

zone is found to occupy the bend of the U and extends for some distance along the proximal limb. It leads into the receptaculum seminis which is a long straight tube with thick cellular walls, irregular in outline, on the outside. In live and in fixed and cleared specimens, it can be seen to contain a large number of small spermatozoa. The appearance, shape, and disposition of the receptacula seminis were constant features in all the specimens examined and are very different from those of *R. fuscovenosa* recently dealt with by the writer. They afford, with the funnel shaped mouth-cavity, a ready means of separating the two species, both parasites of snakes and very similar in general shape and structure. The uterus is comparatively short and contains correspondingly few eggs which are laid in an advanced stage of segmentation and measure .098-.1 mm. by .04-.041 mm.

#### LARVAL DEVELOPMENT.

No intestinal contents of the snake were available for addition to the soil in the culture and it was probably owing to the absence of certain essential foods provided by these that only two or three larvæ completed their development and became ensheathed. The culture was examined daily but males and females of the free-living generation were never found. A certain amount of growth and multiplication in the cells composing the genital primordium occurred in many of the larvæ as shown in Fig. 9, a drawing of a rhabditiform larva, in which the genital rudiment, instead of remaining as a small lens-like body, has grown and is composed of about ten elements. The few larvæ which completed their development and became ensheathed migrated to the lid of the culture dish. They thus show a direct development similar to that of the larvæ of *R. fuscovenosa*.

The ensheathed larvæ are long and slender and are very active. When killed by gentle heat and examined under the oil-immersion they were found to be similar in all essentials to the ensheathed larvæ of *R. fuscovenosa*. The œsophagus is exactly of the same type, a median swelling or bulb being present and the posterior bulb being lobed. Owing to the scarcity of ensheathed forms it was impossible to make any observations on the biology of the infective stage.

#### REFERENCE.

- GOODEY, T., 1924.—"The Anatomy and Life-History of the Nematode *Rhabdias fuscovenosa* (Railliet) from the Grass Snake *Tropidonotus natrix*." *Jl. of Helminthology*, vol. 11., No. 2, pp. 51-64. Several other references are given in this paper.

## On *Kiluluma* Skriabin, a genus of Strongylid nematodes parasitic in the African Rhinoceros.

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#### INTRODUCTION.

THE earliest account of the Strongylid parasites of the rhinoceros is given by von Linstow (1907) where he describes the only form under the name *Deletrocephalus stylosus*. His description of this type is brief and now inadequate and the illustrations are very few. This form, however, does not show any generic characters in common with the type species, *Deletrocephalus dimidiatus*, Diesing, of the genus. It was, hence, removed by Skriabin (1916) into a new genus, *Kiluluma*, created by him for its reception. Thus the form, *D. stylosus*, von Linstow, was transferred to the genus under the title *K. stylosa*. It may, however, be mentioned that Skriabin in his account suggests that von Linstow's *Deletrocephalus brachylaimus* from rock-rabbit is the probable second species of this new genus, *Kiluluma*. I have examined this form also from the rock-rabbit and find that it could not be classed with either of the two genera mentioned above. A new genus *Theileriana* has recently been created for it by Mönnig (1924).

Skriabin (1916) in the course of his description has added to von Linstow's account but it is still insufficient and in certain respects, misleading. For example, while describing the head of the worm, he mentions that the "cephalic extremity is very peculiarly composed of a whole complex of organs which may be considered under the category of a series of lips: exterior and interior," and then passes on to the description of the œsophagus and the alimentary canal beginning from the mouth. It will be seen from the following account that the series of exterior lips of Skriabin are simply lobes of the mouth-collar on its anterior face. Further he has entirely omitted to mention or to show in his figures the presence and the character of the buccal capsule, a point which is essential for its inclusion in the family *Strongylidæ*.

Recently, Neveu-Lemaire (1924) has given an account of the *Strongylid* parasites of the African rhinoceros where he has described four new genera and several new species, but, for *Kiluluma* he satisfies himself

by simply giving the original descriptions and illustrations of Skriabin. An adequate account of this genus is, therefore, desirable.

Skriabin, though describing von Linstow's *Deletrocephalus stylosus* under a new genus as *Kiluluma stylosa*, gives such different measurements of the various structures that it has been thought advisable to describe all the specimens in the present communication as new species and thus avoid any further confusion. It would be desirable, however, to re-examine both von Linstow's and Skriabin's specimens. If a later worker gets an opportunity to do so and finds any of them conforming to my species then *stylosa* will stand and my specific name will go as synonym.

The materials for the present investigation was taken from the valuable collection of Professor R. T. Leiper, F.R.S., collected from the large intestine of *Rhinoceros africana* shot by him during his expedition to East Africa and Uganda in 1905. The specimens were all well preserved in a thoroughly expanded condition and show every detail of the internal anatomy remarkably well. I am greatly indebted to Professor Leiper for the opportunity he has given me to study this material and for his general guidance. He placed his own valuable library at my disposal and has given me every encouragement and assistance in my work. My grateful acknowledgments are also due to Dr. T. Goodey who has been an invaluable source of information and assistance throughout the course of my work. I am also thankful to Dr. Ortlepp for his occasional suggestions.

#### 1. *KILULUMA RHINOCEROTIS*, sp. nov.

The body is elongated cylindrically and narrows slightly towards the extremities. The female, however, terminates posteriorly in a conical point.

The female is longer than the male and measures 17 mm. long by .8 mm. broad, the male being only 13 mm. long by .6 mm. broad across its greatest diameter.

The cuticle is thick and shows throughout its entire length distinct annulations which are rather wide apart and each annulus is further transversely striated with fine markings. In the anterior region of the body the cuticle is more widely separated from the body wall than in the posterior part.

The anterior end is provided with a *mouth collar*, generally presenting four distinct lobes on its anterior face. Skriabin considered these as the *outer series of lips*. It is separated from the body wall of the trunk by a more or less pronounced *cephalic groove*. There are the normal number of *circum-oral papillæ*—two laterals, two subdorsals and two subventrals—borne on the lobes of the mouth collar. The *lateral papillæ* are blunt and inconspicuous and open out in the *cephalic groove*. They are in reality the openings of the *cephalic glands*. The *submedian papillæ* are each composed of two distinct parts. There is a broad basal piece resting on the lobe of the mouth collar and rounded off in front. It serves as a sort of collar round the narrower elongated process that pierces through it, projecting out in front in a club-shaped termination. The latter constitutes the second part of the papilla.

The *cervical papilla* are laterally situated on either side of the intestinal region at a distance of 1.1 mm. from the anterior end in the female and .85 mm. in the male. Each *cervical papilla* consists of a broad basal portion arising from the body wall and extends throughout the thickness of the cuticle. Its outer edges are slightly rounded. Projecting through the middle of this cuff-like structure is a narrow core which gradually tapers to form a flagelliform outgrowth. The total length of each cervical papilla is .09 mm.

The *nerve ring* is situated at a distance of .3 mm. from the anterior end.

The *excretory pore* lies in the mid-ventral line in front of the cervical papillæ and is 1.04 mm. from the anterior end in the female and .8 mm. in the male.

The *mouth* is in the centre of the mouth collar and leads into the *buccal capsule* composed of a strong ring of cuticular material. Its shape is represented in figures 1 and 2, where it is shown to be slightly curved to the exterior at its anterior end, and is pointed. Posteriorly it rests on a slight indentation of the oesophagus, to which it is attached. It is thickest in its middle. Arising from the base of the buccal capsule internally are a series of six fleshy lobes—two lateral, two ventral and two dorsal. These correspond to the "internal lips" of Skriabin and are probably true lips. As each lip comes out of the mouth collar it swells out considerably to form a thicker lip. At this situation, each lip bears internally a small pointed filiform outgrowth comparable to the "pointed formation" of Skriabin. The outer edges of the lips

are rounded off in front and curve backwards to become continuous with the body wall.

The *oesophagus* is a short club-shaped structure expanded out both anteriorly and posteriorly. It is constricted in the region of the nerve ring. The posterior swelling of the *oesophagus* is larger than the anterior and is .22 mm. wide in the female and .19 mm. in the male. At the anterior face the *oesophagus* is indented for the reception of the capsule and it projects forwards into the latter as a conical protuberance. The total length of the *oesophagus* is .58 mm. in the female and .46 mm. in the male. There is a short triangular *oesophageal funnel* and the cuticular lining of the *oesophagus* forms another shallow cavity.

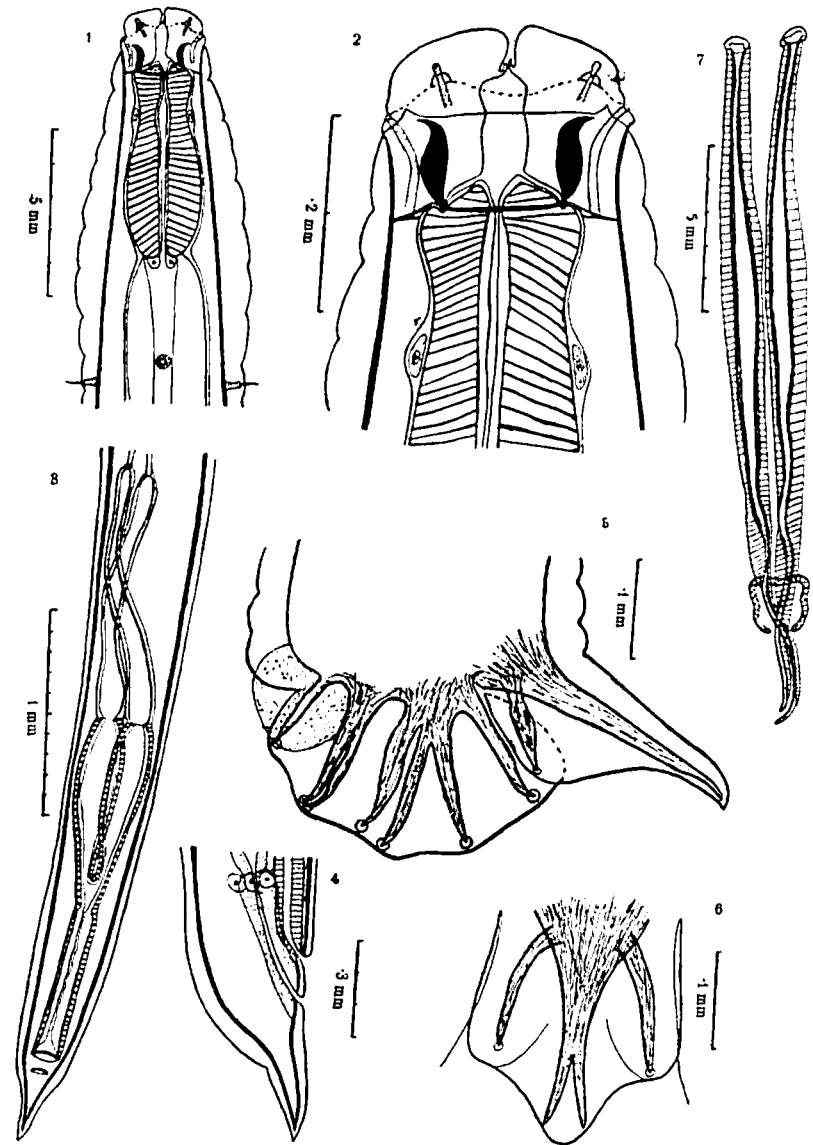
The entrance of the *oesophagus* into the intestine is marked off by the presence of three *unicellular valves*. These cells are all full of granular protoplasm and contain within a large rounded nucleus. The *intestine* is broad at its commencement and gradually narrows down posteriorly. It is lined with large flattened cells full of dark granular bodies. Its lumen is wide at its beginning and becomes narrower towards the posterior end. It leads into a short *rectum* that opens directly to the exterior at the anus in the female and in the male into a cloaca which also receives the genital duct. The lumen of the rectum is the inturned cuticular covering of the surface which also extends into the intestine. At its anterior end where it joins the intestine it is rounded off and is further marked off by the presence of three large cells, the so-called *rectal ligaments*. These cells are full of granular protoplasm with a large nucleus.

*Kiluluma rhinocerotis*.

- Fig. 1.—Anterior end of the adult in ventral view.  
 Fig. 2.—Head end in dorsal view greatly enlarged showing buccal capsule, lips, circum-oral papillae, etc.  
 Fig. 3.—Posterior end of the young female showing vagina, horns of the vagina, and uteri, ventral view.  
 Fig. 4.—Tail of female in lateral view.  
 Fig. 5.—Lateral view of bursa.  
 Fig. 6.—Dorsal view of bursa.  
 Fig. 7.—Spicules, showing the disposition of the ala and gubernaculum.

MALE CHARACTERS.

The posterior extremity of the male bears a wide bursa composed of three main lobes—two large lateral lobes and one median conical dorsal lobe with a rounded apex. Each lobe of the bursa is a cuticular expansion of the body and is supported by a number of rays, each bearing



*KILULUMA RHINOCEROTIS*,

a rounded knob at its end. Besides these, the cuticle of the ventral side of the body is also expanded at the posterior end and forms a large rounded lobe-like expansion, the *dermal collar*, round the cloacal aperture.

Each lateral lobe of the bursa is distinctly marked off from the dorsal lobe and is supported by seven rays arranged as follows :—

1. The *preventral ray* is single and arises from the ventral side of the body. It is backwardly directed and reaches the edge of the bursa.

2. The *ventral rays* arise by a common stem from the body and the two rays run together closely parallel to each other to the edge of the bursa.

3. The *lateral rays*, unlike other Strongylids, are four in number. Their arrangement is also peculiar. They all arise together by a common stem. The externo-lateral and the medio-lateral run together parallel to each other. Of these two, the externo-lateral is stouter. The postero-lateral ray diverges from the two rays just described and also reaches the edge of the bursa. The fourth ray of the lateral series, the extra-lateral, runs distinctly separate from all others and arises from the common stem near its base, reaching, however, the edge of the bursa like all other rays of the series. If we leave out of account the extra-lateral ray we can say that the arrangement of the lateral rays is just the reverse of what we find in the genus *Æsophagostomum*. In this latter genus, the externo-lateral is distinct and the medio-lateral and postero-lateral run together parallel to each other.

The dorsal lobe of the bursa is slightly longer than the lateral lobe and is bluntly conical at its apex when viewed from above. The dorsal ray supporting it is fairly stout at its base and gradually narrows down after giving off the externo-dorsal ray on either side. Each externo-dorsal ray arises ventrally from the dorsal ray soon after the origin of the latter from the body wall. It curves outwards and then backwards, almost reaching the edge of the bursa. The dorsal ray itself runs backwards into the dorsal lobe, gradually narrowing down towards its extremity. In its posterior third it divides into two divergent branches, which reach the edge of the dorsal lobe.

The *genital cone* is a highly contractile organ and presents a variable appearance in different individuals. It consists, however, of a dorsal and a ventral lip; the dorsal lip is provided with a pair of lateral spherical papillæ which do not carry the usual flagelliform structures at their tips, as are usually present in the *Æsophagostomes* and *Cylicostomes*.

The *Cloacal chamber* is situated ventrally to the spicular canals and receives at its anterior angle the openings of the rectum and the vas deferens.

There are two equal *spicules* and an accessory piece or *gubernaculum* is present. Skriabin in his description of *K. stylosa* mentions that the gubernaculum is absent, but in my examination of a large number of specimens belonging to different species I find it invariably present and seems to be of a generic value. In the present species, it is roughly horse-shoe-shaped in appearance and consists of a transverse piece that turns backwards on either side as a narrow curved process, terminating posteriorly in a rounded tip. It lies obliquely within the body.

The *spicules* are 2.1 mm. long and have the maximum diameter of .11 mm. Each spicule consists of an elongated tapering axis which, in its posterior part, is spirally coiled. The head of each spicule is flanged out and the tip is blunt. The axis bears on either side a lateral cuticular expansion in the form of an ala that shows very fine transverse striations throughout its extent. In the spirally coiled portion of the spicule the alæ are not quite regular in their arrangement. One of the alæ appears to stop short and the other runs round with a spiral twist of the spicule, showing one of the spicular edges devoid of the ala. The tips of the spicules are devoid of such cuticular expansions.

#### FEMALE CHARACTERS.

The *caudal end* of the female is straight and gradually rounds off. At its posterior end it bears an elongated conical tail in continuation of the ventral side of the body. It is about .22 mm. long and the tip is bluntly pointed.

The *anus* is .41 mm. in front of the tip of the tail and leads into a short rectum which is .42 mm. long. It is lined throughout, as has been previously pointed out, by the invaginated cuticular covering of the surface. The *rectal cells* (rectal ligaments) are smaller than those of the male.

The *vulva* is situated .13 mm. in advance of the anus and leads into an elongated wide *vagina* that runs forwards ventral to the gut. It is .87 mm. long and has the usual cuticular lining. At its anterior end, its outer wall is very slightly constricted off, and then divides into two horns, about .78 mm. long, running side by side. In a fully matured specimen they are filled with numerous eggs and their anterior

termination is recognised not without some difficulty. There are no true ovejectors in these forms, the horns represent in a very rudimentary way the complicated ovejector apparatus of the other genera of the *Strongylidae*. The horns of the vagina are fairly broad in the young forms, as is represented in Fig. 3. Each leads forward into a thick-walled muscular *uterus* that curves upwards along the intestine and lies above the latter in its anterior part. The *uterus*, after running forward for a short distance, joins the narrow long *ovaries* of the corresponding side. The ovaries are much coiled on themselves curving backwards as far as the anterior ends of the uteri.

The *eggs* are oval, thin-shelled and measure .07 mm. long by .05 mm. broad.

2. *KILULUMA AFRICANA*, sp. nov.

The female is longer than the male and is 17 mm. long; the male measures between 13 and 14 mm.

The *cuticle* is thick and is slightly inflated round the anterior end, where it stands out distinctly. It also possesses well-marked annulations, each of which is again striated transversely.

The *mouth collar* is of the usual type with four distinct lobes on its anterior face, each lobe carrying a *submedian papilla*. It is separated from the trunk wall by a well-developed *cephalic groove*.

The *head papillæ* are, as in *K. rhinocerotis*. The lateral papillæ, unlike *K. rhinocerotis*, open .03 mm. in front of the cephalic groove.

The *mouth opening* is oval and is surrounded by the six lobe-like lips that arise from the base of the buccal capsule. These lips swell out distally in the same way as in *K. rhinocerotis*. The *filiform processes* on the inner edges of the lobes are absent.

*Kiluluma africana*.

Fig. 8.—Anterior end of the adult in ventral view.

Fig. 9.—Head end in dorsal view, greatly enlarged to show buccal capsule, lips, circum-oral papillæ, etc.

Fig. 10.—Posterior end of the female showing vagina and its horns in ventral view.

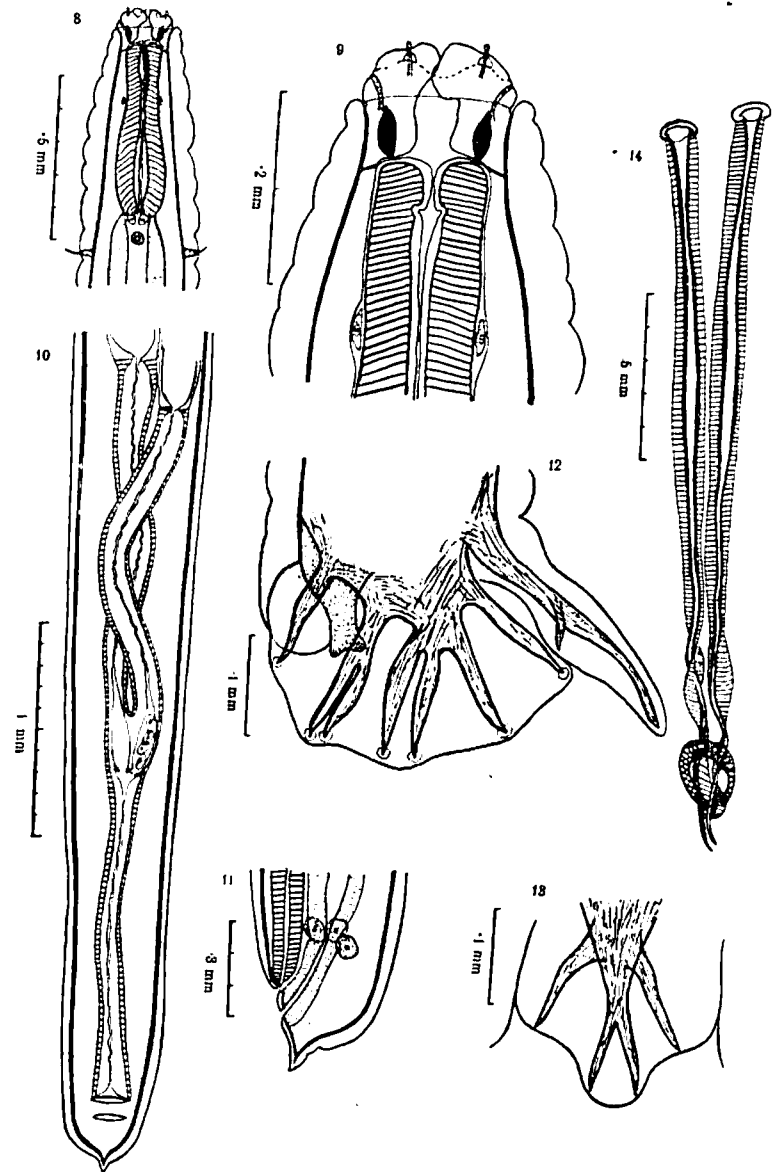
Fig. 11.—Tail of female in lateral view.

Fig. 12.—Lateral view of bursa.

Fig. 13.—Dorsal view of bursa.

Fig. 14.—Spicules showing alæ in ventral view, and gubernaculum.

The *buccal capsule* is straight, being thickest, as in *K. rhinocerotis*, in the middle of its extent. It has no everted anterior edges and rests in front of the œsophagus. The *buccal cavity* is wide and shallow.



The *oesophagus* is club-shaped and is .52 mm. long in the male and .56 mm. in the female. It is nearly cylindrical in its anterior half and is swollen out in its posterior half, thus assuming a club-shaped structure. Its maximum diameter is .15 mm. in the male and .18 mm. in the female. The *oesophageal funnel* is present and is much narrower than in *K. rhinocerotis*. The posterior margin of the funnel is reflected outwards and forms a triangular chink in the *oesophagus*.

The *excretory pore* is nearer the anterior end than in *K. rhinocerotis*. It is situated just behind the *oesophagus* and is .74 mm. from the head end of the female. In the male it is .69 mm. from the anterior end.

The *cervical papillæ* are situated a little behind the level of the excretory pore and are .78 mm. in the female and .73 mm. in the male from the head end. Their general character is the same as in *K. rhinocerotis*.

The *nerve ring* is .3 mm. in the female and .26 mm. in the male from the anterior end.

#### MALE CHARACTERS.

The bursa is well developed and all the bursal rays show a similar disposition to those of *K. rhinocerotis*. The *preventral* ray presents a slight swelling in its proximal part and the *ventral* rays are normal. The *lateral* rays are rather widely separated from one another and the *extra-lateral* ray arises from the base of the common stem, having almost the appearance of an independent ray rather than to belong to the lateral series. The *externo-dorsal* ray arises at a little higher level from the dorsal ray than is the case in *K. rhinocerotis*. It is also slenderer than in that species.

The *genital cone* is, as in *K. rhinocerotis*, very contractile and the *dermal collar* is not so well marked. It forms only a small swelling.

The *spicules* have the same structure as in *K. rhinocerotis*, but are longer than in that species, being 2.25 mm. long. The increase in length corresponds to the greater length of the vagina in this form.

The *gubernaculum* has a more rounded appearance and is more or less heart-shaped in outline.

#### FEMALE CHARACTERS.

The main characters of the female are similar to those of *K. rhinocerotis*. The posterior end is rounded off and bears only a short stumpy tail, about

.06 mm. long, in continuation of the ventral side of the body. The *anus* is .165 mm. from the tip of the tail and the *rectum* is short, being only .26 mm. long.

The *vulva* is nearer the anus than in *K. rhinocerotis* and is .08 mm. in front of it. It leads into a rather long *vagina* which runs forwards and measures 1.8 mm. in length. The *horns* of the *vagina* are also long and measure about 1.57 mm. in length. Both the *horns* of the *vagina* are twisted round each other, so that possibly by their mutual pressure against each other, together with the muscular contraction of their walls, the eggs are passed out into the *vagina*. The two horns of the *vagina* are enclosed within a common sheath for a short distance, thus forming a false pars ejectrix of a double nature. The *eggs* are elongated oval structures, their length being twice that of their breadth. They are thin-shelled and measure .08 mm. long by .04 mm. broad.

#### 3. *KILULUMA PACHYDERMA*, sp. nov.

The *cuticle* is thick and shows the general characters described for *K. africana*. The *inflation* of the cuticle round the anterior end of the body is not so pronounced.

The *mouth collar* is of the common type, being produced in front into four distinct rounded lobes, each with a *submedian papilla* of the common type at its end. The *submedian papillæ* are a little longer than those found in *K. africana*. The *cephalic groove* separates the mouth collar from the wall of the trunk and bears the opening of the lateral papillæ.

The *lips* surrounding the mouth are six and the inner anterior corner of each is produced in front into a small conical outgrowth, the *filiform process*, differing however from the similar process of *K. rhinocerotis* only in the point of origin from the lips. The lips have the same thickness throughout and do not present any enlarged swelling in their anterior part as is exhibited in the previous two species.

The *buccal capsule* is a shallow cylindrical structure composed of thick cuticular material with a diameter of .06 mm. and is connected by strands to the body wall. The elements of the lips arise from its base.

The *oesophagus* is cylindrical in its anterior half and swells out in its posterior half. Its length is .335 mm. in the male and .38 mm. in the female, the maximum width being .11 mm. The *oesophageal funnel*

is present and is deeply invaginated within the oesophagus. In the region of the nerve ring it is very slightly constricted.

The *cervical papillæ* are situated .65 mm. from the anterior end. Their general characters are similar to those described for the previous species, the only difference being in size, their total length in the present species is .055 mm.

The *nerve ring* is situated .2 mm. from the anterior end.

The *excretory pore* is in front of the cervical papillæ and is .61 mm. from the anterior end. It is, however, further removed from the oesophagus than is the case in the previous two species.

#### MALE CHARACTERS.

The body of the male is cylindrical and has a length of 11 mm. The *bursa* is well developed; the dorsal lobe is smaller than the lateral lobes and is broader than is the case in the two species considered previously. The general disposition of the bursal rays is however similar to that of *K. africana*. The chief differences are given below. The *externo-lateral* is stout and swollen out. The *extra-lateral* arises just at the base of the common stem and appears to be quite independent of the other rays of the lateral series. The *dorsal ray* gives off the *externo-dorsal* at about the same level as in *K. africana* and divides into the two divergent branches. The *externo-dorsal* ray near its termination gives off a small narrow offshoot, thus forming an unsymmetrical fork.

The *dermal collar* is small in extent.

#### *Kiluluma pachyderma*.

Fig. 15.—Anterior end of the adult in ventral view.

Fig. 16.—Head end greatly enlarged, dorsal view.

Fig. 17.—Posterior part of female genitalia in ventral view.

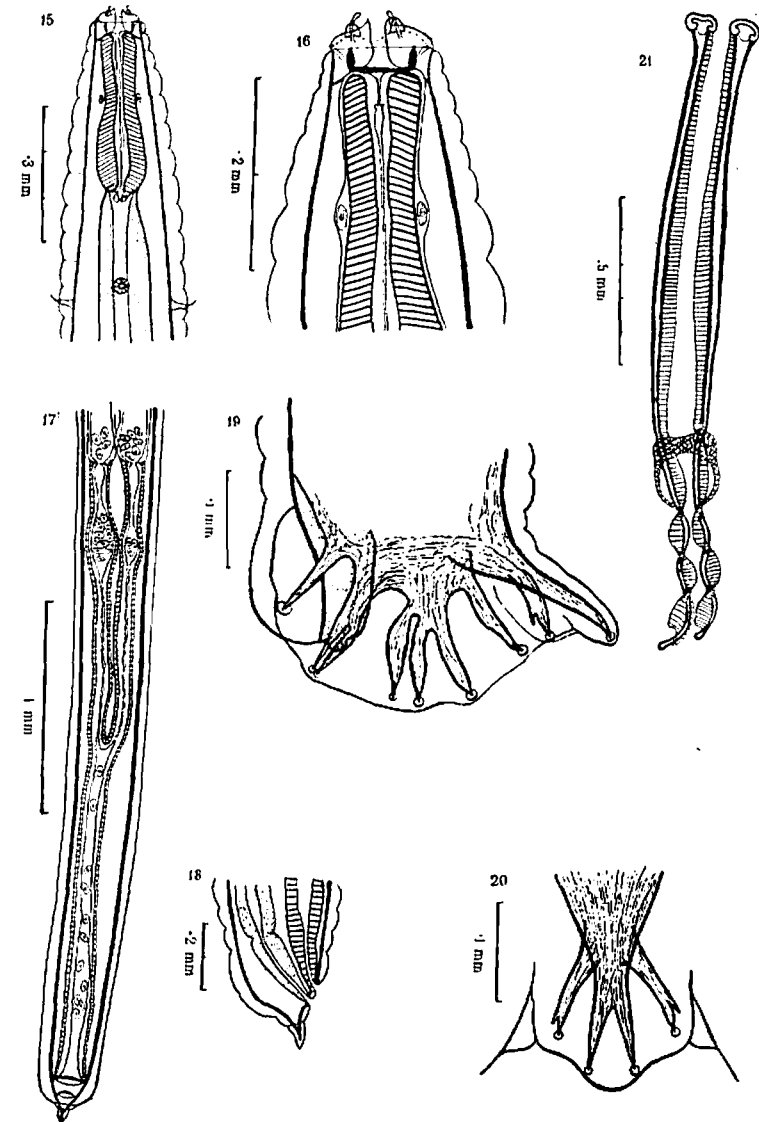
Fig. 18.—Tail of female in lateral view.

Fig. 19.—Lateral view of bursa.

Fig. 20.—Dorsal view of bursa.

Fig. 21.—Spicules with gubernaculum. Note a single ala on each spicule.

The *spicules* are of the common type, the head being flanged out and the ends are without any cuticular expansion. There is only one cuticular wing-like expansion, the ala of the other side is absent. The ala in the posterior spiral region of the spicular axis curves round along with the spiral twist of the spicule itself, filling the hollow of the spire. The ends of the spicules are rounded and knobbed. Each spicule is 1.95 mm. long.



*KILULUMA PACHYDERMA*.

The *gubernaculum* is more closely allied to *K. rhinocerotis* in shape and is represented in Fig. 21 along with the spicules.

The *genital cone* is of the common type.

#### FEMALE CHARACTERS.

The length is 14 mm. and the body is approximately cylindrical throughout, being slightly narrower near the extremities. The posterior end is rounded off and its termination bears a short conical stumpy tail in continuation of its ventral side. The tail is .13 mm. long and the tip is straight.

The *anus* is situated just near the commencement of the tail and is .145 mm. in front of its tip. It leads into a short rectum .23 mm. long.

The *vulva* is close to the anus and is only .045 mm. in front of it. The *vagina* is lined with cuticle and is fairly long and muscular, being approximately 1.6 mm. long. In front it divides into two long limbs about 1.34 mm. long, the *horns* of the vagina. The horns are likewise muscular and run parallel to each other throughout. Each in its course forwards has an oval swelling containing eggs. It passes on anteriorly into a very thick-walled muscular *uterus*.

The *eggs* are oval, thin-walled, and measure .058 mm. long by .03 mm. broad.

The largest number of specimens belonged to this species, and on comparing with von Linstow's figures, it appears that this species might be his *D. stylosus*, but unfortunately the lengths of the spicules and a few other measurements are so different and the subsequent description and figures of Skriabin make one doubt the advisability of identifying it with the *Kiluluma stylosa*.

#### 4. *KILULUMA MACDONALDI*, sp. nov.

The material examined contained a number of specimens, both male and female, and presented certain distinct peculiarities.

The *body* is elongate cylindrical gradually tapering to a point towards the posterior end.

The *cuticle* is inflated round the anterior part of the body and stands out rather distinctly. It shows the general characters described for other species.

The *mouth collar* presents the usual characters described for other species and is rather low. The *cephalic groove* is well developed and separates it from the body wall of the trunk.

The *submedian head papillæ* are in the usual position at the ends of the lobes of the mouth collar and are long. The *lateral papillæ* open out a little in front of the cephalic groove.

The *mouth opening* is bounded by six *lips*, greatly dilated at the base, and their inner anterior angles are pulled out into short conical outgrowths with their lips everted to the outside. These arise as usual from the inner side of the base of the buccal capsule. The *buccal capsule* is straight and is composed of cuticular material thickest towards the base, and pointed anteriorly.

The *œsophagus* is dumb-bell shaped and swollen at the ends, each swelling having a maximum diameter of .095 mm. Its length is .32 mm. *œsophageal funnel* is well developed and the *œsophageo-intestinal* valves are large.

The *cervical papillæ* are posterior to the œsophagus on either side of the intestine about .636 mm. from the tip of the head.

The *nerve ring* is .18 mm. from the anterior end of the body and surrounds the anterior part of the œsophageal constriction.

The *excretory pore*, unlike other species, is posterior to the cervical papillæ and is .68 mm. from the anterior end.

#### MALE CHARACTERS.

The body is 10 mm. long and bears a well-developed *bursa* with distinct lateral and dorsal lobes. The *dorsal lobe* is equal to the *lateral lobe* in length and is in the form of a flattened cone.

The *lateral lobe* is supported by six rays only, the seventh ray which corresponds to the preventral ray of the other species, has shifted forward to assume the position usually occupied by the pre-bursal papillæ in other Strongylids. It is still long and narrow and is swollen at its base. Of the *lateral rays*, the *externo-lateral* arises first from the common stem leaving a stout stem for the *medio-lateral* and the *postero-lateral* rays. The rays are all swollen at their bases and are quite stout and more widely apart from each other than in other species. The extra-lateral ray arises independently from the body-wall in the lateral lobe of the bursa and does not reach the edge of the bursa. By reference to the



extra-lateral ray in the other species described, it would appear that this ray presents a regular gradation in its origin from the body wall on the one hand and from the common stem of the lateral series of the rays on the other.

The *externo-dorsal* ray arises from near the base of the dorsal ray and bears a large pear-shaped swelling at its base and is quite stout. It gradually tapers to its termination near the edge of the bursa and is outwardly directed. The division of the dorsal ray into two divergent branches takes place a little beyond the middle of its length and each branch forms a small swelling at its origin and then gradually narrows down to a point at its extremity.

The *genital cone* is built on the same general plan as in the species already dealt with and is highly contractile. It can be retracted within the cloaca. The *dermal collar* is very prominent.

The *spicules* are long and narrow, their length being 2.55 mm. The axis of the spicule is only .016 mm. at its maximum diameter and bears along one of its edges a cuticular wing-like expansion which is about twice as broad as the axis itself. This *ala* is spirally coiled round the axis along its entire length and is finely striated. It is very difficult to represent on a plane sheet but an attempt has been made to represent it as closely similar to the original as possible. The head of the spicule is as in other forms flanged out and the posterior end is blunt and devoid of the alar fold or expansion.

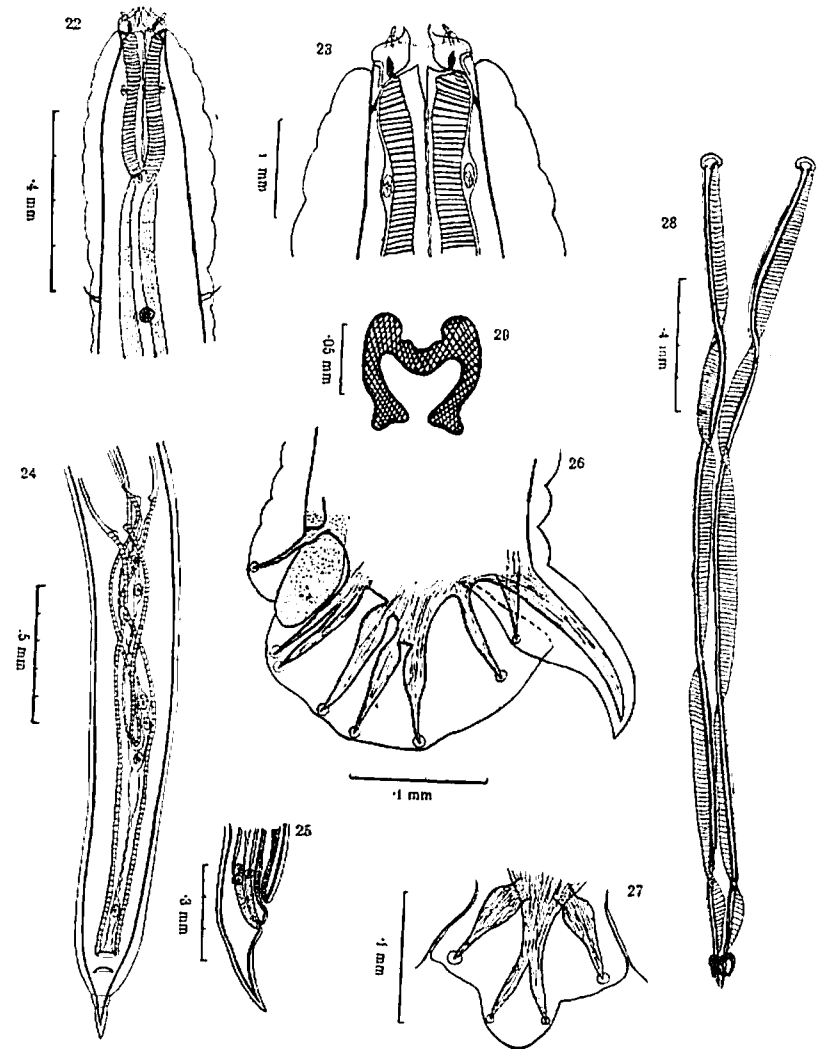
The *gubernaculum* is present and has a peculiar shape. It might be described as a modified horse-shoe-shaped structure with the transverse piece reflected inwards. Its exact shape is represented in Fig. 29.

*Kiluluma macdonaldi*.

- Fig. 22.—Anterior end of the adult, ventral view.  
 Fig. 23.—Head end greatly enlarged, dorsal view.  
 Fig. 24.—Posterior part of female genitalia, ventral view.  
 Fig. 25.—Tail of female, lateral view.  
 Fig. 26.—Lateral view of bursa.  
 Fig. 27.—Dorsal view of bursa.  
 Fig. 28.—Spicules, showing spiral twist of ala round the axis.  
 Fig. 29.—Gubernaculum greatly enlarged.

FEMALE CHARACTERS.

The female is slightly longer than the male and is 11 mm. long. The posterior end gradually narrows down and ultimately ends in a long drawn-out tapering tail gracefully curving ventrally.



*KILULUMA MACDONALDI*.

The *anus* is .28 mm. from the tip of the tail and stands out rather prominently. The rectum is about .17 mm. long and bears the rectal cells (rectal ligaments) at its junction with the intestine. Besides the rectal cells there is a large triangular cell extending from the rectal cells to the posterior end of the body in the tail. This is the *pulvalis postanal* and has granular protoplasm with a large spherical nucleus.

The *vulva* is .06 mm. in advance of the anus and leads into a long *vagina* about .76 mm. in length. It lies ventral to the intestine and leads into two elongated *horns* about .9 mm. long, spirally twisted round each other. The mutual pressure of the horns against each other probably aids their muscular contraction in the expulsion of the eggs out into the *vagina*.

The *eggs* are oval, thin-walled, and are .05 mm. long by .028 mm. broad.

This species, though agreeing in general with the previous form, is peculiar in its dumb-bell shaped oesophagus; in the position of the excretory pore in relation to the cervical papillæ; in well-developed bursal lobes; in the curious swellings at the bases of the bursal rays; in the prebursal position of the preventral ray; and in a much elongated tail in the female.

##### 5. *KILULUMA SOLITARIA*, sp. nov.

The material consisted of one male and one female in a very well expanded condition and all the features in their internal anatomy were properly made out. Both male and female are 15 mm. long.

The *body* is elongated cylindrically and gradually tapers towards the posterior end where it terminates in the female in a broad conical tail about .32 mm. long.

The *cuticle* is inflated round the anterior end and stands out more distinctly than in the posterior part of the body. It has the usual annulations with fine striations.

In front the body is provided with a broad ribbon-like *mouth collar* with a slightly greater diameter than the part immediately behind it. Anteriorly it is thrown out into four small lobes each bearing a submedian papilla at its end. Posteriorly it is separated from the body wall of the trunk by a *cephalic groove* which is quite prominent and well developed. The *lateral papillæ* open in front of the ribbon-like portion of the mouth collar.

The *mouth* opening is circular and is surrounded by six inflated *lips* arising from the base of the buccal capsule internally. At the anterior end the lips bear small pointed *flagelliform outgrowths*, one for each lip. These processes are directed outwards. The outer anterior edges of the lips are rounded off.

The *buccal capsule* is composed of thick cuticular material and is thickest in its posterior end. Anteriorly it is narrow and pointed and is slightly dilated. Arising from its posterior end is a narrow cuticular outgrowth running inwards towards the oesophageal opening.

The *oesophagus* is club-shaped, .54 mm. long and has its maximum diameter of .18 mm. near its posterior end. *Oesophageal funnel* is small and the cuticular lining of the oesophagus is irregularly folded internally.

The *cervical papillæ* are 1.12 mm. from the anterior end and have the typical characters.

The *nerve ring* is situated .31 mm. from the anterior end.

The *excretory pore* is in front of the cervical papillæ, being .97 mm. from the anterior end.

##### MALE CHARACTERS.

The male is about 15 mm. long and slightly narrows towards either end. Posteriorly the *bursa* is well developed. The *lateral lobes* are smaller than the dorsal lobe in length and are slightly overlapped by the latter. The *dorsal lobe* has a rounded end.

The general disposition of the bursal rays is similar to those described for other species. All the *lateral rays* are equal and, with the exception of the extra-lateral ray, arise together at the same level from the common stem, gradually tapering towards their apices. The *extra-lateral* ray arises from near the base of the common stem. The *dorsal ray* gives off externo-dorsal ray soon after its origin and itself runs forward, dividing into two branches in its posterior third. Each branch of the dorsal ray tapers gradually.

The *genital cone* is, like all other species, highly contractile and bears two lateral pear-shaped papillæ on its dorsal lip. The *Dermal collar* is well developed and is prominent.

There are two long *spicules* of the common type, having a length of 1.9 mm. with a maximum diameter of .1 mm. The head is flanged

out and the axis is elongated, tapering towards the posterior end. The posterior part of the spicule is spirally coiled. The axis bears a single cuticular wing-like expansion that is transversely striated. This ala in the posterior spiral region of the axis is coiled round the spicular axis along with its spiral twist, and runs within the hollow of the spire. The end of each spicule is pointed and devoid of the cuticular expansion.

The *gubernaculum* is short and wide and has the general characters described for the other species. It is represented in figure 34.

#### FEMALE CHARACTERS.

The posterior end of the female is, as has been pointed out above, gradually tapering to form a tail. The *anus* is .32 mm. in front of the tip of the tail and leads into the rectum which is .34 mm. long. It bears the usual rectal ligaments at its commencement in front.

The *genitalia* of the female follow the common plan of structure. The *vulva* is .13 mm. in front of the anus and the *vagina* is long and lined with cuticle. Its length is 1.32 mm. and it divides in front into two *horns* that are enclosed, like the horns of *K. africana*, by a common sheath for a short length in its posterior part. The total length of the horns is 1.2 mm. each, and, at the point of its entry into the vagina, each opening of the horn is marked by the presence of two small valves. The uterus presents no special feature that deserves mention and leads into the ovaries of the corresponding side in front.

The *eggs* are oval, thin-walled, and measure .05 mm. long by .025 mm. broad.

The enclosure of the horns of the vagina within a common sheath towards their posterior end gives an indication of the beginning of the formation of pars ejectrix of other Strongylids.

#### 6. *KILULUMA MAGNA*, sp. nov.

A large number of specimens belonging to both sexes were obtained.

The body is elongated cylindrical, slightly narrower towards either end. The female is longer than the male.

The *cuticle* presents the general characters given in other forms and is very finely striated. At the anterior end the *mouth collar* has four

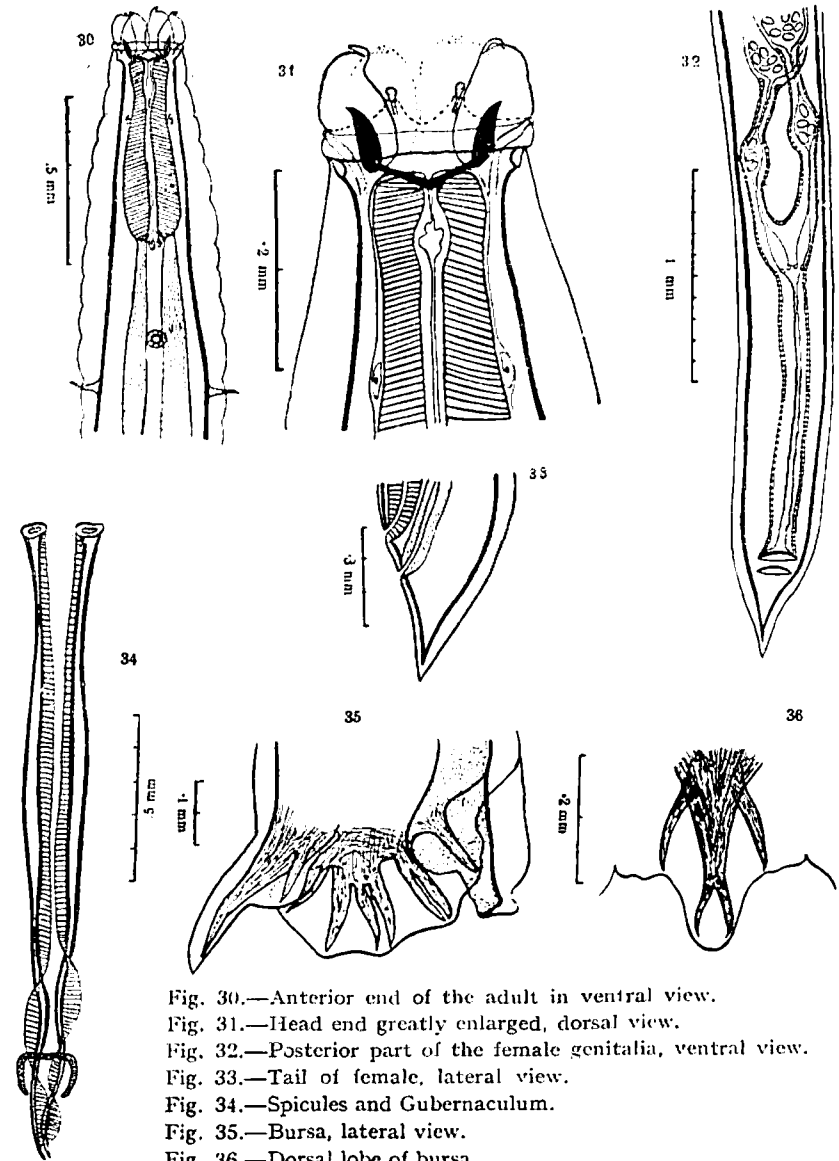


Fig. 30.—Anterior end of the adult in ventral view.  
 Fig. 31.—Head end greatly enlarged, dorsal view.  
 Fig. 32.—Posterior part of the female genitalia, ventral view.  
 Fig. 33.—Tail of female, lateral view.  
 Fig. 34.—Spicules and Gubernaculum.  
 Fig. 35.—Bursa, lateral view.  
 Fig. 36.—Dorsal lobe of bursa.

*KILULUMA SOLITARIA*.

prominent lobes on its anterior face, each carrying a two-jointed *papilla* at its extremity. It is separated from the body wall of the trunk by the *cephalic groove* as is the case with other forms.

The *head papillæ* have the usual characters for the submedian papillæ and the *lateral papillæ* are small and open further forward from the cephalic groove.

The *mouth* is surrounded by four prominent *lips* that bear long pointed processes arising internally from the base of the buccal capsule. They arise from the lips at their inner lower angles within the buccal capsule, and may be compared with the leaf crowns.

The *buccal capsule* is composed of a thick cuticular material and is two jointed, the two pieces being placed end to end one above the other. The anterior piece is longer than the posterior element of the capsule, and is curved outwards.

The *oesophagus* is very long and is roughly speaking cylindrical. The *oesophageal funnel* is short and the *oesophageo-intestinal valves* are large and prominent.

The *intestine* is wide in front and gradually narrows down towards its posterior end. The intestinal cells are large and flattened, containing highly granular cytoplasm, at places full of dark pigment granules. The lumen of the intestine is lined with cuticle.

The *cervical papillæ* are situated laterally on either side of the oesophagus about 1.04 mm. from the anterior end. They present the common form of structure.

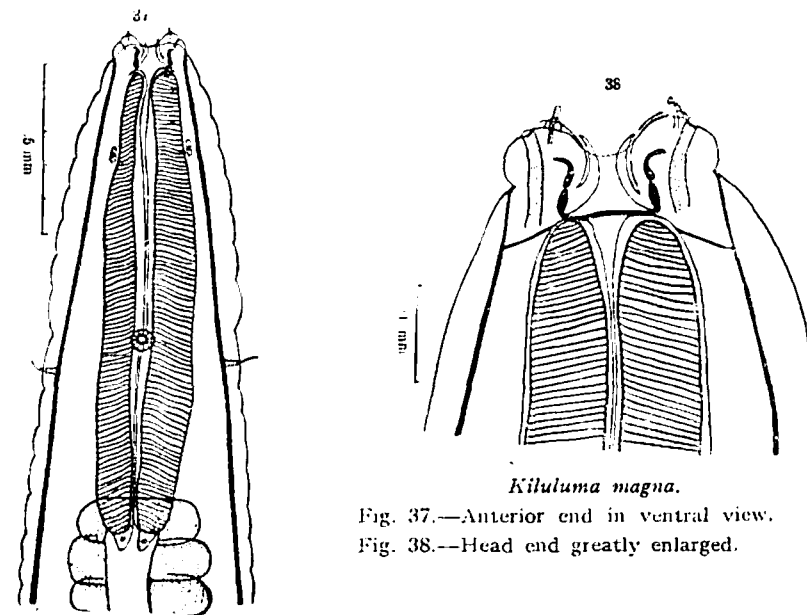
The *nerve ring* is .36 mm. from the anterior end.

The *excretory pore* is in the region of the oesophagus and is situated on the ventral side in front of the cervical papillæ, about .91 mm. from the anterior extremity. It has a thick muscular sphincter surrounding the opening which has the diameter of .04 mm.

#### MALE CHARACTERS.

The males are about 20 mm. long and attain the greatest diameter of .85 mm. at about the middle of the length of the body. The *caudal bursa* is short and reduced and the lobes are quite distinct. The *bursal rays* also show a similar disposition of parts to that described in the other forms above. There are seven rays supporting each lateral lobe of the

bursa. The *preventral ray* and the *ventral rays* are of the common type. Of the lateral rays the *extra-lateral ray* arises more or less independently from the body wall and the other three laterals arise together from the common stem. The *postero-lateral ray* runs along with the medio-lateral ray during its proximal half and then suddenly diverges from it.



*Kiluluma magna*.

Fig. 37.—Anterior end in ventral view.

Fig. 38.—Head end greatly enlarged.

The *dorsal lobe* of the bursa bears a small conical outgrowth notched at its apex. It is not longer than the lateral lobe. The *dorsal ray* divides into two divergent branches near its end and the two branches run into the conical outgrowth of the bursa, one on either side of the notch.

The *genital cone* is contractile and the *dermal collar* is well-developed, forming a distinct swelling.

The *spicules* are 2.5 mm. long and have rounded tips. They possess the characters described for *K. rhinocerotis* and have a cuticular ala on either side of the spicular axis. In the posterior part, the spicule is spirally twisted and there is only one ala that curves along with the spiral twist of the axis itself. Here it is not symmetrically arranged. The posterior part of the spicule is represented in Fig. 41.

The *gubernaculum* is ring-shaped and bears a pair of elongated processes running backward at its posterior end.

#### FEMALE CHARACTERS.

The females are about 24 mm. long and gradually taper towards the posterior end which is rounded off. The body terminates posteriorly in a short conical stumpy *tail* about .1 mm. long, in continuation of its ventral side.

The *anus* is ventrally situated about .215 mm. in front of the tip of the tail and leads into a short rectum which is .6 mm. long. The rectal ligament cells are present at its junction with the intestine. Towards the posterior end the rectum becomes narrower.

The *vulva* is .12 mm. in front of the anus, and leads into a short *vagina* 1.2 mm. long. It is lined with cuticle throughout and the lumen is wide in front. The *horns* of the vagina are very long—about five times as long as the vagina—and measure 5 mm. in length. In their forward course the horns cross each other and there are three distinct swellings in each of them. These swellings were found full of eggs. The *uterus* is short and has the common characters.

The *eggs* are oval, thin-walled structures, being .12 mm. long and .05 mm. broad.

#### *Kiluluma magna*.

Fig. 39.—Female genitalia.

A.—Posterior part showing vagina and hinder end of horns.

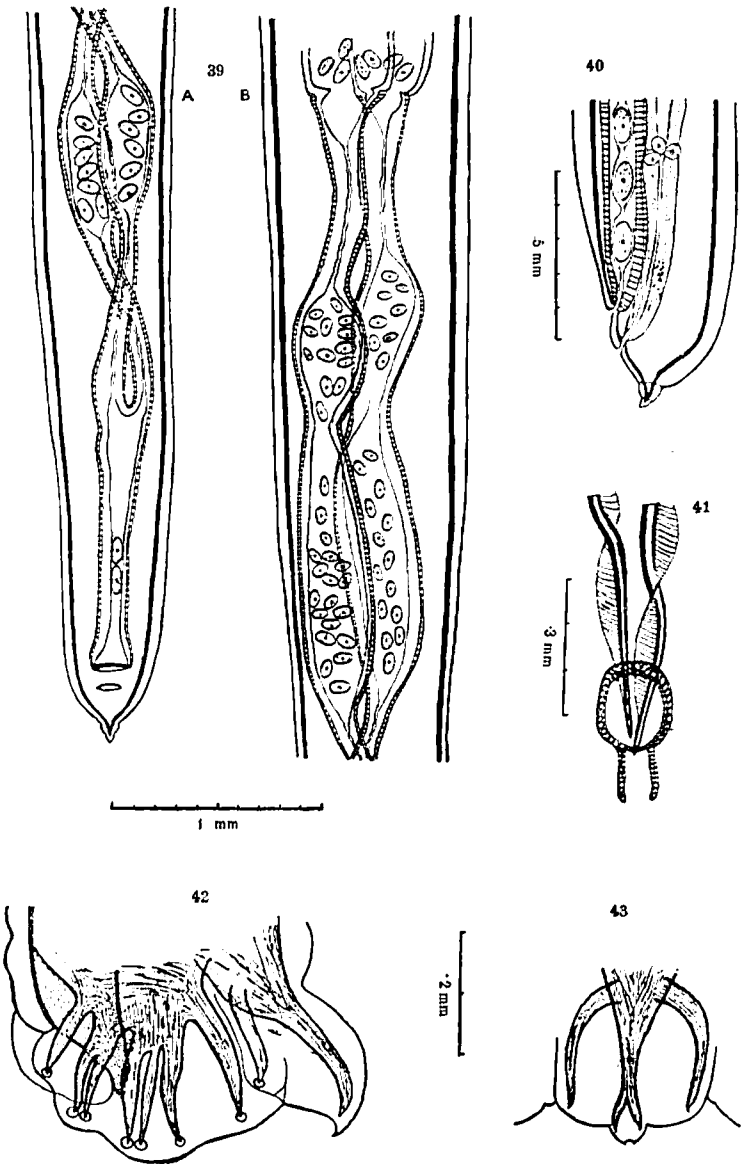
B.—Continuation forward of the same, showing horns and the beginning of uteri.

Fig. 40.—Tail of female, lateral view.

Fig. 41.—Distal portions of spicules showing the spiral twist of ala. Gubernaculum is also shown.

Fig. 42.—Lateral view of bursa.

Fig. 43.—Dorsal view of bursa.



*KILULUMA MAGNA*.

## DISCUSSION.

The family *Strongylidae* is one of the largest amongst the parasitic Nematodes containing nearly 40 genera placed in different subfamilies. It has been the subject of frequent study and various attempts have been made to classify it. Of the numerous accounts of its classification, the names of Weinland, Leiper and Clayton Lane may be mentioned. The results of all the earlier workers have been revised by Railliet (1916), who gave a general key of the parasitic Nematodes, recognising eight different superfamilies. This has been further elaborated by Travassos (1920), who has attempted to give a useful key for the identification of the parasitic Nematodes. In his classification Travassos placed the genus *Kiluluma* along with the genus *Stephanurus* under the subfamily *Stephanurinae* (Raill. & Bausch, 1919). Daubney (1923), while describing the *Stephanurus dentatus*, suggested that the genus *Kiluluma* be removed from the subfamily *Stephanurinae* and be classed with the *Cylicostomes*. The present investigation definitely establishes the conclusion of Daubney that the two genera, *Kiluluma* and *Stephanurus* have nothing in common and hence should be separated from each other.

The characters of the subfamily *Stephanurinae* are "mouth with small crowns, and the caudal bursa is atypical and rudimentary." (Trav.) The genus *Stephanurus* does exhibit both of these characters, but neither of these characters are shown by any of the species of *Kiluluma*. In the latter genus the bursa is well developed and is distinctly lobed. The nature of the crowns is quite different in the two. This would be a sufficient reason to separate the two genera from each other. As a further argument against the inclusion of these genera in the same subfamily, the following points may be considered.

The peculiar "tooth-like" folds arising out of the base of the cuticular wall of the buccal capsule of *Stephanurus dentatus* are entirely wanting in *Kiluluma*.

The female characters are also different in the two cases under consideration. In *Stephanurus* the vagina is a very short structure transversely placed and divides into two divergent uteri, each with its own ovejector apparatus. The posterior uterus, after proceeding backwards for some distance, curves forwards and runs parallel to the other. In *Kiluluma*, as we have seen, the vagina is invariably long and extends

forwards towards the anterior end ventral to the gut and divides into two horns that run parallel to each other and sometimes twist round each other. The complicated ovejector apparatus is here replaced by these horns which intervene between the vagina on the one side and uterus on the other. Thus the female genitalia are based on quite a different plan in the two genera, and hence on the basis of this character it would not be advisable to put them together. It may, however, be mentioned that the female genitalia of *Kiluluma* are different from those of the other *Strongylinae*, in possessing no definite ovejector apparatus. In the *Cylicostomes* and their allies the vagina leads into an ovejector apparatus consisting of pars ejetrix and pars haustrix before entering the uterus. In the present genus the place of this complex apparatus is taken by the simple horns of the vagina. In two of the species, *K. africana* and *K. solitaria*, the posterior portion of both the horns is enclosed in a common sheath, but the tubes can be distinctly identified running separately from each other. Thus in the characters of the female genitalia the genus *Kiluluma* stands alone amongst the *Strongylinae*.

Lastly, the male characters are peculiar to the genus *Kiluluma*. The bursa is well developed and distinctly lobed, whereas in *Stephanurus* it is rudimentary and very much reduced. The bursal rays are also distinctive for the genus. The presence of an extra-lateral ray in the lateral series is unique amongst the members of the family *Strongylinae* and has no correspondence in any other genus. It may, however, be suggested that this extra-lateral corresponds to the postero-lateral ray of *Strongylinae* and that the externo-lateral has split up into two parallel branches which run side by side and so they collectively correspond to the externo-lateral ray. I have no embryological data in support of this view and merely put it forward tentatively as a possible, though not a probable, explanation. On the other hand the study of the conditions in other genera point to the fact that no splitting has taken place. Thus in *Æsophagostomum* we find that the medio-lateral and postero-lateral rays run together and the externo-lateral is distinct, a condition which, as has already been stated, is the opposite of that found in *Kiluluma*. In certain other genera of *Strongylinae* all three rays run together and it would be difficult to justify the claim that they have resulted from the splitting-up of one single ray of the bursa into three. The view taken by the writer is that the fourth ray of the series is an extra development in the present genus having no correspondence whatsoever in any known genus of the family *Strongylinae*.

The preventral ray is slender and fairly conspicuous in *Kiluluma*, and its relation to the prebursal papilla of other members of the family *Strongylinæ* may now be considered.

In the genus *Æsophagostomum* we find that there is a prebursal ray on either side of the body in front of the bursa. This is a short stumpy outgrowth from the body wall and is covered over by a slightly thick cuticle in this region. In *Triodontophorus*, the prebursal papillæ are fairly long and slender and resemble a bursal ray in appearance, but are in front of the bursa. In *Cylicostomum* the prebursal papillæ are also ray-like in appearance but are found in the region of the dermal collar. The first ray of the bursa in all these genera is the ventro-ventral and is followed by latero-ventral. Both of these are preceded in *Kiluluma* by the preventral ray. If now we turn to the condition of the bursal rays found in the *K. macdonaldi*, described in the present communication, we find that the preventral ray has actually left its position within the bursa and has shifted forwards to appear on the body-wall to assume the same position as that occupied by the prebursal ray in certain *Cylicostomes*. A little further shifting of this ray on the body wall and its reduction in size would bring about the condition found in the genus *Æsophagostomum* and a number of other genera of the family *Strongylinæ*. It would, thus, appear that the general character of the preventral ray is similar to that of the prebursal papilla of other *Strongyliids*, the only difference being that in *Kiluluma* it has actually entered into the formation of the bursal rays by a backward shifting. We may, therefore, look upon the two structures as homologous.

If we accept the view of removing the genus *Kiluluma* from the sub-family *Stephanurinae*, as has been suggested by Daubney and has been confirmed above, there remains to be considered whether it should be classed with the *Cylicostomes* or not. To ascertain this we have to depend upon the diagnostic characters of the family that rests on the following points:—

1, the mouth capsule; 2, the bursa and its supporting rays; 3, the nature of the genital cone and the spicules; 4, the female genitalia.

Of these we have already considered 2 and 4 and have found that the condition in *Kiluluma* is unique. It may further be stated that the dorsal ray of the bursa divides into two simple branches after the middle of its length. As regards the genital cone we find that it is highly contractile and its dorsal lip carries a pair of laterally-placed mammalliform

papillæ that are devoid of the nipple-like process commonly found in the *Strongylinæ*. The spiral twist in the posterior part of the spicular axis is also peculiar.

Coming to the characters of the buccal capsule we find that the *Strongylinæ* have one or two crowns in the longitudinal axis of the body at the anterior end. These leaf-crowns are narrow acicular structures of a "cuticular nature" and may or may not be pointed at the ends. They are formed by the "splitting-up" of the anterior sharp edge of the mouth collar into a number of small leaf-shaped processes and are of the same nature as the septa of the Anthozoan skeleton. They may arise from inside the buccal capsule, and in that case are the inturned portions of the mouth collar that have divided there. In *Kiluluma* the mouth collar presents anteriorly four distinct lobes that could be clearly observed, each lobe carrying a papilla. Inside the collar we have a row of fleshy lobes arranged round the mouth and arising from the base of the buccal capsule. Each lobe bears along its inner edge a small pointed flagelliform outgrowth arising from it at a variable level. In some it is found at the extremity of the lobes and in others it is in a sunken position inside the mouth. These lobes not being entirely cuticular and also bearing these secondary processes cannot, in the writer's opinion, be homologised with the leaf-crowns which are, according to Looss, the split-up parts of the mouth collar. They are thick, fleshy structures and do not arise from the mouth collar. They, however, surround the mouth like lips to which they could be more properly compared. I, therefore, regard these forms as quite distinct from the other *Strongylinæ*, thereby necessitating the creation of a special sub-family, *Kiluluminae*, for their reception, on the following characters:—

1. The presence of a series of lips round the mouth.
2. The condition of the bursa and the disposition of its rays.
3. The inclusion of the prebursal papillæ within the bursa as pre-ventral rays,
4. The presence of an extra-lateral ray in the lateral group,
5. The great contractility of the genital cone, and
6. The peculiar condition of the female genitalia; the replacement of the complex ovejector apparatus by simple horns of the vagina.

N.B.—All figures are drawn with the help of Camera Lucida.

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Notes on the eggs and early development of some species of *Oxyuridæ*.

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## OXYURIS VERMICULARIS.

ALTHOUGH *Oxyuris vermicularis* occurs very frequently in children, material from which to study the early development, mature female worms, was difficult to obtain.

Specimens were found both in the normal stool and in the stool after treatment with santonin. Egg-laying began as soon as the worms came into contact with air; those which happened to be on the surface very quickly became surrounded by a white deposit of eggs and the worms themselves became reduced to fine threads, which were difficult to detect. Egg-laying was also induced by bringing females into water at body temperature.

Exposure to normal saline for more than twenty-four hours caused a certain degree of mortality among the eggs. The highest percentage of development was obtained when the females from the stool were placed directly in a small quantity of tapwater. If kept cool in this medium for about twenty-four hours and then incubated at body temperature, practically 100 per cent. of the eggs continued development.

The eggshell at the time of deposition showed fine radial striations over the entire surface; these became somewhat more conspicuous as incubation proceeded. There was present at one end (anterior) and extending down for a short distance on to the ventral side, a thin area—the point of emergence of the future larva. The shell could not withstand prolonged exposure to water. In those eggs which were kept in water with insufficient aeration and at a temperature which inhibited further development of the embryo, the shell began to disintegrate after about five days; by ten days it had entirely disappeared, leaving the granular remains of the embryo enclosed in the vitelline membrane.

The "tadpole" embryo of the freshly deposited egg showed no definite gut formation, but passing in from the anterior end was a clear, granule-free area, indicating the future oesophageal region.