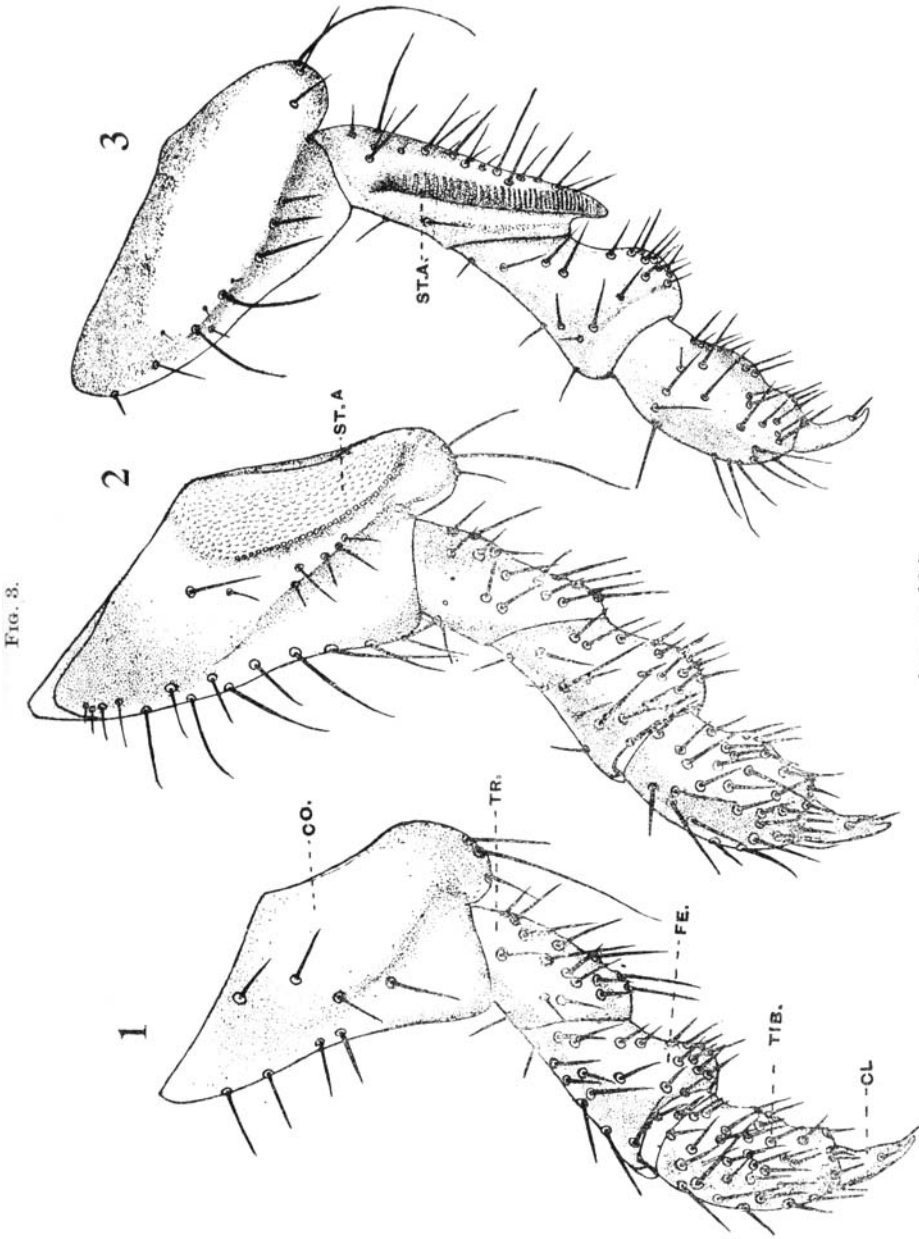


FIG. 3.

Legs, X 12.5.

1. Prothoracic, external lateral view. 2. Mesothoracic, external lateral view. 3. Metathoracic, internal lateral view.
 CL., claw; CO., coxa; FE., femur; ST.A., stridulating area; TIB., tibio-tarsus; TR., trochanter.

The *hypopharyngeal sclerite* (fig. 2, II *a* and *b*) is an asymmetrical transverse structure. Dorsally it is produced into a strong buccal projecting tooth (T_1) which together with a shallow fossa on upper part of right mandible (fig. 2, I, F_2) forms a resistant surface against which upper portion of the molar area of the left mandible works. On either side the sclerite is produced into a somewhat conical projection (LC.) covered with short spines which articulates with hypopharyngeal fossa of the mandible (fig. 2, I, F_1). Dorsally the sclerite bears a blunt posterior tooth (T_2), and close to left extremity of the latter there is a fossa which receives the molar process on the buccal surface of the left mandible.

(b) *Thorax.*

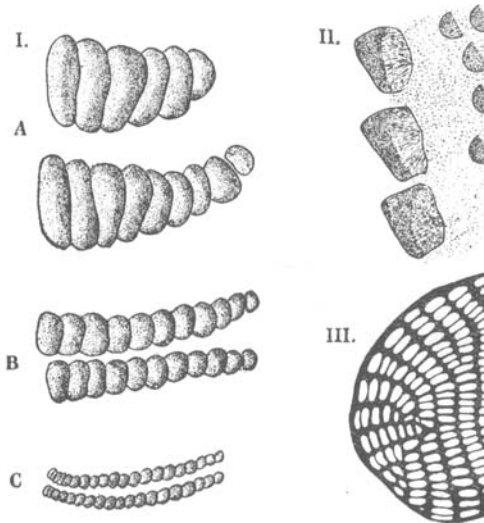
The prothorax is divided dorsally into two slightly raised areas by a transverse groove. Each area bears a transverse row of setæ. Laterally imbedded in the tergum above and in front of first spiracle is an elongated, dorso-ventrally directed, chitinous area. The mesothorax is also dorsally duplicated, the anterior area bearing a transverse row of setæ. The metathorax is simple (dorsally) and likewise carries a transverse row of setæ. A hypopleural chitinization is present at base of legs on all the segments.

The *legs* (fig. 3) are 5-jointed, rather long and stout, with trochanter, femur, and tibia thickly beset with spine-like setæ. The *coxa* (CO.) is well developed, about twice as long as thick, with its proximal margin oblique; distally each coxa is produced into a rounded process which projects beyond the articulation with the trochanter on the inner side; coxa of second leg the longest and bearing a well-defined stridulatory area (fig. 3 (2), fig. 4 (II)) on its external posterior surface. The *trochanter* (TR.) large, about half as broad as coxa, with maximum length in proportion to breadth of pro- and meso-thoracic pairs nearly as 2 : 1 and of metathoracic pair about as 3 : 1; that of metathoracic leg provided on interior surface with a stridulating area (fig. 3 (3), S.T.; fig. 4 (1)). The *femur* (FE.) somewhat club-shaped, broadest distally, with maximum length related to maximum breadth as 3 : 2. The *tibio-tarsus* (TIB.) ovate, slightly constricted basally and almost as long as femur, but distinctly narrower. The *claw* (CL.) slightly curved and pointed, strongly chitinized and dark in colour, nearly half the length of tibio-tarsus, with a short but strong seta on inferior or concave side near apex; another and similar seta somewhat close to it on outer or posterior aspect.

(c) *Abdomen.*

The first five abdominal segments are each divided dorsally into three areas: the median area is the most extensive and is provided with a transverse row of long fine setæ and is also thickly beset with small denticles, while the other areas are smooth and naked. The sixth segment is divided into two areas, viz.: (1) an anterior area with a transverse row of fine setæ and in front of these the cuticle is thickly set with denticles similar to those on the preceding segments, (2) a posterior area which is smooth and naked. The seventh to ninth segments

FIG. 4.

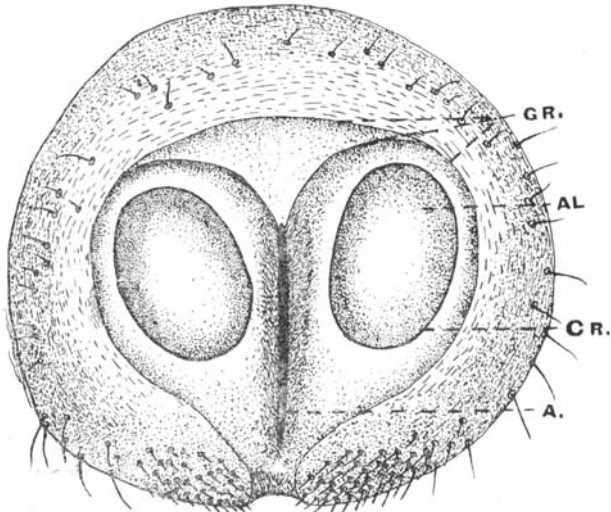


I. Stridulating area on meta-trochanter.
 A. 6th and 7th rows from base. B. Middle region. C. 6th and 7th rows from base.
 × 341.

II. Stridulating area on meso-coxa, × 341.

III. Portion of mesothoracic spiracle, × 228.

FIG. 5.



Tenth abdominal segment, posterior view.

A., anus; AL., anal lobe; CR., chitinized ring; GR., groove. × 16.

are likewise each divided into two areas, viz., an anterior area bearing a row of long fine setæ and a narrow, smooth, naked posterior area.

The tenth abdominal segment (fig. 5) is much smaller than the ninth and is short and somewhat conical in shape. On its posterior surface it bears the anus (A.), which is a dorso-ventral slit. Embedded in the body-cuticle on each side of the anus is a chitinous ring (CR.) which encloses distinct well-defined anal lobes (A.L.). At the postero-ventral margin this segment is deeply emarginated, and the lip thus formed on each side is thickly beset with fine, inwardly-directed setæ.

(d) *Spiracles.*

Nine pairs of functional spiracles are present. They are located on the mesothorax and the first eight abdominal segments; a rudimentary spiracle can with suitable magnification be detected on the anterior margin of metathorax. The mesothoracic spiracle is located on a deeply seated lobe sunk into the posterior part of the prothorax, while the abdominal spiracles are placed anteriorly on their respective segments, except those on 7th and 8th segments, which are seated nearer the middle. They vary to a marked extent in shape and size. Each spiracle appears externally as a minute circular or oval area, surrounded by a broad, C-shaped, cribriform, chitinous respiratory plate and with the "C" directed obliquely cephalad and ventrad. In the last four spiracles the respiratory plate is much reduced and only slightly crescentic. The spiracle on the first abdominal segment is the largest, being about twice the size of those on 5th to 8th abdominal segments. The spiracle on the 6th abdominal segment is the smallest, being about half the size of that on the mesothorax. The perforations of the respiratory plates are comparatively large (fig. 4, III), almost oval in shape, and regularly distributed in more or less radial series.

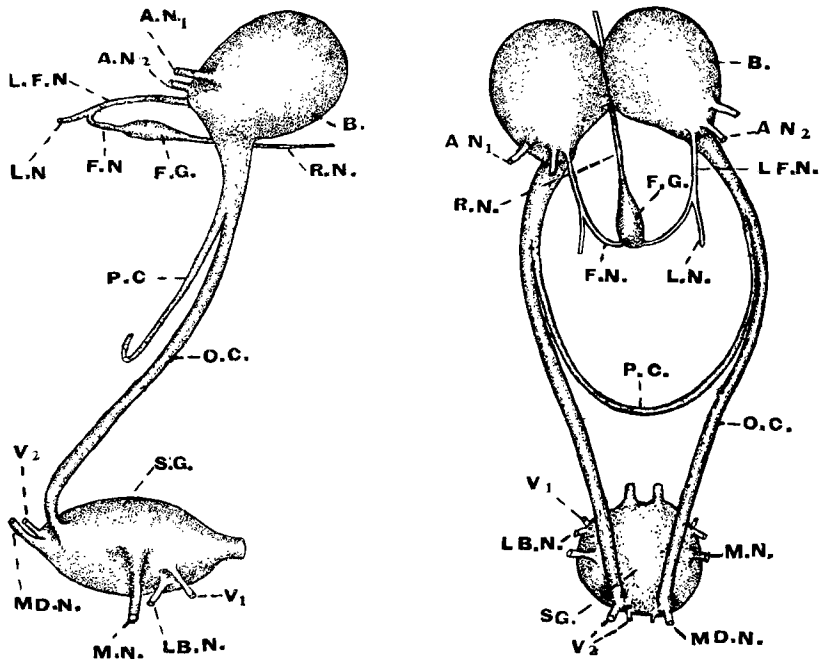
III. INTERNAL STRUCTURE.

(a) *Digestive System.*

Digestive System (fig. 7).—The alimentary canal extends as an almost straight tube from the front of the head-capsule to the last body-segment.

The *fore intestine* is short, extending back only as far as the middle of the mesothoracic segment, but, owing to the contraction and relaxation of the muscles of the head-capsule, the junction of the fore intestine and mid-intestine may be somewhat displaced from the normal position. Immediately behind the mouth the fore intestine dilates to form a *pharynx* from whose walls muscles radiate to the walls of the head-capsule. The pharynx quickly narrows to form a very short *œsophagus* (O.) of nearly uniform calibre: it is lined internally by a chitinous intima which is much folded longitudinally. Posteriorly, the œsophagus gradually expands into a thin-walled *crop* (CR.) which is also lined with chitin. Just where the fore intestine joins the mesenteron a very muscular constriction occurs which probably functions as an *œsophageal* or *cardiac valve*.

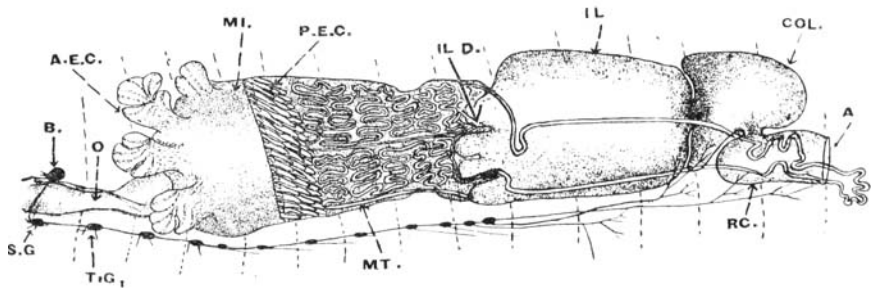
FIG. 6.



Supra- and sub-oesophageal ganglia. Left, lateral view. Right, frontal view. $\times 40$.

A.N₁, antennary motor nerve; A.N₂, antennary sensory nerve; B., brain; F.G., frontal ganglion; LB.N., labial nerve; L.F.N., labro-frontal nerve; L.N., labral nerve; MD.N., mandibular nerve; M.N., maxillary nerve; O.C., para-oesophageal connectives; P.C., post-oesophageal commissure; R.N., recurrent nerve; S.G., sub-oesophageal ganglion; F.N., frontal nerve; V₁, V₂, 4th and 5th pairs of nerves.

FIG. 7.



Alimentary canal and central nervous system, lateral view, $\times 4$.

(The fine broken lines indicate the limits of the segments.)

A., anus; A.E.C., anterior enteric caeca; B., brain; COL., colon; IL., ileum; ILD., diverticulum of ileum; MI., mid-intestine; MT., Malpighian tubes; O., oesophagus; P.E.C., posterior enteric caeca; RC., rectum; SG., sub-oesophageal ganglion; T.G₁, first thoracic ganglion.

The *mid-intestine* (M.I.) forms the largest part of the digestive tract of this species. It passes as a straight tube from near the middle of mesothorax to the beginning of the 6th abdominal segment. It is broadest in front, gradually narrowing to the 4th abdominal segment, where a slight constriction is apparent; from here it again slightly dilates to meet the hind intestine. In large-sized larvæ it has a diameter anteriorly about two-thirds of that of the body and its posterior portion has a diameter of almost two-thirds that of the widest part. The most characteristic feature of the mid-intestine is the presence of an anterior and posterior series of short pouch-like enteric cæca. The *anterior enteric cæca* (A.E.C.) are eight in number, four on each side; two are latero-dorsally placed, one behind the other, while the other two are situated laterally and latero-ventrally, respectively. Each cæcum is lobulated, and it differs histologically from the remainder of the mesenteron. Internally each lobe is much folded and the folds themselves are composed of very elongated narrow cells. The *posterior enteric cæca* (P.E.C.) are about 100 to 120 in number, 50 to 60 on each side, and are arranged in a band of three rows which presents a somewhat U-shaped appearance with the arms dorsally directed and almost meeting at the mid-dorsal line. The cæca of the hindmost row are the longest, while those of the middle row are intermediate in this respect. Furthermore, the cæca in each series gradually increase in size from the dorsal towards the ventral side.

The *hind intestine* consists of three regions—ileum (IL.), colon (COL.), and rectum (RC.). The *ileum* occupies the greater part of the body-cavity from the beginning of the 6th to the rear part of the 8th abdominal segment. It has the form of a straight tapering tube whose posterior diameter is about two-thirds that of the anterior end. At its juncture with the mesenteron in front there is a well-marked constriction which possibly functions as a *pyloric valve*. From the anterior margin of the ileum there arise five short lobular diverticula, which are appressed to the walls of the posterior end of the mid-intestine. Four of these diverticula lie laterally, two on each side, while the other is seated ventrally. The dorso-lateral diverticulum is unilobed and shorter than the others. The ventro-lateral diverticulum is bilobed and slightly longer than the ventral diverticulum. The latter is trilobed, the median lobe being extremely short and blunt. The *colon* which follows is separated from the ileum in front and the rectum behind by distinct constrictions. Its shape and size vary enormously with the amount of residual products of digestion present. Generally it occupies the greater part of the body-cavity of the 9th and 10th abdominal segment. Anteriorly it is usually concave where it is applied to the hind end of the ileum. From this point it overlies the rectum and forms with the latter a somewhat **Z**-shaped bend. The *rectum* is pyriform in shape, with the narrower end posteriorly directed. It is very muscular, and there are also strong bands of muscle-fibres which originate on the external surface of the rectum and are inserted into the body-wall. Finally, the rectum opens to the exterior through the anus (A.), which is a simple dorso-ventral slit situated in a groove in the centre of the 10th abdominal segment.

The *Malpighian tubes* (fig. 7, M.T.) are simple, long, thread-like tubes of uniform diameter throughout, closely appressed to the walls of the mesenteron in front and to the rectum behind. They open at their proximal extremities into the alimentary tract at the juncture of the mesenteron and the hind intestine. There are four of these vessels, two on each side, whose points of origin are latero-dorsal and latero-ventral, respectively. At their apices the tubes of each side are confluent, thus presenting the appearance of loops.

The dorsal tube at first runs ventrally, passing beneath the dorso-lateral diverticulum of the hind intestine, and then proceeds forward along the mid-lateral line of the mesenteron to a point close to the posterior enteric cæca. From here it curves dorsally and pursues a winding course, being thrown into numerous folds and loops on the dorso-lateral surface of the mesenteron from the region of the posterior enteric cæcæ to the anterior margin of the hind intestine. It then continues posteriorly almost in a direct course along the side of the hind intestine on to the dorsal surface of the rectum. Here it becomes convoluted before passing to the oval areas at the tail end of the body, where it is thrown into several folds which are closely applied to the external cuticle of the body-wall.

The ventral tube (M.T.) arises between the ventro-lateral and ventral diverticula of the hind intestine, and passes forwards in an almost direct course close and parallel to the mid-ventral line of the mesenteron. At a point near the posterior enteric cæca it curves dorsally and forms very numerous convolutions which almost completely cover the ventro-lateral surface of the mesenteron. The tube then continues posteriorly, following near the mid-ventral line of the ileum. From here it takes a direct course and becomes continuous with the dorsal tube at the hind end of the body.

(b) *Nervous System.*

The general features of the nervous system of *Dorcus* larva indicate on the whole, a conformity to the simple type found in many insect-larvæ. It may be conveniently divided into the brain, the ventral nerve-cord, and the visceral (or stomatogastric) system.

Brain (fig. 6, B.).—The brain is two-lobed and lies in the upper part of the head-capsule directly below the rear half of the frons. Each lobe is somewhat ovoid in shape with the narrow end directed obliquely forward and downward. Three nerves arise from the antero-dorsal surface of each lobe. The outer and most posterior one (A.N₁) takes a lateral course and innervates the muscle-fibres near base of antenna, and is therefore probably a motor nerve. The median nerve (A.N₂) runs almost parallel with, and in front of, the outer nerve and enters the cavity of the antenna. The root of the remaining nerve, the *labro-frontal nerve* (L.F.N.), lies close and to the inside of the median. Near the posterior margin of the labrum it divides into a *frontal nerve* (F.N.), which unites with the *frontal ganglion* (F.G.), and the *labral nerve* (L.N.). The latter passes forward along the lateral region of clypeus and finally enters the labrum.

The *subœsophageal ganglion* (S.G.) is somewhat oval in shape and is situated slightly anterior to the brain. It lies between the hypopharynx and the labium, immediately behind the posterior margin of hypopharyngeal sclerite and above the anterior border of submentum. The *para-œsophageal commissures* (O.C.) are thick bands which arise from the underside of the anterior extremity of the brain and unite with the upper surface of the anterior end of the sub-œsophageal ganglion. The *post-œsophageal commissure* (P.C.) is a relatively thin strand of nerve-fibres which forms a loop below the œsophagus immediately in front of the para-œsophageal commissures, and is joined with the latter dorsally. The sub-œsophageal ganglion gives rise to five pairs of nerves, as follows :—

(a) The *mandibular nerves* (MD.N.) which arise just below and slightly in front of the insertion of the para-œsophageal commissures (O.C.). Each passes to the base of the mandible, where it divides into branches innervating this appendage.

(b) The *maxillary nerves* (M.N.) arise from the dorso-lateral face of the ganglion about midway along its length. Each nerve passes into the cardo, giving off branches which are distributed to the musculature of this sclerite, and continuing onward enters the stipes where it gives rise to several fine branches.

(c) The *labial nerves* (LB.N.) arise from the latero-ventral face of the subœsophageal ganglion about two-thirds its length from anterior end. Each of these nerves passes to the apex of the labium, dividing along its course into several branches.

(d) The *fourth pair of nerves* (V_1) arises from the lateral surface of the ganglion about third its length from the posterior end. These nerves are very slender and correspondingly difficult to trace. They pursue a caudal course, turning slightly ventrad and laterad, to the posterior region of the submentum. Here each divides into two branches, the course of which has not been followed.

(e) The *fifth pair of nerves* (V_2) are also short and extremely slender. These arise from the anterior face of the subœsophageal ganglion. Their point of origin is to the inside of the mandibular nerves, directly below the inner borders of the para-œsophageal commissures. Each of these nerves passes to the latero-posterior margin of the hypopharyngeal sclerite, where it divides into several extremely fine branches.

The *Ventral Nerve-cord* (fig. 7) consists of 11 ganglia united by separate connectives. In the thorax the three ganglia (T.G.) show no sign of fusion and each lies in its respective segment. There are eight abdominal ganglia, the first lying just within the third thoracic segment; the second abdominal ganglion thus comes to lie inside the first abdominal segment, and, in this way, each of the first five abdominal ganglia is displaced and is situated in the segment in front of the one to which it actually belongs. The sixth abdominal ganglion

lies just within the fourth abdominal segment and the 7th and 8th are situated close together in the fifth segment. The eighth abdominal ganglion is slightly larger than the others and probably represents a fusion of the last three abdominal ganglia.

Each thoracic ganglion gives off two pairs of lateral nerves. The first pair arises from the connectives close to the points where the latter join their respective ganglia anteriorly. These nerves give off branches to the ventral and lateral body-musculature, and ultimately break up into several branches on the latero-dorsal aspect of the body. The mesothoracic pair also gives off an ascending branch which supplies the spiracle.

The second pair of nerves is much stouter and takes origin from the middle of the lateral margins of the ganglion. Each nerve gives off two main branches which innervate the muscles at the base of the coxa, and finally enter the cavity of the coxa itself.

Each of the abdominal ganglia, exclusive of the last ganglion, possesses but one pair of lateral nerves. Each of these arises from the postero-lateral margin of the ganglion close to the point where the latter joins the connective. Each nerve runs posteriorly, almost parallel to the main nerve-cord, into its respective segment and then passes laterally, giving off branches along its whole length to the musculature of the body-wall. It finally passes to the muscles on the latero-dorsal surface of the body.

The 8th abdominal or terminal ganglion gives off two pairs of nerves. The first pair arises from the lateral margins of the ganglion little behind the middle. Each nerve runs posteriorly into the 8th abdominal segment and, after giving off a branch to the ventral trunk-muscles and another to the viscera, passes to the latero-dorsal trunk-muscles.

The second of the two pairs of nerves given off is much stouter and arises from the posterior margin of the ganglion. Each nerve passes posteriorly, giving off a branch which divides into smaller branches supplying the viscera and muscles of the 9th abdominal segment: it then continues backward and becomes sub-divided into several branches innervating the viscera and muscles of 10th abdominal segment.

The Visceral Nervous System.—The visceral or sympathetic nervous system consists of the *frontal ganglion* and the nerves associated with it. The frontal ganglion (fig. 6, F.G.) is pyriform in shape and is situated above the œsophagus, a short distance in front of the brain. It is connected with the latter by means of the *frontal nerves* (F.N.) which arise from the ganglion at its anterior extremity. From this point they curve gradually posteriorly to join with the roots of the labral nerves (L.N.) as already described. Posteriorly the frontal ganglion gives off a *recurrent nerve* (R.N.) which runs in close contact with the dorsal line of the alimentary tract and, passing beneath the brain, expands a short distance behind the latter centre into a *hypocerebral ganglion*. The recurrent nerve leaves the hypocerebral ganglion and immediately divides into two branches. Each branch passes obliquely backwards and ventrally and becomes lost to sight among the muscles of the posterior margin of the fore intestine.

IV. CONCLUDING REMARKS.

In the foregoing description the detailed external morphology of the larva of *Dorcus* is described, together with the salient features exhibited by the digestive and nervous systems.

Apart from other characters the larva of *Dorcus* can be separated from those of other European genera of Lucanidæ by the form and arrangement of the tubercles composing the coxæ and trochanteric stridulatory areas.

In its internal anatomy it exhibits affinities with certain genera of Scarabæidæ in the presence of three series of cæca or diverticula of the alimentary canal. The great lateral pouch-like cæcum of the colon, described in *Cetonia* and in the Coprinæ, is represented in *Dorcus* by a general dilatation of that region of the gut, rather than by a lateral diverticulum. The Malpighian tubes were found to differ considerably from the early account given by Dufour (1842), in that the two tubes of a side form a complex loop, owing to their distal extremities being confluent instead of terminating independently as described by that observer. This condition is rare among insects, but is described by Bugnion (1920) in the Lampyridæ.

The nervous system is of an exceptionally primitive character as in *Lucanus*, and does not exhibit the great concentration of the ganglia of the ventral nerve-cord prevalent in larvæ of the allied family Scarabæidæ.

V. LITERATURE.

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