Original Articles.

MEASUREMENT AS THE BASIS OF DIAGNOSIS OF THE FURCOCERCOUS CERCARIÆ.

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MEASUREMENTS in such contractile bodies as Cercariæ are necessarily open to inaccuracies, yet the study of those of the *Furcocercous cercariæ* recorded by different authorities has yielded such marked and unexpected results that they seem worthy of record, the more especially as they would seem to enable us to lay down the long desired definition of a Schistosome cercaria.

Up to the present no one has laid down definitely what is and what is not a Schistosome cercaria. It is generally accepted that they are *Furcocercous cercariæ* without a pharynx and containing well marked "mucin glands" grouped in pairs around the acetabulum, from which well defined ducts, capped with hollow piercing spines lead, to open at the margin of the opening of the "head gland," and with an excretory system built up of symmetrically placed "flame cells," capillaries, collecting tubules, excretory bladder and excretory ducts, but with the exception of the absence of a pharynx these characteristics are common to a number of organisms having no pretension to being schistosomes.

The records upon which this paper is founded are merely those which I have been able to collect from time to time and are by no means exhaustive. They refer to but 22 species of *Furcocercous cercariæ,* but they have the merit of having been taken in Egypt, India, the Cape and both North and South America, and are thus representative of the parasites found in widely separated parts of the world.

In spite of the different conditions and methods under which these measurements have been recorded, they all are capable of being brought into certain well defined classes, and the grouping thus arrived at appears to be supported by a similar grouping of the molluscan hosts in which the individual cercariæ develop.

An objection might be raised that the classification here attempted is arranged on a basis of larval, and therefore, decidual parts of the organisms classified instead of upon adult and permanent structures.

The force of this may be admitted, but, on the other hand, outside the larval structures, there is very little in the anatomy of the cercariæ by which they can be contrasted. The genital system is the merest of rudiments, the alimentary system is undeveloped and stops short at a more or less defined fore-gut which, even in the most advanced specimens, does not proceed much beyond the early division of the "cæca" and in no case extends beyond the level of the acetabulum, the nervous system is an undefined symmetrical mass and the excretory system is undergoing a process of rapid development and fundamental change.

The measurements used in the following tables are :—

1. The length of the body of the parasite.
2. The length of the stem, or undivided part of its tail.
3. The length of the flukes or rami of the tail.

TABLE 1.

Measurements of certain *Furcocerous cercariæ.*

		Body	Stem	Rami	Ref.
	e C. polonicæ ..	12	18	4	1
	e C. bombayensis No. 8 ..	13	24	6	2
P	e C. bombayensis No. 9 ..	22	32	30	2
	e C. bombayensis No. 13 ..	35	85	35	2
	e C. bombayensis No. 19 ..	38	43	29	2
P	e C. Bahr & Fairley No. 1 ..	12	19	15	1
P	C. douglasi ..	14	18	16	3
	e C. elephantis ..	16	59	11	3
P	C. emarginatæ ..	16	23	20	3
? P	o C. gracillima ..	13	6.5	6.5	4
P	C. gladii ..	11	19	15	5
	e C. gigas ..	28	32	18	6
	C. hæmatobii ..	24	20	8	7
	C. indicæ XXX ..	20	22	9	8
	C. japonici ..	10	10	0.5	1
	e Kemp "B" ..	19	20	6	9
	e Kemp "C" ..	20	30	12	9
	C. mansoni ..	14	27	8	10
? P	o C. minor ..	14	20	20	6
	C. spindalis ..	20	29	10	11
	C. spinosa ..	16	24	8	12
	C. tuberistoma ..	20	16	16	4

In the above Table P means Pharynx present.

? P means Rudimentary Pharynx present.
e „ Pigmented Eye-spots present.
o „ Unpigmented Eye-spots present.

The differences to be observed are the relative lengths of these parts of the organisms, and this would appear to lead to the division of the specimens into the following natural Groups :—

Group I. Cercariæ in which the rami of the tail are markedly shorter than the stem, the difference being as 1 to 2 or even greater, and in which the body whilst it is longer than the rami is shorter than the stem.

NOTE.

This latter is not strictly true of the measurements given for C. japonici, but since everything else demands the inclusion of this cercaria in this particular group, and since no more than an allowable margin of error, the substitution of 8 or 9 for 10 in the observation is necessary to bring it into complete conformity; I think this error may safely be assumed, the more especially as the observation on which the record used is based is not an original one and indeed contains another obvious error.

Group II. Cercariæ in which the rami and stem are nearly equal, the stem being slightly longer than the rami, and either of these longer than the body.

Group III. Cercariæ in which the rami and stem are of equal length and in which either of these is less than the length of the body.

On this basis the groups will be made up as follows :—

GROUP I.

Rami less than half the length of the stem and body of intermediate length between the two.

e	C. bombayensis No. 8 ..	13	24	6
e	C. bombayensis No. 13 ..	35	85	35
e	C. bombayensis No. 19 ..	38	43	29
e	C. elephantis ..	16	59	11
e	C. gigas ..	28	32	18
	C. hæmatobii ..	24	20	8
	C. indicæ XXX ..	20	22	9
	C. japonici ..	10	10	0.5
e	C. Kemp "B" ..	19	20	6
e	C. Kemp "C" ..	20	30	12
	C. mansoni ..	14	27	8
e	C. polonicæ ..	11	17	4
	C. spindalis ..	20	29	10
	C. spinosa ..	16	24	8

GROUP II.

Rami and stem nearly equal. Rami and stem both longer than the body.

P	C. emarginatæ ..	16	23	20
P	C. douglasi ..	14	18	16
P	C. gladii ..	11	19	15
P e	C. bombayensis No. 9 ..	22	32	30
P	Bahr & Fairley No. 1 ..	12	19	15

GROUP III.

Rami and stem equal and either less than the body.

? P o	C. gracillima ..	13	6.5	6.5
? P o	C. minor ..	14	20	20
	C. tuberistoma ..	20	16	16

NOTE.

I cannot help thinking that an error has been made in the description of C. minor. Faust says, (6), "the length of the oval body is 0.14 mm., the unforked tail measures 0.2 mm. which is the same length as the furcæ." If these figures are correct it would take the organism out of any of my groups and would give us an unique form with a body of 0.14 mm. and a tail of 0.40 mm. Were the figures body 0.14 and tail, stem and rami together, 0.20 mm. with the stem and rami of equal length, this would make the Cercaria conform exactly with the other two which I have placed in this class.

It will be seen at once that these groups contain forms differing from each other anatomically, inasmuch as eye-spotted and non-eye-spotted forms are mixed up together.

Sorting out these dissimilar forms we arrive at the following groups and sub-groups :—

GROUP I.

Rami less than half the stem and body intermediate.

SUB-GROUP A.

A-Pharyngeal and Non-eye-spotted.

C. hæmatobii	C. mansoni
C. indicæ XXX	C. spindalis
C. japonici	C. spinosa

SUB-GROUP B.

A-Pharyngeal but with well marked eye-spots.

C. polonicæ	C. Kemp "B"
C. bombayensis No. 8	C. Kemp "C"
C. bombayensis No. 13	C. elephantis
C. bombayensis No. 19	C. gigas

GROUP II.

Stem slightly longer than rami and either of these longer than the body.

SUB-GROUP A.

Well marked Pharynx but no eye-spots.

C. emarginatæ	C. Bahr & Fairley No. 1
C. gladii	C. douglasi

SUB-GROUP B.

With Pharynx and eye-spots.

C. bombayensis No. 9.

GROUP III.

Rami and stem of equal length and body longer than either.

SUB-GROUP A.

Neither Pharynx nor eye-spots.

C. tuberistoma.

SUB-GROUP B.

Rudimentary Pharynx and un-pigmented eye-spots.

C. gracillima C. minor.

NOTE.

C. tuberistoma is entered here as being A-Pharyngeal, but I believe this to be wrong and I expect it will turn out to be a pharyngeal form. The description given by Faust (4) is very incomplete and unfinished. The digestive system is dismissed with the words "is of the usual type for the furcocercariæ," the flame cells of the excretory system "have not been made out," and no mention is made of any "mucin glands." C. tuberistoma if without a pharynx would have to be classed with the true schistosomes but its measurements are against this. I think we are justified in presuming that the examination of this parasite was incomplete, and we need not take the want of any reference to a pharynx as evidence of its absence any more than we must regard the "mucin glands" as absent since they are not mentioned.

This grouping by measurements appears to be supported by the distribution of the intermediary hosts.

GROUP I.

SUB-GROUP A.

C. hæmatobii	develops in	Bullinus	Physopsis	Limnæ
C. indicæ xxx	,,	Planorbis	,,	,,
C. japonici	,,	Hypsobia	,,	,,
C. mansoni	,,	Planorbis	,,	
C. spindalis	,,	,,	,,	Limnæ
C. spinosa	,,	,,	,,	

The intermediary hosts of the sub-group present considerable diversity, but even here it will be noted that Limnæa is common to four out of the six forms, Planorbis to three, and Bullinus with its sub-genus Physopsis to four.

NOTE.

The true position of the host of C. indicæ XXX and C. spindalis is not accurately defined. They both develop in what has been known as Planorbis exustus, a form which Annandale (13) claims is not a Planorbis and which he has isolated as a new genus to be called Indoplanorbis and which, according to him, is, anatomically nearer to Bullinus than to Planorbis.

GROUP I.

SUB-GROUP B.

C. polonicæ	develops in	Planorbis and	Melania
C. bombayensis No. 8	"	"	Limnæa
D. bombayensis No. 13	"	"	"
C. bombayensis No. 19	"	,	
C. elephantis	"	"	Limnæa
C. gigas	"	"	Physa
C. Kemp "B"	"	Gyraulus	(Planorbinæ)
C. Kemp "C"	"	"	"

All the forms in this sub-group develop in Planorbis or its sub-genus Gyraulus, with the single exception of C. bombayensis No. 19, and seeing that this form has only been found on a single occasion, and that other members of the sub-group have most of them been found in a second or alternative host, it is by no means improbable that the true host of C. bombayensis may be Planorbis and that Limnæa is only its alternative host.

GROUP II.

SUB-GROUP A.

C. emarginatæ	develops in		Limnæa.
C. Bahr and Fairley No. 1	"	Bullinus	
C. douglasi	"	"	Limnæa.
C. gladii	"	"	

A uniformity which is complete if C. emarginatæ has so far been found only in its alternate host Limnæa, which is also the alternate host of C. douglasi.

GROUP II.

SUB-GROUP B.

C. bombayensis No. 9 develops in Planorbis.

GROUP III.

SUB-GROUP A.

C. tuberistoma develops in Physa gyrina.

GROUP III.

SUB-GROUP B.

C. gracillima develops in Physa gyrina.
C. minor " " " "

The host in the whole of this group is uniform both as to genus and species.

Of course, the whole question of the specific intermediary hosts is mixed up with the questions of adaptability and of the completeness of research.

There is no longer any doubt, but that the *Furcocercous cercariæ* do show a marked adaptability to new molluscan hosts, otherwise we should never find so many of them thriving in two different families such as Bullinus and Limnæa, Planorbis and Physopsis, Planorbis and Limnæa, Planorbis and Physa and even in different orders as Hypsobia and Limnæa, and Planorbis and Melania, and we are only too well aware that research is by no means complete and that further hosts are likely to be found.

It is interesting in this connection to note how frequently Limnæa crops up as the intermediary host of these *Furcocercous cercariæ*, irrespectively of the (?) primary host of the parasite. It does not appear to be the sole host of any one form (except C. bombayensis No. 19, but as this has only been found on a single occasion, the fact is not conclusive) but it is associated as alternate host with Bullinus, Physopsis, Planorbis, Gyraulus, Hypsobia and Melania. One wonders whether Limnæa might not have been the original host of the primitive form and all other hosts adaptations only.

In conclusion it is to be noted that Group I, Sub-group A, contains all the at present known Schistosomes parasitic in man together with C. spindalis, a Schistosome of bovines, and the uncertain forms C. indicae XXX and C. spinosa. Group I, Sub-group A. then contains only Schistosomes parasitic in mammals.

Group I, Sub-group B. contains only A-pharyngeal eye-spotted forms and probably represents the true Schistosomes parasitic in birds.

Groups II and III, consisting of forms with a more or less well developed pharynx are not Schistosomes and as the subsequent development of none of them has yet been made out we cannot say what they are.

Should further research uphold the classification here noted we shall have arrived at a definite definition of a Schistosome cercaria as being a *Furcocercous* distome cercaria characterised by the absence of a pharynx and having a tail, the rami of which are less than half the length of the stem, and with a body intermediate in length between the stem of the tail and its rami.

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THE ROLE OF VITAMINS IN TROPICAL DISEASES.

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ALTHOUGH the subject on which I am to address you this evening is one of recent growth, a proper understanding of its various aspects is of prime importance not only to the pathologist but to the general practitioner in this country. In fact, I hope to demonstrate clearly in the course of this lecture that vitaminic deficiency in its broad sense is a potent—if not the most potent —factor in the production of ill-health in tropical countries. Hindhede the Dane, quoted by McCarrison, is reported to have said that "the principal cause of death lies in food and drink." The bacteriologist would probably smile and say "yes" in the form of cholera, dysentery, enteric fever. Therefore boil your milk and your vegetables, never eat raw fruit, and so on; but, what of the vitamins which boiling destroys and abstinence from fresh fruit deprives—these subtle substances which have been proved to regulate metabolism and increase our resistance against infection, as well as supply some essential chemical factor to our body cells. To most of us it is not a question of "death in the cup" but "absence of life from the cup." Indeed, the subject of vitaminic deficiency is one which no medical man can afford to ignore.

Before tackling the main theme of my lecture, *viz.*, "The Rôle of Vitamins in Tropical Diseases," it is necessary for me to review briefly the history of this interesting chapter of medicine and to explain concisely the physiological problems involved.

Hopkins (1) was the first investigator to adduce convincing experimental proof to show that, in addition to the long recognised proximate principles of diet, *viz.*, proteins, fats, carbohydrates, water and salts, certain other substances, which he termed "accessory food factors," were necessary to maintain health. Hopkins' first paper was published in 1906. Since then the work has been carried on by a host of investigators, including Funk, Chick, Hume, Harden, Zilva, McCarrison, and Mellanby in England, and Osborne, Mendel, McCollum, Davis, Holst, Frohlick, Hess and others in America. It was Funk who introduced the term vitamin on the assumption that these substances were chemically "amines." As considerable doubt has been thrown on this assumption, Drummond has proposed dropping the final 'e' and calling the substances vitamins. This is the nomenclature usually adopted now, though many other terms have been suggested. Meanwhile it has been conclusively established by various observers that there are at least three of these substances known as vitamins A, B, and C;—sometimes called "fat soluble A," "water soluble B," and "water soluble C."

It is convenient to consider each of these vitamins in turn; but a few general remarks may first be made. Vitamins have not been isolated and we do not know if they are chemical entities. It is possible (the suggestion is mine) that they are of the nature of catalysts, which, as you know, are substances which increase the velocity of chemical reactions. This would explain the differences in sensitiveness to the action of heat as inorganic catalysts are relatively resistant to heat (*Cf.* Vitamin B), and organic catalysts, being colloids, are readily destroyed by heat (*Cf.* Vitamin C.). Funk isolated an amine which he concluded was Vitamin B, but his work has not been confirmed.

Vitamins come eventually from the Vegetable Kingdom. They are synthetised by plants; but animal cells do not appear to possess this power, although they can be stored up in certain tissues and thus transferred to other animals who eat the flesh, fat, milk or eggs of such animals. Our source of vitamins is therefore two-fold:—

(1) Directly from the Vegetable Kingdom.
(2) Indirectly from the Animal Kingdom.

In the Vegetable Kingdom, vitamins are found in abundance in young leaves and shoots, in grasses, grains, pulses, vegetables, fruits, tubers and roots (McCarrison). It is important to note that while fresh fruits, vegetables, etc., contain sufficient vitamins for all our needs, the amount may be diminished by the methods used in preparing such articles of diet for consumption. The vitamin value of food may be reduced by "boiling, cooking and pasteurization; by storage oxidation and decomposition; by subjection to heat or to the action of alkalies; by drying, canning, or other methods of preservation; and by various manufacturing and refining processes" (McCarrison). This applies to vitamins of both animal and vegetable origin. Different classes of vitamins vary in their susceptibility to the abovementioned influences, and certain vegetables are more susceptible than others.

In the Animal Kingdom, the distribution of vitamins is not uniform, certain tissues are rich in one class of vitamin, other tissues, in another, and "one class is abundant in cellular organs, a second in fatty tissue, a third in muscles and liver" (McCarrison). The same remarks apply as regards loss of vitamins in the course of preparation for the table as do to vegetable foods,