VII. *The Parasites of Elephants.* By T. SPENCER COBBOLD, M.D., F.R.S., F.L.S.,
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(Plates XXIII. & XXIV.)

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Preliminary Remarks.

CONSIDERING the importance of Elephants as domesticated animals and the abundant opportunities for post-mortem examinations that occur in India, it is surprising how little has been done towards completing our knowledge of the parasites of these large quadrupeds. As we proceed it will be found that most of the facts of parasitism at present known have been gathered from the examination of animals that have died in captivity either in Europe or in America.

For some years past I have been engaged in collecting materials, which thus far have only served to supply occasional and very incomplete records; moreover the notices in question have chiefly appeared in a periodical inaccessible to most naturalists.

Either from the mistaken notion that the study of parasites is unattractive, or that it is unremunerative, this subject has been strangely neglected; for there is no animal of equal importance with the Elephant about whose parasites so little is known. Naturalists abroad have done almost nothing in this direction; and of those at home one noteworthy exception alone occurs in the person of the late Dr. Baird, who described several species contributed by Dr. Murie and Mr. Gerrard respectively to the British Museum. The entozoa preserved in that institution, however, have been for many years past practically inaccessible to investigators.

It is now desired to supply a summary of all that has hitherto been published, corrected and extended by data that are entirely new. Only such anatomical details as present points of zoological interest can be given; but it is proposed to supplement the natural-history facts with certain particulars which serve to explain the rôle of parasites in the production of fatal epizootics. This method, with the Society's approval, may stimulate further inquiry, and thus ultimately lead to the adoption of measures calculated to lessen the mortality amongst domesticated Elephants.

The materials placed at my disposal for this investigation have been contributed at different times, and severally, by Professor Huxley, by Assistant Commissary-General Colonel H. P. Hawkes, of the Madras Staff Corps—whose earlier contributions reached me through the late Dr. Baird and Dr. Hugh Cleghorn,—by Veterinary Surgeon Thacker, also of the Madras Army, by Mr. John Henry Steel, A.V.D., late Demonstrator of Anatomy the Royal Veterinary College, and by Veterinary Surgeon Frederick Smith, who had professional charge of some Elephants that died at the stables attached to

Sanger's Circus. An independent examination of the viscera of one of the Circus animals likewise supplied me with several new species of internal parasites. I am also indebted to Prof. Flower and Dr. Garson for permitting the examination of two tusks preserved in the Hunterian Museum.

At the time that Dr. Baird wrote his first paper (1859) only two species of Entozoa were supposed to infest the Elephant; and one of these had been imperfectly described. He then added a third. In 1868 Dr. Baird indicated a fourth species; and one year later the hitherto imperfectly but best-known parasite was pretty fully described by myself. Thus up to the year 1869 only four internal parasites were known to infest Elephants; and of these one had been referred to the genus *Ascaris*, two to the genus *Sclerostoma*, whilst the fourth species was supposed to be identical with the common fluke. This was an error. To show how little progress has since been made, I may observe that when, so lately as 1878, Dr. O. von Linstow published his useful 'Compendium der Helminthologie,' the actual number of known and really genuine species had not increased. To be sure, Dr. von Linstow did not hesitate to record the occurrence of six distinct species; but he accomplished this result by placing the fluke parasite under three separate specific names. There is not the smallest ground on which to justify this process of species-splitting. If my determinations are correct, it follows that up to the present time only four Entozoa proper to Elephants are known to science; however, notwithstanding my reduction of Dr. von Linstow's list, and the consequent rejection of several recorded species, I am now enabled to furnish proofs as to the occurrence of at least twelve distinct species of internal parasites in the Indian Elephant. This includes the bots or larvæ of a dipterous insect. Of the external parasites I have made no special study; but if these be added to the parasitic fauna, the total number of Ectozoa and Entozoa comprises not less than fourteen good species. A simple table will best express their zoological position and relations.

PARASITES.	ENTOZOA ...	<i>Ascaris lonchoptera</i> , Diesing.	NEMATODA ...	HELMINTHA.	
		<i>Sclerostoma sipunculiforme</i> , Baird.....			
		<i>Strongylus clathratus</i> , Baird.....			
		<i>Strongylus foliatus</i> , sp. nov.			
		<i>Strongylus falcifer</i> , sp. nov.			
		<i>Dochmius Sangeri</i> , sp. nov.			
		<i>Filaria Smithii</i> . sp. nov.....			
		<i>Amphistoma Hawkesii</i> , Cobb.			
		<i>Amphistoma ornatum</i> , sp. nov.			
		<i>Amphistoma papillatum</i> , sp. nov.			
		<i>Fasciola Jacksoni</i> , Cobb.			
		<i>Gastrophilus elephantis</i> , Cobb.			
	ECTOZOA ...	Ova of a dipterous insect (Sclater) ...	INSECTA	ARTHROPODA.	
		<i>Hæmatomyzus elephantis</i> , Piaget			
		<i>Homopus elephantis</i> , Mégnin.....			ARACHNIDA ...

For reasons that will be given later on, I have not reckoned Sclater's dipterous ovum as representing a separate species.

Description of Species, and Comments.

1. ASCARIS LONCHOPTERA, Diesing.

A. lonchoptera, Diesing, Syst. Helm. Bd. ii. S. 176, Supp. S. 560; idem, Denkschrift. d. math.-nat. Cl. d. k. Akad. d. Wissenschaften, Bd. xiii. S. 13 (with figures).

Ascarides, Jackson, Catalogue of the Anat. Mus. &c., Boston, 1847, p. 317.

Strongylus elephanti (sic), Rudolphi, Synopsis Entozoorum, Berlin, 1819, p. 36.

Body of uniform thickness, but rather narrowed in front and behind, with an acutely pointed conical tail. *Head* with three large almost spherical lips, the margins of the neck having two lateral semilanceolate winged appendages.

Male unknown.

Length of the female 3 inches (or more). Breadth fully $\frac{3}{4}$ of a line.

Hab. Biliary ducts and duodenum of *Elephas indicus*.

The only published description of this worm is that given by Diesing. He states that the parasite was discovered quite accidentally by Herr Mayor in the year 1822. Several parasites (but it is not stated how many) were found in the gall-ducts of an Asiatic Elephant. This animal had been held in captivity at Geneva, where it was destroyed on account of madness (wegen Lobsucht). Not until the year 1847 do we find any second record of the occurrence of this entozoon. In this instance several specimens were obtained from the biliary ducts and from the duodenum of an Indian Elephant which died in captivity at Boston, U. S. A. It is not stated how many of the parasites existed; but Dr. J. B. S. Jackson, to whom both the find and its record are apparently due, states that these *Ascarides* were associated with numerous flukes. As Dr. Fitz has recently pointed out, the flukes themselves were at the time considered to be examples of the common liver-fluke of ruminants (*Distomum hepaticum*).

It would be interesting to have further particulars respecting the American "find." Of the Geneva specimens, only two, both females, were sent to Vienna; and these were originally entered in the Catalogue as Strongyles. As at present we possess no published description of the male parasite, it may be that the Boston-Museum specimens would, if carefully examined, supply us with the missing link. Even the few particulars that we have respecting the characters of the female worm require verification. The specimens noticed by the illustrious Rudolphi were the same as those described by Diesing; and supposing that Rudolphi actually examined the worms, it is difficult to understand why he should have called them Strongyles, or rather, why he should have placed them amongst his *species dubiæ*, and, as such, in the genus *Strongylus*. The conspicuously three-lipped mouth ought to have afforded sufficient proof of its true generic position. But for Diesing's figures, one might still have remained sceptical as to the ascarid character of the Geneva specimens; and certainly as regards the nature of the Boston find I am still somewhat in doubt, all the more so since the specific characters of the flukes found with the *Ascarides* were from the outset misunderstood. Perhaps Dr. Fitz, who has cleared up certain points respecting the organization of the flukes, will set this matter at rest. At all events, until our own naturalists in India bestir themselves and

make fresh finds, it may be said that the first helminth discovered to infest the Elephant is just that very species about whose structure and economy we are least informed.

2. *SCLEROSTOMA SIPUNCULIFORME*, Baird. (Plate XXIII. figs. 1, 2, & 6, 7, 8.)

S. sipunculiforme, Baird, Proceed. Zool Soc. 1859, p. 427; also P. Z. S. 1868, p. 262 (with figures).

Body smooth, with extremely fine transverse striæ, sipunculiform, thickset. *Head* distinct, separated from the body by a distinct neck or constriction. *Mouth* circular, armed with numerous upright denticles arranged in two rows, with four larger teeth, one on either side, and one in front and behind, springing from between the denticle-rings. *Bursa* longer than broad, apparently supporting twenty rays, the anterior ray being double; the posterior ray quadruple, its innermost division supporting two rudimentary branches of unequal size; posterior lateral ray short. *Spicules* equal, long, straight, and narrow. *Tail* of the female obliquely truncate, the extremity conical and suddenly turned backwards. *Reproductive outlet* immediately above a projecting lobe or tubercle in front of the tail. *Anus* situated in a deep hollow at the base of the cone-shaped end of the tail.

Length of male nearly 1 inch (11 lines).

Length of female above 1 inch (14 lines).

Hab. Intestines of *Elephas indicus*.

If this description be compared with that given by Dr. Baird, it will be seen that our records differ in several important particulars. As regards the position of the reproductive outlet of the female, I have relied upon his authority; but in respect of other characters, especially those of a microscopic kind, my interpretations of the facts observed are wholly different.

As the study of the helminth-fauna of Elephants is in its infancy, it is necessary to be precise in the few details at my command. According to Baird the body is "cylindrical in shape, thicker in the middle, tapering towards each extremity, and finely striated across, though the striæ are rather distant from each other." This is correct, except that Baird's description of the distant striæ must, I think, refer to two or more rings in the neighbourhood of the neck, since the ordinary striæ placed between these rings and all over the body are excessively delicate markings. They cannot be clearly seen under low magnifying powers; and therefore I have not attempted to represent them in my enlarged representation of the neck and head. In respect of the head itself, Baird says it is "rather large, cylindrical, about one line in length, thicker than the neck, and separated from it by a distinct line or groove. This groove I find to be succeeded by other similar rings below it; and as they are tolerably distant from each other, I think Dr. Baird must have referred to them when he spoke of the striæ as being rather widely separated. The remainder of his description of the head stands as follows:—"The mouth is orbicular, placed in the centre of the truncated part of the head, and surrounded with two horny capsules or bullæ, the limbs or margins of which are each armed with a row of numerous teeth. The limb of the external capsule is the larger of the two, and the teeth, though numerous, are less so than in the internal limb, and are stronger and pointed outwards. The limb of the inner capsule is much smaller, the teeth

very minute, and exceedingly numerous. This portion of the body does not differ in the two sexes."

With this part of Dr. Baird's description my observations generally agree; but he appears to have overlooked the four larger equidistant denticles, of which the lateral pair are especially conspicuous. I examined the mouth with some care. By a little pressure the buccal apparatus and narrow muscular oesophagus are well seen under a half-inch objective, several abductor and adductor muscles being plainly visible through the transparent skin. The buccal cavity itself is broadly cup-shaped, being armed, as Baird has said, with two rows of closely set and erect denticles. I did not observe any marked disparity of size, as between the two sets of teeth; and their number is probably the same. I twice counted the denticles of the outer circle, and found their number to be 44; consequently, with the four larger teeth, the mouth cannot be armed with less than 92 of these organs. The length of each tooth was about the $\frac{1}{250}$ of an inch only, the teeth of the inner circle alternating in position with those of the outer.

The bursa, or hood, of the male worm is a very striking object. By reason of the unusual number of rays or, rather, I should say, of ray-divisions, a correct interpretation of these parts is not easy. Dr. Baird's account and that which I am about to offer are scarcely reconcilable. If my account should prove the more correct, it must be remembered that Dr. Baird had not the advantage of knowing Schneider's published views respecting the typical number of parts to be recognized in this organ. It is difficult to interpret the facts given in Dr. Baird's memoir, though they have evidently been recorded with great care.

"The tail of the male," says Dr. Baird, "is in the form of a membranous expansion or pouch surrounding this extremity of the body, and is divided into three lobes. The central lobe is the largest, and is supported by seven ribs or rays, three in the middle and two at each side. The three central ribs are dichotomous, and the middle one of these has its two branches sending off two or three short processes, like buds; the two others are simple. Of the lateral ribs (two on each side) the innermost one is dichotomous, the two branches into which it is divided sending off short processes or buds; the outer rib is simple. The two lateral lobes of this caudal expansion are smaller than the central one, and are each supported by four simple ribs."

In the right and left views (profile and oblique respectively) which I have selected for general illustration of the appearances presented by the tail of the male worm, little more than the points of the rays can be seen (Pl. XXIII. figs. 2 & 8). As there shown, nearly all the rays extend to the border of the hood, whilst some of them point beyond the ordinary level of the margin, which consequently assumes a slightly serrated outline. This appearance is not constant. Having only two specimens of the male to examine, I found some difficulty in arriving at a true interpretation of the parts; but I believe they are correctly rendered in the accompanying scheme. It is, of course, immaterial to which half of the hood-rays the description is taken to refer, since, practically, the arrangement and symmetry are perfect throughout. The anterior ray (*a*, *a'*) is dichotomous and cleft to the base. The antero-lateral ray (*b*) is straight and simple. The middle ray (*c*, *c'*) is dichotomous, cleft to the base, and the branches incline toward

each other at their points. The postero-lateral ray (*d*) is simple, and rather short. The posterior ray is furnished with a remarkably broad base (*e*); it is tetrachotomous (*e'* to *e'''*), its innermost branch being united at the upper part to its fellow of the opposite side. The innermost branch gives off two rudimentary secondary branches, the inner of the two necessarily lying nearly parallel to that of the opposite side, and therefore also parallel to the intervening middle line forming the vertical axis of the hood. As regards the membrane of the bursa itself, the three lobes are fairly distinct, the posterior lobe being large, well marked, and slightly truncated at the apex.

If the above description be compared with that given by Dr. Baird, a correspondency may be traced here and there. Thus his so-called middle ray of the central lobe evidently agrees with the inner division of the posterior ray in Schneider's system (as applied to the present species). Thus, also, the two or three bud-like processes to which Baird refers must clearly be the same as those rudimentary rays observed by myself, and called the outer and inner secondary branches of the innermost division of the great posterior ray. Of course in attempting to reduce and describe this complicated set of rays to the proper number assumed by Schneider to be typical of the strongyles, my interpretation may be open to dispute. I do not think there is any important error in this record, although the occurrence of such a number of separate ray-divisions in any single hood is altogether outside my previous experience.

The spicules of *Sclerostoma sipunculiforme* are long, equal, and remarkably narrow. They measure about $\frac{1}{15}$ of an inch in length, and have their points irregularly twisted, and directed backwards. In their retracted state they are apt to be overlooked, although gentle pressure of the covering glass will readily reveal their presence and position (Pl. XXIII. fig. 2). When partly exerted, their shafts protrude from a cloacal outlet immediately in front of which there is a conspicuous prominence (Pl. XXII. fig. 8). Neither in Dr. Baird's figures nor in his description of this worm is there any mention made of the existence of the spicules. Doubtless they were retracted within their sheaths, and thus escaped observation. As these organs vary remarkably in the different species of strongyles infesting Elephants and other animals, no diagnosis can be considered complete if all mention of their characters be omitted.

Dr. Baird's description of the tail of the female worm agrees generally with what I have observed. "It terminates," as he says, "in a rather long sharp point, which is oblique in position to the body, owing to a sort of tubercle about half a line from its

Fig. 1.

Diagram of the hood and rays of *Sclerostoma sipunculiforme* ($\times 36$ diameters).

extremity, under which is situated the anus. This aperture is very distinctly seen immediately underneath the tubercle; and the vulva, which is not very conspicuous, and is in the form of a narrow slit across the body, is situated immediately above the tubercle."

Seen in profile from the side, the observer cannot fail to remark upon the resemblance which the tail of the female shows to the outline of a Chinese lady's foot; the narrow lower end of the body having the form of the ankle, and the so-called tubercle corresponding with the heel (Pl. XXIII. figs. 6, 7). I made no special examination of the internal anatomy of this species; but so far as the transparency of the body permitted, the arrangements seen by me corresponded with what Baird has stated to occur. "The œsophagus is rather long, and terminates in a lobed stomach which extends for a short distance and then ends in a straight intestinal canal running through the whole length of the animal. The uterus is peculiar in form, and presents a very pretty appearance under the microscope; it is two-branched, and has during its length several expansions or swellings followed by contractions. The ovaries are very long and twisted round the intestine."

In the course of his paper Dr. Baird calls special attention to the relative size of the sexes, more particularly with the view of comparing the characters of this species with those displayed by certain well-known *Sclerostomata* from the horse (*S. armatum* and *S. tetracanthus*) and other animals. In Baird's specimens the males were longer than the females—a circumstance which, as his remarks imply, is of most unusual occurrence. There may have been some mistake here; at all events, in my set of specimens the females are longer than the males. Not improbably Dr. Baird's female worms were immature. Another curious feature connected with the external anatomy of this species related to the presence of certain markings beneath the skin. These appearances were evidently seen by Dr. Baird, who, strange to say, refers them to the species which I shall next describe. More than this, they are actually figured in one of his otherwise generally accurate woodcuts, and are held to be of value in reference to the identity of the species. Thus, as will be seen, Dr. Baird has selected this very striking appearance as affording sufficient grounds for the special nomenclature which he proposed for the following species. Accordingly he has named that worm *Sclerostoma clathratum*, on account of the clathrate or lattice-like markings which may be seen at or near the surface of the body. Now, after a long study of this matter, I am obliged to conclude that the enlarged figure of the head of the female worm given by Baird, in which the appearances in question are represented by no means accurately, is not that of his second new species, but really and truly a representation of the head of the species now under consideration. If this surmise be correct, it might seem necessary to alter Baird's nomenclature; but although, in my view, the specific name applied by him is altogether a misnomer, I propose to retain the nomenclature which, by some oversight, he concluded to adopt.

The appearances in question are very peculiar. They are not due to external sculpturing, as Baird's figure would imply, but to the presence of an internal network, limited, as I think, to the surfaces of the longitudinal muscles. Under low magnifying

lenses the markings pretty closely correspond with the polyhedral networks figured as well as described by Schneider from two species of *Gordius*. In our Elephant's nematode the network seems to lie somewhat deeper (Pl. XXIII. figs. 1, 2). To myself the finer markings present the appearance of vascular ramifications proceeding from common stems, each muscle having a group of its own. There are thus several sets of vessels; and these groups, as such, do not anastomose with each other. Probably there are main trunks connecting all the secondary stems together; and, taken as a whole, they have not the uniformly reticulated characters seen in the network of the *Gordii*. I believe them to form special developments of the water-vascular system. Their structure deserves further study. I should not, indeed, have hazarded thus much concerning them, had not Dr. Baird emphasized their importance as a basis of specific nomenclature. As it appears to me, either Dr. Baird or his artist has made the head and neck of a female *Sclerostoma sipunculiforme* do duty for the next equally well marked species; at least I find the clathrate appearance in this worm, and not in the worm which he has called *Sclerostoma clathratum*. The two worms are undoubtedly good species; and their respective heads bear no sort of resemblance to each other, either as regards form, size, markings, or oral armature. If Dr. Baird's own admirably clear diagnosis be examined, one can hardly fail to see that his description of the head and neck of *Sclerostoma clathratum* only corresponds with some of the particulars given in the illustration to which I have referred. In making this statement I am far from supposing that my own observations are free from error.

3. STRONGYLUS CLATHRATUS, Baird. (Plate XXIII. figs. 3, 4, 5.)

Sclerostoma clathratum, Baird, Proceed. Zool. Soc. 1868, p. 262 (with figs.).

Body linear, subfiliform, cylindrical, but rather suddenly narrowed in front and behind. *Head* small, scarcely half the width of the body, truncated, surrounded by five very small auricular folds. *Mouth* armed with a few teeth. *Bursa* broader than long, obscurely three-lobed; anterior ray short and double; antero-lateral ray simple and straight; middle ray double, of very great size; postero-lateral ray moderately long and slender; posterior ray cleft at the extremity. *Spicules* two, broad, and highly coloured. *Tail* of the female bluntly pointed, with the reproductive outlet slightly removed from the base in front.

Length of the male 2 inches.

Length of the female 2 inches to 3 inches.

Hab. Stomach and intestines of *Elephas indicus* and *Loxodonta africana*.

In my account of the previous species the origin of the nomenclature adopted by Dr. Baird is explained; and, excepting that I prefer to place this worm with the strongyles, properly so called, rather than in the genus *Sclerostoma*, no alteration of the title seems necessary. If our diagnosis be compared, it will be seen that whilst much has here been added, little, save as regards the clathrate character, has been altered in respect of Dr. Baird's description. With the exception of the enlarged head of the female worm, all the figures given by Dr. Baird are thoroughly characteristic, and probably

accurate. That marked by him 2 *a* (woodcut P. Z. S.) is perplexing. The head is not only altogether out of all proportion, but the slight cutaneous folds, which form mere sculpturings or elevated lines, have in his figure all the appearance of large auriculate lappets (see Plate XXIII. fig. 3). As already explained, lattice-like markings have not been seen by me in this worm. Dr. Baird's life-size representations correctly show that the head and neck are finely drawn out to a blunt point; but the enlarged figure of the head above referred to conveys the contrary impression. Although not expressly so stated, his figures imply that the heads of the two sexes closely resemble each other in respect of shape, if not in size. This is usually the case in Nematodes. Unfortunately I do not possess a female *Strongylus clathratus*, and have therefore been guided in my inferences from the characters presented in the head of the male worm. It follows from this that what has here been said respecting the form of the tail of the female rests entirely on Dr. Baird's authority; and here also I may remark that his enlarged view of the tail of the female, which I have no doubt is correct, presents no trace of the remarkable latticed structure that forms so striking a feature in his enlarged representation of the head and neck of the female. In the male *Sclerostoma sipunculiforme* this network occurs both near the head and tail, and throughout the length of the body. It occurs in the female likewise; but I have not shown it in my less highly magnified illustrations of the tail of that species.

In reference to the habitat of this worm, Dr. Baird states that his specimens were obtained by Dr. Murie from the stomach of a young female African Elephant (*Loxodonta africana*). These Dr. Murie sent to the British Museum. The Elephant died in London in October 1867; and Dr. Baird concludes his account of the worm by saying, "I am not aware of any Entozoa having been previously described as inhabiting the body of this species of Elephant." Dr. Baird's conjecture was perfectly correct; and although I have to record the occurrence of a dipterous larva in the African Elephant, yet even up to the present time no other true helminth than that discovered by Dr. Murie has yet been described from this animal. My own specimens of *Strongylus clathratus* were obtained from the Indian Elephant (*Elephas indicus*), and were, I believe, all removed from the small intestines. In Murie's find "the specimens were rather numerous, and, with only one exception, all were females." It is stated that the male worm was white, whilst the others were of a "dark brownish red colour, the contrast between the two sexes being for a long time distinctly visible." As Baird says, on comparing this parasite with the previous species, the head of *Strongylus clathratus* "is much smaller, both in male and female, and the caudal bursa differs in structure from that of *Sclerostoma sipunculiforme*." As supplementing the diagnosis, he adds the following particulars:—"The head is distinctly separated from the rest of the body, and is cylindrical and small; the mouth is dentated inwardly, and on the outer edge is marked with five distinct auricles, which descend upon the upper portion of the body, but do not form a distinct part of it. The body is attenuated at both extremities, and is linear in shape; in the female it is, as it were, minutely clathrate, being situated transversely with fine lines, and having the spaces between the lines minutely longitudinally striated or sulcated, giving, under tolerably high power, the appearance of being latticed or

clathrate. The tail is obtuse, not so sharp-pointed as in *Sclerostoma sipunculiforme*, and has the genital organs situate a short distance from the extremity. It is frequently, but not in all cases, convolute. The body of the male is longitudinally striated; and the bursa at the extremity of the tail is lobed."

Notwithstanding what I have advanced respecting the clathrate appearance, the fact of my not having examined a female worm of this species will probably leave the question still an open one. As regards the male, the characters of the hood are particularly striking, even more so than they are in *Sclerostoma sipunculiforme*.

Whilst Dr. Baird's enlarged view of the bursa makes this sufficiently apparent, he has not supplied any description of details. In the hood before us we find two enormously exaggerated divisions of the middle

ray (*c, c'*); but in *Sclerostoma sipunculiforme* we found that most of the rays were of more or less uniform length and thickness. Here also we have the anterior ray double (*a*), with its halves closely applied, as obtains in most Strongyles; we have the antero-lateral ray (*b*) simple and widely separated from those above and below it; we have the ends of the huge finger-like divisions of the middle ray (*c, c'*) extending far beyond the terminal points of the posterior

rays; and we have both postero-lateral (*d*) and posterior rays (*e*) reduced to within extremely narrow limits. Any one at all familiar with the typical forms of Strongyle bursæ cannot fail to see at a glance that the morphological departures here displayed are not merely distinctive of the species as such, but altogether unique in themselves. In this connexion another noteworthy feature relates to the form of the spicules. Neither in this nor in the preceding species do these organs appear to have come under Dr. Baird's observation. Whilst retracted they are not readily visible under the microscope; however, a strong light, aided by slight pressure, is sufficient to expose them to view. In this species each spicule consists of a shaft which is truncate above and pointed below. The lateral blade-like expansions are unequally developed, the right side being flabelliform, diaphanous, and marked by branching striæ, which proceed from the axis and are radiantly disposed (Pl. XXIII. fig. 5). The spicules are of equal size, each measuring $\frac{1}{20}$ of an inch in its long diameter. Immediately above the hood, and in front of the spicule, there is a slight enlargement, which, even in spirit-specimens, preserves a yellowish colour (Pl. XXIII. fig. 4). This is probably an unusually large seminal reservoir.

Concerning the special part played by this and the preceding species in the production of injury to the host, evidences will be produced at the close of this memoir.

Fig. 2.

Diagram of the hood and rays of *Strongylus clathratus*
($\times 24$ diam.).

4. *STRONGYLUS FOLIATUS*, sp. nov. (Plate XXIII. figs. 9-13.)

Body smooth, of nearly uniform thickness, finely striated transversely. *Head* indistinct, truncated in front, with five small auriculate folds. *Mouth* slightly oblique, leading to a deep buccal cup, armed with a few coarse teeth, succeeded by a long muscular oesophagus. *Neck* marked by two short conical papillæ at the upper part, one on either side, and by two larger and longer tapering papillæ placed lower down. *Hood* bilobed, foliate. *Rays* few in number, and widely separated. *Spicules* long, flattened, and twisted at the base, tapering and finely pointed below at the apex. *Tail* of the female well marked, long and conical, with a wavy contour, directed backwards, and rapidly narrowing to form a subulate point. *Anus* in front, and immediately above the base of the tail.

Length of the male $\frac{1}{2}$ an inch.

Length of the female $\frac{5}{8}$ of an inch.

Hab. Tumours within the coats of the stomach of *Elephas indicus*.

On the 24th of August 1876, I examined part of the carcass of an Elephant at the Royal Veterinary College. The viscera had been removed from one of several animals that had died at the Circus stables of Mr. Sanger. Mr. Steel, during his previous dissections of this animal, had already encountered some parasites; but in addition to these, I obtained others occupying tumours in the walls of the stomach. The morbid swellings were of two sizes, the larger and more rounded kind containing the species under consideration, the smaller and comparatively flat tumours being occupied by worms of a different generic type.

On the external or mucous surface of one of the larger growths there was an opening of the diameter of a crow-quill. This appeared to be the only communication between the cavity of the stomach and the interior of the tumour. On section the growth displayed a coarsely alveolar structure, its freely intercommunicating loculi being filled with thick mucus, in which a few parasites were found imbedded.

The swellings in question are very similar to the well-known verminous tumours, occupied by maw-worms, of the horse; the parasites, however, are perfectly distinct. Through the help of Mr. Spooner Hart of Calcutta, I have had opportunity to examine specimens of the growths removed from a horse that died at Calcutta stables. In Mr. Hart's experience these formations are rather common in India; but it would probably be incorrect to assume that they are more prevalent in eastern countries than in Europe. Be that as it may, it is scarcely more than forty years since M. Valenciennes found these singular worm-tumours to exist in eleven horses out of the twenty-four animals whose stomachs he specially submitted to examination. Not improbably, therefore, if medical men, army veterinary surgeons, and others practically interested would make use of their opportunities, the statistics of gastric parasitism, both as affecting elephants and horses, would afford much curious instruction. The natural-history value of the facts would be further increased by similar investigations amongst the Rhinoceroses and other large herbivora. Although Schneider and Molin have both described parasites taken from similar tumours in the American Tapir, we as yet know absolutely nothing of the entozoa infesting the Tapir of the Malayan peninsula.

In reference to the reproductive apparatus of *Strongylus foliatus*, I am unable to state the position of the female outlet, whilst the rather small hood of the male presents appearances that are difficult of interpretation. The anterior ray (*a*) is clearly dichotomous and normal in other respects. The next ray, or pair of rays (*b*), forms a puzzle. Either the antero-lateral ray is altogether suppressed, or, if present, it is dichotomous and very similar in appearance to the anterior rays, the two halves being closely applied. According to Schneider's mode of interpretation, the antero-lateral ray is invariably single; and thus, if his view be correct, the lower half of the ray (*c*) must, in the particular case before us, belong to the middle ray. Strange as it may seem, this is probably the correct interpretation of the facts here exhibited.

From this it will follow that the next two large and conspicuous rays (*c'*, *d*) are not (as one might have supposed) the divided shafts of a great dichotomous middle ray, but the upper division (*c'*) represents the lower segment of the middle ray (as in Schneider's system), and the lower division will thus represent the usually solitary postero-lateral ray (*d*). The latter ray, according to Schneider, is also always single. In this fashion I am contented to interpret the facts, though, looking to the exaggerated ray-divisions in question, it is difficult to disassociate them so as to conform to Schneider's plan. It seems as if the large pair of half-rays

must correspond with the yet more exaggerated half-rays of the great middle ray of *Strongylus clathratus*. When we come to the posterior ray (*e*) all difficulties of homology vanish. In *Strongylus foliatus* it is dichotomous or deeply cleft, the base being united to its fellow of the opposite side.

The spicules, though offering nothing remarkable in structure, are characteristic of the species. At the base they are bent in a spiral manner, and slightly flattened. Their shafts lie parallel to one another, and become narrowed very gradually towards the tips, where they are slightly turned forwards and finely pointed. Each measures about $\frac{1}{16}$ of an inch from end to end.

In regard to the membrane of the hood, I should have stated that under moderately high powers one may observe regularly arranged and excessively delicate striæ radiating from the base to its circumferential border.

5. *STRONGYLUS FALCIFER*, sp. nov. (Plate XXIII. fig. 14, and Plate XXIV. figs. 1-3.)

Body of a bright orange-red colour anteriorly, more or less curved, smooth, and rather narrowed in front and behind. *Head* well marked, short, with radiating external lines, and truncated. *Mouth* simple, surrounded by an outer series of four large conical papillæ and by an inner circle of numerous small papillæ or granulations; oral cavity shallow. *Bursa* conspicuously three-lobed, with the posterior rays large and dichotomous. *Spicules* long, strongly bent towards their ends, which are blunt, spatulate, and

Fig. 3.

Diagram of the hood and rays of *Strongylus foliatus* ($\times 60$ diam.).

directed backwards. *Tail* of the female very distinct, scythe-shaped, and finely pointed. *Reproductive outlet* placed at a short distance above the anus, at the base of the tail.

Length of the male 1 inch (or 11 to 13 lines).

Length of the female 1 to $1\frac{3}{5}$ inch (or 12 to 20 lines).

Hab. Intestines of *Elephas indicus*.

With the unassisted eye this species is readily recognized by its bright colour, the orange-red tint about the head gradually becoming feeble towards the anterior third of the body. Out of two dozen examples of this worm I only secured two males; and these were picked out from amongst a quantity of other nematode species. The worms had not been well preserved; and their bodies had become coated with fungi.

Not wishing to mutilate the only two male worms I possessed, my interpretation of the appearances of adhesion and union at the base of the bursa may be partly incorrect. So far as I made out, the rays not only conform to the type-number, but present little that is striking either as regards their shape or their arrangements. Speaking generally, those of the side lobes of the hood are short and stumpy, whilst those of the middle lobe are comparatively large and long. The anterior ray (*a*) is dichotomous, with adherent divisions. The antero-lateral ray (*b*) is simple and normal in position. The middle ray (*c c'*) is bifurcated, and has its branches rather widely apart. The postero-lateral ray (*d*) is comparatively long and well within the middle hood-lobe. The posterior ray (*e e'*) is unusually large, and divided into subequal halves, both of which nearly reach the lower border of the hood. A considerable space separates the inner branch from its fellow of the opposite side.

The spicules form a striking object. Viewed from before or in front, the two shafts present a lyrate figure, owing to their lower ends being bent first outwards laterally, then inwards laterally, and finally, in an oblique direction, backwards divergently (Pl. XXIV. fig. 2). Seen in profile the shafts appear rather narrower; and they appear to lie parallel to each other, except at their somewhat flattened and blunt points. The sheaths in which the spicules usually lie, more or less concealed, can be seen within the half-transparent body, powerful adductor muscles being inserted at the upper or closed ends of these pouches.

The body of the male at the lower part measures about the $\frac{1}{25}$ of an inch in transverse diameter, whilst the spicules, which are of equal size, afforded a length of fully $\frac{1}{15}$ of an inch.

The best-preserved female worms had their oviducts crowded with eggs. Each ordinary ovum gave an average long diameter of $\frac{1}{300}$ by $\frac{1}{350}$ of an inch in breadth. Such eggs contained a dense and finely segmented yolk. On one occasion I observed a solitary empty egg-envelope, which gave a measurement of no less than $\frac{1}{40}$ of an inch from pole to pole, by $\frac{1}{50}$ of an inch in breadth. At the same time, and certainly from the same source, the field of the microscope displayed an embryo that had evidently escaped

Fig. 4.

Diagram of the hood and rays of *Strongylus falcifer* ($\times 43$ diam.).

from this ruptured envelope. The embryo measured $\frac{1}{75}$ of an inch long by something less than $\frac{1}{500}$ of an inch in breadth. Although there were no intermediate stages observed between the two kinds of ovum, I could not regard the presence of the much longer egg and its embryo as merely resulting from accident. Before I examined these worms they had been carefully separated from the other nematodes. As regards the uterus itself, I have only to add that the two horns may be easily traced downwards to their junctions together and with the oviducal or vaginal passage (Pl. XXIV. fig. 3). Distinct openings, with very slightly elevated margins, mark alike the position of the vulva and the anal aperture.

6. *DOCHMIUS SANGERI*, sp. nov. (Plate XXIV. figs. 4-6.)

Body smooth, transversely striated, and narrowed both in front and behind. *Head* very distinct, and bent well forward. *Mouth* simple, oval, and surrounded by regularly disposed elevations; buccal cup capacious, and armed with a few small teeth; pharynx distinct, separated from the oesophagus by a well-defined constriction. *Bursa* obscurely three-lobed, the posterior ray being slender and bifurcated at the extremity, its inner branch extending to the border of the membrane. Spicules short, nearly equal. Tail of the female long and pointed, the tip being subulate, and armed with a short, filiform, transparent, and finely pointed appendage. *Anus* situated at the base of the tail.

Length of the male 8 lines.

Length of the female 10 lines.

Hab. Intestines of *Elephas indicus*.

On the 24th of August 1876, I discovered large numbers of these small worms in the intestinal canal of the Circus Elephant already referred to. To the naked eye they look like ordinary thread-worms; but a hand-lens is sufficient to demonstrate their stronglyloid character. The parts about the mouth were not well made out; but my representation of the head is perhaps sufficiently characteristic (Pl. XXIV. fig. 4).

In its retracted condition the tail of the male worm, when its end is directed towards the spectator, presents a distinctly hexagonal outline, the incurved points of the rays of the hood creating six well-marked angular projections. The appearance in question is at once both striking and delusive. When the hood is flattened or artificially expanded, then an oval or more or less heart-shaped outline results (Pl. XXIV. fig. 5). After repeated examinations I constructed the following diagram. The anterior ray (*a*) is double, and has the divisions closely applied; it is bent forward towards the axis of the body. The antero-lateral is simple, normal, and also bent forward. The middle ray (*c*, *c'*) is dichotomous, and directed at a right angle to the axis of the hood. The postero-lateral ray (*d*) is simple, long and narrow, but does not reach the margin of the membrane. The posterior ray (*e*) is characteristic of the species, being long, narrow, and divided near its end into two unequal portions. The inner branch is nearly twice as long as the outer, and extends to the border of the membrane. When the hood is expanded the end of the posterior ray is widely, because divergently, separated

Fig. 5.

Diagram of the hood and rays of *Dochmius Sangeri* ($\times 30$ diam.).

from its fellow. The third lobe of the bursa is deeply notched in the middle line, thus imparting to the hood a spuriously four-lobed figure. The spicules are short, rather broad at the base, and pointed at the tip or lower end. When the tail of the male is viewed either from the front or from behind, the spicules display the not uncommon V-shaped outline.

The tail of the female worm presents well-marked characters (Pl. XXIV. fig. 6). In addition to those mentioned in the diagnosis of the species, the uniform and rather sudden narrowing of the body in this region, together with the presence of a conspicuous and somewhat gaping anal cleft, would render the future recognition of this species a very easy matter, even if no male were procurable. In some specimens the neck in either sex is much more contracted than in the particular example which I have figured.

7. *FILARIA SMITHII*, sp. nov. (Plate XXIV. figs. 7-10.)

Body smooth, with very fine transverse striæ, filiform, and of equal thickness throughout. *Head* furnished with two rows of translucent auriculate appendages, supporting a few minute papillæ. *Mouth* simple, surrounded by four small papillæ and numerous slight elevations exterior to the papillæ. *Œsophagus* of great length, without bulb or constrictions. *Tail of the male* short, bluntly pointed, with winged appendages supported by eight stalked papillæ, four on either side. *Spicules* long, slender, unequal. *Tail of the female* short, bluntly pointed, usually directed backwards. *Anus* sub-terminal at the base of the tail.

Length of the male $\frac{1}{6}$ of an inch.

Length of the female $\frac{1}{3}$ of an inch.

Hab. Coats of the stomach of *Elephas indicus*.

The delicate little worms thus named cannot be confounded with the larger species of nematode already stated to occupy tumours in the walls of the stomach of the Elephant. Apart from the relative disparity of the worms themselves, the parasitic growths or abodes containing them are of much smaller size. The tumours enclosing the *Filarie* barely exceed the size of an ordinary filbert nut, presenting also an oval flattened figure. As in the larger formations, however, each tumour displays a single round aperture communicating with the cavity of the stomach. The interior structure of the growths does not depart in any marked degree from the alveolar or multilocular character of the abodes of *Strongylus foliatus*; but a relatively far greater number of worms were found to occupy the "abodes" of this species. I have named the species after the veterinary surgeon through whose instrumentality I had an opportunity of making the "find." Well enlarged, and seen in profile, the head shows sculpturings which together form a double festooned border, whilst within the concavity of each ear-shaped fold of integument there are minute papillæ. In the neighbourhood of the mouth there are also other prominences, as well as special papillary elevations which probably serve as taste-organs (Pl. XXIV. fig. 7).

In consequence of their larger size, the females are easily recognized. The actual position of the reproductive outlet evaded my observation; but the diagonal direction

of an interior tube (which I took to represent the empty vagina) led me to infer that the outlet is placed about $\frac{1}{100}$ of an inch below the point of junction of the œsophagus with the chyle-intestine. The œsophagus itself, in the female, measures $\frac{1}{17}$ of an inch in length, and only $\frac{1}{250}$ in breadth. I subjoin an outline of the female tail. It is here seen strongly bent backwards. Another striking character is that shown by the ova. These minute bodies, linear-oblong in shape, give an average diameter of only $\frac{1}{2000}$ of an inch from pole to pole. Each female worm contains a prodigious number of eggs, probably not less than 100,000, exclusive of the unimpregnated ovarian ova. The perfect ovum always exhibits an embryo folded within its excessively delicate chorional envelope. This embryo itself is thicker in front than behind; but it is bluntly pointed at either extremity. Even at its thickest part the transverse diameter of the body of the embryo scarcely exceeds the $\frac{1}{8000}$ of an inch.

Outline of the tail of a female
Filaria Smithii; a, anus
($\times 30$ diam.).

The head of the male forms a miniature representation of that of the female worm. The difference in thickness in the two sexes is considerable, the body of the female measuring $\frac{1}{100}$ and that of the male about $\frac{1}{130}$ of an inch. Seen from the ventral surface, the contour of the tail of the male presents a lanceolate outline and spatulate form. It displays eight papillæ furnished with long stalks (Pl. XXIV. figs. 8-10). On each side three of the papillæ are rooted or arise from above the level of the anal opening, and one originates from below the anus. I did not observe any sessile papillæ beneath the stalked papillæ. The spicules are always visible, whether partially (figs. 8, 9) or wholly retracted (fig. 10). They are strikingly narrow, the anterior spicule being almost twice the length of the posterior. The length of the shorter spicule scarcely exceeds the $\frac{1}{140}$, whilst the anterior one gives a long diameter of fully $\frac{1}{80}$ of an inch.

Fig. 7.

Outline of the tail of a male
Filaria Smithii; a, anus
($\times 30$ diam.).

8. AMPHISTOMA HAWKESII, Cobb.

A. Hawkesii, Cobbold, The Veterinarian, Oct. 1875; ibid. Nov. 1875; also in Treatise on Parasites, 1879, p. 395.

A. Collinsii, var. *Stanleyi*, Cobb., Parasites, 1879, p. 357.

Masuri or *Mussoorie* of the Hindoo Mahouts (Gilchrist, Hawkes, &c.).

Body of a pink colour, smooth, plano-convex, finely wrinkled transversely, bluntly pointed and contracted in front, broadly rounded behind. *Head* surrounded by a few regular but not well pronounced folds, armed with numerous short and extremely minute warty papillæ. *Mouth* terminal, circular. *Ventral surface* often slightly depressed near the centre, forming slight prominences on either side. *Caudal sucker* placed well forward, rather large, circular, with a broad lip and smooth concavity.

Reproductive papilla small, situated nearly midway between the mouth and upper margin of the caudal sucker.

Length, on the average, $\frac{3}{8}$ of an inch; the longest specimen $\frac{7}{16}$ of an inch.

Breadth $\frac{1}{4}$ of an inch.

Hab. Large intestines of *Elephas indicus*.

In my general treatise, and likewise in the pages of the 'Veterinarian' antecedently, I have recorded the occurrence of this entozoon; but hitherto it has, zoologically speaking, remained undescribed. My first acquaintance with it dates as far back as June 1875. Towards the close of that month I received from Lieut.-Colonel Hawkes a set of parasites for identification. Attached to the Madras Staff Corps, Colonel Hawkes forwarded the specimens from Secunderabad, at which station there had been a recent and rather serious mortality amongst the Elephants. The cause of that mortality will be subsequently considered when I treat of the injurious effects of the parasites already described. Having explained by a letter to the donor that these parasites were new to science, I provisionally named the species *Amphistoma Hawkesii* in his honor.

Fig. 8.

Outline of *Amphistoma Hawkesii*
($\times 4$ diam.).

In the fresh state the parasites have a bright rosy tint, or, as the finder states, a "delicate flesh-colour." Probably this colour, more or less pronounced, is invariable amongst the Amphistomes; at least such has been the case with all the forms that I have examined in the fresh state. Similarly some Amphistomes received by me from an Indian horse were reported by the finder as having a brick-red colour when removed, post mortem. Here it is desirable that I should speak more fully of these equine Amphistomes. They were found in the year 1875, by Veterinary-Surgeon Collins, of H.M.'s Indian army, stationed at Simla. As equine parasites, however, they do not appear to have been the earliest-seen specimens. None, indeed, had hitherto been scientifically described as coming from the horse; but my attention was subsequently called to a set of specimens preserved in the private collection of Professor Simonds, at the Royal Veterinary College. As since stated in my latest work, the parasites belonging to Simonds were at the time regarded by me as mere varieties of the species found by Vet.-Surgeon Collins. I accordingly spoke of them as *Amphistoma Collinsii*, var. *Stanleyi*. I employed the variation-term in order to give expression to the circumstance that Professor Simonds received his specimens from Vet.-Surgeon Stanley, who also obtained the Amphistomes in India. The date of Mr. Stanley's 'find' has been lost; but from Professor Simonds's recollection it would be about the year 1865.

I have recorded these few facts respecting the equine Amphistomes because, after a recent and more careful study of the worms, I have come to the conclusion that the parasites found by Mr. Stanley, though comparatively large, are really identical with the particular Amphistomes I am now describing from the Elephant. At present, however, I do not pronounce definitely respecting Collins's Amphistome, which will probably be found to remain as a good species. In the horse dissected at Simla,

Mr. Collins reckoned that there were about a thousand of these parasites lodged in the colon.

9. *AMPHISTOMA ORNATUM*, sp. nov.

Body of a pink colour, plano-convex, but slightly concave anteriorly, pointed in front, broadly rounded off behind, and furnished with inconspicuous transversely disposed rugæ. *Head* and *neck* more or less pronounced. *Mouth* surrounded by circular folds, which are armed with prominent, regularly arranged, and bluntly pointed papillæ. *Ventral surface* marked by lateral projections, which fold regularly, sometimes showing a V-shaped groove at the base of the neck. *Caudal sucker* subterminal. *Reproductive papilla* large, and placed well forward.

Length $\frac{1}{4}$ to $\frac{5}{16}$ of an inch.

Breadth $\frac{3}{16}$ of an inch.

Hab. Intestines of *Elephas indicus*.

On the 24th of August, 1876, as already mentioned, I obtained a variety of parasites from one of the herd of performing Elephants that perished at Sanger's Circus. Amongst the parasites were quantities of amphistomes of various shapes and sizes. As all of them were found in the same general situation, I at first concluded that they were of the same species as those sent from India by Colonel Hawkes. However, subsequent investigation led to the conclusion that, although we obtained two distinct forms of Amphistome from the Circus Elephants, neither of them corresponded with the species received from Southern India.

When I removed the parasites from the colon, they had the characteristic bright pink colour, and were so transparent that a pocket lens was sufficient to show the general arrangement of the internal organs. These will be referred to when dealing with the next species.

I separate this form from Hawkes's Amphistome chiefly on account of its smaller size, its more conical figure, its large reproductive papilla, its slightly concave ventral surface, and, more particularly, on account of the presence of papillæ in the neighbourhood of the head. These papillary eminences are so conspicuous that with a magnifying power of three or four diameters their projecting points are rendered visible.

10. *AMPHISTOMA PAPILLATUM*, sp. nov. (Plate XXIV. fig. 11.)

Body of a bright pink colour, smooth, conical, bluntly pointed in front, broadly rounded off behind, with fine and regularly disposed transverse rugæ forming distinct rings in the region of the head. *Caudal sucker* subterminal, very large, its cup being armed with numerous large fungiform papillæ, closely set, and regularly disposed over the entire surface of the concavity. *Reproductive papilla* placed well forward.

Length $\frac{1}{8}$ to $\frac{1}{4}$ of an inch.

Breadth $\frac{1}{8}$ to $\frac{1}{7}$ of an inch.

Hab. Large intestines of *Elephas indicus*.

Fig. 9.

Outline of *Amphistoma ornatum*
($\times 5$ diam.).

This species is the smallest of the Amphistomes hitherto obtained from Elephants. Regard being had to the occurrence of large papillæ within the cup of the caudal sucker, no one could mistake it for either of the two previously described species. However, it is just possible that the somewhat similar Amphistome from the Tapir, described many years back by Diesing, may turn out to be either the same or a mere variety. Dr. C. M. Diesing's *Amphistoma asperum* differs in form, the anterior part of the body being much constricted, whilst the caudal sucker is wider and terminal*.

Fig. 10.

Outline of *Amphistoma papillatum* ($\times 5$ diam.).

The enlarged view that I have given of this worm was taken from a perfectly fresh specimen (Pl. XXIV. fig. 11). In examples preserved in spirit the aperture of the sucker gapes more widely, and consequently looks larger. In the fresh state one not only sees the digestive organs through the transparent envelope, but also the testes, part of the uterus, the branching ducts of the vitellaria, and even also their terminal sacs. The latter are so small that I have not attempted to represent them; moreover, except as regards position, neither these nor the other internal organs offer any striking peculiarities. In this species the vitellary glands are limited to the sides of the body; but in Hawkes's Amphistome the sacs and their ducts seem to underlie the whole surface of the body. From hardened specimens I obtained fine transverse sections in which the disposition of the muscle-fibres and general stroma of the body were well displayed.

As a believer in the common origin of all genera and species, of whatever zoological type they may happen to be, I was not unprepared to find representative and parallel forms of parasites in different animals. Thus it seems to me that the two Amphistomes known to infest the Tapir represent two of the Amphistomes found in Elephants. On the one hand my *Amphistoma papillatum* comes near to *A. asperum*, whilst on the other my *A. Hawkesii* comes near to *A. pyriforme*. The Amphistomes of the American Tapir were obtained by Natterer in Brazil in 1829, and were described by Diesing in the *Museum Annals* already quoted. The Vienna helminthologist had not then lost his eyesight; and his elaborate memoir convincingly proves that modern anatomists, notwithstanding our improved methods, have added little to our knowledge of the organization of the trematode worms.

The fungiform papillæ within the sucker of *Amphistoma papillatum* forcibly call to mind the more striking processes lining the ventral disk of the amphistomoid worm which I have called *Gastrodiscus Sonsinonis*. In this remarkable genus, established as such by Leuckart, the gastric papillæ display each a central depression at the summit; and I have therefore spoken of them as suckerlets. On this account, also, I pointed to their close affinity with those seen in the equally singular genera *Notocotylus* and *Aspidocotylus*, as established by Diesing. The possession of the small suckers in question, shared as it

* "Neue Gattungen von Binnenwürmern, nebst einem Nachtrage zur Monographie der Amphistomen," *Annalen des Wiener Museums*, 1839, S. 236.

is by all the three aberrant genera, seems to imply that their position amongst the Amphistomes is somewhat doubtful; and I am informed by Professor Leuckart that a recent anatomical investigation of *Gastrodiscus*, made by one of his pupils, tends to confirm this conclusion. Be that as it may, the simple papillæ within the caudal sucking-disk of *Amphistoma papillatum* are evidently of the same character as those found in *A. asperum*. Diesing describes them as little prominences (Erhabenheiten). As contrasted with the integumentary papillæ so frequent on the general surface of the body of Amphistomes the papillæ placed within the disk of *A. papillatum* are remarkably large and altogether distinctive.

11. FASCIOLA JACKSONI, Cobb. (Plate XXIV. fig. 12.)

Fasciola Jacksoni, Cobbold, Quart. Journ. Micr. Science, Jan. 1869; Supplement to Entozoa, 1869, p. 80.

Distoma hepaticum, Jackson (non descriptum), Boston Museum Catalogue, 1847, p. 317.

Distomum elephantis, Diesing, Syst. Helm. Bd. ii. p. 560; Revision der Myzelminthen, 1858, S. 354.

Body flat, orbicular, often folded towards the ventral surface, smooth to the naked eye, but armed throughout with numerous excessively minute dermal spines, which are larger above than below. *Oral sucker* terminal, small. *Ventral sucker* large and well forward. *Reproductive papilla* in the middle line, and placed considerably above the upper lip of the acetabulum; intromittent organ of great length. *Digestive apparatus* branched, its ramifications ending in cæcal terminations, which occupy nearly the whole extent of the body internally; œsophageal bulb distinct.

Length $\frac{1}{2}$ to $\frac{5}{8}$ of an inch.

Breadth $\frac{1}{3}$ to $\frac{1}{2}$ of an inch.

Hab. Biliary ducts and duodenum of *Elephas indicus*.

As has been already stated, Dr. von Linstow has fallen into the error of assuming that three species of fluke infest the Elephant. They are, in reality, all one and the same species. Although long previously discovered, this worm was first recognized as a good species by myself in the year 1869. Its discoverer, Dr. Jackson, gave no description of the worm; and it is clear, from what Dr. Fitz has said, as well as from the entry in the Boston Catalogue, that Jackson supposed that he had encountered the common fluke of ruminants in the Elephant. The description originally given by me in the journal above quoted differs in no essential particular from that now offered. I have merely emphasized and extended certain characters.

As causing disease, and zoologically speaking, this entozoon is the most important of the whole group of parasites infesting Elephants. Now that this fact is becoming known to those interested in the preservation of the domestic pachyderms, more attention is likely to be paid to the source and distribution of the parasite. In order, therefore, to clear away certain misconceptions that have already arisen, it is desirable to restate the facts of discovery.

As remarked in my recent work, the first specimens of Elephants' flukes received in this country were transmitted by Vet.-Surgeon Thacker, of the Madras Army. They were, as he expressly remarks, "forwarded for classification." The specimens, indeed,

were brought from India by Dr. Hugh Cleghorn, who conveyed them to the late Dr. Baird, who, again, honourably carried out the wishes of the donor by handing them over to myself. At the Norwich Meeting of the British Association in 1868 two of the flukes were exhibited for the first time in this country; and I then stated that they "were identical with certain flukes long previously obtained from the duodenum and liver-ducts of an Indian Elephant that died in America." I further stated that, although the original 'find' was carefully preserved in the Boston Museum, the worms had never been properly described. In the summer of 1868 fifteen specimens of fluke, removed from one or more Burmese Elephants, had been forwarded to Professor Huxley from Rangoon, and the 'send' was accompanied by a statement to the effect that the parasites were the cause of an extensive and fatal disease in Burmah. Through the kindness of Professor Huxley, I was permitted to make use of his specimens for the purpose of comparison; and thus it became evident that his specimens and mine were of the same species. I then published the original description already referred to; and it was afterwards repeated in the supplement to my elementary treatise on the Entozoa. The second description of the worm was accompanied by an illustration, in which the general plan of the mode of branching of the digestive canals was given on a reduced scale.

In his well-known systematic work, C. M. Diesing at first recorded the American 'find' in his list of doubtful species; but in his latest revision he formally recognized the fluke as a good species. No description, however, was added. That revision was published in 1858. Three years later, although I had not then seen any specimens, I recorded Jackson's fluke as a *Distoma*, in the Synopsis of the Distomidæ published in the Linnean Society's Journal (1861). These references practically exhausted the literature of the subject up to the year 1873, when I again had occasion to speak of these flukes. ('Manual of the Parasites of our Domesticated Animals,' p. 13). Some of the specimens received from Professor Huxley were afterwards added to the entozoal series of preparations contained in the Hunterian Museum.

I think it necessary to explain the reasons for altering Diesing and Jackson's nomenclature as applied to this species, and all the more so since some helminthologists persist in ignoring the generic term originally employed by Linnæus in connexion with the common fluke of Ruminants. Whilst (excluding the Amphistomes and their allies) I recognize the genus *Distoma* of Retzius as applicable to all the two-suckered flukes that possess a simple unbranched dichotomous gastric organ, I think it unfortunate that my proposal to retain the Linnean generic title, *Fasciola*, for such true flukes as possess a dendriform or branched gastric organ has not been fully accepted. This structural peculiarity is eminently characteristic of a few forms of fluke, and gives us a well-marked type. Besides the species under consideration, only two other flukes are known to possess the dendriform gastric apparatus. We have not yet even encountered any transition types (in this particular), although, on evolutionary principles, one must conclude that, if not now existing, flukes with their digestive tubes much less branched must have existed. The only three fluke parasites yet shown to possess this remarkable dendriform system of gastric canals are the Elephants' fluke (*Fasciola Jacksoni*), the common fluke of Ruminants (*F. hepatica*), and the fluke found by me in the Giraffe (*F. gigantea*).

In 1864 I went fully into this question, and endeavoured to show that, at least as regards the common fluke, the priority of the genus established by Linnæus was indisputable. The genus *Fasciola* was accepted and recognized some twenty years before the genus *Distoma* was proposed by Retzius, and more than thirty years before it was adopted by Zeder and his followers. (For dates, &c., see my 'Entozoa,' 1864, p. 149; also 'Parasites,' 1879, p. 15).

As furnishing interesting evidence of the value of cooperation in zoology, I may mention that in one of my earlier notices I appealed to American naturalists, requesting them to examine the original specimens of *Fasciola Jacksoni* preserved in the Boston Museum. This appeal met with a suitable response at the hands of Dr. R. H. Fitz, who afterwards published the results of his anatomical inquiry. In regard to the original find, we are told that "Dr. Jackson preserved a large number of flukes, and generously placed them at the disposal of Dr. H. P. Quincy, who made and presented to the Warren Museum a series of admirable preparations." These preparations consisted of longitudinal, transverse, and other sections, stained in carmine, and rendered transparent in the oil of colours. Dr. Fitz expressly states that a study of them satisfied him that my "surmise" as to the true character of the species they represented was correct; and I am glad to perceive that so able an observer did not hesitate to accept the generic nomenclature that I had adopted.

The anatomical investigation made by Dr. Fitz resulted in not a few clear additions to our knowledge, especially as regards the sexual organs. There is a very close correspondence between the arrangements of the reproductive parts of this species and those of the common fluke. In some particulars Dr. Fitz's observations and my own are at variance. Thus Dr. Fitz appears to think that I have erred in attributing to *Fasciola Jacksoni* the possession of integumentary spines. In my original diagnosis I affirmed that the body is "armed with minute spines." I still adhere to that matter-of-fact statement; but Dr. Fitz says:—"Instead of finding the body armed throughout with minute spines, the cuticle covering the abdominal surface presents a series of ridges pointing backwards, and extending the entire length of the animal. Traces of a similar formation are present on the dorsal surface or the neck; *elsewhere the back is smooth.*" The italics are mine. I am sorry to correct Dr. Fitz. The little spines not only exist, but when the skin of the parasite is examined by direct light under a 2-inch objective, their equidistant and otherwise regular arrangement becomes obvious. Under higher powers the spines are measurable, giving an average of $\frac{1}{750}$ to $\frac{1}{700}$ of an inch in length, their basal diameter being less than $\frac{1}{2000}$ of an inch. It must be admitted that their size is insignificant when compared with the similar dermal spines of the common fluke. In *Fasciola hepatica* the spines are about twice as long and thrice as broad. The differences therefore are sufficiently striking to be emphasized in any diagnosis of the species; and, further, it may be said that they are perfectly independent of the ridges or folds of the skin described by Dr. Fitz.

On other grounds than those already stated, the peculiarities of the digestive channels call for remark. Although drawn to a large scale (Pl. XXIV. fig. 12), I was not able to represent the entire set of canals. The branches coming off from the main trunks of this dendriform stomach, if such it may be called, are faithfully represented, both as regards number, size, position, and extent of branching. In no two specimens, however, is their form and distribution absolutely identical, though in all these flukes the general arrangement of the canals is the same throughout. The specimen on which I chiefly relied for an interpretation of the facts was injured in the mounting; and in drawing that specimen (without reproducing the injuries), I have derived much help from an outline camera sketch made for me by Dr. John Foulerton. In spirit-specimens the natural green tint or bile-stained appearance of the fresh worms is not entirely destroyed.

In the only hitherto published representation of the worm, I have purposely reduced the digestive apparatus to the lowest possible expression consistent with the general plan ('Entozoa,' Supplement, p. 19). That plan epitomizes, as it were, the larger illustration now given; yet neither the one nor the other fully expresses the degree of complexity which the secondary and tertiary ramifications of the channels exhibit. My drawing represents the tubes and their cæcal ends as seen from the back of the worm. Though unaccompanied by any figure, Dr. Fitz's description closely corresponds with what little I had already observed and written on this point; but as he pushes the details much further, and as many of his observations concur with what I have recently ascertained to exist, I prefer to quote his accurate record of the facts, as follows:—"Just beyond the terminal oral sucker is a voluminous bottle-shaped muscular pouch, the pharynx, with which a short tube, the œsophagus, communicates. The latter has a crenated outline, as if capable of a considerable elongation. This tube bifurcates at its lower end; the two short branches thus formed pass respectively to the sides of the animal, and enter the main intestinal canals, which extend, one on either side, almost the entire length of the body. These canals are widely separated from each other until they approach the tail; and between them lie the sexual organs both male and female, towards the front—the remaining space between, behind, and around being filled in by the yolk-glands or tubes and the cæcal pouches of the intestine. The latter arise as primary, secondary, and even tertiary divisions, from branches given off more or less alternately from the main canals; and their general direction is backward. Those running towards the median line are short, with comparatively few branches, while the external tubes are considerably longer, often bifurcating before the secondary and tertiary canals arise. The largest number of cæcal pouches are thus observed in the outer portions of the parasite. Another peculiarity of the external canals is, that their secondary branches are almost invariably given off from the posterior aspect of the tubes from which they arise."

In describing the other internal organs, Dr. Fitz supplies some interesting particulars; but it is not always clear whether he is dealing with the facts as he actually found them or with appearances which he correctly inferred to exist. Although in my own specimens I obtained clear evidences as to the general distribution of the reproductive organs, and especially of the yolk-glands, yet I could neither trace out the ducts of the vitellaria

nor even the vaginal prolongation of the uterine coils. Their position, however, can be perfectly well understood from the position of the parts actually seen. I have not attempted to figure the yolk-sacs; but the illustration shows a portion of the uterine coils and their contained ova. As in the common fluke, the eggs are oval, and furnished with a lid at one end of the shell. They are comparatively small, affording an average of $\frac{1}{30}$ of an inch in length and $\frac{1}{30}$ in breadth. Dr. Fitz doubts the existence of any true reproductive papilla, but speaks of a pocket or depression midway between the pharynx and the ventral sucker. Certainly the depression referred to is occasionally very marked; but in the centre of this depression, even in the retracted state of the cirrus, there is a papillary eminence, which may be seen with an ordinary hand-lens. The exerted cirrus was not seen by Dr. Fitz; consequently he could not confirm my statement as to its remarkable length. As shown in my figures, this whip-like organ nearly equals in length the transverse semidiameter of the body.

In my previous account of this worm the invariable distention of the digestive tubes by inspissated bile derived from the host has been remarked. Dr. Fitz noticed the same thing in Jackson's specimens. Neither in the common fluke nor in the fluke of the Giraffe has this natural injection been found to be so perfect. For anatomical purposes it renders any artificial distention of the ducts quite superfluous.

NOTE.—The foregoing observations complete my account of the helminths properly so called. Although, without question, as regards their zoological significance and the production of injury to Elephants this class of parasites holds the chief place, yet I cannot omit all notice of the Arthropodous parasites. Doubtless much more remains to be done in reference to the insects and mites that attack Elephants either as parasites or as tormentors. The burden of this research, however, must fall rather on the entomologist than on the helminthologist. Arguing from what is already known respecting the ectozoal Arthropoda of other pachyderms, I should suppose that we have here a wide field for further discovery. When it is considered how large a number of cestridean larvæ take up their abode in herbivorous quadrupeds, to say nothing of the ectozoal Anoplura and Trachearia, it seems strange that not more than three or four arthropodous parasites are at present known to infest Elephants. These I proceed to notice.

12. GASTROPHILUS ELEPHANTIS, Cobb.

Cæstrus of the Elephant, Cobbold, Catalogue of Entozoa in the Museum of the Royal College of Surgeons, 1866, p. 24.

Cæstrus elephantis, Steel, Med. Examiner, 1878, p. 886.

Head and neck of the larva turned forwards, prominent, spinous; epicranial lobes armed at the tip. *Maxillæ* large; mandibles concealed. *Somites* of the body all more or less armed, the hook-circles of the middle somites supporting five rows of spines, of which the two upper rows are more conspicuous in consequence of the relatively greater size of the separate spines; penultimate somite with very few spines, and the last somite nearly destitute of them. Caudal lobes furnished with six prominent

papillæ, two in front and four behind, numerous spines occurring in the space between the papillæ and the border of the oval caudal plate.

Length of the larva $\frac{3}{4}$ to 1 inch.

Breadth $\frac{3}{10}$ of an inch.

Hab. Stomach of *Loxodonta africana* and *Elephas indicus*.

When in the year 1865 I rearranged the Entozoa preserved in the Hunterian Museum, I added a few new forms of Œstridean larvæ which had been presented to me by the late Mr. Andrew Murray and by Dr. (now Sir John) Kirk. Amongst the 'bots' obtained during Livingstone's Zambesi expedition were several taken from the stomach of a female Elephant shot by Dr. Kirk himself. Some of these, with others from a Hartebeest, remain in my possession. Those that I placed in the Hunterian Museum were entered in the Catalogue as donations from the eminent naturalists to whom I stood indebted.

Although hitherto undescribed, probably many Indian as well as African sportsmen have encountered these parasites in slaughtered Elephants. Be that as it may, no one appears to have had any opportunity of comparing and identifying the 'bots' derived from the widely dissimilar proboscidean pachyderms of the two countries in question. In the autumn of 1878, one of the victims of the epidemic at Sanger's Circus fortunately supplied me with the means of comparison. The longest of Dr. Kirk's specimens barely measured $\frac{6}{10}$ of an inch, whereas two of the specimens removed from Sanger's Elephant exceeded an inch in length. At first sight probably few would hesitate to separate the bots of the Indian and African Elephants, thus regarding them as the larval representatives of different species of gad-fly. However, a careful examination of the somites, of the arrangements and proportions of the spines, of the papillæ, and of other characters, has convinced me of their identity. Not only so; the African and Indian Elephant bots, though identical in themselves, differ from the bots hitherto found in the stomachs of other animals.

The Indian Elephant, a male, which yielded the specimens obtained in this country, was examined by Veterinary-Surgeon Frederick Smith, R.H.A., and by Mr. Steel, to whose memoir on the circus-epidemic allusion has already been made. Speaking of the post-mortem results, Mr. Steel says:—"The very numerous bots (*Œstrus elephantis*) were found in the stomach adhering to the lining membrane. They were, as a rule, larger than the bots of the horse, and exhibited a greater degree of ferocity. As soon as removed from the membrane they struggled violently; and several grasped my finger firmly with their hooklets. The female animal died shortly afterwards; but we had not an opportunity of making a post mortem examination of her. A fourth Elephant died about a week after delivery" [to Mr. Sanger]. Mr. Steel then goes on to speak of the opinion which he gave in a court of law as to the cause of these animals' deaths; but

Fig. 12.

Bot of *Gastrophilus elephantis* ($\times 3$ diam.).

it is evident that the 'bots' were little, if at all, concerned in bringing about the fatal issue.

These bots are perfectly distinct from those obtained from the stomachs of other large animals. Not many years back Mr. Spooner Hart, V.S., of Calcutta, sent me some fine larvæ taken from an Indian Rhinoceros. They are evidently identical with the *Gastrophilus rhinocerotis* obtained by Prof. Owen from the stomachs of African Rhinoceroses (*R. bicornis* and *R. sinus*), and cannot be confounded with the bots of the Elephant. As regards size, the bots of *Rhinoceros indicus* quite equal the measurements recorded by Brauer as characterizing the bots of the African Rhinoceroses.

Parasitic Ova.—In this place it is fitting to notice the curious kind of parasitism believed either to result from or to have some immediate connexion with the deposition of eggs of an insect.

At a meeting of the Zoological Society held on the 21st of February 1871, Mr. Sclater showed some tusks of a female Indian Elephant, their surfaces being "corroded or eaten away" near the gums. Egg-like bodies, probably those of a dipterous insect, were found attached below the affected spot. According to Mr. Roden, who shot the Elephant, the eggs were on the tusks at the time he killed the animal; but "there were no maggots in the grooves at the end of the tusks." To whatever circumstances the injuries were due, it is clear that the corrosions were not accidental; for, as Mr. Sclater pointed out, a well-known Indian sportsman had already called attention to the matter in the columns of 'The Field.' Under a pseudonym ("Smoothbore") the sportsman solicits information from zoologists, and remarks in particular on the circumstance that the corrosions or injuries "have never been observed in the tusks of the male." In confirmation, Professor Flower also called attention to the fact that the Hunterian Museum contains a pair of tusks similarly marked. Thus, to whatever parasite the appearances in question are due, it is clear that their occurrence is sufficiently common, and that there ought to be no difficulty in procuring materials for further investigation.

Dr. Max Schmidt, the Director of the Zoological Garden at Frankfort, has also referred to the ova of insects on the tusks of Elephants. His well-known memoir is exhaustive and elaborate as regards the general diseases of pachyderms; but little is said about their parasites. Not one of the entozoa of Elephants described by Baird and myself appears to have come under Dr. Schmidt's notice.

Through the help offered by Professor Flower, I have had an opportunity of examining the tusks preserved at the Royal College of Surgeons. In the Catalogue it is stated that one was obtained from a young Ceylonese female Elephant. This tusk was presented to the College by Mr. G. H. K. Thwaites. The other tusk, presented by Mr. Sclater, was removed from a wild and full-grown female Elephant killed at Malabar. Both teeth display deep erosions at the surface, near the edge of the gum; and in the smaller specimen from the young Elephant the erosion is about a quarter of an inch in depth. The eggs are deposited on the tusks side by side in single file, but not in perfectly straight lines. They form gracefully curved groups, each group presenting a

festooned appearance. On the small tusk, from which a large number of the eggs had evidently been rubbed off, I counted 150 ova—that is, reckoning the perfect and imperfect shells, as well as the impressions left by such as had been detached. The counting of the eggs and markings on the larger tusk was a more tedious process; but I satisfied myself that at least 2000 ova had been deposited. The Assistant Conservator, Dr. Garson, obligingly removed one or two egg-shells. I found that these ova gave an average length of $\frac{1}{13}$ of an inch. Separately they presented a linear-oblong figure, being rather thicker at one pole than at the other. In a perfect specimen the narrow end measured the $\frac{1}{80}$ of an inch, the broad end being about the $\frac{1}{65}$ of an inch in diameter. From certain appearances I am inclined to think that the intra-ovular maggots make their escape by the opening of the shell in a lid-like manner. Large numbers of the eggs, have their shells open as if three fifths of the exposed surface had fallen away after the manner of a lid. The external configuration shows a rather sudden transition from the thicker to the thinner part of the egg, which circumstance also favours this view. Considering, moreover, the known facts relating to the form and contents of the eggs of gad-flies generally, it appears to me not improbable that the ova in question have been deposited by the mature *Gastrophilus elephantis*. It is a question which the entomologist is alone competent to settle; but I may observe, as favouring this view, that since the tongue of the Elephant could not reach the ova if the gad-flies deposited their eggs on the legs and shoulders (as obtains in the Horse), it becomes a necessity for the gadfly of the Elephant to deposit her eggs either on the coarse hairs in the neighbourhood of the mouth, or in situations similar to those actually occupied by these dipterous ova. It is scarcely likely that the trunk of the Elephant would or could be employed to detach ova measuring only the $\frac{1}{13}$ of an inch in length.

Fig. 13.

Egg of a Dipteron
($\times 20$ diam.).

Ectozaa.—There are two other arthropodous parasites known to infest the Elephant: the one is a huge louse, the other a species of mite. *Hæmatomyzus elephantis* differs from ordinary lice in many particulars, but it has been remarked by Piaget that the reproductive organs resemble those of the genus *Hæmatopinus*. Mr. C. H. Richter described, in the pages of 'Science Gossip' for 1871, what, at the time, was supposed to be "a new form of parasite," which he called *Idolocoris elephantis*. This insect, one line in length, was found upon an Elephant in Ceylon. According to Walker, who defined the genus, it not merely has supplied us with the type of a new genus, but with that of an entirely new family of the *Hemiptera Heteroptera*, coming very near to the bed-bugs (*Acanthidæ*). In the same publication (p. 234) Dr. Buchanan White suggested the name *Phantasmocoris* for the genus; but a subsequent writer (*ibid.* p. 278) cleared up the difficulty by referring the parasite to Piaget's *Hæmatomyzus*.

The excellent figures given by Richter and Piaget leave little to be desired; but notwithstanding Piaget's explanation, the specific term *longirostris* would perhaps have

been preferable. This Ectozoon is no longer a rarity, specimens having been exhibited at a recent meeting of the Royal Microscopical Society and elsewhere.

I have nothing new to add respecting the mite of the Elephant. Its position is still doubtful. By Fürstenberg this Acarus was called *Homopus elephantis*, and by Gerlach *Symbiotes elephantis*. According to Mégnin, it is a *nymphe adventive*, or *hypope*, of a variety of *Tyroglyphus siro*, which is very abundant in old forage. Now, if the views of Mégnin be correct, *Homopus elephantis*, considered as a good species, falls to the ground. Not only so; it cannot fairly be called a parasite proper to the Elephant, since its occurrence on the only animal on which it had been found was purely accidental. The original specimens which supplied the means of description were sent by Gurlt to Fürstenberg. They were found in immense numbers on the skin of an Elephant recently packed with straw (*empaillé*). It was referred by Fürstenberg to the parasitic Acaridæ, but not to the true itch-mites, properly so called. As implied by his nomenclature, Gerlach had taken the latter view. After studying Mégnin's criticism of the whole Acarine question, one feels bound to acquiesce in his authority. On the question, however, which he has recently raised respecting the dimorphism of the Cestodes, I think M. Mégnin's views are altogether at variance with any correct interpretation of the facts known to result from experimental research.

So far as I am aware, no other parasites of Elephants have been discovered; but without doubt several more species will in time be brought under observation, especially from amongst the Arthropoda.

Practical Considerations.

Although much has been written on the diseases of Elephants, little has been said of the injuries produced by parasites. Having, by correspondence, supplied Colonel H. P. Hawkes and other residents in India with particulars respecting the various parasites transmitted for identification, these gentlemen have, in their turn, furnished me with the practical results of their observation and inquiry. What I have already published on this head has been either extended or confirmed by subsequent correspondence; but the most considerable additions to our knowledge have been made by the valuable communication of Mr. John H. Steel, in which full details of the Circus epizoöty are described. If properly looked after, Elephants in captivity ought to suffer less from parasites than their companions in the wild state. We have not, indeed, any reliable facts on which to form an opinion as to the extent to which wild animals are thus victimized. That, like their captive congeners, wild Elephants perish from 'flake-rot,' there cannot, I think, be the slightest doubt; for in the natural state they have the same or even increased facilities for swallowing the parasitic larvæ. Guided by the recent determination of Leuckart respecting the intermediate or Molluscan bearer of the common fluke, there is every likelihood that the mollusk harbouring the Cercarian larva of *Fasciola Jacksoni* is small, and possessed of amphibious habits. Not impossibly more than one species of mollusk is concerned in the intermediate office, although I strongly suspect that in the case of *Fasciola hepatica* the representative Cercarian larvæ limit their temporary residence to the body of a single mollusk. If this be so, *Limnæa truncatula* is the responsible 'host,' and the source of sheep-rot. Be that as it may, we shall never settle this question in connexion with the flukes of the Elephant unless our Indian zoologists take up the study of parasites in the same earnest spirit in which so many of them have advanced other branches of natural history.

Captain Williamson's 'Oriental Field Sports' is one of the earliest works in which any thing is said

respecting the parasitic diseases of Elephants; and what he states about the habits of these pachyderms affords a clue to the source of fluke-infection. Of course, he wrote at a time when it was not known that freshwater mollusks, especially those frequenting marshy grounds, were the responsible media of fluke-infection. Captain Williamson says:—"The Elephant, like the Buffalo, delights in wallowing, and never thrives so well as when he is allowed to visit a rapid stream, there to exercise himself in swimming, as well as to lie immersed and cool himself." Further on he says:—"Elephants are much troubled with worms, for the cure of which complaint the Elephant eats earth; this acts both as an absorbent and operates as a powerful aperient. Those who may have kept Elephants for years, and have not attended to the minutiae, have yet to learn that the Elephant, being sensible of his malady, resorts to this simple remedy voluntarily; all the *mohout* has to do on such an occasion is to keep him from eating other food, but to allow him abundance of drink. If the faeces be inspected there will be seen an amazing number of moving objects, which so much resemble pieces of sugar-cane or of green bough as to require some attention to distinguish. They are ordinarily about the size of a grain of oats, and from their peculiar form no doubt prove particularly distressing and injurious to the stomach and intestines." In making this brief extract I have omitted one or two words and synonymized another. It is clear that Williamson was speaking of the Nematodes, and was probably unacquainted with the fluke-disorder. Referring to the intestinal worms, he remarks the rapid decomposition of Elephants after death, as a ground of apology for not having by dissection ascertained more precisely the true "seat of this disease." He shows that the administration of the "solution of the *Kallah-nimok*, or bit-noben (the quantity, perhaps, of four ounces to as many gallons or more of water)," is amongst the best remedies that could be selected. Williamson says this drug "is well known as the most common purgative in use throughout India." On the authority of Dr. E. J. Waring, I may state that it is merely "an impure chloride of sodium, containing a varying proportion of sulphuret of iron." It is, Waring adds, "a very popular Hindu nostrum."

On the subject of earth-swallowing, the statements of Williamson are quite in harmony with the opinions held in India at the present day. As Mr. George Fleming has remarked, the same opinions are recorded by Captain Forsyth. This sportsman says:—"Elephants are very liable to intestinal worms. They generally cure themselves when they [*i. e.* the worms] get very troublesome, by swallowing from ten to twenty pounds of earth. They always select a red-coloured earth for the purpose. In about twelve hours after, purging commences and all the worms come away. When this occurs the hard food should be stopped for a week, fodder only being allowed, and a ball of spices should be given every day. Some Elephants will not eat earth when they require it, and they are considered a very bad lot in consequence." Probably most of us have witnessed this earth-eating habit of which Indian writers make so much. With others I have watched the same habit on the part of the African Elephants at the Zoological Gardens in the summer time. It is one thing to observe a common-place fact, and quite another to accept popular inferences. The credit for intelligent self-doctoring which the mahouts ascribe to Elephants, is on a par with certain other tales that are told us respecting the wonderful self-culture and instinct of these animals. Assistant Commissary-General Hawkes and other officers, both civil and military, with whom I have conversed, seemed all more or less committed to this view. Speaking of the Amphistomes as *Masuri*, Hawkes says:—"These parasites appear to be very generally present in the Elephant. When their numbers are few, the host is probably not much inconvenienced; but when present in any great quantity they undoubtedly cause much irritation. When this is felt the animal instinctively resorts to a simple and effectual remedy: he eats a quantity of earth, which purges him thoroughly, and expels the Amphistoma. The Mahawats are of opinion that whilst the Elephant is eating earth to relieve himself of the pests, the daily allowance of rice should be scrupulously withheld; and they say that if the rice, which is given uncooked, is eaten by the animal under these circumstances, excessive purgation is induced which frequently results in death." Colonel Hawkes adds that the

Mahawat's name for the disease means 'fasting,' which expression "bears testimony to the generally received notion of the necessity of withholding the rice when the animal is eating earth."

In 1841 Mr. Gilchrist published his often quoted 'Practical Memoir on the History and Treatment of the Diseases of Elephants;' and in this work, without any attempt at scientific definition, he alludes to the parasites termed *Mussoorie*. He also speaks of the Nematodes as *Shotee*, and likewise of the bots or, rather, the disorder they create, under the term 'Lemgum.' The rendering of native names in English varies amongst Hindustani scholars; and thus Hawkes spoke of the Amphistomes and Nematodes as *Masuri* and *Soorti* respectively.

From the evidences I have collected it is clear that epizootics affecting Elephants are more or less frequent in India and the East. The flukes received by Professor Huxley from Rangoon were obtained from an animal which was only one out of many victims that perished from 'rot' in 1867. A resident in Burmah, under the signature of R. B., described this outbreak in a public journal. The Secunderabad epidemic, of which I received full particulars from Commissary-General Colonel Hawkes, was also parasitic, and, in my opinion, partly due to the presence of flukes and partly to the Amphistomes. Speaking of the post-mortem examination, where several kinds of parasites existed, Vet.-Surgeon W. S. Adams says:—"The large number of flukes in the liver and the intestinal parasites account in a great measure for some of the symptoms shown; and these symptoms accord in many respects with those shown in Elephants that died in Burmah during the epizootic in 1867." Mr. Adams adds that the liver-parasite is the same as that which I had described as *Fasciola Jacksoni*; and in regard to the symptoms in the Elephants, he noticed especially the "refusal of food, standing with the mouth open, restlessness, and puffiness about the head and shoulders." Speaking of another of the Secunderabad victims, the same observer remarks:—"There were flukes in the liver, but in no great quantity; and the structure of the liver was sound. Although not assisted by *this* case in attributing the mortality to parasitic origin, I am strengthened in my opinion that the death of the previous Elephant was due to disease caused by the presence of the fluke." Mr. Adams does not himself speak distinctly as to the presence or absence of Amphistomes in the Secunderabad outbreak; but, as we have seen, Colonel Hawkes remarked both upon their prevalence and the power of mischief that they had exerted in this epidemic.

In various published papers I have shown that Amphistomes frequently infest horses in India; and in one case (examined after death, and reported to me by Veterinary-Surgeon F. F. Collins) it was calculated that about a thousand of these parasites were present. "Nearly the whole of them were situated close to the cæcum, and were loose in the gut." Mr. Collins sent me thirty-three of the specimens.

In the Secunderabad epizooty fourteen elephants perished. Writing to me in May 1875, Colonel Hawkes said:—"Out of twenty-eight Elephants under my charge, no less than twelve have died within the last sixteen months, whereas the average annual mortality has been hitherto only two per annum out of thirty-eight on our establishment." My military informant, much to his credit, caused a post mortem to be made in almost every instance; and he supplied me with the results obtained and recorded by the various veterinary surgeons. Two of these records (made by Mr. Adams) I have already quoted. Taking the report as a whole, I am sceptical as to the accuracy of the deductions it embodies. It is clear that the mortality was unusual, not to say unprecedented, and that therefore some special cause must have arisen as a chief, if not as an exclusive, factor in its production. In my opinion, and even supposing the parasites were not the real cause of the mortality, the report is eminently unsatisfactory. Parasites or not, here was a local and fatal epidemic; and yet, as a result of the examination of thirteen carcasses, the deaths are attributed to no less than eight different causes—inflammation of the intestines, inflammation of the lungs and liver, splenic apoplexy, sunstroke, and so forth. Knowing, from long and special professional experience, the scepticism which prevails in the medical world in respect of the injurious effects of parasites, I cannot affect surprise at the conclusions formed by the veterinary surgeons in India. To the mass of practitioners helminthological science and its practical issues remain a *terra incognita*.

Colonel Hawkes himself was evidently perplexed by the record of results. He wrote, saying :—" In every case at which I was present flukes were found in greater or less numbers in the gall-ducts of the liver; and the Amphistoma was also as constantly present in the intestines, the Soorti (*Ascaris lonchoptera*), contrary to the general experience of the elephant-attendants, being less frequently met with, though, from its colour and its shape, it is not so easily detected among the huge mass of fæces as the larger Amphistoma." There must, of course, be some misapprehension here, unless the Strongyles are included in the general term of *Soorti*; for the particular nematode above mentioned was not present in any of the bottles of specimens which I received from Secunderabad. " In some cases flukes were in large numbers, apparently collected in bunches in the gall-ducts; but disease of the liver did not necessarily appear to follow, nor, where disease was actually present, did it seem to bear a constant ratio to the number of flukes in the gall-ducts." Colonel Hawkes subsequently remarked upon the impossibility of concluding to what extent the flukes were responsible for the outbreak, and the difficulty of singling out any symptom as characteristic of their presence. This does not surprise me, considering the number and variety of parasites that were admitted to have been present, not alone in the liver, but also in the intestines. In one instance there was the characteristic swelling beneath the jaw, similar to that found in sheep in the advanced state of 'rot,' when the animals are said to be suffering from "bottle-jaw." This "suggestive" feature, as Hawkes himself called it, seemed in his view somewhat neutralized by the fact that in "only the one other case (in which the parotid glands were swollen) the liver was more healthy and had fewer flukes than any in the whole series" of dead Elephants.

In what has been called the English outbreak, affecting Sanger's performing Elephants, the injuries appear to have been principally due the Amphistomes. In the animal examined by me, these Entozoa were present in prodigious numbers. In all, five animals perished, one during the sea-voyage, and the remaining four some time after their arrival. I feel assured that all the parasites found in these animals were brought by their hosts from India. Mr. Steel records the symptoms separately observed in three of the victims. The record is too long for quotation; and, as one might expect, there is not much that is distinctive about the symptoms. Speaking of the post mortem of a young female Elephant, Mr. Steel states that the large intestine "was studded with very numerous, small, vesicular, blood-coloured parasites, about the size of grains of wheat. In addition, we found specimens of nematode worms intermingled with the bowel-contents, some being found in the dilated portion of the bile-duct, where it terminates at the duodenum. We found a few specimens of a thread-worm on the surface of an incised part." By an anonymous writer in the 'Lancet' it was stated at the time that this female Elephant had suffered from "double pleuritis;" but, as Mr. Steel himself subsequently pointed out, "the absence of a pleural sac has been proved to be a normal condition in this animal." It is worthy of remark that in the case of the remaining patients the treatment adopted sufficed to expel some of the parasites; but from the first it seemed pretty clear that the animals were past all remedial help. One of these young Elephants, a male, died suddenly. "In this case the parasites, both Amphistomata and Ascarides, were much more numerous, the former existing almost in thousands." It was this animal also which supplied the stomach-bots described in this memoir.

Considering the heavy losses thus incurred, it was not surprising that the owner made the matter a subject of litigation on the ground that there had been a breach of warranty. Without giving Mr. Steel's views in full, I may state that he shared with me the opinion that these animals were infested by parasites at the time of their landing in this country; and further, he believed that if it could not be shown that they were the sole cause of the epidemic, the parasites at least very materially contributed to bring about the fatal issue.

One passage in Mr. Steel's communication is perhaps a little too significant. He says:—"The parasites in the bowels gave rise to irritation; and the Amphistomes, like so many small leeches, were withdrawing large quantities of blood from the animal; the bowel-lesions were most marked where these parasites were found." Mr. Steel seems inclined to set little store by the action of the Nematodes;

but as these turn out to be not *Ascarides*, but *Strongyles*, armed with more or less formidable teeth, I am inclined to think that he has underrated their powers of mischief. On the other hand, whilst I quite think with him that the Amphistomes, by their sucking action and consequent irritation, are capable of giving rise to severe inflammatory lesions, yet I doubt their capacity for drawing blood in the way Mr. Steel implies. If the Amphistomes really gorge themselves in this sucking process, they must needs be continually detaching themselves for the purpose of ejecting the contents of the stomach. In true leeches, as also in those *Strongyles* which have bloodsucking propensities, the presence of an anal outlet enables them, whilst still attached, to discharge freely those constituents of the blood that are not necessary for their nourishment.

In reference to the Ectozoa, I possess no sufficient data whereby to estimate their power of producing mischief amongst Elephants. Judging from what happens in the case of other domestic animals, it is certain that strict attention to sanitary matters will diminish the chances of invasion either from external or from internal parasites. Mr. Steel speaks with evident satisfaction of the cleanliness and care taken by the grooms at Sanger's Circus-stables, where the flooring was "subjected to frequent disinfection." At the Zoological Gardens I have frequently made inquiries of the Head Keeper (Scott) whose diligent search for Entozoa has hitherto been attended with negative results. This speaks well for the cleanliness observed there; and at the same time the absence of parasites shows that the habit of earth-eating, which the African Elephants at the Gardens are wont to indulge in, is not consequent upon the presence of Entozoa. This habit is not confined to any one class of animals. My friend Mr. Arthur Folkard, during his residence in Ceylon, noticed that the Elephants of that island were large earth-eaters; and the late Dr. J. P. Rowe assured me that Australian horses and sheep largely indulge in the same propensity. Dr. Rowe thought that the sheep thus sought instinctively to relieve themselves from the irritation produced by parasites in the stomach. My own belief is that when colic-symptoms are associated with a depraved appetite, the animals affected swallow mud, soft earth, or sand indiscriminately. A remarkable instance was brought under my notice by Colonel Hawkes, where the accumulation of "sand or gravel" in the intestines of a military horse amounted to 14½ lb. It was supposed at the time to have resulted from careless feeding with impure grain or rather 'pulse;' but this is impossible, as only two or three ounces of sand could be swallowed as the result of the daily meal. At this rate, as Hawkes observes, "it would take from 77 to 116 days to accumulate 14½ lb. In consequence of this earth-eating habit, he adds (from memory) it was found necessary, some twenty years ago "to remove the mud-walls round the picket enclosing some of the horses of a mounted corps. If the conclusion formed by Commissary Hawkes and others be correct, all foul-feeding horses and elephants must either be suffering from Amphistomes or some other kind of internal parasites. Be this as it may, any sanitary measures which prevent the ingress of parasitic larvæ cannot fail to prove beneficial. In like manner any agencies which prevent a parasite completing its life-cycle must be equally effective. Thus clean water and fodder given to Elephants in captivity prevents the possibility of their contracting either *masuri* or *soorti*. I think it extremely improbable that any Elephant should contract internal parasites in this country. Mr. Steel thinks otherwise, and that, as regards the Trematodes, they, or rather their larvæ, "might make shift with an English mollusk." It is not, however, so much a question of making shift on the part of a Cercarian as it is a question of an allotted or appropriate territory. Some Trematode larvæ are limited to one host, and others to a few hosts. In all cases there is a measure of restriction; and I think we must therefore look to one or more Indian mollusks as the legitimate and only bearers of the Cercarian larvæ of *Fasciola Jacksoni*. But, as before hinted, the final settlement of this question is not yet awhile. Even with a large accession of labourers in this field of research, the process will be tedious, when it is considered how long a time, aided by frequent observation and experiment, helminthologists have taken to acquire the meagre results already arrived at in connexion with the parasites of cattle; it is evident that as regards the origin of, and transformations undergone by the internal parasites of Elephants, we are only on the threshold of inquiry. It may be said,

indeed, that our efforts have not yet properly commenced. If this be the case, any thing like an exhaustive knowledge of the development of the Elephants' helminthiases is a matter likely to be realized only in the far future. There is not much done to encourage research in this special direction. Those who have charge of Elephants have usually so little knowledge of zoology that their observations are either common-place or altogether unworthy of credence. Even thoroughgoing naturalists shirk the subject. Certainly the 'Challenger' and other expeditions expressly fitted out to collect all kinds of natural-history objects might have accomplished much more in this direction had they been minded to follow the example of previous explorers. The most interesting private contribution of parasites in my possession I owe to the liberality of Mr. Darwin, he having obtained some Entozoa about forty years ago during his travels in Patagonia. But I must conclude. If the publication of this imperfect memoir should do no more than gain for the helminths greater consideration at the hands of naturalists, I shall feel that my efforts in a really useful though unpopular cause have not been altogether fruitless.

APPENDIX.

Since the reading of this memoir took place, Mr. R. McLachlan, F.R.S., has referred me to a paper written by Dr. F. Brauer in the 16th vol. of the Transactions of the Zoologico-Botanical Society of Vienna. It is entitled "*Pharyngobolus africanus*, ein Oestride aus dem Rachen des afrikanischen Elephanten." Mr. McLachlan also subsequently received a letter from Dr. Brauer, in which the latter *savant* refers to the abstract of my paper already given in the Linnean Society's Proceedings. Not unnaturally Dr. Brauer appears surprised that the parasite described by him has been omitted from my list; and he thinks it probable that his *Pharyngobolus* is either similar to or identical with my *Gastrophilus elephantis*. Dr. Brauer's inference is not correct. The two bots found by Herr E. J. C. Marno in the oesophagus of the African elephant that died at Vienna are quite distinct. Their characters, as given by Brauer with extreme minuteness of detail, neither correspond with those of the bots found by Sir John Kirk in the stomach of the elephant shot by him in Africa, nor do they resemble the characters presented by the bots which were procured from the stomach of one of the Indian elephants which died in this country. The specific differences refer to size, shape, armature, and habitat. In *Pharyngobolus* the larva is, we are told, scarcely more than twice as long as it is broad, and the two anterior rings are only a trifle narrower than the third ring. The number and disposition of the spines are also especially noteworthy. In Brauer's larva each armed segment displays two widely separated circles of spines, the circle occupying the centre of each somite consisting of large spines with their points directed downwards. In our larvæ the armed somites at the middle of the body support several circles of spines, which are closely set together; moreover, whilst the uppermost circle is composed of spines that are paramount in size, the second circle carries rather large spines, the third, fourth, and fifth rows becoming smaller and smaller. Besides these, it will be seen, on comparison, that there are other more or less well-marked differences; and therefore I do not hesitate to say that the throat- and stomach-bots of Elephants represent two totally distinct species of dipterous insects.—T. S. C.

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DESCRIPTION OF THE PLATES.

PLATE XXIII.

- Fig. 1. Head and neck of a male *Sclerostoma sipunculiforme*, showing the double circle of oral denticles, buccal cup, œsophagus, retractor muscles, upper part of the chylous intestine, and the sub-dermal vascular network. ($\times 33$ diam.)
- Fig. 2. Semiprofile and oblique view of the lower end of the body of a male *Sclerostoma sipunculiforme*, showing the folded hood, the points of the rays, the vascular network, and the position of the spicules in their retracted state. ($\times 27$ diam.)
- Fig. 3. Side view of the head and neck of *Strongylus clathratus*, showing two auriculate folds, the buccal cup, and the œsophagus. ($\times 23$ diam.)
- Fig. 4. Side view of the tail of a male *Strongylus clathratus*, giving a complete representation of the right lobe of the hood and its rays, and also indicating the position of the spicules and caudal swelling in front. ($\times 23$ diam.)
- Fig. 5. One of the spicules of *Strongylus clathratus*. ($\times 40$ diam.)
- Fig. 6. Lower end of the body of a female *Sclerostoma sipunculiforme*. ($\times 13$ diam.)
- Fig. 7. Another view of the lower end of the body of a female *Sclerostoma sipunculiforme*, showing the altered shape of the tail when seen from the front. ($\times 13$ diam.)
- Fig. 8. Additional side view of the tail of the male *Sclerostoma sipunculiforme* (to contrast with fig. 2), showing the altered position and direction of the spicules when exerted. The vascular network omitted. ($\times 27$ diam.)
- Fig. 9. Head and neck of *Strongylus foliatus*, seen from the front, displaying the upper and lower pair of papillæ, mouth, buccal cup, and long œsophagus. ($\times 27$ diam.)
- Fig. 10. Profile view of the left side of the head of *Strongylus foliatus*, showing auriculate folds of the skin. ($\times 33$ diam.)
- Fig. 11. Similar representation of the right side of the head of *Strongylus foliatus*, with the focus altered to show the buccal teeth. ($\times 33$ diam.)
- Fig. 12. Left side of the lower end of the body of a male *Strongylus foliatus*, showing the retracted spicules, bursal lobes, and entire system of rays on one side. ($\times 60$ diam.)
- Fig. 13. Left side of the lower end of the body of a female *Strongylus foliatus*, showing the anal cleft and subulate extremity of the tail. ($\times 40$ diam.)
- Fig. 14. Head, neck, and upper part of the body of a female *Strongylus falcifer*, showing especially the outer and inner series of oral papillæ. ($\times 23$ diam.)

PLATE XXIV.

- Fig. 1. Lower end of the body of a male *Strongylus falcifer*, seen from the front, exposing the interior of the bursa, caudal papilla, lobes of the hood, points of the rays, and more particularly the spicules with their sheaths and retractor muscles attached to the upper end of the blind pouches. ($\times 23$ diam.)

- Fig. 2. Profile view of the lower end of the body of another *Strongylus falcifer*, exposing the bursal lobes of one side and the projecting spicules. ($\times 27$ diam.)
- Fig. 3. Lower end of the body of a female *Strongylus falcifer*, showing the mode of termination of the reproductive and digestive organs, and more especially the characteristic form of the tail. ($\times 23$ diam.)
- Fig. 4. Half-profile view of the head and neck of a female *Dochmius Sangeri*, showing the mouth, buccal cup, œsophagus, and upper end of the chylous intestine. ($\times 33$ diam.)
- Fig. 5. Lower end of the body of a male *Dochmius Sangeri*, seen from behind. It shows the expanded hood and entire system of rays, as well as the spicules in their retracted position. ($\times 33$ diam.)
- Fig. 6. Profile representation of the lower end of the body of a female *Dochmius Sangeri*, showing the anal cleft and finely pointed tail. ($\times 33$ diam.)
- Fig. 7. Upper part of the body of a female *Filaria Smithii*, exposing the head, a double row of auriculate folds, papillæ, œsophagus, and commencement of the chylous intestine. ($\times 30$ diam.)
- Fig. 8. Front view of the lower end of the body of a male *Filaria Smithii*, displaying the spicules, the anal opening, and the relation of the latter to the stalked papillæ. ($\times 30$ diam.)
- Fig. 9. Profile view of the tail of another male *Filaria Smithii*, in which the papillæ are not seen. ($\times 30$ diam.)
- Fig. 10. Another side view of the lower end of the body of a male *Filaria Smithii*. The tail is more curved, the spicules being completely retracted, the papillæ of the left side being also seen throughout their whole extent. (Flattened by pressure, and $\times 50$ diam.)
- Fig. 11. Front aspect of an *Amphistoma papillatum*, giving a general view of the internal organs as seen through the transparent integuments. It also shows the oral sucker, reproductive papilla, circular folds or rugæ of the body, and especially the disposition of the fungiform papillæ within the concavity of the caudal sucker. ($\times 18$ diam.)
- Fig. 12. This illustration represents a *Fasciola Jacksoni*, viewed from behind, and with the aid of transmitted light. It explains the position of the oral and ventral suckers, reproductive papilla, exserted cirrhus, two or three of the uterine coils, their contained ova, and also, more particularly, the mode of branching and distribution of the digestive tubes. ($\times 10$ diam.)

Fig. 4.

Fig. 1.

Fig. 2.

Fig. 7.

Fig. 6.

Fig. 5.

Fig. 3.

Fig. 9.

Fig. 10.

Fig. 12.

Fig. 11.

Fig. 13.

Fig. 8.

Fig. 14.

T.S. Cobbold adnat del.

C. Berjeau lith.

PARASITES OF ELEPHANTS.

Hanhart imp.

T. S. Cobbold adnat. del.

C. Berjeau lith.

PARASITES OF ELEPHANTS.

Hanhart imp.