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To the Committee on Graduate Study:

33

I submit herewith a thesis by Mrs. Mary Lance Vance, "Survey of Intestinal Parasites at the Knox County Industrial School". I recommend that this thesis be accepted for twelve quarter hours credit in fulfillment of the requirements for the degree of Master of Science in Education.

Ernest L. Banning
Major Professor

At the request of the Committee on Graduate Study, I have read this thesis and recommend its acceptance.

Edwin B. Powers

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Accepted by the Committee

R. M. Hames
Chairman

**SURVEY
OF INTESTINAL PARASITES
AT THE
KNOX COUNTY INDUSTRIAL
SCHOOL**

A THESIS

**Submitted to the Graduate Committee
of
The University of Tennessee
in
Partial Fulfillment of the Requirements
for the Degree of
Master of Science in Education**



**by
MARY LANCE VANCE**

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STATEMENT OF PROBLEM

Throughout American development the South has shown a high per cent of parasitization because of climatic conditions and slow progress in improving sanitary conditions. Human infections, always of interest, have attracted the attention of numerous workers whose aim was to determine the extent of the infections. Since 1902, surveys that covered practically the entire state have been made in Tennessee. Although these surveys have been extensive, they, on the whole, have involved a rural population. This survey of the Knox County Industrial School is more intensified for a given locality and deals with a more specific group, for here we have a survey of children representative of the urban as well as of the rural population.

The children in the Knox County Industrial School are normal children between six and eighteen years of age and come from an industrial class. Physically, they are an average group not demanding medical attention, and, since they have come from all sections of the county and are now living under good conditions, they represent a typical cross-section of the poorer industrial classes. Fully two-thirds have come from homes located in the city of Knoxville. These homes, as a rule, are small cottages supplied with city water and sewage system that are typical of industrial workmen.

The Knox County Industrial School is located on a hill in west Knoxville. In all, it accommodates about two

hundred and sixty children, and has about the same number of each sex. The boys and girls are housed separately, the girls living in Elizabeth Gibson, Eliza Brownlow, Phoebe Park and King's Cottages and the boys in James Maynard Hall and King's Cottage.

With the exception of James Maynard Hall, the dormitories are made to house about thirty children, but in recent years they have accommodated more than that number. James Maynard Hall houses eighty-six boys and serves as an administration building and an emergency hospital. To eliminate the danger of fire, the dormitories are of brick construction, well spaced, and heated from a central heating plant.

Acknowledgements

The author wishes to express her appreciation to Dr. Graeme A. Canning, University of Tennessee, under whose direction this survey was made and to whom she is indebted for assistance and advice, and to Professor G. M. Bentley for his directions in photography. She is grateful to Dr. W. H. Ennis, Dept. of Public Health, and to Miss Leah Fletcher, Miss Hall and other members of the staff of the Knox County Industrial School whose splendid cooperation and interest made the work possible; she is also indebted to the Department of Zoology for materials used.

REVIEW OF LITERATURE

From 1910 to 1914 the Rockefeller Sanitary Commission conducted surveys in Tennessee as well as in other states and determined the per cent of helminth infections. *Necator* was the most outstanding parasite and infected 21.3 per cent of the population; *Ascaris* infected 21.3 per cent; *Trichacephalus* 4.7 per cent; and *Hymenolepis nana* 2.4 per cent. A similar survey was made from 1929 to 1930 by Keller. Comparison of his findings with those of the 1910-1914 survey shows that during the intervening years greater emphasis has been placed on reducing hookworm infections; consequently, the incidence has fallen from 25.4 per cent to 7.4 per cent. The per cent of infection of roundworm (*Ascaris lumbricoides*), whipworm (*Trichacephalus trichiura*), and tapeworm (*Hymenolepis nana*) have remained the same or have increased. *Ascaris* infected 21.3 per cent in 1910 but increased to 26.3 per cent in 1930. *Trichacephalus* increased from 4.7 per cent to 7.8 per cent. *H. nana*, however, has not shown any appreciable change, the per cent of infection in 1910 being 2.4 and in 1930, 2.7 per cent. This indicates that little or no progress has been made in sanitary measures controlling *Ascaris*, *Trichacephalus*, or *H. nana* infections although *Necator* infections have been reduced.

Ransom (1904) made a complete study of the tapeworms belonging to the genus *Hymenolepis*. He reports one hundred and

six cases of Hymenolepis nana and twelve cases of Hymenolepis diminuta. In discussing the relative importance of H. nana he says:

"This makes altogether for the United States something over twenty-five cases, all but one having been recorded since August 1902, and sixteen of which have been found by members of this laboratory in a systematic examination of intestinal parasites of about three thousand five hundred persons. It is significant that in all these examinations only two cases of the beef-measle tapeworm, Taenia saginata, and none of the pork-measle tapeworm, Taenia solium, were found. These facts continue not only to bear out the original assumption of Dr. Stiles that the dwarf tapeworm is going to prove a common American parasite, but seems to indicate, furthermore, the likelihood that it will turn out to be the most common of the tapeworms parasitic in man in this country."

This prophesy has been substantiated by later investigations, for we find in Keller's (1931) report only three cases of Taenia infection, a 3.8 per cent infection of H. nana, and eight cases of H. diminuta.

While the surveys of helminthic infections in Tennessee are rather complete, those of a protozoal nature are not as comprehensive. The most comprehensive one is that by Meleny (1930-1931). In this survey he found a 55.3 per cent infection with one or more protozoa; and of this, 17.3 per cent (34.6 per cent on the basis of six examinations) harbored Endamoeba histolytica. These families, at the time, were a rural population living in their own homes. Other surveys show that E. histolytica infections run from 7.0 per cent (Dobell, England) to 45.4 per cent (Foust, Wise County, Virginia). Williamson, Kaplan and Greigor (1929) examined one thousand one hundred and forty-eight food handlers in

Chicago and found 2.35 per cent to be carriers of E. histolytica. With other protozoa Meleny found that Endamoeba coli occurred in 31.7 per cent of the people examined, Endolimax nana in 9.8 per cent, Iodamoeba butschlii in 5.8 per cent, Chilomastix mesnili in 3.8 per cent and Giardia lamblia in 18.9 per cent. During the examination of food handlers in Chicago, other types of protozoa were also detected, and the following per cents were found: E. coli 19.16, E. nana 20.0, I. butschlii 5.31, Trichamonis intestinalis 1.82, C. mesnili 1.91, and G. intestinalis 6.53.

TECHNIQUE

Specimen were collected at the Knox County Industrial School in half pint paraffined containers, and were carried to the University of Tennessee for examination. In most cases, these examinations were made twenty-four hours after collection, but at times the intermediate period was two or three days. This lapse of time made it more difficult to differentiate between *Necator* and *Strongyloides*, but it had no effect on the detection of protozoan cysts as they are known to be viable over a period of several weeks.

The smear method of examination was used. Although this does not concentrate ova or cysts, and live worms are not readily found, it is an accepted means of diagnosis, and is a simple direct method. The smears were prepared on glass slides from a small piece of fecal material which was mixed with distilled water and applied with a wooden applicator. The smears were never heavier than "reading opacity". Generally, two smears were used, one preparation for the detection of larvae and ova, and a lighter preparation for the detection of cysts. This dual procedure increased the accuracy of the examination, because any ova or larvae can usually be detected in one of the two smears made from different parts of the stool. The entire surface of the cover-slip was examined under

a 16 mm. lens, the whole surface being transversed by means of a mechanical stage. All eggs, larvae, and cysts were further examined and checked. The mount was then stained with an iodine preparation (five per cent aqueous solution of potassium iodide treated with iodine crystals until a rich wine color was obtained) and examined under both the 16 mm. and 4 mm. lens for cysts. Except for special observation, a 10 X ocular was used.

Where there was any doubt, a number of examinations and preparations were made and observed by other members of the department. Subsequently, all cases of Necator and Strongyloides infections were rechecked from fresh stools, and hookworm infections were distinguishable from those of Strongyloides.

GIRLS' DORMITORIES

Among the girls, 31.4 per cent were free of any protozoa or helminth; thus, 68.6 per cent were parasitized. Of this 68.6 per cent, there were 15.2 per cent which harbored such protozoa as Iodamoeba butschlii, Endolimax nana, Endamoeba coli, Chilomastix mesnili, or Giardia lamblia, but which did not harbor Endamoeba histolytica or worm infections. As these forms are not considered detrimental to the physical welfare of the individual, we may add to the percentage of non-infected individuals those which harbor no pathogenic form. This brings the percentage of individuals harboring no harmful organism to 46.6 per cent and those harboring injurious organisms to 53.4 per cent. Of the dormitories, Elizabeth Gibson had the highest infection, namely, 74.1 per cent, Eliza Brownlow had the lowest rate of infection, showing 40.0 per cent non-infected and 60.0 per cent with no pathogenic form. Considering all non-pathogenic protozoa, 48.0 per cent of the girls harbored one or more species. Elizabeth Gibson had the greatest per cent of non-pathogenic protozoa, 62.0 per cent and Phoebe Park had only 33.3 per cent.

A consideration of the individual parasites shows *Ascaris* present in the largest number of individuals; 31.3 per cent of the girls were infected with this round-worm. Here again, Elizabeth Gibson had the highest percentage of infection (40.0), and East Cottage the lowest (8.25).

Second in frequency of infection among the pathogenic parasites is Endamoeba histolytica. Among the girls in all dormitories, 17.1 per cent were infected. The infection varies in the different dormitories from 37.0 per cent in Elizabeth Gibson to 5.0 per cent in Eliza Brownlow.

As one would expect, the tapeworm infection in an institution is higher than that indicated in a state wide survey. Hymenolepis nana was found in 8.5 per cent of the girls and Dipylidium caninum in 3.1 per cent. East Cottage, where the younger girls live, showed a 21.9 per cent infection which is distinctly higher than in any other dormitory.

Necator americanus and Strongyloides stercoralis, here considered together, occurred in but 8.6 per cent of the girls. The highest infection was 14.3 per cent in Phoebe Park, and the lowest was 5.0 per cent in Eliza Brownlow. Necator infection constitutes 2.3 per cent of the above cases and Strongyloides 4.9 per cent.

Trichacephalus trichiura infected 7.6 per cent. The highest incidence was in East Cottage where 18.5 per cent were infected, and the lowest was in Elizabeth Gibson where no case was discovered. Enterobius vermicularis, due to the nature of the worm, are not found in feces, but was observed in two cases. Consequently, the percentage here given furnishes no idea of the actual percentage of infection existing.

BOYS' DORMITORIES

Considering the boys as a whole, 31.9 per cent were free of any parasite, and 49.2 per cent have no form considered pathogenic. In King's Cottage 61.1 per cent had no pathogenic form and 38.9 per cent had no parasites; in James Maynard Hall 43.2 per cent had no pathogenic form and 29.1 per cent had no parasites.

Infection with non-pathogenic protozoa, Endamoeba coli, Iodamoeba butschlii, Endolimax nana, Chilomastix mesnili, and Giardia lamblia, was present in 40.1 per cent of the boys. Both dormitories showed about the same per cent of infection, namely, 38.9 and 40.7.

Tapeworm infections in the boys' dormitories is very high, especially in King's Cottage where the smaller boys live. Hymenolepis nana infection is found in 22.2 per cent of the boys in King's Cottage and in 6.9 per cent of the boys in James Maynard Hall. Thus, with this one tapeworm 14.5 per cent of the boys are infected. Dipylidium caninum infections were also found. However, D. caninum is a rare parasite of man, it being necessary to eat the flea which serves as the intermediate host. For this reason a recheck was made on the first findings. Although the second examination did not reveal the eggs, there is, without doubt, some infection present, for the ova were photographed (Fig. 11).

Ascaris infection among the boys was but 17.1 per

cent, 8.3 per cent in King's Cottage and 20.9 per cent in James Maynard Hall.

Endamoeba histolytica infection occurred in 13.9 per cent of the boys, the rate being higher in King's Cottage (16.1) than in James Maynard Hall (12.7 per cent).

Necator appears in 6.5 per cent of the boys. In James Maynard Hall 6.2 per cent are parasitized by this Nematode, and 2.7 per cent in King's Cottage.

Trichacephalus trichiura infection are low being found in but 2.4 per cent of the children. The two boys' dormitories show about equal percentages of infection.

SUMMARY OF THE SCHOOL

A study of the whole school accommodating two hundred twenty-seven children, one hundred and five girls and one hundred twenty-two boys, shows that 31.6 per cent of the children harbor no parasite, 47.7 per cent are parasitized by E. coli, I. butschlii, E. nana, C. mesnili or G. lamblia, which are considered as symbiots. Therefore, a total of 52.3 per cent harbor pathogenic organisms. Ascaris infection occurs in the largest number, 24.2 per cent, then E. histolytica, 15.5 per cent, H. nana, 11.0 per cent, Necator, 7.5 per cent, Whipworm 5.0 per cent.

DISCUSSION

The interesting revaluation of this study is that 52.0 per cent of these children considered to be in good physical condition and not demanding medical attention harbor parasites. In most cases the parasites cause no definite symptoms, but undoubtedly there is a constant drain on the entire system of the child. Many of the cases considered to be problems of discipline are merely cases of children suffering from heavy infections. Especially is this true of those infected with tapeworm or *Ascaris*. In making a study of the blood of these children it was found that only those who were infected with tapeworm refused to have their fingers pricked. Some of the children most heavily infected broke out in tears and required two people to hold them for such a minor thing as the pricking of the finger. These same children are known to laugh and cry spasmodically.

Other children who were infected with *Endamoeba histolytica* were found to have poor circulation; their hands were constantly cold. Although *E. histolytica* infections here were not known to be associated with diarrhoea, in one case, particularly, the child showed the effect of the parasitization. This child was decidedly thin and pale. In most cases, however, the children do not look sick for they are well fed. From the herd of cows at the school seventy gallons of milk are

received daily and all of this is consumed by the children. However, an individual study of the children infected reveals indefinite symptoms as stunted growth, poor color and nervousness.

Considering all the parasites, the girls seem to have the higher percentage of infection with the exception of the tapeworm infections which are higher in the boy. This condition would be expected since the girls are the food handlers. Meleny (1931) and Williamson, Kaplan, and Greigar (1929) found that food handlers are the chief cause of the spread of infections, especially in respect to the distribution of E. histolytica. In this connection it is interesting to note that in Elizabeth Gibson where the girls range in age from ten to eighteen years of age the highest protozoal infection exists.

The spread of protozoan infections may also be facilitated if the toilets are permitted to stand unflushed; the collection of feces on moist paper offers an ideal condition for the mechanical transfer of cysts by flies. Flies have been observed (Neely) to deposit E. histolytica cysts in their vomit fifteen minutes after feeding about infected stool. Examination of the intestinal contents also revealed cysts. Thus, flies are incriminated as potential vectors of dissemination. The spread of protozoan infections, therefore, seem to lie between two sources, human carriers and flies. The fact that the infection exists in all dormitories indicates that the

agencies operating for the spread of the specific infections are the same in all dormitories.

It has been the general belief that Ascaris lumbricoides infections are frequently acquired from pigs, for these animals are nearly always infected with Ascaris identical morphologically and immunologically (Canning 1929) with that of the human form. Therefore, one would expect the boys to show the greater infection, because they care for the hogs. This is not the case; so obviously, the hog as a vector is relatively non-important. The infection must come from human sources and not from animal ones. It is interesting to philosophize as to whether the girls are more susceptible to the infection, or whether some force is operating among the girls to a higher degree for the spread of the infection than among the boys.

Tapeworm infections are always high in institutions, and especially would this be true in a home for children. Ransom (1904) found that boys show the higher rate of infection, and this infection is concentrated largely in the smaller children.

Better sanitary conditions and meat inspection have practically eradicated the beef and hog tapeworm, but far too little consideration has been given other tapeworm infections. Neither Taenia solium nor Taenia saginata were observed in this survey, but Hymenolepis nana, Dipylidium caninum, and Hymenolepis diminuta were found.

H. nana is the most common cestode parasite among

children in the South. It is also frequent in dogs and cats, but in these forms the toxic substances it generates often kills the host. This tapeworm, unlike most cestodes, does not require an intermediate host and not only can one acquire it directly from a pet, but may reinfect oneself or transmit it to another. It is therefore probable that the infection originally came from a pet, but, having once started, human infection plays even a more important part in the dissemination of this parasite than animals.

Although boys show a higher percentage of infection than girls, there is little difference in incidence of infection between the girls in East Cottage and the boys in King's Cottage where the ages are comparable (6-8 years). Unquestionably, much more attention should be paid to sanitation controlling this parasite.

Hymenolepis diminuta was observed in three cases among the girls. This parasite is obtained by eating the larvae stage of the meal ~~wormer~~ moth (Tenebrio molitor). Though meal is frequently found to be infected in Tennessee, this cestode infection is not prevalent. The worm, likewise, is easily dislodged, and in this case a recheck of the stool three months later did not reveal the parasite.

The high per cent of Dipylidium caninum in James Maynard Hall is not clear, for, as stated, infection depends upon eating the flea which serves as the intermediate host.

Necator americanus and Strongyloides

Stereocoralis are considered together in this report because of their similar means of transmission. They show a 7.5 per cent infection. In 1910 the hookworm infection at the Industrial School was 25.4 per cent, while today it is but 7.5 per cent. Sanitation and treatment here, as in the rest of the state, have done much to decrease the incidence of this particular Nematode. It seems that the possibility of becoming infected with Necator or Strongyliodes at the Industrial School is remote. The toilet facilities are good, and the stool disposal is through the city sewage system. There is very little soil pollution; and, even though there were, the soil about the school is a heavy red clay not suitable for the development of hookworm larvae. Therefore, it seems likely that this infection is acquired at the summer camp or before coming to the school. At the camp where the children spend most of their time barefoot, ideal conditions exist for the spread of infections as hookworm.

Trichacephalus trichiura (whipworm) varies proportionately (7.6 per cent and 2.4 per cent) in the girls and boys as did Ascaris. This is to be expected since their means of transmission are very similar. However, whipworm eggs will not live except under moist conditions while Ascaris eggs will develop under any conditions. Consequently, since there are certain environmental requirements necessary for the development of Trichacephalus, one would expect to find Ascaris occurring more frequently.

The frequency of pinworm (Enterobius vermicularis) infection could not be determined since the eggs are not found in feces. However, in two cases it was observed; once as the worm on the stool and again when the egg was found in examination for ova. Although the infection does exist, the individual beds and good laundry facilities prevent the spread of pinworm.

CONCLUSIONS

1. 52.0 per cent of apparently healthy children harbor some intestinal parasite.
2. A higher percentage of girls are infected.
3. Tapeworm infections are higher than in state wide surveys.
4. Tapeworm infections appears in the largest numbers in the younger children.
5. The forces operating for the spread of protozoal infections are apparently the same in all dormitories.
6. Hookworm infection at the Industrial School has been greatly reduced.

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APPENDIX
Photographs



Fig. 1. James Maynard Hall



Fig. 2. Elizabeth Gibson Cottage



Fig. 3. Girls at Play



Fig. 4. Boys at Play

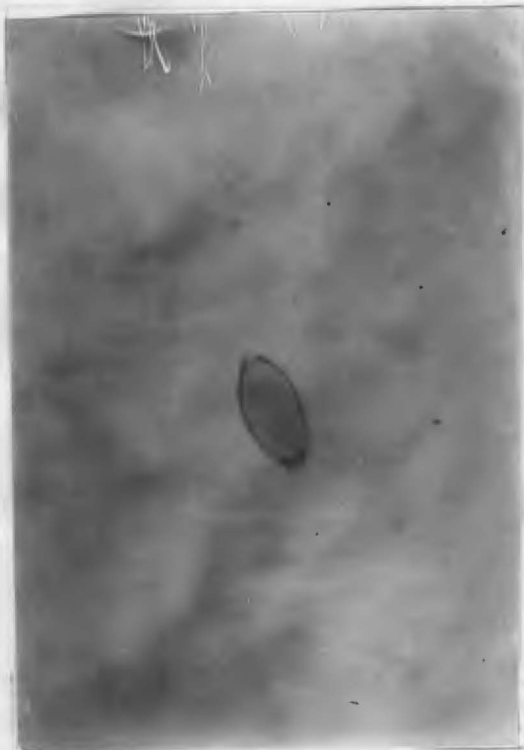


Fig. 5. Trichacephalus trichiura.

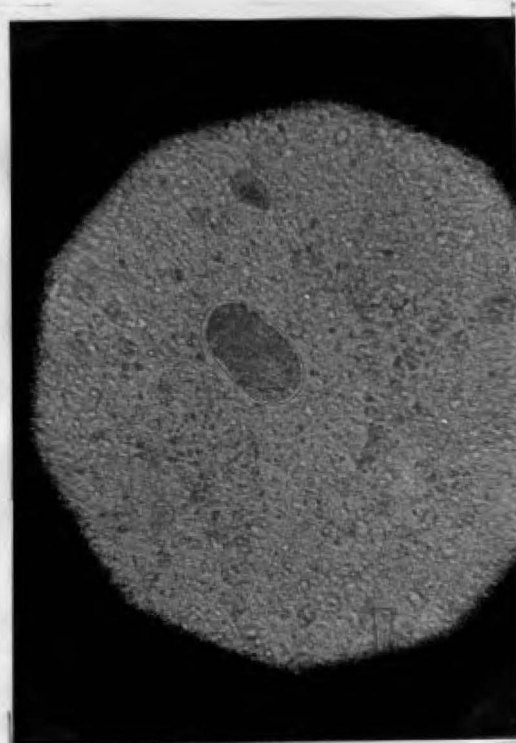


Fig. 6. Necator americanus.

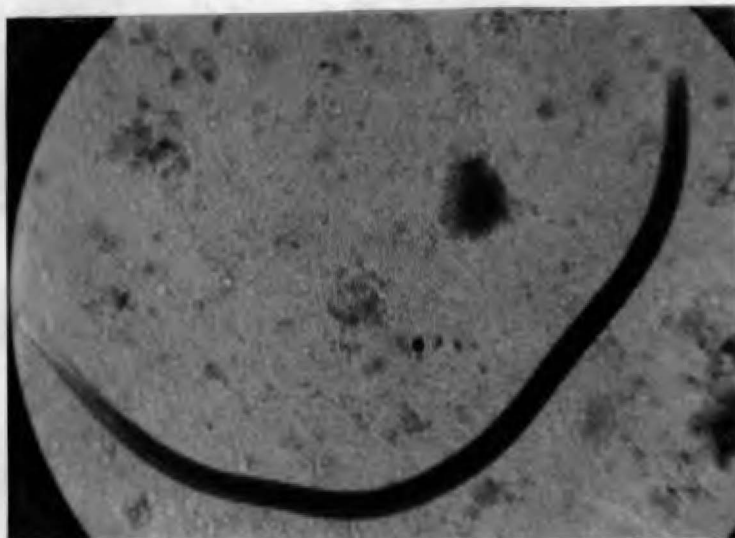


Fig. 7. Strongyloides stercoralis.

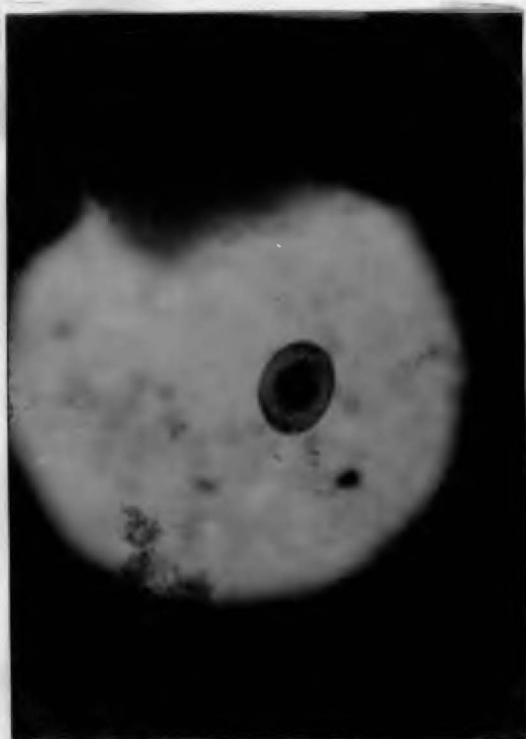


Fig. 8. Hymenolepis nana.

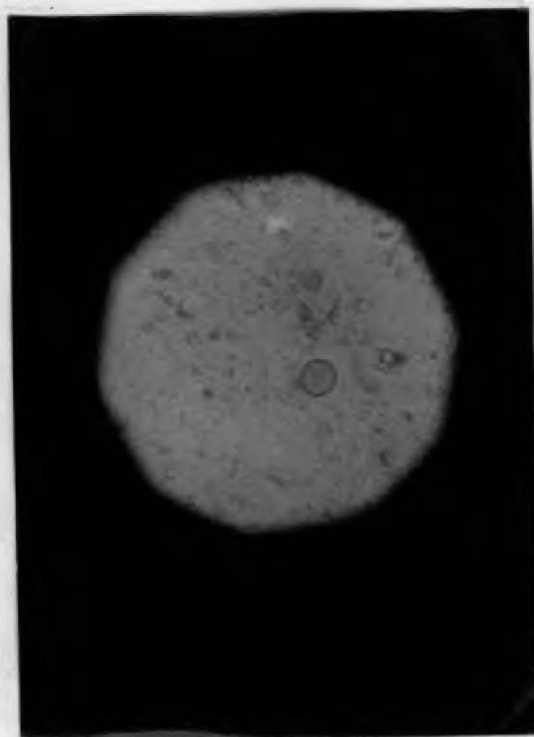


Fig. 9. Dipylidium Caninum.

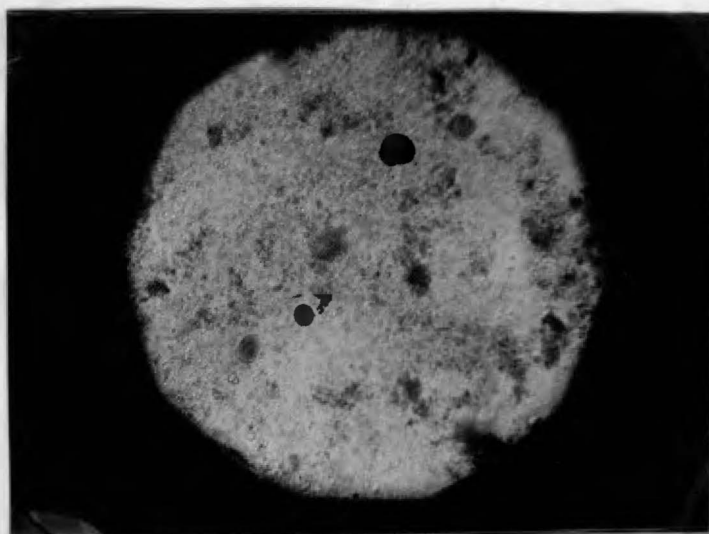


Fig. 10. Endamoeba histolytica and E. coli.

Table of Percentage of Infection

Cottage	Number	GIRLS									
		No Parasites	Non- Pathogens	Non-Path. Protozoa	End. histolytica	Ascaris	Necator	Trich. trichiura	Cestoda	H. nana	E. vermicularis
Eliz. Gibson	27	22.2	25.9	62.9	37.0	40.7	11.1	00	14.8	7.4	0
Eliz. Brownlow	20	40.0	60.0	45.0	5.0	35.0	5.0	5.0	15.0	0	0
Phoebe Park	21	33.8	52.4	33.3	9.5	28.6	14.3	4.8	4.8	4.8	4.8
East Cottage	32	31.2	50.0	43.0	9.4	25.0	6.2	18.5	21.9	21.9	0
Kings Cottage	5	40.0	60.0	40.0	40.0	20.0	0	0	0	0	20.0
Total(Girls)	105	31.4	46.2	43.5	17.1	31.3	8.6	7.6	14.3	8.5	3.1
BOYS											
King's Cottage	36	38.9	61.1	38.9	16.6	8.3	2.7	2.7	25.0	22.2	0
James Maynard	86	29.1	43.2	40.7	12.7	20.8	6.9	2.3	30.2	6.9	0
Total(Boys)	122	31.9	49.2	40.1	13.9	17.2	6.5	2.4	28.7	14.5	0
Total(School)	222	31.6	47.7	41.8	15.5	24.2	7.5	5.0	21.5	11.0	0.9