DESCRIPTION OF ANCYLOSTOMA PLURIDENTATUM, A HOOKWORM OF CARNIVORES, AND A REVIEW OF THE GENUS ANCYLOSTOMA

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INTRODUCTION

Ancylostoma pluridentatum was described by Alessandrini (1905) under the name *Uncinaria pluridentatum* from the intestine of *Felis mitis*, in Brazil. The special characteristics of this worm, as noted by that writer, are the two unequal pairs of teeth in the anterior and ventral portion of the mouth capsule, the inner or median pair being described as very small—in fact, almost rudimentary—and the presence of three small projections or teeth on each side of the dorsal edge of the mouth capsule. Alessandrini also noted in this species a small process with a rugged surface on each side of the cloacal aperture in the male.

Ancylostoma pluridentatum was not reported again for 17 years, and then Vevers (1922) reported it from the intestine of *Felis tigris*, in the Malay States, noting certain minor differences between his specimens and Alessandrini's description of this species. Two years later Chapin (1924) recorded it from a South American carnivore (*Felis tigrina*), which had died in the National Zoological Park in Washington, D. C. Chapin merely noted the presence of this species in the United States, but did not discuss the morphology of the worm.

In the opinion of Lane (1918) this species should be made the type of a new genus. Lane has also considered the possibility that Alessandrini may have misinterpreted the structures on the dorsal edge of the mouth capsule as well as the two rugged structures near the cloacal aperture of the male, in which case the question of the possible identity of *Ancylostoma pluridentatum* with *Ancyclostoma*

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55216—27——1

braziliense deserved serious consideration. Lane concluded, however, that: "The doubt can only be cleared up by the reexamination of Alessandrini's original material, if this be still in existence." Darling (1923) appears to accept the view that *A. pluridentatum* is probably identical with *A. braziliense*, basing this view on Alessandrini's statement that the inner pair of teeth is almost rudimentary, a feature noted by Darling as well as by other investigators with reference to the corresponding teeth of *A. braziliense*. Darling states further that there is a possibility that the three dorsal teeth on each side of the mouth capsule as noted by Alessandrini may have been the result of some pathological condition.

In view of the doubt expressed by Lane and Darling concerning the present status of *Ancylostoma pluridentatum* the writer examined the specimens collected by Chapin from *Felis tigrina* as well as specimens of this species from two other lots present in the Helminthological collections of the United States National Museum. One lot was collected about a year ago from the intestine of a South American carnivore (*Felis eyra*) that had died in the National Zoological Park, the specimens having been determined by Chapin and the writer. The second lot was discovered by the writer in the course of examinations of various specimens of hookworms from carnivores present in the helminthological collections of the United States National Museum. The lot in question was collected in January, 1905, from *Felis* species by Dr. Albert Hassall in the course of a post-mortem examination of the animal which had died in the National Zoological Park. These specimens were later examined by Dr. C. W. Stiles, of the hygienic laboratory of the United States Public Health Service, who labeled them "*Ancylostoma*, new species." It should be noted in this connection that Doctor Stiles's determination was made before Alessandrini's description of *A. pluridentatum* was published.

The observations recorded in this paper not only confirm the specific validity of *A. pluridentatum*, based on a study of specimens from the type locality, but also clear up certain points in the morphology of these worms that led Darling to the view that *Ancylostoma pluridentatum* and *Ancylostoma braziliense* are probably identical.

DESCRIPTION OF ANCYLOSTOMA PLURIDENTATUM

The features of the mouth capsule that differentiate *Ancylostoma pluridentatum* from all other species of the genus *Ancylostoma* are the structure of the two pairs of teeth in the anterior and ventral portion of the mouth capsule, coupled with the presence of three small teeth on each side of the dorsal wall of the mouth. (Fig. 1.) As has already been said these features were noted and emphasized by

Alessandrini who described the inner ventral teeth as being very small in comparison with the large outer teeth. So far as concerns the relative size of the pair of inner teeth, the writer has not been able to confirm Alessandrini's findings, as the inner pair of teeth in the specimens examined was found to be of good size. However, Alessandrini's interpretation of the size of the inner teeth may have been due to his study of imperfectly cleared specimens or to an interpretation of the tips of the teeth as teeth with the remaining broad portion regarded as a basal plate to which they were attached, instead of regarding the entire structure as a tooth in each case as the writer has regarded them. In specimens imperfectly cleared only the tips of the inner teeth which point caudad are visible, since they protrude beyond the margin of the outer teeth, the remaining portion of these teeth, which lie in a more or less horizontal plane, being covered by the outer teeth. When the buccal capsule is viewed through the ventral surface, however, the inner teeth which are more ventrally placed than the outer teeth, stand out quite distinctly in well cleared specimens, and are seen to be discrete structures, and of good size. The tips of the outer teeth are relatively large and conspicuous, and have the shape of a triangle.

In certain specimens from *Felis tigrina* the tips of the outer teeth were found to be truncated in a number of specimens (fig. 4), resembling in this respect the corresponding teeth of *Ancylostoma braziliense*, in which similar malformations of the outer teeth are by no means uncommon. In *A. pluridentatum* the abnormality in the outer teeth is sometimes unilateral and sometimes bilateral. In some specimens the tip of the tooth appears to be cut off cleanly whereas in other specimens it presents the appearance of an uneven surface suggestive of erosion. Abnormalities were also observed in the three pairs of small dorsal teeth in specimens from *Felis tigrina*. The middle tooth on one or both sides is the one affected, and appears to be eroded in certain specimens. In some specimens the tips of the teeth are almost entirely absent, the characteristically pointed tooth being replaced by a slightly concave or by a more or less irregularly flattened cuticular elevation. Normally the dorsal teeth end in sharp points. No abnormalities of the teeth were observed in specimens from *Felis eyra* and from *Felis* species.

The cephalic papillae are very conspicuous and are located anterior to the nerve ring. Their position with respect to the middle of the esophagus is by no means constant, being either slightly anterior or posterior to the middle of the esophagus. The position of the excretory pore is slightly posterior to the nerve ring.

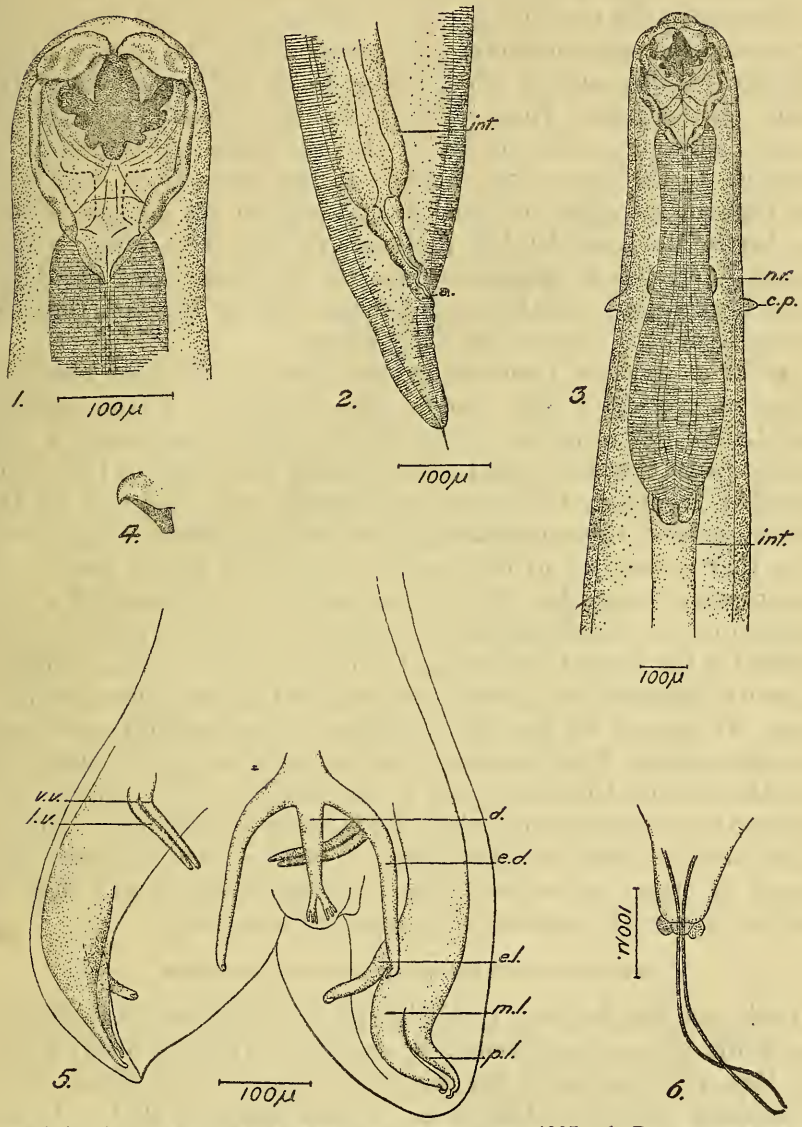
Male.—The males are from 7 to 8 mm. long by about 294μ wide in the middle of the body. The maximum width of the body is immediately in front of the bursa which has a diameter of from 302 to

310μ. The buccal capsule is from 131 to 178μ wide. The esophagus (fig. 3) is from 638 to 740μ long by 168μ in maximum width. The nerve ring is located anterior to the middle of the esophagus, dividing the latter into two parts having an approximate ratio of 4 to 6. In a specimen from *Felis tigrina* the cervical papillae divide the esophagus into two parts, the ratio of the anterior part to the posterior part being 17 to 13, whereas in a specimen from *Felis eyra* this ratio is 25 to 17.

The spicules are long and slender (fig. 6), and are from 1.15 to 1.17 mm. long. The short gubernaculum is from 60 to 74μ long by 10μ wide. The bursa (fig. 5) is from 470 to 554μ wide when spread out. The ventro-ventral ray is a little longer and also somewhat wider than the latero-ventral ray. The tips of these rays extend to within a short distance from the margin of the bursa. The externo-lateral ray, which terminates at a considerable distance from the edge of the bursa, is much smaller than the medio-lateral and postero-lateral rays from which it diverges. The medio-lateral and postero-lateral rays are large and parallel, their tips extending almost to the posterior margin of the lateral lobes of the bursa. The distance between the tips of the externo-lateral rays when the bursa is viewed from the dorsal aspect is 180μ. The dorsal ray is from 151 to 168μ long and divides into two branches at a distance of about 35μ from the posterior end. Each branch of the dorsal ray is tridigitate. The prebursal papillae are located at a distance of 504μ from the posterior margin of the lateral lobes of the bursa. As noted by Alessandrini, a rugged structure is present on each side near the anogenital opening (fig. 6), the surface of which appears granular in optical section.

Female.—The females are from 10 to 11 mm. long by 344 to 378μ wide in the region of the vulva. The maximum diameter of the buccal capsule varies from 168 to 210μ. The esophagus is from 739 to 806μ long by 185 to 210μ in maximum width. The cephalic papillae divide the esophagus into two unequal parts, the ratio of the portion anterior to the papillae to that posterior to the papillae being 26:20 in a specimen from *Felis tigrina*, whereas in a specimen from *Felis eyra* the ratio is 22:23. The nerve ring is anterior to the cephalic papillae, the excretory pore being in a position intermediate between the nerve ring and cephalic papillae.

The vulva is located near the beginning of the posterior third of the body. In an immature specimen about 8 mm. long the vulva is located at a distance of 2.8 mm. from the tip of the tail. In a specimen about 11 mm. long the distance from the vulva to the tip of the tail is 3.3 mm. The tail (fig. 2) is from 126 to 176μ long and is gradually attenuated. The slender bristle that is inserted in the tip of the tail is from 17 to 25μ long.



FIGS. 1–6.—ANCYLOSTOMA PLURIDENTATUM ALESSANDRINI, 1905. 1, BUCCAL CAPSULE; 2, POSTERIOR END OF FEMALE; 3, ANTERIOR PORTION OF WORM; 4, PAIR OF VENTRAL TEETH; 5, BURSA OF MALE (SOMEWHAT DIAGRAMMATIC); 6, REGION OF CLOACAL OPENING SHOWING SPICULES. *a.*, ANUS; *c. p.*, CERVICAL PAPILLAE; *d.*, DORSAL RAY; *e. d.*, EXTERNO-DORSAL RAY; *e. l.*, EXTERNO-LATERAL RAY; *int.*, INTESTINE; *l. v.*, LATERO-VENTRAL RAY; *m. l.*, MEDIO-LATERAL RAY; *n. r.*, NERVE RING; *p. l.*, POSTERO-LATERAL RAY; *v. v.*, VENTRO-VENTRAL RAY

55216—27——2

DISCUSSION

It will be noted from the description that there are certain slight differences in the morphology of the worms from *Felis tigrina* and *Felis eyra*, the most important differences being in the position of the cephalic papillae and in what appear to be malformations of the teeth. In specimens from *Felis tigrina* the cephalic papillae are located anterior to the middle of the esophagus and but slightly posterior to the nerve ring, whereas in specimens from *Felis eyra* the cephalic papillae are located posterior to the middle of the esophagus and considerably posterior to the nerve ring. Other minor differences in specimens from the two hosts were noted but these were rather variable, and possibly due to the fact that the worms from *F. tigrina* are not fully grown.

So far as concerns Lane's suggestion that *Ancylostoma pluridentatum* represents a new genus, the writer is of the opinion that Lane's judgment was sound in not actually proposing a new generic name, that the special differentiating characters of this worm should be regarded at this time as of specific rank, and that for the present, at least, these parasites may be left in the genus *Ancylostoma* since they possess all of the essential characters of this genus. If for no other reason than that of convenience, the creation of a new genus for *A. pluridentatum* is avoided in this paper as not justified at the present time owing to the comparatively small number of easily differentiated species now assigned to the genus *Ancylostoma*. In general we feel that dividing a comparatively small and coherent genus to form from one of its species a new genus containing only that species frequently adds unwarrantably to the already burdensome nomenclature with which the taxonomist must cope. Should other forms be found to share with *A. pluridentatum* characters not shared by other species assignable to *Ancylostoma*, it will then be time to consider the proposal of a genus for this group.

SPECIES OF THE GENUS ANCYLOSTOMA

Yorke and Maplestone (1926) list the following species as belonging to the genus *Ancylostoma: A. duodenale* (Dubini, 1843) Creplin, 1845, type species of the genus; *A. braziliense* de Faria, 1910; *A. caninum* (Ercolani, 1859); *A. conepati* (Solanet, 1911); *A. gilsoni* Gedoelst, 1917; *A. malayanum* (Alessandrini, 1905); *A. minimum* (Linstow, 1906); *A. mucronatum* (Molin, 1861); *A. mycetes*, new name, Yorke and Maplestone, 1926 (=*Diploodon quadridentatum* Molin, 1861); *A. pluridentatum* (Alessandrini, 1905). Molin's two species are inadequately described, but his figures indicate quite clearly that they belong to the genus *Ancylostoma*. His figure of *A. mucronatum* shows two equal spicules nearly one-fourth as long as the total length of the male. In this connection it is interesting

to note that the males of *A. conepati*, which have an average length of 8.8 mm., have long spicules, their average size being 2 mm., the ratio of the length of the spicules to the total length of the body being practically the same in this species as in *A. mucronatum*. The fact that both of these species occur in South America is of further interest in connection with their possible identity. It may be noted, however, that *A. mucronatum* is from an edentate, *Dasypus gilvipes*, whereas *A. conepati* is from a carnivore, *Conepatus suffocans*. However, owing to the paucity of morphological data regarding *A. mucronatum* the question of the possible identity of this form with *A. conepati* is left open. Both of these species appear to be closely related to *A. caninum*, differing from the latter primarily in the lengths of the spicules. Molin's figure of *Diploodon quadridentatum* (=*A mycetis*) shows two pairs of well-developed teeth in the anterior portion of the mouth capsule. Male specimens of this species were not available to Molin, his description and figure being based on a female. Whether this form, collected from a primate (*Mycetes coraya*), is *A. duodenale* or whether it represents a distinct species can not be decided on the basis of Molin's description. *A. minimum* is inadequately described, there being no reference to teeth in the anterior portion of the buccal capsule. Von Linstow's figure of the bursa suggests that the species may belong to the genus *Ancylostoma*, although the possibility that he was dealing with a species of *Uncinaria* must also be taken into consideration. So far as can be judged from the arrangement of the bursal rays, this species is related to forms such as *A. braziliense* and other species of this genus, which have but two pairs of teeth in the anterior portion of the buccal capsule. *A. gilsoni* Gedoelst, 1917, from *Sciurus prevosti*, is regarded by the writer as a synonym of *A. braziliense*, since the figures and measurements of this species given by Gedoelst agree in practically all respects with available figures and descriptions of *A. braziliense* and with the writer's observations on that species based on a study of specimens from the United States, South America, and various parts of Asia. Gedoelst has apparently created *A. gilsoni* largely on the basis of host relationship and does not point out in what respects this species differs from *A. braziliense*. Our present knowledge of host relationships of species of the genus *Ancylostoma* does not appear to justify the erection of a new species on this basis alone, since certain species of this genus are known to occur in aberrant hosts. This is especially true with reference to *A. braziliense*, which occurs not only in species of carnivores but also occasionally in man, in which host it attains fertile maturity.

Lane (1916) has called attention to the fact that in species of the genus *Ancylostoma* which contain three pairs of teeth in the anterior

ventral portion of the mouth capsule, the medio-lateral and postero-lateral rays are divergent, the cleft between these rays being deeper than that between the externo-lateral and medio-lateral rays, whereas in forms having two pairs of teeth in the anterior ventral portion of the buccal capsule the medio-lateral and postero-lateral rays lie close together and parallel, the cleft formed between these rays not being deeper than that formed between the externo-lateral and medio-lateral rays.

The following key will serve to differentiate the species of *Ancylostoma*[1] and to indicate their relationships.

I. Three pairs of teeth in anterior ventral portion of buccal capsule; medio-lateral and postero-lateral rays divergent.
  1. Inner pair of teeth small or rudimentary---------- A. duodenale.
  2. Inner pair of teeth well developed.
    A. Species inadequately described; from an edentate (*Dasypus gilvipes*)---------- A. mucronatum.
    B. Species adequately described; from carnivores.
      a. Spicules 600–900 μ long----------A. caninum.
      b. Spicules 1.8–22 mm. long----------A. conepati.

II. Two pairs of teeth in anterior ventral portion of buccal capsule; medio-lateral and postero-lateral rays close together and parallel.
  1. Inner pair of teeth small or rudimentary.
    A. Three pairs of small toothlike projections present on dorsal wall of buccal capsule----------A. pluridentatum.
    B. Toothlike projections not present on dorsal wall of buccal capsule---------- A. braziliense.
  2. Inner pair of teeth well developed.
    A. Species inadequately described; from a primate (*Mycetes coraya*)---------- A. mycetis.
    B. Species adequately described; from carnivores (*Ursidae*). A. malayanum.

In connection with the above key it is worth noting that the teeth in the anterior ventral portion of the buccal capsule of species of *Ancylostoma* show a series of stages which may be interpreted as being either progressive or regressive in nature. In *A. caninum*, *A. conepati*, and *A. mucronatum* three pairs of well-developed teeth are present in the anterior ventral portion of the buccal capsule; in *A. duodenale* the inner of the three pairs of teeth is very small, in fact, almost rudimentary; in *A. malayanum* and, so far as can be judged from Molin's figure, in *A. mycetis*, only two pairs of well-developed teeth are present in the anterior ventral portion of the buccal capsule; in *A. pluridentatum* and in *A. braziliense* two pairs of teeth are present, the inner pair of teeth being reduced in size, the

[1] *A. minimum* is not included in this key owing to the absence of knowledge regarding the presence of teeth in the anterior ventral portion of the buccal capsule. Assuming that von Linstow's species belongs to the genus *Ancylostoma*, it has affinities with the forms in Group II so far as can be judged from his figure of the bursa.

buccal capsule containing in the anterior ventral portion one pair of well-developed teeth and one pair of small or rudimentary teeth. In certain specimens of *A. braziliense* collected by the writer from a cat which was shipped from Florida the inner pair of small teeth was found to be entirely absent, whereas in other specimens from the same host it was present. This observation suggests the possibility of the occurrence of a variety of *Ancylostoma braziliense* containing but a single pair of teeth. Such variation, if germinal in character and not due merely to external causes, undoubtedly represents an incipient species. It is suggested, purely as an interesting speculation, that the various species of *Ancylostoma* containing less than three pairs of well-developed teeth in the anterior oral margin may have arisen from forms containing three pairs of teeth, each species representing a mutation.

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