

HUMAN INTESTINAL PROTOZOA IN NORTH QUEENSLAND

BY

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This investigation was undertaken with the object of ascertaining if carriers of *Entamoeba histolytica* exist among the healthy population of North Queensland, as in other parts of the world. This has been shown in England by Yorke and others (1917), and by Matthews and Smith (1919), and in Egypt by Wenyon and O'Connor (1917).

In the present series the number of people examined is five hundred, and the specimens were obtained from among a number of about one thousand five hundred, which were collected by members of the "Hookworm Campaign" staff, during their investigation of that disease. With the exception of seventy-one stools from the Townsville Orphanage, they were chosen quite at random. They include all ages of the community, from 1 year to 80 years of age, and embrace a wide area of country to the North and West of Townsville, within a radius of seventy miles of the town. All the houses are small, and built of wood or galvanized iron, and are not crowded together, in many cases miles separating them. The conservancy system is pans, and the privies are not fly-proof.

From their manner of collection, the specimens were at least three, and perhaps as much as fourteen, days old before being examined, therefore no vegetative forms of the various organisms were seen, but only their cysts. And for the same reason only one examination of each case was possible. This point should be borne in mind throughout the perusal of the paper, because it has been

shown by Carter and others (1917) that only about one quarter of the total *Entamoeba histolytica* infections are revealed at the first examination, and similarly one-third of the *Entamoeba coli*, and one-half of the *Lambia intestinalis* infections only are found.

The following protozoal cysts were seen, viz.:—*Entamoeba histolytica* (Schaudinn), *Entamoeba coli* (Loesch), *Lambia (Giardia) intestinalis* (Lamb), *Tetramitus (Chilomastix) mesnili* (Wenyon). Other cysts of a vegetable nature were encountered, which are mentioned at the end of the paper.

General results. The total figures are given in Table I, and call for no special comment.

TABLE I.

Type of infection	No. of stools examined	No. infected	Percentage
<i>E. histolytica</i>	500	23	4.6
<i>E. coli</i>	500	134	26.4
<i>L. intestinalis</i>	500	59	11.8
<i>T. mesnili</i>	500	11	2.2
'? cyst'	500	9	1.8

Mixed infections occurred as follows:—

E. histolytica, *E. coli*, and *L. intestinalis*, five times.

E. histolytica and *E. coli*, five times.

E. coli and *L. intestinalis*, sixteen times.

E. coli and 'cyst,' three times.

E. coli and *T. mesnili*, once.

For purposes of comparison, Table II has been compiled from a paper by Carter and others (1917), with the addition of the figures given in a series of examinations by Matthews and Smith (1919), and those of the present paper.

TABLE II.

	Present series	Matthews and Smith (1919)	Carter and others (1917)	Wenyon (1915)	Dobell (1916)	Jeggs (1916)	Matthews and Smith (1917)
No. examined {							
Dys. ...	1	2	3	4	5	6	7
Non-dys. ...	...	...	910	556	90	153	...
Total examined ...	500	450	...	...	110	204	250
<i>E. histolytica</i> ...	...	450	910	556	200	426	250
<i>E. coli</i>	4.6	1.5	10.3	10.8	11.0	7.7	8.0
<i>L. intestinalis</i> ...	26.8	6.7	25.4	39.0	40.9	35.8	19.0
<i>T. intestinalis</i> ...	11.8	6.0	18.6	16.0	19.5	19.0	...
<i>T. mesnili</i> ...	...	...	1.2	1.6	2.4	...	...
'? cyst' ...	2.2	1.5	2.7	0.5	7.8	...	...

All the figures in the above table are in percentages. It must be borne in mind that columns 1 and 2 give the results of a single examination, and the remaining columns are the aggregate of repeated examinations of each case.

The objection may be raised that some of the figures refer to dysenteric, and others to non-dysenteric cases. But Wenyon and O'Connor (1917) have shown that there is very little difference between the two classes of case, as far as percentage of carriers is concerned. This fact is well sustained in the table given above.

It is obvious, allowing for the single examination, that the figures in the present series are high, especially in regard to *E. histolytica*, *E. coli*, and *L. intestinalis*. But when compared with those of a series of examinations by Matthews and Smith (1919), in which they made one examination only, of a number of

of the figures for England.

This is shown in Table III, in which all the figures are in percentages, and are the result of a single examination of healthy people in every case.

TABLE III.

	No. examined	<i>E. biolytica</i>	<i>E. coli</i>	<i>L. intestinalis</i>	<i>T. mesnili</i>
Present series	...	...	...	...	...
Batch 1	500	4.6	26.8	11.8	2.2
Batch 2	263	5.0	12.1	4.5	...
Batch 3	241	6.6	23.2	7.5	1 case
Batch 4	230	5.9	14.8	6.1	...
Batch 5	98	6.1	21.4	8.2	...
Batch 6	84	8.2	22.4	11.8	1 case
Batch 7	124	5.8	17.1	6.7	...
	78	12.8	23.1	10.2	...

Age incidence. The effect of age on the incidence of infection is shown in Table IV. It is in agreement with the findings of Matthews and Smith (1919), and supports the tentative view expressed by them in this connexion, that the proportion of young people infected is higher than that of adults. The present investigation covers a much wider range of ages than that of the above observers, as it embraces people from 1 year to 80 years. Nevertheless, it is open to the objection, that the numbers in the various age-groups are somewhat small, and, consequently, do not give quite accurate results, which would be obtained if a higher number were examined. This is especially noticeable in the Orphanage group 1 to 5 years, with only nine cases, and three infections by *E. coli*, thus giving a percentage of 33.3 per cent., which is obviously much too high. The fact of the relatively high incidence of *L. intestinalis* among children is well shown. This is also pointed out by the above workers.

In this, and all subsequent tables, *T. mesnili* and '*?cyst*' are not shown, because the actual number of these infections is too small for such comparison.

TABLE IV.
(PEOPLE IN PRIVATE HOUSES)

Age group in years	No. examined	Percentage infected		
		<i>E. biolytica</i>	<i>E. coli</i>	<i>L. intestinalis</i>
1-5	48	4.2	4.2	22.9
6-10	55	5.5	12.7	23.6
11-15	41	9.75	41.5	22.0
16-20	39	5.1	23.1	10.2
21-30	72	6.9	29.2	4.2
31-40	57	1.75	26.3	8.8
41-80	117	1.7	23.9	5.1

(ORPHANAGE CHILDREN)

1-5	9	0.0	33.3	11.1
6-10	42	4.8	30.0	14.3
11-15	200	10.0	55.0	20.0

In the above table it will be noted that the Orphanage has been given separately. This is because 33 per cent. of all the children examined live in it, and as they are living with only one or two adults, it is not quite the same as the children living in private houses with a relatively large number of adults.

Sex incidence. The equality with which the three types of organism under consideration is distributed between the sexes is remarkable, and is shown in Table V.

TABLE V.

Sex	No.	<i>E. biolytica</i>	<i>E. coli</i>	<i>L. intestinalis</i>
Male	274	4.9	25.1	12.8
Female	218	4.5	33.4	11.9
Sex ?	8	...	...	...

Matthews and Smith (1919), in a small series of seven houses, showed that when one person in a given house is infected, the other members of the same household show a relatively high percentage of infection. The same has been worked out for the present series, and is shown in Table VI.

On account of the large number of houses from which cases have been examined, the details of infection are not given for each house separately. They are shown as average percentages of the infected population. This figure was obtained by working out the percentage of people infected in each house in which infection occurred, and then striking the average of these percentages.

The Orphanage is again given separately, because with its population of seventy-one it would have an undue influence on the totals of the private houses, whose average population per house is only three to four.

TABLE VI.
PRIVATE HOUSES

Type of infection	Total No. of houses examined	No. of houses infected	Percentage of infected houses	Total population of infected houses	No. of population infected	Average percentage infected per house
<i>E. histolytica</i>	138	13	8.2	64	19	39.5
<i>E. coli</i>	138	66	47.8	223	99	54.2
<i>L. intestinalis</i>	138	25	15.8	95	48	54.3

ORPHANAGE

<i>E. histolytica</i>	1	1	100	71	4	5.6
<i>E. coli</i>	1	1	100	71	35	49.3
<i>L. intestinalis</i>	1	1	100	71	11	15.5

It appears in the above table that, including the Orphanage, there are one hundred and five houses with infections of one kind or another in them. But the actual number of houses containing infections is only seventy-five, because some houses have two or all types of infection in them. Similarly among the people two hundred

and sixteen infections are distributed between one hundred and eighty-five individuals.

Further, it is noticed that the figures in the last column are higher than the percentages which would result from comparing the total population of infected houses and the number of population infected. This is because some houses with only one inhabitant who is infected, tend to raise the average.

There is no apparent reason why the Orphanage figures do not more closely agree with the averages for the private houses. Nevertheless, they are distinctly higher than the total infections found, as will be seen by comparing them in Table VI with those of Table I.

The fact of the equal liability of the sexes to infection and that of the high incidence of infection in houses which contain infected people, when taken together seem to be of some value, as an indication of the probable mode of spread of infection.

All the adult males are employed in outdoor work, and the females are occupied in house work. Therefore, the infection most likely occurs in the neighbourhood of houses, as outdoor work has no apparent influence on the infection rate, and vice-versa.

Wenyon and O'Connor (1917) in a series of experiments proved that house-flies can act as the carriers of cysts of *E. histolytica*, and when it is remembered that in the houses under consideration all the privies are of the dry-earth type, and by no means fly-proof, the idea of flies being active agents in the spread of infection, at all events in this district, is worthy of consideration.

Origin of the infection. As a result of inquiries among the twenty-three carriers of *E. histolytica*, it is found that, with one exception, they have all lived in their present houses many years, and in most cases all their lives. The one exception was at the war for three years, but never had dysentery or diarrhoea. All except one, who was born in Ireland, and has been in Australia twenty-seven years, were born in this country, and have not been out of it, except the soldier.

Two of them have had attacks of dysentery, both some years ago, one in the present abode, and one in Western Australia. The true nature of these attacks is not obtainable.

No work has been done on returned Australian soldiers to find

if there are carriers of *E. histolytica* among them. Nevertheless, it is practically certain they exist, because carriers in the British army have been found by Wenyon (1916), Jepps (1916), Matthews and Smith (1917), Turner and Taylor (1919), and many others. And the same has been found in the American army by Kofoed and others (1919). Australian soldiers were living under identical conditions as the soldiers of the above two armies, and, further, many of them had dysentery. It is, therefore, reasonable to assume that there are carriers among them. But H. Johnston (1909) has collected records of six or seven cases of amoebic dysentery or liver abscess occurring in Australia prior to that date. Therefore, *E. histolytica* has probably existed in Australia for many years, and, as in many other countries, only occasionally causes disease. Consequently, the almost certain introduction of a large number of carriers among the returned soldiers need not necessarily be followed by an increase in incidence of the disease.

Special considerations. *E. histolytica* has shown nothing worthy of special notice. *E. coli*: Small cysts of this organism have been relatively common. By small cysts is meant those from 11 μ to 14 μ . This in a total of one hundred and thirty-four infections, a high proportion, as shown by Smith (1919). *L. intestinalis* has been found about an equal number of times in each of the two types described by Matthews (1918), viz., the usually described, brown-staining variety in iodine, and the smaller bluish type described by the above observer. They either occurred alone or both in the same stool. *T. mesnili* in some stained preparations showed the chromatin of the nucleus evenly distributed around the nuclear membrane, and hence did not present the 'signet-ring' type of nucleus described by Matthews (1918) as typical. *Entamoeba nana* (Wenyon) was not found at all. This is somewhat strange, as it seems to occur in most other parts of the world, in company with the protozoa found at this examination. But the number of cases examined is too small on which to make a definite pronouncement as to its presence or absence in Australia, and it will very likely appear at subsequent examinations. *I. cysts* (Wenyon) were encountered five times. In one case these cysts, with the iodine vacuole distinct, were seen at the serial examination. But when the same case was examined after treatment for *Agchlystoma duodenale*,

large numbers of the same cysts were seen, but on this occasion none showed the iodine vacuole.

Blastocystis hominis was fairly common, more especially when reasonably fresh stools were examined. The actual number of times it occurred was not recorded. A single rather interesting observation in connection with this cyst has been noted. A case that showed large numbers of *I. cysts* in a formed stool at the serial examination was again examined after treatment for *A. duodenale*, when the stool was liquid. On the second examination no *I. cysts* were found, but the stool was full of *B. hominis*, none of which were found at the first examination. Wenyon (1917) mentions the development of *B. hominis* and diarrhoea concurrently in a case he was controlling for *E. coli*, and suggests a possible connection between the two, but draws no definite conclusion. The above case, observed at Townsville, raises the question whether *B. hominis* may not appear because of the diarrhoea artificially induced. And the same thing may have occurred in Wenyon's case, although there the diarrhoea was not brought on by the use of drugs. But O'Connor (1919), in a later paper, seems to trace some connexion between *B. hominis*, *I. cysts*, and some other vegetable cysts, and a special form of diarrhoea of which he has observed fifteen cases.

'? cysts.' In fresh preparations, both in saline and iodine solution, this cyst was to all appearance very like *E. nana*. It is a small cyst varying in shape from a distinct oval to one almost circular. It is 5 μ to 12 μ in its long diameter, and contains a few refractile granules, which might easily be mistaken for indistinct nuclei, such as are seen in *E. nana*. But in preparations stained with iron-haematoxylin the granules are seen as small, darkly staining dots, which are quite homogeneous and show no nuclear structure. They vary from one to seven in number. After prolonged search of stained preparations a few budding forms were found, thus definitely proving its vegetable origin. Attention has only been drawn to it because of its likeness to *E. nana*.

Eggs of the following intestinal worms were found during the course of the examination, viz.:—*Agchlystoma duodenale*, *Oxyuris vermicularis*, *Trichuris trichiura*, and those of a *Hymenolepis* sp. (probably *H. nana*). The larvae of *Strongyloides stercoralis* were fairly often encountered.

The number of times these infections occurred is not given because many are missed when the stools are not centrifuged, and, further, they will be published in full, and for a much greater number of cases, in the reports of the 'Hookworm Campaign.'

SUMMARY

The protozoa of the human intestine are substantially the same in Australia as in other parts of the world where similar examinations have been carried out, and they occur in approximately the same proportion of cases, among healthy people.

Confirmation is given to the view that the incidence is higher in children and young adults than in people of more mature age.

Evidence has been put forward to show that flies are very probably carriers of the infection.

In conclusion, I wish to express my thanks to Dr. Breinl for his readiness always to discuss doubtful cases, and also for his assistance and suggestions in connection with the literature, and to Dr. Willis, of the 'Hookworm Campaign,' and the members of his staff, for free access to their material, and for obtaining for me any information I required from any of the cases examined.

REFERENCES

- CARTER, HENRY F., MACKINNON, DOBIS L., MATTHEWS, J. R., and SMITH, A. MALINS (1917). Protozoological Investigations of Cases of Dysentery conducted at the Liverpool School of Tropical Medicine. (First Report). *Ann. Trop. Med. & Parasit.*, Vol. X, p. 411. (Second Report), Part V, with J. W. W. Stephens, *ibid.*, Vol. XI, p. 27.
- DOBELL, CLIFFORD (1916). Incidence and Treatment of *Entamoeba histolytica* Infections at Walton Hospital. *Brit. Med. Journ.*, p. 612.
- DOBELL, CLIFFORD, and JEFFS, MARGARET W. (1918). A Study of the Diverse Races of *Entamoeba histolytica* distinguishable from one another by the dimensions of their Cysts. *Parasitology*, Vol. XI, p. 320.
- JEFFS, MARGARET W. (1916). A note on some Examinations and Treatments for *Entamoeba histolytica* infections. *Brit. Med. Journ.*, p. 616.
- JOHNSTON, T. HARVEY (1909). Notes on Australian Entozoa. *Rec. Aust. Museum*, Vol. VII, No. 4, p. 330.
- KOFOLD, CHARLES A., KOHNHAUSE, SIDNEY L., and SWEZY, OLIVE (1919). *Arch. Intern. Med.* Vol. XXIV, p. 35.
- MATTHEWS, J. R. (1918). Observations on the Cysts of the Common Intestinal Protozoa of Man. *Ann. Trop. Med. & Parasit.*, Vol. XII, p. 17.
- MATTHEWS, J. R., and SMITH, A. MALINS (1919). The Spread and Incidence of Intestinal Protozoal Infections in the Population of Great Britain. *Ann. Trop. Med. & Parasit.*, Vol. XII, pp. 349 and 361.
- O'CONNOR, F. W. (1919). Intestinal Protozoa found during Acute Intestinal Conditions. *Parasitology*, Vol. XI, p. 239.
- SMITH, A. MALINS (1919). Measurements and Observations upon the Cysts of *Entamoeba histolytica* and of *Entamoeba coli*. *Ann. Trop. Med. & Parasit.*, Vol. XII, p. 27.
- TUNNEY, O. POHILL, and TAYLOR, NOEL (1919). Preliminary report concerning the Examination of 3,277 patients for *Entamoeba histolytica*, etc. *Journ. R.A.M.C.*, Vol. XXXIII, p. 245.
- WZAROW, C. M. (1916). The Protozoological findings in 556 Cases of Intestinal Disorder from the Eastern Mediterranean War Area. *Journ. R.A.M.C.*, Vol. XXVI, p. 445.
- WZAROW, C. M., and O'CONNOR, F. W. (1917). An Inquiry into some Problems Affecting the Spread and Incidence of Intestinal Protozoa, etc. *Journ. R.A.M.C.*, Vol. XXVII, pp. 4, 151, 346, 461, 557, 686.
- (1917). The Carriage of Cysts of *Entamoeba histolytica*, etc., *ibid.*, p. 522.
- YORKE, WASHINGTON, CARTER, HENRY F., MACKINNON, DOBIS L., MATTHEWS, J. R., and SMITH, A. MALINS (1917). Persons who have never been out of Great Britain and who have *Entamoeba histolytica*. *Ann. Trop. Med. & Parasit.*, Vol. XI, p. 97.

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