Scottish National Antarctic Expedition. "Scotia" Collections. Collembola from the South Orkney Islands. By **George H. Carpenter**, B.Sc., M.R.I.A., Professor of Zoology in the Royal College of Science, Dublin. (With Two Plates.) *Communicated by* William Evans, Esq.

(Read March 5, 1906.)

Introductory.

Our knowledge of Antarctic Aptera has been growing rapidly during the last few years, a number of species from remote southern regions having been described by Willem (1902) from the countries south of Patagonia explored by the *Belgica*, by Schäffer (1897) from Tierra del Fuego, by Enderlein (1903) from Kerguelen, and a single Isotoma by the present writer (1902) from South Victoria Land.* We find in the Antarctic as in the Arctic regions that in our advance towards the most remote and inhospitable lands, where winged insects cease to be represented, the primitive Aptera are still found fairly numerous in species, and often multitudinous in individuals. A careful study of these small frail insects fully repays the naturalist, both on account of the interest of their structure and the light which their distribution throws on geographical problems. For the wingless—primitively wingless, as we believe—condition of these insects, their frail integument, and their concealed mode of life make it highly unlikely that they can cross broad tracts of sea; therefore the presence of identical or closely allied species on widely separated islands or continents may safely be regarded as sure evidence of the antiquity of the insects, and of the former existence of land-connections to explain their present discontinuous range.

Three species of Aptera are represented in the collections from the South Orkneys. All belong to the Collembola, and all are referable to the family Entomobryidæ and to the sub-family Isotominæ, two being members of the cosmopolitan genus Isotoma,

* While this paper is passing through the press, Wahlgren's memoir (1906) on the Collembola of the Swedish South Polar Expedition appears.

and the third being referable to Willem's recently described Antarctic genus Cryptopygus. The two species of Isotoma indicate, as will be seen, affinities of the apterous fauna of the South Orkneys to that of other Antarctic lands eastwards and westwards, as well as to that of the Arctic regions, and even to that of the land whence the *Scotia* sailed.

Two of the species are so abundantly represented that a study of the jaws has been possible. In this research much help has been gathered from the recent careful paper by Folsom (1899) on the mouth-parts of Orchesella.

Description of Species.

Isotoma Brucei, sp. nov. Pl. I. figs. 1–8.

Length 1·75 mm. Feelers as long as head. Six ocelli on each side of head (fig. 2). Ridge surrounding the post-antennal organ elongate and narrow (fig. 2, *p. a. o.*). Feet without tenent hairs, claws slender and untoothed (fig. 5). Spring evidently borne on the fourth abdominal segment, slender and elongate, one-fourth length of insect; manubrium longer than dens; mucro short, with a prominent thick terminal tooth and two strong basal teeth (figs. 1, 6, 7). Colour slaty grey, the pigment somewhat scattered. Hairs on body short, a very few strong bristles on the tail segment.

Locality. — Laurie Island, South Orkneys. Innumerable specimens on the sea-shore on the carcase of a penguin. 9th January 1904.

The discovery of this insect in the Antarctic regions is of very great interest on account of its close relationship to the Arctic and sub-Arctic *I. Beselsii*, Packard.* In the general build of the body and the structure of the spring—particularly the form of the mucro, with its three prominent claw-like teeth—these two species of Isotoma stand apart from all other members of the genus. *I. Brucei* is somewhat smaller than *I. Beselsii*, and has the spring, especially the dens, relatively longer and more slender; the mucro relatively longer and narrower and its teeth weaker. These differences are, however, less apparent in young individuals.

* *Isotoma spitzbergensis*, Lubbock. See Carpenter and Evans (1899), Schäffer (1900). The species is recorded by Wahlgren (1906) from Tierra del Fuego.

In the shape of the ridge surrounding its post-antennal organ, *I. Brucei* agrees closely with *I. Beselsii*; but while the latter has the sixteen ocelli which are usually present in species of Isotoma the former has only twelve, the two posterior ocelli of the inner row of four, on each side, being absent. The antennal organ consists, as in *I. Beselsii*, of two prominent hemispherical papillæ at the extreme apex of the fourth antennal segment (fig. 2, *a. o.*). The feet in the present species have, as in *I. Beselsii*, untoothed claws and no tenent hairs; the apex of the smaller claw is, however, drawn out in a slender process, which is not so fully developed in the northern species.

The mouth-parts of *Isotoma Brucei* show several interesting peculiarities. The mandibles are remarkably narrow and parallel-sided at the apex (fig. 3), and exhibit two very prominent acuminate processes at the hind dorsal corner of the grinding area (fig. 3, *mo.*). The maxillulæ (fig. 4, *mxl.*) have prominent apexes, armed with several stout curved bristles; the spines, arranged in series along the inner edge of the basal region of the maxillula, are elongate and sharp-pointed.

In the structure of the maxilla (fig. 4, *mx.*) *I. Brucei* differs from other species of Isotoma, and indeed from members of its family generally, by the slender and elongate form of the "head" (compare the typical semi-globose "head" of Cryptopygus, fig. 19). The head in the present species is composed of a strongly chitinised dorsal lobe or "galea" (fig. 4, *ga.*), terminating in three prominent teeth. Ventral to this, and protruding beyond it, is a delicate falcate lamella (fig. 4, *la.'*), fringed with long delicate hairs, while a smaller lamella, also fringed with fine hairs (fig. 4, *la.''*), lies internal to the galea. The palp (fig. 4, *pa.*) carries six prominent bristles, the most distal being inserted on a long acuminate process. The stipes of the maxilla (fig. 4, *sti.*) articulates with the cardo (fig. 4, *car.*), which is itself in connection, as usual, with the supporting "foot" and ligament (fig. 4, *pd. lig.*) of the tongue (fig. 4, *lin.*).

Several at least of these characteristic features of the jaws in *I. Brucei* may also be detected in its northern ally *I. Beselsii*.

The form of the retinaculum in *I. Brucei*, as seen from the side, is shown under high magnification in fig. 8.

Isotoma octo-oculata, Willem, var. *gracilis*, nov. Pl. II. figs 9–12.

Length 1·5 mm. Differs from the type by the short sub-crescentic ridge surrounding the post-antennal organ (fig. 10, *p. a. o.*) and the slender mucro of the spring, with its anterior dorsal tooth pointed and prominent (fig. 12). In this latter character the present variety agrees with that described from Kerguelen by Enderlein (1903).

Localities.—Laurie Island, on cliff and moss 200 feet, one specimen, 18th December 1903; Saddle Island, one young specimen, 4th February 1903.

As only two specimens can be detected in the collection, this is presumably a scarce species in the South Orkneys. The type-form was described by Willem (1902) from insects collected on the shores of Gerlache Strait, between Danco Land and neighbouring islands,* and a sub-species, *Kerguelensis*, has since been described, as mentioned above, by Enderlein. In the form of its mucro our insect agrees with the latter, from which, as well as from the type-form, it may be readily distinguished by the short and relatively broad post-antennal organ. According to Enderlein's figure, however (1903, taf. xxxvi. fig. 66), the organ is broader and shorter in the var. *Kerguelensis* than in the type (Willem, 1902, pl. iv. fig. 11).

Cryptopygus crassus, sp. nov. Pl. II. figs. 13–23.

Length 2 mm. Post-antennal organ elongate, crescentic. Six ocelli on each side of head (fig. 16). Feet with two tenent hairs, not clubbed at the tip, and with untoothed claws (fig. 17). Spring with mucro one-third length of dens, bearing two slight teeth, a terminal and a dorsal (fig. 21). Colour very deep blue-violet, almost black in adult specimens.

Localities.—Saddle Island, innumerable specimens, 4th February 1903; Laurie Island, two specimens in moss on cliff 200 feet, 18th December 1903.

The remarkable genus Cryptopygus, showing affinities to Anurophorus and to Isotoma, was erected by Willem (1902) for a new species of springtail (*C. antarcticus*) found in numbers on the shores

* Recorded also by Wahlgren (1906) from South Shetland, Graham Land and Paulet Island.

of Danco Land and the neighbouring islands.* The present species from the South Orkneys is very closely related to Willem's insect, differing chiefly in having only twelve ocelli (instead of fourteen), and in the comparatively short and stout mucro of its spring. In the adult *C. crassus* the six ocelli on either side are arranged in an anterior triangular group of three and a posterior curved row of three (fig. 16), (the fourth ocellus, nearest to the centre of the head, which is present in *C. antarcticus*, being here absent). In the very young *C. crassus* the six ocelli are more closely grouped (fig. 15). These very young individuals (fig. 13), only ·5 mm. in length, have the violet pigment mottled over their bodies, contrasting strongly with their almost black parents. The springs of these young—especially the dentes and mucrones—are shorter and stouter than those of the adults (figs. 21, 22, 23). Among the adults the males may be distinguished from the females (fig. 14) by their more slender form and more elongate feelers (fig. 16). In the male these have the terminal segment half as long again as the third, while in the female there is no appreciable difference in length. The antennal organ consists of a single papilla at the extreme tip of the terminal antennal segment (fig. 16, *a. o.*).†

In the excessive reduction of the hindmost abdominal segment (fig. 14, *abd.* vi.), retracted and almost hidden in a depression of the genital segment (fig. 14, *abd.* v.), *C. crassus* agrees closely with *C. antarcticus* as described and figured by Willem. This character gives the name to the genus.

Examination of the mouth-parts of *C. crassus* (figs. 18–20) shows that they conform to the type usual in the Collembola. The mandible is very slender at the tip, which bends markedly towards the centre of the head (fig. 18, *ap.*) and ventralwards (fig. 20); the apical teeth are feeble and close together. On the outer edge of the mandible, opposite the grinding surface (figs. 18, 20, *mo.*), is a characteristic prominent shoulder (fig. 18, *hu.*), and the conical process (for attachment of a rotatory muscle) on the dorsal aspect of the base of the mandible (fig. 20, *pro.*) is also prominent.

* Recorded by Wahlgren from South Shetland, Graham Land, Paulet Island, and South Georgia.

† *Cryptopygus cinctus*, newly described by Wahlgren (1906) from Tierra del Fuego and East Falkland, has, like *C. crassus*, only twelve ocelli, and no clubbed hairs on the feet. It is, however, variegated in coloration when adult.

The maxillulæ (fig. 19, *mxl.*) are simple in form, with a few minute bristles at the tip or their inner faces; the arm (fig. 19, *br.*) which supports the maxillula is bent and irregularly furcate in shape. It is connected by a ligament (fig. 19, *lig.*) with the outer framework of the maxillula, this being itself continuous with the inner chitinous rod of the maxilla (fig. 19, *rh. int.*), as explained by Folsom (1899) for Orchesella.

The maxillæ (fig. 19, *mx.*) are of the typical Collembolan form; the palp, however, is remarkable on account of the production of its tip into a tongue-shaped process bearing four bristles, and the excessive development of the long proximal bristle and its papilla (fig. 19, *pa.*).

Distributional Notes.

As mentioned in the introduction to this paper, the existence of identical or of nearly allied species of Collembola on widely separated areas may be regarded as strong evidence for ancient land connections between those areas. Many recent writers on zoological geography have expressed belief in a former extension of the Antarctic continent, wide enough to connect with America, Africa, and Australia. A full discussion of the problem has recently been given in Ortmann's valuable paper (1904, pp. 310–324, with map, pl. xxxix.) on the Tertiary invertebrate fauna of Patagonia, and there can be no doubt that the trend of modern speculation is against the doctrine of the permanence through past ages of the great ocean basins of the present day, as upheld in the classical writings of Darwin and Wallace. Hutton, who many years ago suggested the Antarctic continent as a former means of communication between Australia and Patagonia, and subsequently withdrew the hypothesis in favour of a trans-Pacific continent, has now re-affirmed his former belief (1905), laying special stress on the Collembola of South Victoria Land as evidence for the former connection of that remote region with the northern continents.

From the facts established in the present paper, further support for the ancient extension of Antarctica may be readily drawn. The existence of the genus Cryptopygus and of the species *Isotoma octo-oculata* on the South Orkneys as well as on Danco

Land, together with the presence of the Isotoma on Kerguelen, point to the former existence of extensive land tracts south of the American continent, with connection, either by way of Antarctica or of South Africa, to Kerguelen. It cannot indeed be inferred from the distribution of these springtails that there was at any one period a continuous land surface from Patagonia and Graham Land to Kerguelen. But it can hardly be denied that the insects must have travelled overland, though the land connections may have varied in extent, and become broken at different points during different periods. The bathymetrical work of the *Scotia* Expedition, as set forth by Bruce (1905), demonstrating a continuous bank, less than 2000 fathoms beneath the surface of the South Atlantic, stretching eastwards from the South Orkneys towards South-East Africa, makes the former existence of one such land-tract the more credible. And the geological structure of the South Orkneys leaves no doubt that they must be regarded as strictly "continental" islands. Similarly, the "Kerguelen plateau," as mapped by the explorers of the *Valdivia* (Schott, 1902), renders in the highest degree probable the former union of Kerguelen with Antarctica; and a connection thence to South Africa is not impossible of acceptance.

If, as we believe, these springtails—apparently members of a typically Antarctic fauna—owe their presence on the islands that they now inhabit to a former extension of the Antarctic continent, they must be of a considerable geological age. Ortmann (1904) considers that the greatest extension of Antarctica existed in the Cretaceous and Eocene eras. Hutton (1905) argues for the Jurassic as the period of most extensive land in southern regions. We may safely conclude that Cryptopygus and *Isotoma octo-oculata* have survived throughout the Tertiary epoch at least, with comparatively little change of structure.

The affinities of *Isotoma Brucei* open up a problem of even greater interest. It is closely allied, as we have seen, to *I. Beselsii*, a springtail which has been found in Spitzbergen, Jan Mayen Island, Scotland (shores of the Firth of Forth), Greenland (Polaris Bay), and Massachusetts. We cannot doubt that this affinity points to a former connection between the Antarctic continent, of which the South Orkneys once formed part, and the

northern continents. The presumption seems that this connection was by way of America, and the distribution of some allied springtails supports this presumption.* The common European *Isotoma palustris*, Müller, occurs both in North and South America; and Schäffer (1897) has described an Isotoma—*I. obtusicauda*—from Valparaiso, closely allied to two peculiar northern species, *I. crassicauda*, Tullberg, and *I. littoralis*, Della Torre. These last-mentioned insects come nearer than any other species of Isotoma to *I. Brucei* and *I. Beselsii*, agreeing with them in the evident position of the spring on the fourth abdominal segment, but differing in the absence of prominent teeth on the mucrones. We find, therefore, that these groups of springtails, considered until a few years ago characteristically Arctic and sub-Arctic, are represented in the Andean sub-region of South America, in Tierra del Fuego, and in the distant South Orkney Islands.

Must *I. Brucei*, with its northern affinities, be regarded as an older or a newer member of the South Orcadian fauna than the distinctively Antarctic species that share its present home? Northern species, at or beyond the southern limits of the present American continent, must be either comparatively recent immigrants—Pliocene or later—or else carry us back to early Mesozoic times; for the existence of some sea-channel across America, checking migration from north to south, during the Cretaceous and Early Tertiary periods, is generally admitted. Von Jhering, for example, lays stress (1891) on the faunistic distinction between southern and northern South America, and suggests the existence in Secondary and Early Tertiary times of two continents—an "Archiplata" connected with Antarctica, and an "Archicguyana" connected by an Atlantis with West Africa. Now it seems unlikely that *I. Brucei* can be a late Tertiary immigrant into the Antarctic regions. The necessary connection of the South Orkneys with Patagonia can hardly have lasted late enough. And the group to which the species belongs is a primitive group even of this comparatively primitive genus and order. In these insects, as mentioned above, the spring evidently belongs to the fourth abdominal segment, whereas in most species of the genus and

* Which receives unexpected confirmation from Wahlgren's discovery (1906) of *I. Beselsii* in Tierra del Fuego.

family it is apparently borne on the fifth. Willem (1900) has shown, however, that in reality it always belongs to the fourth. Thus we see that in the group of *I. Brucei* an ancient character has been retained, and the shore-haunting habit of all the species belonging to it is another mark of high antiquity. It seems probable, therefore, that *I. Brucei* is older than the typically Antarctic species ; and that, for the land connections over which its ancestors travelled, we must go back to early Secondary times.

It is startling to conclude that these frail insects of the far north and the remote south, now separated by thousands of miles of land and sea and ice, have passed through so great a length of geological time with such slight structural deviation from their common progenitors.

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DESCRIPTION OF PLATES.

PLATE I.

Fig. 1. *Isotoma Brucei*, side view, × 40.

Fig. 2. Do. left side of head, dorsal view, showing ocelli, feeler, antennal organ (*a. o.*), and post-antennal organ (*p. a. o.*), × 100.

Fig. 3. Do. right mandible, ventral view, × 200; *ap.*, apical teeth; *mo.*, grinding surface.

Fig. 4. Do. right maxilla (*mx.*), ventral view, shown in association with the tongue (*lin.*), and the right maxillula (*mxl.*); *ga.*, galea; *la.'*, ventral lamella; *la."*, inner lamella; *sti.*, stipes; *car.*, cardo; *pa.*, palp; *pd.*, foot of tongue; *lig.*, ligament of tongue. The left maxilla and the left half of the tongue are removed to expose the left maxillula (*mxl.'*), and its supporting arm, *br.*, × 200.

Fig. 5. Do. hindmost leg, showing claws, × 200.

Fig. 6. Do. dorsal view of spring, × 200.

Fig. 7. Do. dens and mucro of spring, side view, × 250.

Fig. 8. Do. retinaculum, side view, × 600.

PLATE II.

Fig. 9. *Isotoma octo-oculata*, var. *gracilis*, side view, × 40.

Fig. 10. Do. left corner of head, showing ocelli, post-antennal organ (*p. a. o.*), feeler, and antennal organ (*a. o.*), × 100.

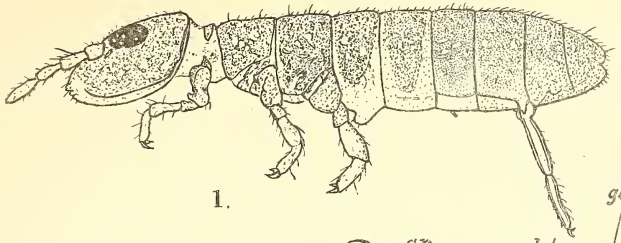
Fig. 11. Do. hindmost foot, with claws, × 200.

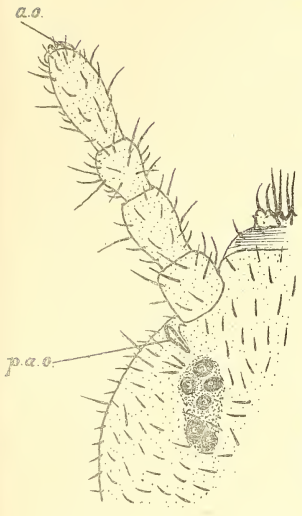
Fig. 12. Do. tip of dens with mucro, side view, × 300.

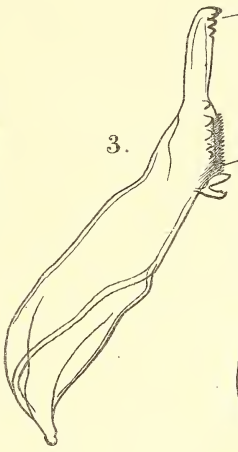
Fig. 13. *Cryptopygus crassus*, young specimen, × 40.

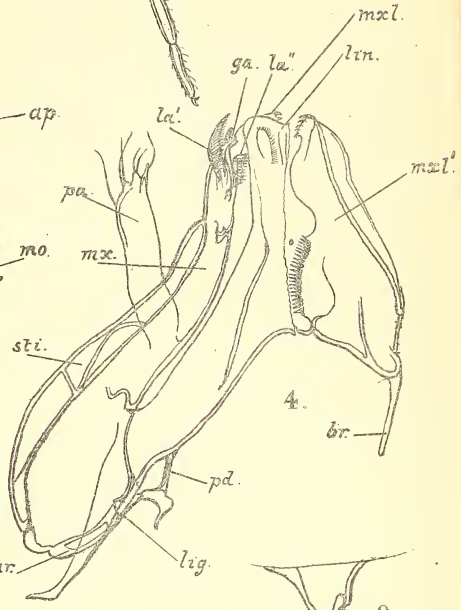
Fig. 14. Do. adult female, side view, × 40.

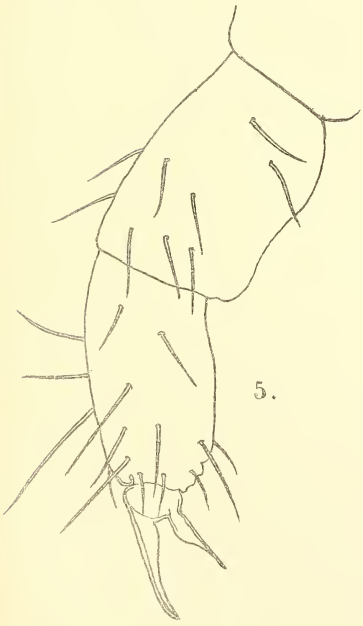
CARPENTER : ANTARCTIC COLLEMBOLA. Plate I.

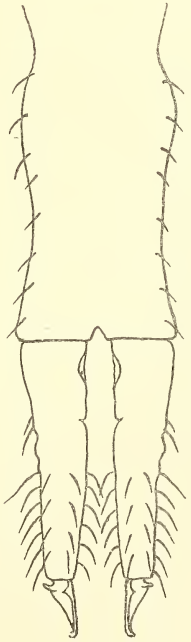


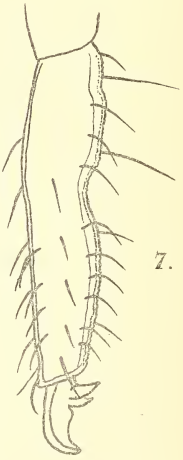




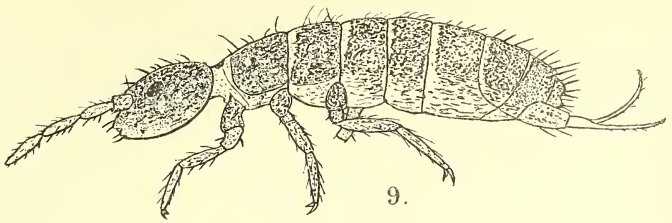


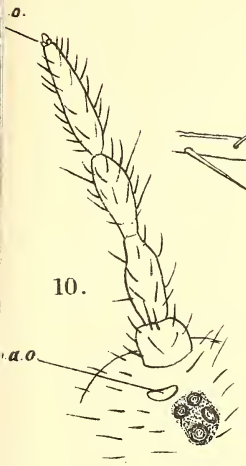


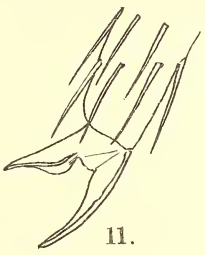


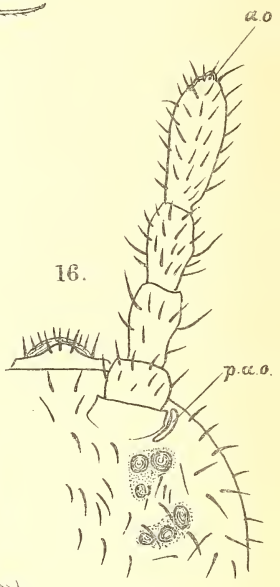


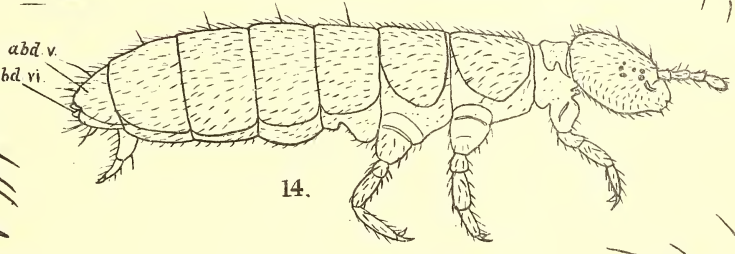
CARPENTER: ANTARCTIC COLLEMBOLA. Plate II.

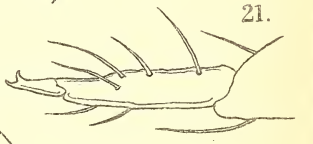












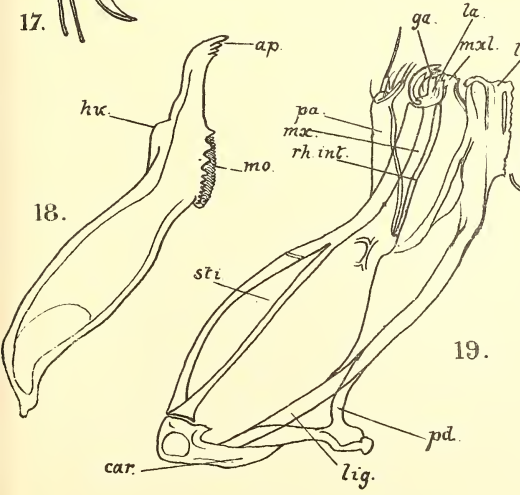


Fig. 15. *Cryptopygus crassus*, ocelli and post-antennal organ of right side of young individual (fig. 13), × 150.

Fig. 16. Do. ocelli, post-antennal organ (*p. a. o.*), feeler, and antennal organ (*a. o.*) of right side. Adult male, × 150.

Fig. 17. Do. hindmost foot, with claws, × 200.

Fig. 18. Do. right mandible, ventral view; *ap.*, apical teeth; *mo.*, grinding surface; *hu.*, external shoulder; × 200.

Fig. 19. Do. right maxilla (*mx.*), maxillula (*mxl.*), and tongue (*lin.*), ventral view; *ga.*, galea; *la.*, lamellæ; *pa.*, palp; *rh. int.*, internal chitinous rod; *sti.*, stipes; *car.*, cardo; *pd.*, foot of tongue; *lig.*, ligament of tongue. The left maxilla and left half of the tongue have been removed to expose the left maxillula (*mxl.*), with its supporting arm (*br.*), and ligament (*lig.*), × 200.

Fig. 20. Do. right mandible, viewed from inner aspect; *ap.*, apical teeth; *mo.*, grinding surface; *pro.*, dorsal process, × 200.

Fig. 21. Do. dens and mucro of spring, adult specimen, side view, × 250.

Fig. 22. Do. spring, half-grown individual, × 250.

Fig. 23. Do. spring, very young individual (fig. 13), × 250.

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