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Article XXI.— PARASITIC MUSCID LARVÆ COLLECTED FROM THE AFRICAN ELEPHANT AND THE WHITE RHINOCEROS BY THE CONGO EXPEDITION.[1]

By J. Bequaert.

I am greatly obliged to the American Museum for the opportunity which has been given me to study certain parasitic larvæ collected by Messrs. Lang and Chapin in the course of their expedition to the Belgian Congo. The parasites here reported upon are all of known species but our knowledge of these insects is, as yet, so fragmentary that I think it worth while to review the material which is before me, especially as it may encourage hunters and sportsmen in Africa to collect such parasites.

A. Larvæ parasitic upon the African Elephant (*Loxodon africanus* Blum.).

1. Larvæ in the sole of the foot: *Neocuterebra squamosa* Grünberg[2]; one vial containing larvæ in the third stage with the label "Fly larvæ from sole of foot of elephant ♂, Avakubi, May 10, 1914" (Belgian Congo: Ituri). These larvæ do not differ in any particular from the original description or from those which I have seen from the Lower Uele.[3] They seem to be rather rare and, as yet, have been found only in the forest region.

Through the courtesy of Mr. Chas. Schaeffer, of the Museum of the Brooklyn Institute, I was able to compare the larvæ from the foot of the African Elephant with the cuticolous parasites forming the Muscoidean genus *Cuterebra* B. Clark (= *Cutiterebra* Scudder). The latter is peculiar to North and South America, where it appears to present numerous forms; but, as a whole, our biological knowledge of these insects is in a very unsatisfactory state. There have been described, so far, over thirty species, but nearly all of them from imagoes only; furthermore, the specific identity of some of the few recorded larvæ has not been definitely cleared up.

From an examination of a good series of *Cuterebra* and *Dermatobia* Br. it seems to me that both genera must be included, on account of the morphological structure of the imagoes, in Girschner's Muscoidean group "Tachi-

[1] Scientific Results of the Congo Expedition. Entomology, No. 1.
[2] Sitz. Ber. Ges. Naturf. Freunde, Berlin, 1906, p. 46, fig. 6–9.
[3] See J. Rodhain and J. Bequaert, Bull. Soc. Path. exot. Paris, VIII, 1915, p. 765.

nidæ."[1] The hypopleural bristles are present and numerous, but distributed irregularly over the hypopleuræ and in the same hairy (apparently degenerate) condition as in some other parasitic Muscoidean groups (Œstrinæ *s. str.* Hypoderminæ); the sternopleural bristles are completely wanting; the curve of the fourth longitudinal wing-vein is well marked, the raised branch forming a distinct apical cross-vein. The thoracic calypter (*squamula thoracalis*) is strongly developed and projects far behind the margin of the alar calypter (*squamula alaris*); the alulets are separated by a narrow acute notch but are contiguous at the base. As to the further affinities of these genera in the "Tachinidæ" group, they are nearly related to the Œstrinæ *s. str.* and Hypoderminæ, presenting like both of these, a very strongly developed ventral membrane, which surrounds entirely the relatively small, somewhat depressed abdominal sternites. At the present time, however, it would seem best to leave them as a special tribe or subfamily "Cuterebrinæ," although, apart from the deep oral slit containing the rudimentary geniculate proboscis, I was unable to find any peculiar character. Probably we must include in the same group the genera *Rogenhofera* Br. and *Bogeria* Austen, and perhaps also *Pseudogametes* Bischof; but these three genera are, thus far, unknown to me.

Returning now to the larvæ of *Cuterebra*, their morphological characters apparently do not give any indication as to the systematic position of these parasites. So far as I am aware, these larvæ are only described in the third stage, and in this stage their general structure is, at first glance, very similar to that of most cuticolous larvæ, even of distant relationships, and this results, I suppose, merely from convergent adaptations. I must refrain, however, from any detailed discussion of the *Cuterebra* larvæ, but I think that a comparison of these parasites with the dipterous larvæ from the foot of the African Elephant will not be without interest.

As to the external morphological characters, *Neocuterebra* and *Cuterebra* look very much alike indeed. Their general aspect and shape are the same. They present the same peculiar structure of the posterior end of the abdomen. In *Neocuterebra* the twelfth segment is very small, smaller indeed than in the *Cuterebra* larvæ I have examined, and completely retracted in the eleventh. The mouth-hooks are also very slender and probably functionless. Furthermore, the spinulation is formed by the same flattened, scale-like spines, covering nearly the whole of the body; in both genera intermediate median fields between the segments are completely lacking. With regard to the longitudinal pads on the sides, I do not think there is so

[1] See Berliner Entom. Zeitschr., XXXVIII, 1893, pp. 297–312; Illustr. Wochenschr. f. Entom., I, 1896.

much difference between *Cuterebra* and *Neocuterebra* as was pointed out by Grünberg (*loc. cit.*). The figures of "*Cuterebra emasculator* Fitch" as published in Insect Life, I, 1889, p. 214, show such lateral pads very strongly marked, but from what I could see on the Brooklyn Museum material this is rather a post-mortem appearance. The living *Cuterebra* larvæ must be, I believe, nearly double-convex, only slightly or not at all dorso-ventrally depressed, although somewhat broader than thick.

A closer examination, however, of the internal structure of the larvæ reveals that *Neocuterebra* and *Cuterebra* have not the slightest affinity: *Cuterebra* is amphipneustic, the anterior spiracles being very strongly developed and becoming horn-like structures projecting anteriorly in the puparium (as I could see in a fine example kindly given to me by Mr. Wm. T. Davis). These horn-like projecting spiracles were sometimes mistaken for larval antennæ, with which they have no relation whatever. The two cephalic segments (proto- and postcephalon) are distinctly separated (the body thus presents twelve distinct segments) and each of the antennal papillæ bears two small ocellar chitinous spots. The two posterior stigmatic plates are large, semilunar or reniform, openly exposed at the bottom of the retracted twelfth segment and easily detected in most larvæ; they are of the so-called "porous" type (as those of *Œstrus* and *Hypoderma*), but their inner structure has never been worked out.

In *Neocuterebra* on the other hand, the larvæ are metapneustic, the anterior spiracles being not at all visible externally. The two cephalic segments are completely fused in a single pseudocephalon (therefore the larvæ have apparently only eleven segments); each antennal papilla bears a single distinct ocellar spot. The two posterior stigmatic plates are small, oval, entirely hidden in a deep cavity of the anal segment closed by two somewhat chitinized falcate lips (these may be at first glance mistaken for the posterior spiracles); each plate bears three elliptical, elongate, transverse peritremes, which are straight or slightly curved.

From the preceding remarks it appears that *Neocuterebra* cannot be reasonably placed in the American group of the Cuterebrinæ. Its relations to the true cuticulous group Hypoderminæ are still less apparent.

Judging from the characters afforded by the larvæ, the nearest allies of *Neocuterebra* are perhaps some Calliphorinæ parasites belonging to the African genus *Cordylobia* (especially the more strongly developed form *C. rodhaini* Ged.); but as the imago is still unknown, it is not possible to fix definitely the systematic position of *Neocuterebra squamosa* among Diptera.

2. Larvæ in the stomach.— In a paper written in collaboration with Rodhain (*loc. cit.* 1915, p. 768–778) we have brought together the facts concerning these parasites and have shown that there are two distinct species of larvæ in the stomach of the African elephant.

The material collected by Messrs. Lang and Chapin, which is very abundant, contains but one of these species: *Cobboldia loxodontis* Brauer (Denkschr. k. Ak. Wiss. Wien, math. naturw. Cl., LXIV, 1897, p. 267). Certain of these larvæ are fully developed, attaining a length of 26 mm. and a breadth of 6.5 mm.; all are in the third stage; the smallest is not more than 10 mm. in length but, nevertheless, has three peritremes in each stigmatic plate. The second stage larva of *Cobboldia* does not seem to have been described.

The larvæ collected by Messrs. Lang and Chapin were found in the savannah region of the Uele (northeastern Congo), a smaller number from Bagboro (near Yakuluku, October 1911); and by far a larger number from Vankerckhovenville (April 9, 1912).

I think that it is not without interest to state here that, thanks to the kindness of Mr. R. Van Saceghem, I have recently been able to study gastric larvæ from elephants collected at Bokala (Middle Congo, near the mouth of the Kasai). In this way I have been able to determine that in this region, just as in the forest region of the Lower Uele, the two species of *Cobboldia* (*C. loxodontis* Br. and *C. chrysidiformis* R. & B.) live together in the stomach of the same individual elephant. Perhaps it is normal for the two species to live together in the forest region of Africa whereas in the savannah region *C. loxodontis* Br. may occur alone. This suggestion could be easily and with interest verified by collecting larvæ in the different regions. These two species of *Cobboldia* may be easily separated in their larval state in the following way: *C. chrysidiformis* R. & B. has a conical papilliform protuberance on each side of segments eight to eleven, while these protuberances are absent from *C. loxodontis* Brauer.

B. Gastric larvæ of the White Rhinoceros (*Rhinoceros* [*Ceratotherium*] *simus cottoni* Lyd.).

The existence of larvæ in the stomach of rhinoceroses has been known for a long time but it is only recently that we have had any definite information concerning the life history of these parasites. The first reference to the presence of Œstrid larvæ in the stomachs of African rhinoceroses dates from 1839: Hope, in a paper on the parasitic larvæ of man[1] figures incidentally (but without description) one of these parasites as "*Œstrus rhinocerontis* Owen," under which name it was classified in a museum (*op. cit.*, p. 259, Tab. XXII, fig. 1 and 1*a*). In 1863, Brauer (Monogr. d. Œstrid, p. 92) briefly described, after the figure of Hope, the same larva under the name of

[1] Trans. entom. Soc. London, II, pt. 3, pp. 256–271, Tab. XXII.

"*Gastrophilus rhinocerontis.*" As there exist many similar gastric Œstridæ in the African rhinoceroses, it is impossible to refer the parasite of Hope to one of those described later.

The presence of gastric larvæ in the rhinoceroses of South Africa was referred to by the explorer Delegorgue, in this way: "Le rhinocéros simus en avait aussi quelque peu, non sous la peau, mais dans son estomac. Le rhinocéros africanus bicornis pourrait bien réclamer le titre de père nourricier des œstres. On ne saurait s'imaginer la quantité contenue dans son estomac, c'était à les mesurer au boisseau, à les prendre à la pelle. Cette différence en nombre est constante chez les deux espèces et j'incline fortement à penser que le rhinocéros africanus bicornis ne doit sa méchanceté, la fureur qui le distingue, qu'à la présence de ces milliers de parasites, absolument comme l'homme qu' habite le ténia." [1]

Although these parasites are abundant in their hosts, definite information concerning them is of relatively recent date. In 1885, Brauer was able, for the first time, to examine the gastric larvæ from a specimen of *Rhinoceros sumatrensis* which died in the Zoölogical Garden at Hamburg. He recognized that they were distinct from *Gasterophilus* and placed them in a new genus *Gyrostigma*, under the name of *G. sumatrensis*.[2] In 1892 [3] he referred to the same genus the African larvæ of *Œstrus rhinocerontis* Owen, figured by Hope.

A very remarkable Œstrid imago was described in 1895 by Corti, from the Galla country, under the name of *Spathicera pavesii*.[4] The author made the suggestion that perhaps it came from a gastric larva, probably *Cobboldia* or *Gyrostigma*. Brauer, in completing the description of this fly, showed also the great probability of the identity of *Spathicera* with *Gyrostigma*.[5] He again refers to this hypothesis in the description of *Gyrostigma rhinocerontis bicornis* on larvæ from an East-African rhinoceros.[6]

It was not until ten years later that this identity was definitely established by Y. Sjöstedt [7] who succeeded in rearing an imago from a larva collected in *Rhinoceros* (*Diceros*) *bicornis* from Kilimanjaro. The species which he named *Spathicera meruensis*, seemed to him different from the imago *Spathicera pavesii* Corti and also from the larva *Gyrostigma rhinocerontis bicornis* Brauer.[8] In commenting upon this discovery of Sjöstedt,

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[1] Voyage dans l'Afrique australe, II, 1847, p. 351.

[2] Verh. k. k. zool. bot. Ges. Wien, XXXIV, pp. 269–270, Tab. X.

[3] Sitz. Ber. K. Ak. Wiss. Wien, math. naturw. Cl., CI, Abth. 1, p. 8.

[4] Ann. Mus. civ. Genova, Ser. 2, XV, pp. 144–147.

[5] Sitz. Ber. K. Ak. Wiss. Wien, math. naturw. Cl. CIV, Abth. 1, 1895, pp. 582–588, Tab.

[6] Denkschr. k. Ak. Wiss. Wien. math. naturw. Cl., LXIV, 1897, p. 261, Tab. fig. 19.

[7] Wiss. Ergebn. Schwed. Zool. Exp. Kilimandjaro, 1905–1906, Bd. II, Abth. 10, 2, 1908, pp. 11–19, Tab.

[8] See also E. Bau, Centralbl. f. Bacter. Parasitenk. Abth. 1. Orig. Bd. XLVIII, 1908, pp. 164–167.

Poulton[1] refers to a curious observation by S. A. Neave: in 1908 that entomologist observed, in the valley of the Luangwa River (N. E. Rhodesia), three very large flies, on the carcass of a freshly killed rhinoceros. These Diptera, which were without doubt *Spathicera*, were unwilling to leave the carcass and allowed themselves to be picked off by hand. Neave noticed also the astonishing resemblance of these flies to certain large Hymenoptera (*Salius* sp.) which are bluish black with orange legs.

The studies of G. Enderlein on the gastric larvæ of rhinoceroses should also be noted. In 1899, he made a very complete histological examination of the respiratory organs of *Gyrostigma* and incidentally pointed out the existence of *G. sumatrensis* Br. in *Rhinoceros lasiotis*.[2] He later described, under the name of *Gyrostigma conjungens*, a remarkable larva from *Rhinoceros bicornis* from Kilimanjaro, and at the same time referred to *Gyrostigma rhinocerontis bicornis* Br. other larvæ from East Africa (according to Sjöstedt, 1908, *op. cit.*, the latter larvæ really belong to *Spathicera meruensis* Sjöst.[3]). Finally, more recently, Enderlein, noting that the characters of his *Gyrostigma conjungens* were in certain respects intermediate between *Gyrostigma* Br. (= *Spathicera* Corti) and *Gasterophilus* Leach, made his species the type of a new genus *Stomachomyia*.[4]

The rearing of the imago of *Gyrostigma meruensis* by Sjöstedt (1908) has definitely proven the identity of the genera *Gyrostigma* Brauer (1885) founded on the larvæ of a species from Sumatra, and *Spathicera* Corti (1895) described from an imago captured in Abyssinia. According to the rules of zoölogical nomenclature now in use, there is no doubt that the first of these names should have priority. As yet *G. meruensis* Sjöst. was the only species of the genus known both from larva and imago. Moreover, there were described three different larvæ for which the corresponding imagoes had not been obtained:

G. sumatrensis Brauer 1885, from Sumatra;

G. rhinocerontis bicornis Brauer 1897, from Africa;

G. conjungens Enderlein 1901, from Africa.

Finally *G. pavesii* Corti 1895 had been described from an Abyssinian imago and no larva corresponding to it was known.

In 1914 my good friend Dr. J. Rodhain, who by his patient researches has contributed very largely to the progress of African parasitology, succeeded in rearing a number of imagoes from gastric larvæ collected from *Rhinoceros simus cottoni* Lyd. in the Uele district (northeastern Congo).

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[1] Proc. Entom. Soc. London, 1908, p. XXIX–XXX.

[2] Sitz. Ber. K. Ak. Wiss. Wien, math. naturw. Cl. CVIII, Abth. 1, pp. 235–303, Tab. I–III.

[3] Arch. f. Naturg. Jahrg. LXVII, Beiheft, 1901, pp. 23–39. Tab. I.

[4] Stettin. entom. Zeitg., LXXII, 1911, pp. 141–144.

He was also able to clear up the mystery of oviposition and of the first larval stage of that insect.[1] Dr. Rodhain kindly turned over this precious material to me for study. It was, therefore, possible for me upon my return to Europe, tó establish the identity of the reared imagoes with *Gyrostigma* (*Spathicera*) *pavesii* Corti; on the other hand, the larvæ from which these flies came could in no way be distinguished from those to which Brauer gave the name *Gyrostigma rhinocerontis bicornis*. This species, therefore, should bear the name of *Gyrostigma pavesii* (Corti).[2]

The Congo Expedition collected in the same region as did Dr. Rodhain numerous larvæ from the white rhinoceros. The label which accompanied these specimens bore the note "Faradje, Feb. 3 and 5, 1912, from Rhinoceros; most of the stomach practically studded." They did not differ from those which I had previously examined from the Uele district and must also be referred to *Gyrostigma pavesii* Corti (syn: *G. rhinocerontis bicornis* Brauer).

The larvæ collected by Dr. Rodhain (May, 1914) are in the third stage. This is true also of a large number (60 to 70) of the parasites collected by Messrs. Lang and Chapin; some of them are of very large size, measuring 35 mm. in greatest length and 15 mm. in greatest breadth; the others are much smaller, being not more than 16 mm. in length and 6 mm. in breadth; but the presence of three peritremes on each stigmatic plate shows that they have already moulted twice. These larvæ of the third stage correspond very well to the description given by Brauer and Sjöstedt. Every stigmatic plate bears three peritremes, each of which is very strongly sinuate, like a number of *S*'s joined end to end; the result is that the plate is completely covered by their numerous windings. The spines of the girdles are numerous, those of the anterior row on each segment are so close together that they nearly touch each other at their bases. The color of the tegument is uniform, without dark spots; it is dirty white in the small larvæ and pale horny brown in the larger ones.

The material provided by the Congo Expedition contains also a number of *larvæ of the 2nd stage*. This stage does not appear to have been recorded as yet, so that I think it worth while to describe them more in detail. (Fig. 1.)

They may be immediately recognized by the peculiar structure of their posterior stigmatic plates, each of which shows only two feebly sinuated peritremes. Some of them attain a length of 20 mm. and a greatest breadth

[1] Cf. J. Rodhain, Note sur la ponte des Œstrides des genres *Gyrostigma* et *Cobboldia*. Bull. Soc. Path. exot. Paris VIII, 1915, pp. 275–279.

[2] I hope to publish later, in collaboration with Dr. Rodhain, a complete study of the gastric parasites of rhinoceroses.

of 6 mm.; others are much smaller, not surpassing 10.5 mm. in length and 3 mm. in breadth. Their general aspect is somewhat different from that of the full-grown larvæ; they are much longer and vermicular, three to three and a half times as long as broad. The greatest breadth is not at the middle of the body but towards the posterior extremity, usually at the

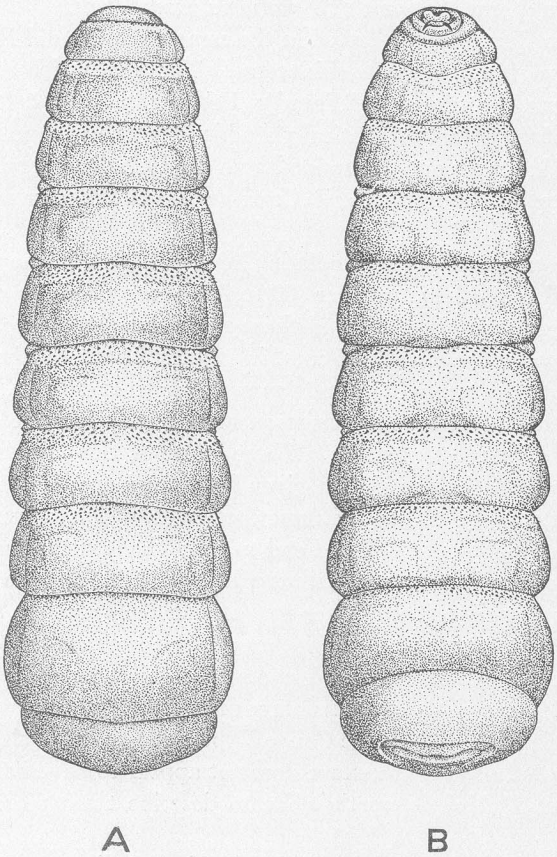

Fig. 1. *Gyrostigma pavesii* (Corti). Larva of the second stage. × 5. A. Dorsal view. Ventral view.

eleventh segment; in front of this segment the body gradually tapers toward the cephalic extremity, which is slightly more pointed than in the third stage. The larvæ are very slightly flattened dorso-ventrally, often nearly cylindrical, especially in the posterior half.

The twelve segments are very distinctly separated and they increase in length from the first to the eleventh; the latter segment is very well developed, especially on the dorsum; the twelfth is cut much shorter than the eleventh and slightly larger on the ventral than on the dorsal face.

On the ventral side there are sometimes traces of median, intermediate fields between segments five and eight; and there are even broad transverse elevations on each side of the median line, which perhaps may be used as ambulatory pseudopodes. On the sides the longitudinal superposed pads and the transverse intermediate pads have the same arrangement as in the third stage.

The concavity on the posterior face of the anal segment (twelfth) is usually deeper and inclosed by better developed lips than is the case in the full-grown larva, so that the small stigmatic plates are not usually seen. However, each of these anal lips bears four superficial papillæ, as in the third stage.

The cephalic (first) segment bears two antennal pads constricted at the base, very broad and flattened at the apex, relatively much nearer the median line than in the third stage. Each of these shows two very pale (sometimes almost invisible) ocellary spots; I was not able to make out a chitinous basal ring. There are two pairs of buccal hooks which are practically of the same shape and arrangement as in the full-grown larva. The external pair are claw-shaped, dark brown, and their bases inclose the internal pair which are much shorter, often retracted, conical stiletto-shaped, pale, slightly brownish.

The larvæ are amphipneustic. The anterior stigmata have the same structure as in the third stage. Their external aperture is situated on the side in the fold between the second and the third segments, but it is very small and difficult to see. The posterior stigmatic plates are small (about 0.8 mm. long and 0.52 mm. in greatest breadth) and occupy only a small area of the posterior face of the twelfth segment. They are oriented as in the full-grown larvæ, but their shape is somewhat different: they are oval, much broader toward the ventral third; their inner margin is only slightly emarginate toward the dorsal third, and it is at this level that one sees between the two plates the scar of the stigmatic orifice of the first stage.

In each plate are two sinuate peritremes each forming a single irregular S, so that two well marked curved angles are present; their general aspect then is nearly that noticed in the third stage of *Gyrostigma sumatrensis* Br. (according to the figures of Brauer and Enderlein, for I have never seen specimens of this species). Each peritreme attains a length of about 1.12 mm. and shows on the outside a series of transverse chitinous ridges numbering

sixty to sixty-five and placed about 0.018 mm. from each other; every one of these ridges corresponds to an internal curved supporting plate.[1] (Fig. 2.)

The spinulation has a somewhat different appearance from that of the third stage larva: the spines are scarcely visible, nearly colorless, only the points slightly brownish; they are very small, quite numerous and close together. The first segment (protocephalon) bears a complete girdle of minute spines which cover the inferior labial pad and extend even back of the antennæ; the second (postcephalon) is unarmed. Segments three to nine are furnished on the anterior border with a continuous girdle of spines, very close together in three or four rows, covering about the anterior quarter of the segments, the spines of the anterior row being slightly stronger than the others. On the tenth segment the spinous girdle is continuous on the ventral face and slightly interrupted along the median line on the dorsal

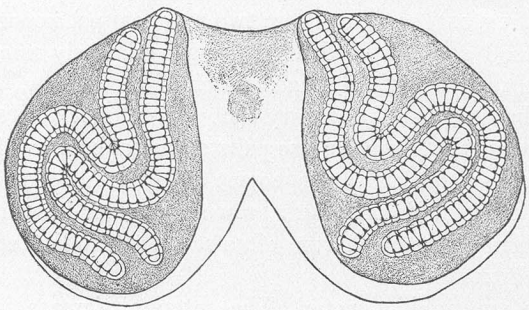

Fig. 2. *Gyrostigma pavesii* (Corti). Posterior stigmatic plates of second stage larva. × 50.

face; the eleventh segment seems to be unarmed on the dorsal face and on the ventral face bears one or two feeble lateral rows of spines; the twelfth segment is unarmed. The intermediate lateral pads between segments five to nine also have three or four minute spines; the one between the ninth and tenth segment is unarmed.

Behind the spiny girdles there are often on the dorsal and ventral faces of each segment a transverse series of minute elongated brownish spots: in some larvæ they are quite visible to the naked eye and they then somewhat resemble spines. These spots seem to be sub-epidermal and, moreover, they are not always very distinct; their significance is unknown, but perhaps they are nerve-endings.

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[1] For the detailed structure of the stigmatic plates of *Gyrostigma* compare Enderlein, Sitz. Ber. k. Ak. Wiss. Wien, math. naturw. Cl., CVIII, Abt. 1, 1899, pp. 235–303, Tab. I–III.

It should be noted that the rhinoceros from which Messrs. Lang and Chapin collected both the second and third stages was shot early in February, a date which corresponds to the height of the dry season in the savannah of the Uele district. Mr. Chapin informs me that the dry season in this region is very pronounced from December to April. At the beginning of the rainy season (May) Dr. Rodhain found only larvæ of the third stage in the rhinoceros. Therefore, there must be a period of the year (probably corresponding to the last half of the dry season) during which no adult flies emerge. But here again it is desirable to have further observations made on the spot before we can establish the different periods in the seasonal development of this parasite.

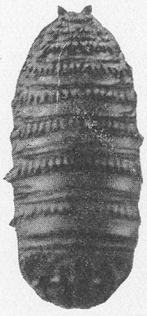

Fig. 3. *Gyrostigma pavesii* (Corti). Puparium. Natural size. (Photographed by M. Lebrun.)

Thanks to the kindness of Dr. Rodhain, I am able to figure for the first time the puparium of *Gyrostigma pavesii* (Corti) from a photograph taken in the Congo by Mr. Lebrun (Fig. 3).

In the material collected by the Congo Expedition there are a certain number of larvæ attached to other parasites of the alimentary tract; *e. g.* Scoleces of Tæniids. But according to the verbal explanation given by Mr. Lang, this attachment certainly happened after the parasites left the stomach, since there they are always attached to the walls. This seems to be indicated furthermore by the fact that larvæ of *Gyrostigma* sometimes are found attached to true intestinal worms. Mr. Lang also observed that when placed on the hand, the larvæ of *Gyrostigma* are able to attack the human skin by their powerful hooks and thus produce a sharp pain.