# A SURVEY OF ECTO- AND ENDOPARASITES OF THE BROWN NORWAY RAT RATTUS NORVEGICUS (Erxleben, I777) OBTAINED ESSENTIALLY FROM THE REGION OF THE "QUARRY" AT MACDONALD COLLEGE, QUEBEC, CANADA.

BY

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A Thesis

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# I. INTRODUCTION

Little need be said here concerning the common brown rat Rattus norvegicus, since its economic importance is so widely understood. They have, due to their migratory and prolific breeding habits, invaded and colonised all lands throughout practically the entire world. However, financial losses occasioned by these rats is relatively insignificant when the risk of disease due to their presence is considered. Plague, Rat-bite Fever, Spirochaetal Diseases, Equine Influenza, Foot-and-mouth Disease, together with various helminths and perhaps Entamoeba histolytica, are all known to be disseminated by rats. With regard to the helminths, it may act as an intermediate host for cestodes of the genus Taenia, and as a direct or indirect spreader of cestodes and nematodes; indirect infection is accomplished when the helminth has, as intermediate host, some arthropod as in the case of certain cestodes and nematodes, or some mollusc such as in the trematodes. The increased recognition of the importance of rats as reservoires of disease lends additional value to a knowledge of their parasites.

## II. Parasites Reported From Rattus Norvegicus

Of the numerous studies of rat parasites made in different parts of the world, some were primarily on particular species or phyla, others on more complete surveys, while several authors have compiled lists of all the known parasites of all rodents up to the time of their publication.

### (i) Protozoa

The results of protozoa surveys are meagre and the least quantitative due to limited examination time, lack of time-consuming cultural and concentration methods, and the personal error and oversight inherent in microscopy. However, reports have been published by Balfour (I922) of England who examined 444 brown rats, Baldassari (I935) of Toulons, France, 222 rats, and Price and Chitwood (I93I) of Columbia, I00 rats. In I936 Andrews and White of Baltimore, on examination of 2500 rats, produced by far the most comprehensive results.

The protozoa are listed on pages 3 and 4. The columns I to 4 indicate the different authors as follows: Col. I, Balfour; Col. 2, Baldassari; Col. 3, Price and Chitwood; and Col. 4, Andrews and White. An 'x' placed in a column indicates that the parasite opposite the 'x' has been reported by the author represented by the column number. The percent incidence is given in each case.

(a) Intestinal Protozoa

| Parasite | (I) | (2) | (3) | (4) | percent incidence |
|---|---|---|---|---|---|
| Entamoeba muris Grassi, I882. | x | . | . | . | I0.7 |
| | | x | . | . | 0.44 |
| | | | | x | I0.4 |
| Entamoeba histolytica[i] Schaudin, I903. | . | . | . | x | I.I |
| Endolimax ratti[ii] Chiang, I925. | . | x | . | . | 0.44 |
| | | | | x | 0.04 |
| Balantidium coli[iii] (Malmsten, I857) Stein, I862. | . | . | . | x | 0.44 |
| Giardia muris Bensen, I909. | x | . | . | . | 6.8 |
| | | x | . | . | 20.0 |
| | | | | x | I.7 |
| Chilomastix bettencourti Fonseca, I9I6. | x | . | . | . | I.8 |
| | | | | x | 2.I |
| Hexamita muris (Grassi, I88I) | x | . | . | . | I.7 |
| | | | | x | 0.04 |
| Trichomonas muris Galli-Valerio, I9I0. | x | . | . | . | I2.7 |
| | | x | . | . | 20.0 |
| | | | | x | I.8 |
| Trichomonas parva Alexeieff. | . | . | . | x | I9.I |
| Retortamonas Grassi, I879. | . | . | . | x | I.7 |
| Sarcosystis muris Blanchard, I885. | . | . | x | . | 7.0 |
| | | | | x | I0.8 |
| Coccidia | x | . | . | . | 2I.0 |
| | | x | . | . | 32.0 |
| | | | | x | 7.0 |

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i. Entamoeba histolytica-like amoebae have been reported as a natural infection of rats by Andrews (I934), Tsuchiya and Rector (I935), Andrews and White, and Frye and Melleney (I932). That the rat can be infected with E. hist-

olytica of human origin is proven by the results of Tsuchiya (I938), Frye and Melleney, Atchley (I936), and by some fourteen other authors as reported by Andrews and White.

The rat, as a suitable host of the dysenteric amoeba of man and capable of transmitting the infection to other rats, may be a very important and dangerous source of widespread human infection.

ii. Endolimax ratti , as reported by Andrews and White, and Baldassari, appears to be similar in size and appearance to E. nana of man.

iii. Balantidium coli was reported only once by Andrews and White from a rat caught in a slaughter-house district. This infection was probably acquired accidentally by the ingestion of pig offal. However, Atchley (I935) and Gabaldon (I935) have experimentally infected rats with this ciliate.

(b) Haematozoa

| Parasite | (I) | (2) | (3) | (4) | percent incidence |
|---|---|---|---|---|---|
| Trypanosoma lewesi (Kent, I880) | x | . | . | . | I9.0 |
| | | x | . | . | 28.5 |
| | | | x | . | 7.0 |
| | | | | x | 7.4 |
| Hepatozoon muris[iv] (Balfour, I905) | x | . | . | . | I0.8 |
| | | x | . | . | I7.0 |
| | | | x | . | I7.0 |
| | | | | x | 0.04 |
| Grahamella muris Brumpt, I9I3. | x | . | . | . | 0.2 |
| | | x | . | . | I7.0 |

iv. Hepatozoon muris was first reported by Balfour in I905 who found them in the leucocytes of the rat.

(ii) Helminths

The helminths of Rattus norvegicus have been given much more consideration than the protozoa and the reports are more numerous. Surveys have been reported by Balfour, Baldassari, and Price and Chitwood already mentioned; by Moll (I9I7) of Madison Wisconsin who examined 25 rats, Cram (I928) of Washington D.C., Forbes (I942) of Ohio, 50 rats and Luttermoser (I936) of Baltimore, 2632 rats. In I9I6, Maurice Hall published a compilation of all the nematodes of rodents in all parts of the world and in I93I, Oldham compiled a list of all the helminths of "common rats" found in all parts of the world.

The helminths are listed in their respective classes. Columns I to 7 indicate the different authors as follows; Col. I, Balfour; Col. 2, Baldassari; Col. 3, Price and Chitwood; Col. 4, Moll; Col. 5, Cram; Col. 6, Forbes; and Col. 7, Luttermoser. The percent incidence is also given.

(a) Cestoda

| Parasite | (I) | (2) | (3) | (4) | (5) | (6) | (7) | percent incidence |
|---|---|---|---|---|---|---|---|---|
| Hymenolepis murina[i] (Dujardin, I845) Blanchard, I89I. | x | . | . | . | . | . | . | I.2 |
| | | x | . | . | . | . | . | 23.0 |
| | | | x | . | . | . | . | ---- |
| | | | | | x | . | . | 23.0 |
| | | | | | | x | . | 26.4 |
| | | | | | | | x | II.4 |
| Hymenolepis diminuta[ii] (Rudolphi, I8I9) | x | . | . | . | . | . | . | 28.4 |
| | | x | . | . | . | . | . | 24.0 |
| | | | x | . | . | . | . | ---- |
| | | | | x | . | . | . | ---- |
| | | | | | | x | . | 28.0 |
| | | | | | | | x | I6.6 |
| Cysticercus fasciolaris[iii] Rudolphi, I808. | x | . | . | . | . | . | . | ---- |
| | | x | . | . | . | . | . | 6.0 |
| | | | x | . | . | . | . | ---- |
| | | | | | | x | . | I0.0 |
| | | | | | | | x | I9.2 |

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i. Hymenolepis murina. There has been much controversy over the proper classification applying to this tapeworm and at present there still seems to be no universally accepted specific name.

The complete synonymy is as follows:- (Southwell, I930.)

Taenia murina Dujardin, I845.
Taenia nana Siebold, I852.
Diplacanthus nanus (Siebold, I852) Weinland, I858.
Lepidotrias murina (Dujardin, I845) Weinland, I858.

Taenia aegyptica Bilharz, I852.
Hymenolepis nana (Siebold, I852) Blanchard, I89I.
Hymenolepis nana var. fraterna Stiles, I906.
Hymenolepis inexpecta Cholodkovsky, I9I2.
Hymenolepis longior Baylis, I922.

In I922, Baylis described a new species of Hymenolepis in Rattus norvegicus which he called H. "longior" . However, in I924, on examination of worms of mice which were presented to him by Woodland, he concluded that H. "longior" was identical with H. "fraterna". Woodland, having successfully infected mice with H. nana from man states:

> "The proof that rats and mice can be infected with H. nana eggs from man, the identity of structure of the two parasites and their eggs and their uniform geographical distribution render it practically certain that H. nana and H. "fraterna" are one and the same species. The fact that up to the present there is practically no evidence that man can be infected with eggs derived from rats and mice does not militate against this conclusion."

Luttermoser and Balfour used the name H. nana-fraterna; Price and Chitwood called it H. nana; while Baldassari reported it as H. fraterna.

Southwell "Fauna of British India" vol. 2, p I23 says:

> "It will be noted that the species H. murina found in the rat is here considered identical with the species H. nana found in man. Apparently the name

murina has priority."

ii. Hymenolepis diminuta.

The complete synonymy is:- (Southwell)

Taenia leptocephala Lussnana and Romaro, no date
Taenia diminuta Rudolphi, I8I9.
Taenia leptocephala Creplin, I825.
Taenia flavopunctata Weinland, I858.
Lepidotrias flavopunctata Weinland, I858.
Hymenolepis flavopunctata Weinland, I858.
Taenia flavomaculata Leukart, I863.
Taenia varesina Parona, I884.
Taenia minima Grassi, I886.
Taenia relicta Zschokke, I887.
? Hymenolepis relicta Zschokke, I887
Cysticercus hymenolepis-diminutae Railliet, I892.
Cysticercus taenia-diminutae (Rudolphi, I8I9) Dolley, I894.
Taenia megaloon Linstow, I90I.
Hymenolepis crassa Janicki, I904.
Hymenolepis sp. Janicki, I904.
Hymenolepis diminutoides Cholodkovsky, I9I2.

This species of Hymenolepis is identical with that found in man.

iii. Cysticercus fasciolaris is the larval form of the cat tapeworm Taenia taeniaeformis (Batsch, I786) Wolffhügel, I9II. Rats and mice act as intermediate hosts for this tapeworm harbouring the cysticercus in their body cavity and liver.

On the following page is a list of cestodes in alphabetical order as taken from Oldham. The location of each is indicated.

(a) Cestoda cont'd

| | | |
|---|---|---|
| | Catenotaenia pusilla (Goeze, I782) ... | ... Europe<br>U.S.A. |
| | Diphyllobothrium mansoni (Cobbold, I883)... | ... China<br>Japan<br>Porto Rico |
| | Dithyridium elongatum (Bloomberg, I882) ... | ... Europe<br>U.S.A. |
| | Dithtridium sp. Skrjabin and Schulz, I926. | ... Russia |
| | Hymenolepis contracta Janicki, I904. ... | ... Germany |
| ' | Hymenolepis crassa Janicki, I904. ... | ... ----- |
| | Hymenolepis diminuta (Rudolphi, I8I9) Blanchard, I89I. ... | ... Cosm. |
| ' | Hymenolepis diminutoides Cholodkovsky, I9I2. | ... ----- |
| '' | Hymenolepis inexpectata Cholodkovsky, I9I2. | ... ----- |
| | Hymenolepis horrida Linstow, I900. ... | ... Germany |
| '' | Hymenolepis longior Baylis, I922. ... | ... ----- |
| | Hymenolepis microstoma (Dujardin, I845) ... | ... France<br>Germany<br>S. Oran |
| | Hymenolepis nana (Siebold, I852) Blanchard, I89I. | ... Cosm. |
| ' | Hymenolepis relicta (Zschokke, I887) ... | ... ----- |
| † | Mesocestoides lineatus (Goeze, I782) ... | ... Europe<br>U.S.A.<br>S. Africa |
| | Multicapsiferina guineansis (Graham, I909) | ... Africa<br>London (Zoo) |
| † | Multicepts serialis (Gervais, I847) Stiles and Stevenson, I905. | ... Cosm. |
| | Raillietina celebensis paucicapsulata Meggitt and Subramanian, I937. | ... Rangoon |
| | Raillietina fatalis Meggitt and Subramanian, I927. | ... Rangoon |
| | Raillietina fluxa Meggitt and Subramanian, I927. | ... Rangoon |

(a) Cestoda cont'd

| | | | |
|---|---|---|---|
| | Raillietina funebris Meggitt and Subramanian, I927... | | Dahomey |
| | Raillietina sp. (Johnston, I9I8) | ... ... | Australia |
| | Taenia brachydera Diesing, I854. | ... ... | Ireland |
| † | Taenia hydatigena (Pallas, I766) | ... ... | Cosm. |
| † | Taenia taeniaeformis (Batch, I786) | ... ... | Cosm. |

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' Synonyms of Hymenolepis diminuta.

'' Synonyms of Hymenolepis nana.

† These worms have only their larval stages in the rat and generally in the liver or body cavity or both.

(b) Trematoda

| Parasite | (I) | (2) | (3) | (4) | (5) | (6) | (7) | percent incidence |
|---|---|---|---|---|---|---|---|---|
| Amphimerosus speciosus[i] (Stiles and Hassal, I896) Barker, I9II. | . | . | . | . | x | . | . | ---- |
| Apophallus donicus[ii] (Skrjabin and Lindtrop, I9I8) | . | . | x | . | . | . | . | I.0 |

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i. Amphimerosus speciosus had formerly been known only from birds.

ii. Apophallus donicus.

Syn. (Rossicotrema donicum). Price and Chitwood reported finding this trematode from the rat for the first time. They found two varying considerably in size but nevertheless morphologically indistinct and the same as those found in dogs and cats.

On the following page is a complete list of trematodes of Rattus norvegicus as taken from Oldham. They are listed alphabetically and the location is indicated.

(b) Trematoda cont'd

| | | |
|---|---|---|
| Ascocotyle (Phagicola) arnaldoi Travassos, I928. | ... | Brazil |
| Ascocotyle (Phagicola) diminuta Stunkard and Haviland, I924. | ... | U.S.A. |
| Clonorchis sinensis (Cobbold, I875) Loos, I907. | ... | S.E. Asia |
| Cryptocotyle concavum (Creplin, I825) ... | ... | ------ |
| Distoma sp. Podiapolsky, I924. ... | ... | Russia |
| Distomun migrans Dujardin, I845. ... | ... | ------ |
| Echinoparyphium japonicum Ando and Ozaki, I923. | ... | Japan |
| Echinostoma cinetorchis Ando and Ozaki. I923. | ... | Japan |
| Echinostoma gotoi Ando and Ozaki, I923. ... | ... | Japan |
| Echinostoma macrorchis Ando and Ozaki, I923. | ... | Japan |
| Echinostoma spiculator Dujardin, I845. ... | ... | France Germany |
| Euparyphium guerreroi Tabangui, I93I. ... | ... | Phillipines |
| Euparyphium ilocanum (Arrison, I908) Tabangui, I93I. ... | ... | Manila Luzon |
| Heterechinostoma magniovatum Stunkard and Haviland, I924. | ... | U.S.A. |
| Lepiderma muris Tanabe, I922. ... ... | ... | Japan |
| Metagonimus yokogawai (Katsurada, I9I2) ... | ... | S.E. Asia |
| Pygidiopis (?) macrostomum Travassos, I928. | ... | Brazil |
| Stamnosoma armatum Tanabe, I922. ... | ... | Japan |

(c) Nematoda

| Parasite | (I) | (2) | (3) | (4) | (5) | (6) | (7) | percent incidence |
|---|---|---|---|---|---|---|---|---|
| Trichosomoides crassicauda (Bellingham, I840) Railliet, I895. | x | . | . | . | . | . | . | 48.3 |
| | | | x | . | . | . | . | 73.0 |
| | | | | x | . | . | . | ---- |
| | | | | | x | . | . | 23.6 |
| | | | | | | x | . | 42.0 |
| | | | | | | | x | 90.4 |
| Heterakis spumosa Schneider, I866. Syn. (Ganguleterakis spumosa) Lane, I9I4. | . | . | x | . | . | . | . | 49.0 |
| | | | | x | . | . | . | ---- |
| | | | | | | x | . | 42.0 |
| | | | | | | | x | I.6 |
| Capillaria hepatica (Bancroft, I894) Travassos, I9I5. Syn. (Hepatica hepaticola) Hall, I9I6. | x | . | . | . | . | . | . | 0.22 |
| | | x | . | . | . | . | . | I.3 |
| | | | x | . | . | . | . | 77.0 |
| | | | | | x | . | . | ---- |
| | | | | | | | x | 85.6 |
| Capillaria annulosa (Dujardin, I845) | x | . | . | . | . | . | . | 0.4 |
| Trichinella spiralis (Owen, I835) Railliet, I895. | . | . | x | . | . | . | . | 3.0 |
| | | | | x | . | . | . | ---- |
| | | | | | | | x | I.2 |
| Syphacia obvelata (Rudolphi, I802) | . | . | . | . | x | . | . | 24.0 |
| | | | | | | x | . | 4.0 |
| Trichuris muris (Schrank, I788) Hall, I9I6. | . | x | . | . | . | . | . | 2.2 |
| Gongylonema neoplasticum (Fibiger and Ditlevson, I9I4) Ransom and Hall, I9I6. | . | . | x | . | . | . | . | 5.0 |
| Strongyloides ratti Sandground, I925. | . | x | . | . | . | . | . | 0.22 |
| | | | | | | | x | 20.2 |
| Nippostrongylus muris Lane, I923. Syn. (Heligmosomum muris) Yokogawa, I920. | . | . | . | . | . | x | . | 4.0 |
| | | | | | | | x | I6.8 |
| Heligmosomum braziliense[i] Travassos, I92I. | x | . | . | . | . | . | . | 8.6 |
| Mastophorus muris var. muris[ii] Travassos, I938. Syn. (Protospirura muris) Gmelin. | . | x | . | . | . | . | . | 20.0 |
| | | | | | x | . | . | once |

(c) Nematoda cont'd

| Parasite | (I) | (2) | (3) | (4) | (5) | (6) | (7) | percent incidence |
|---|---|---|---|---|---|---|---|---|
| Protospirura columbiana[iii] Cram, I926. | . | . | . | . | x | . | . | ---- |
| Viannaia? sp. incert.[iv] | x | . | . | . | . | . | . | 0.7 |
| Heligmosomum vexillatum Hall, I9I6. | x | . | . | . | . | . | . | 0.2 |

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i. Heligmosomum braziliense. Travassos and Darriba (I929) state this species to be identical with (H. muris) or Nippostrongylus muris.

ii. Mastophorus muris var. muris. Travassos (I938) placed this worm in the genus Mastophorus and because of its long teeth it further falls into the variety muris n. var. as compared to the variety ascaroides n. var. which includes those with short teeth. As synonyms of Mastophorus muris var. muris, Travassos includes Protospirura columbiana Cram, P. gracilis Cram, P. labiodentata (von Linstow), and P. oligodentata Kreis.

iii. Protospirura columbiana is regarded by Travassos to be a synonym of Mastophorus muris var. muris.

iv. Viannaia? sp. Balfour reports that this particular worm may have been an immature and undescribed form of H. braziliense since no sex organs or eggs were seen and because of its occurence along with H. braziliense.

Again, on the following page, is a list of nematodes of Rattus norvegicus - minus those already mentioned above - taken from Oldham. They are listed alphabetically and the location is indicated.

(c) Nematoda cont'd

| | | |
|---|---|---|
| Capillaria (Thominx) bacilata (Eberth, I863). Hall, I9I6. | ... | ----- |
| Capillaria leidyi (Travassos, I9I4) | ... ... | ----- |
| Capillaria papillosa (Polonio, I860) Hall, I9I6. | ... | Italy |
| Capillaria schmidtii (Linstow, I874) Hall, I9I6. | ... | Germany |
| Gongylonema minimum Molin, I857. | ... ... | Australia |
| Hepaticola gastrica Baylis, I926. | ... ... | Italy<br>Holland<br>Denmark |
| Rictularia tani Hoeppli, I929. | ... ... | China |
| Spiroptera sp. Gerstaecker, I866. | ... ... | Germany |
| Spirura rytipleurites (Deslongchamps, I824) | ... | ----- |
| Strongyloides papillosus (Wedl, I856) Ransom, I9II. | ... | Europe<br>U.S.A.<br>S. Amer. |
| Strongyloides sp. Parona, I894. | ... ... | ----- |

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(d) Acanthocephala

Moniliformis moniliformis (Bremser, I8II) Travassos, I9I5, the only acanthocephalid of the rat, was reported by Luttermoser and Price and Chitwood. It has a cosmopolitan distribution having been found in Australia, England, United States, West and South Africa, British Honduras, South America and Porto Rico.

## (iii) Ectoparasites

The vast majority of surveys of rat parasites have been conducted solely for the determination of the ectoparasites of rats with particular attention - and often only so - to the flea population. These surveys have been centered mainly in seaports throughout the world where the danger and dread of plague-infected rats, generally on ships from the more tropical countries, is greatest; and where, if plague-infected rats and fleas are found, immediate control measures must be employed if the danger of plague is to be averted.

Results of surveys have been reported by the United States Public Health Service for several of the seaports of southern, eastern and western U.S.A., and by Moll of Madison, Wisconsin; Balfour of London, Newstead and Evans (I920) of Liverpool, Strickland and Merriman (I9II) of Suffolk and North Essex, and a list of acari of Rattus norvegicus by Hirst (I9I4-I9I5) of England; Spencer (I937) of Vancouver, Gibbons and Humphreys (I94I) of Vancouver and New Westminster, and Brown (I945) also of western Canada; Baldassari and Marcandier and Pirot (I932) of Toulons, France; and finally, a general synopsis of the fleas of rats by Rothschild (I9I0).

The ectoparasites are listed on the following pages in tables I, 2, and 3 (viz. fleas, lice and acari.)

(iii) Ectoparasites cont'd

Table I

| (a) Fleas | U.S.A. | England | France | Canada | other countries | Vector of: plague | Vector of: endemic typhus | Vector of: T. lewisi | Int. host of: H.diminuta | Int. host of: H.nana | attacks man | natural host |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ‡Xenopsylla cheopis[i] Rothschild. | x | x | x | x | cosm. | x | x | x | x | x | x | rats |
| ‡Nosopsyllus fasciatus[ii] (Bosc) | x | x | x | x | cosm. | x | x | x | x | x | x | rats |
| Xenopsylla braziliensis (Baker, I904) | | | | | Brazil Indies Africa | x | | | | | | rats |
| Ctenophthalmus agyrtes Wagner, I902. | | x | | | Europe | ? | | x | | | | rodents |
| Ct. pentacanthus Wagner, I902. | | x | | | ----- | | | | | | | field vole |
| Ct. bisoctodentatus (Kolenati, I862) | | x | | | ----- | | | | | | | rodents |
| ‡Leptosylla musculi Duges, I832. | x | x | x | | cosm. | x | x | | exp | | x | rats |
| ‡Ctenocephalides canis Stiles and Collins. | x | x | x | x | cosm. | x | x | x | x | x | x | dog |
| Ctenosephalides felis Stiles and Collins | x | x | | x | cosm. | | x | | | | x | cat |
| ‡Pulex irritans Linnaeus, I758. | x | x | | x | cosm. | exp | exp | x | x | x | x | man |
| Ceratophyllus niger Fox. | x | | | | ----- | | | | | | | bird |
| C. walkeri[iii] Rothdchild, I904. | | x | | | Russia | | | | | | | rodents |
| C. gallinae (Schrank, I804) | | x | | | cosm. | | | | | | x | fowl |
| C. hirudinis Rothschild. | | x | | | Europe | | | | | | x | swallows |
| C. londiniensis[iii] Rothschild. | | x | | | ----- | | | | | | | rats mice |
| C. anisus Rothschild. | x | x | | | Japan | | | | | | | ---- |
| C. penicilliger Grube. | | x | | | N. Asia | | | | | | | rodents |
| Archaeopsylla erinacei Bouche, I835. | | x | | | ----- | | | | | | | hedgehog |
| Hystrichopsylla talpae Curtis, I826. | | x | | | Europe | | | | | | | rodents |
| H. tripectinata Tirab. | | | | | Azores Mediterranian | | | | | | | rats mice |
| Echidnophaga gallinacea (Westwood, I875) | x | x | | | cosm. | | | | | | | birds |

‡ As intermediate hosts of tapeworms of the genus Hymenolepis, infection of necessity occurs during larval stages only.

i. Xenopsylla cheopis is known as the Tropical Rat Flea and although practically cosmopolitan, it cannot apparently flourish in temperate climates. It is the most important vector of murine and bubonic plague in the warmer climates.

ii. Nosopsyllus fasciatus was, until very recently, known as Ceratophyllus fasciatus Bosc which name is now restricted to bird-fleas and thereby considered as a synonym.

iii. According to Smart, these species belong to the genus Nosopsyllus with Ceratophyllus falling as a synonym.

On the following page is a table of the lice of Rattus norvegicus with the distribution and habits of each.

(iii) Ectoparasites cont'd

Table 2

| (b) Lice | U.S.A. | England | France | Canada | other countries | Vector of endemic typhus | Vector of T. lewisi | natural host |
|---|---|---|---|---|---|---|---|---|
| Polyplax spinulosa[i] (Burmeister, I838) Syn. (Haematopinus spinulosus) | x | x | x | x | cosm. | x | x | rats |
| Philandesia foxi[ii] Ewing. | x | | | | Cent. & S. Amer. | | | rodents marsupials |
| (Pediculoides capitis)[iii] Nitzsch. | | x | | | cosm. | | | primates |

i. Polyplax spinulosa is the common rat louse and is apparently specific to the rat.

ii. Philandesia foxi was reported found on the rat in New York City and is the only case known.

iii. Pediculus capitis is the synonym of Pediculus humanus Linnaeus, I758 var. capitis de Geer, I778. It is the common head louse of primates and may be a vector of Typhus Fever, Trench Fever and Louse-borne Relapsing Fever.

(iii) Ectoparasites cont'd

Table 3

| (c) Mites | U.S.A. | England | France | Canada | other countries | vector of endemic typh | attacks man | natural host |
|---|---|---|---|---|---|---|---|---|
| Echinolaelaps echidninus[i] (Berlese) | x | x | x | x | cosm. | | | rats |
| Eulaelaps stabularis Koch. | | x | | | ---- | | x | free |
| Liponyssus bacoti[ii] (Hirst, 1913) | x | | | x | cosm. | x | x | rats |
| Dermanyssus muris Hirst. | | | x | | India Egypt Arabia | x | x | rats |
| D. aegyptius Hirst. | | | | | Egypt | | | rodents |
| Haemogamasus hirsutus Berlese. | | x | | | ---- | | | moles |
| H. nidi Michael. | | x | | | ---- | | | small rodents |
| H. oudemansi Hirst. | | x | | | ---- | | | (") |
| Laelaps agilis Koch. | x | x | | | ---- | | | rats |
| Hypoaspis hypudaei Ouds. | | x | | | ---- | | | ----- |
| Asca affinis Ouds. | | x | | | ---- | | | ----- |
| Eugamasus loricatus Wankel. | | x | | | ---- | | | ----- |
| Euryparasitus terribilis Michael. | | x | | | ---- | | | ----- |
| Notoedres muris Megnin. | | x | | | ---- | | | ----- |
| Notoedres notoedres Megnin. | | x | | | ---- | | | ----- |
| Notoedres sp. | | x | | | ---- | | | ----- |
| Myobia ensifera[iii] Poppe. | | x | | x | ---- | | | rats |
| Veignaia sp. | x | | | | ---- | | | ----- |
| (d) Ticks | | | | | | | | |
| Ixodes tenuirostris Neumann | | x | | | ---- | | | rodents |

[illegible] deutonymph found in each case.

i. Echinolaelaps echidninus.

Syn. (Laelaps echidninus Berlese) is the common rat mite found in all parts of the world. Its ability to transmit plague from rat to rat is uncertain, and it is not known to attack man.

ii. Liponyssus bacoti is the tropical rat mite which is now cosmopolitan in distribution. It readily attacks man causing a severe itching. It is a vector of endemic typhus in rats.

iii. Myobia ensifera is a synonym of the genus Radfordia Ewing and is differentiated from Myobia because it has 2 claws on tarsus II. This genus includes M. ensifera, M. lemnina Koch, M. affinis Poppe, M. chiropteralis Michael, M. ingens Vitzthum, M. ewingi Fox, M. trouessarti Poppe, M. rollinati Poppe, and three new species Radfordia subulinger, R. floridensis, and R. inaequalis. (Ewing I938)

## III. REVIEW OF RODENT SURVEYS IN CANADA

So far as I am aware, no complete survey of rat parasites has been made or published in Canada. However, a great deal of work has been done on flea surveys of rodents especially in western Canada. During the recent war, flea surveys were conducted on the eastern sea-coast, but as yet no results have been published. These surveys were mainly for the determination of the "cheopis" index - i.e. the average number of Xenopsylla cheopis per rodent - since this flea is the principle carrier of plague, but more complete results of all existing fleas have been published by Wagner (I936) of British Columbia, Brown of Alberta, and Ewing and Fox (I943).

In the spring of I938 the Alberta Sylvatic Plague Survey was organized under the auspicies of the Alberta Department of Public Health. Brown had collected several fleas during this survey and listed them in his publication along with the several specimins reported by Rothschild and Jordan. In all, there were 53 fleas, II of which are known plague vectors found on I7 different hosts none of which was the brown rat.

Wagner reported 62 species of fleas in British Columbia, none of which was found on the brown rat. In his report he included the works of Spencer.

Gibbons and Humphreys, in a plague survey, reported having examined I222 rats - 99.6% Rattus norvegicus - with 2077 fleas most of which were Xenopsylla cheopis.

Finally, in I943, Ewing and Fox published a list of the Fleas of North America which included 6I genera, I4 subgenera, 209 species and 63 subspecies.

## IV. COLLECTION AND TECHNIQUE

Of the I50 rats examined, I47 came from the "quarry" at Macdonald College which is used as the college "dump". The food of these rats consists mainly of decayed fruits and vegetables, and kitchen refuse exclusive of meats. The greater part of the "dump", however, consists of ashes, brush, tin cans and discarded household equipment. The remaining 3 rats were trapped in the barn immediately behind the Institute of Parasitology at Macdonald College.

Of the I47 "dump" rats, 9 were trapped in guillotine spring traps, 33 were shot in the head with a .22 calibre rifle and I06 were trapped alive in $\frac{1}{2}$ inch mesh galvanized wire cages. Immediately upon death, the 42 rats, shot and trapped in the spring traps, were placed in large paper bags which were securily tied to prevent the escape of ectoparasites and then taken to the laboratory. Before opening, the bags were thoroughly shaken to dislodge any ectoparasites that may have been climbing up the inside. A piece of cotton saturated with chloroform was then dropped into the bag and the bag sealed again for 3 to 5 minutes after which time the entire contents were shaken onto a large white enamel tray. The rat was then combed with a very fine comb, special attention being paid to the neck region and the point of junction of the limbs with the body on the undersurface of the animal and the results therefrom examined under the dissecting microscope. In each case, the ectoparasites were placed in vials for immediate mounting. The rats were then weighed and prepared for dissection.

The remaining I06 rats were trapped alive during the night. In the early evening, the traps were placed in the region of the "dump" where the rats generally came in search of food and while doing so some of them would wander into the cage. The following morning the traps were collected and conveyed to the laboratory where the rats were chloroformed one by one in a small chamber, combed, weighed and prepared for dissection as described previously. In all the cases but two, not more than 6 rats were caught at any one time allowing for immediate examination and a minimum "sweating" time. Balfour states that if wild rats are kept in captivity for any appreciable length of time they become "sweated" and apt to lose their fleas. However, on two occasions, catches of I3 and 25 rats were obtained thus causing some 25 rats to have kept alive in the cages from 2 to 6 days thereby causing them to have become "sweated" and apt to lose some of their ectoparasites. However, since "sweating" affects fleas mostly, and since no fleas were found on any of the rats whatsoever while lice and mites were found on these "sweated rats in the same proportions and percentage as on the remainder, its effects to the overall results may not be considered as very serious.

The post-mortem examination of the rat was performed on a large white tray. Blood was removed from the heart with a hyperdermic needle and syringe and thin films prepared and stained with Leishman's stain. Before going any further, the internal organs were examined macroscopically for abnormalities [illegible] such were observed, a careful examination was made to

urinary bladder was then removed, placed in a castor dish containing normal 0.85% saline, slit open and scraped with the back of a scalpel blade. The normal saline was then examined under the dissecting microscope for Trichosomoides crassicauda. The alimentary tract was removed and placed in a small jar containing normal 0.85% saline for later examination that same day or the next at the latest. All the surfaces of the lobes of the liver were examined for cysts of Cysticercus fasciolaris and for fibrotic encapsulations of Capillaria hepatica and its eggs which appear as white or yellow spots or patches. The cysts were opened and the included cysticerci removed. If spots were noticed, scrapings of the liver were taken and examined under the microscope for ova. The diaphragm was removed and examined in a compressorium for the characteristic encapsulations of the larvae of Trichinella spiralis; and finally, a thin layer of muscle teased from the hind leg and jaw was examined in the same manner for sarcosporidia.

The alimentary tract eas divided into 5 parts - stomacl duodenum - the first 5 inches of the small intestine -, small intestine, caecum and large intestine. Each section was then individually opened and thoroughly cleaned into separate small jars by first washing off the contents with normal 0.85% saline and then running the tissue through the tightened prongs of a pair of forceps. The section was then flattened out on a small glass plate and examined under the dissecting microscope for adhering worms. Smears in saline of the small intestine and caecu

## V. RESULTS

The total number of species of parasires found in this survey is I8 comprised of 3 cestodes, 6 nematodes, 5 protozoa, I louse and 3 mites. They are listed in 4 tables as follows: Table I, Protozoa; Tables 2 and 3, Helminths; and Table 4, Ectoparasites. In each case the percent incidence is given.

### (I) Protozoa[i]

Table I

| Protozoa | percent incidence |
|---|---|
| Coccidia[ii] | 28.0 |
| Trichomonas muris[iii] Galli-Valerio, I9I0. | 9.0 |
| Giardia muris (Grassi, I882) | 6.0 |
| Chilomastix bettencourti Fonseca, I9I5. | 2.I |
| Entamoeba muris (Grassi, I879) | 6.7 |

i. Although blood protozoa have been found in the blood of rats on Montreal Island, a thorough search during this present survey did not reveal the presence of these parasites.

ii. The coccidia of the rat are strictly host-specific several attempts to infect other rodents - other than "rats" - having failed and vice versa. According to Becker, Hall and Hager (I93I, I932,I933), there are three distinct species in the rat.

| | Av. cyst measure |
|---|---|
| (i) Eimeria miyairii Ohira, I9I3. Syn.(E. nieschulzi) | 22.5 x I7.8$_u$ |
| (ii) E. separata Becker and Hall. | I6.0 x I3.85$_u$ |
| (iii) E. carinii Pinto, I923. | 24.4 x 22.I$_u$ |

Coccidial species were not reported numerically but measurements taken from 25 infected rats - cysts obtained by zinc sulphate flotation - showed that all three species were present with E. miyairii being most common, E. separata occupying an intermediate position and E. carinii appearing only once. (doubtful case)

Andrews and White, on examination of 382 similar "dump" rats of Baltimore, report a coccidial infection of 3.9% as compared to a 28.0% infection found in this survey.

iii. Trichomonas muris. On the basis of morphological differences, 4 different species - most of which can be identified only in carefully stained preparations - are claimed by Wenrich to exist in the rat. These are T. muris with large sluggish trophozoites; T. minuta, T. parva and Pentatrichomonas sp. (probably P. ardin-delteili of man) with smaller, more active trophozoites.

From caecal smears, trophozoites were found in 9% of the rats compared with an infection of 20.0% in Baltimore "dump" rats.

## (ii) Helminths

Table 2

| (a) Cestodes | percent incidence |
|---|---|
| Cysticercus fasciolaris Rudolphi, I808. | 44.6 |
| Hymenolepis murina (Dujardin, I845) Blanchard, I89I. Syn. (H. nana var. fraterna Stiles, I906) | I6.5 |
| Hymenolepis diminuta (Rudolphi, I8I9) Blanchard, I89I. | 4.0 |

Cysticercus fasciolaris, the intermediate form of the cat tapeworm Taenia taeniaeformis , was found in 67 rats (45%) with an average of I.55 cysts per rat. This appears to be a natural confirmation in Rattus norvegicus of an acquired immunity for Cysticercus fasciolaris demonstrated by Miller (I93I) in laboratory rats. The longest cysticercus found was 4.5 inches long and the largest single infection was comprised of I5 cysts. The greatest natural infection of Rattus norvegicus was reported by Hopwood (I922) of West Virginia University who found 256 cysts while Miller and Dawley (I928) produced experimental infections of 6000 cysts. All these infections occurred in the liver of the rat. Luttermoser of Baltimore, on examination of 405 similar "dump" rats, reported a 25.4% infection of these cysts.

Hymenolepis murina was found in 25 rats (I6.5%) with a total number of 63 worms - in whole or in part - and with infections ranging from I to I0 worms. All of these worms were found in the small intestine and in one rat 4 scolicies only were found on examination of the intestinal contents.

..... -- -n accordance with the fact that H. "nana" has a direct life-cycle as demonstrated by Woodland (I924) and others. However, the life-cycle can involve an intermediate host such as the fleas Ctenocephalides canis, Xenopsylla cheopis and Pulex irritans, and the mealworms Tenebrio molitor and T. obscurus, but successful experimental results with these intermediate hosts have come from Argentina only, all other attempts having failed.

Luttermoser of Baltimore reported a I4.I% infection in "dump" rats.

Hymenolepis diminuta was found in 6 rats (4.0%), 4 of which were caught at the "dump" and contained single infections while the remaining two were those trapped in the barn and containing multiple infections of 2 and I7 worms. Unlike H. "nana", H. diminuta requires an intermediate host in which the ingested egg hatches and the onchosphere penetrates into the body cavity where it metamorphoses into a cysticercoid larva. Oldham (I93I) has reported successful experimental results with 23 arthropods belonging to the Lepidoptera, Dermaptera, Coleoptera, Siphonaptera and Myriapoda which function as intermediate hosts of this tapeworm in either the larval, adult or more than one stage of their life-cycle.

H. diminuta has a cosmopolitan distribution and has been reported from rodents, dog and man.

Luttermoser reported a 9.9% infection from Baltimore "dump" rats.

Detailed accounts of these 3 species of cestodes can be obtained from any standard parasitology textbook.

Table 3

| (b) Nematodes | percent incidence |
|---|---|
| Heterakis spumosa Schneider, I866. | 79.3 |
| Nippostrongylus muris (yokogawa, I920) | 83.0 |
| Trichosomoides crassicauda (Bellingham, I840) Railliet, I895. | 55.5 |
| Strongyloides ratti Sandground, I925. | 8.0 |
| Capillaria hepatica (Bancroft, I894) Travassos, I9I5. | 6.0 |
| Mastophorus muris var. muris Travassos, I938. | 0.66 |

Heterakis spumosa was found in II9 rats with infections of I to 76 worms. In all there were I355 worms with an average of II.4 worms per rat. All the infections were located in the caecum and large intestine with the greater number of worms being found in the large intestine in the majority of rats. These worms are cosmopolitan in distribution and an excellent account is given of them by Hall.

Luttermoser reported a I.7% infection from 405 similar "dump" rats.

Nippostrongylus muris appeared in the greatest number of infections involving I24 rats (83%). Infections ranged from I to 290 with a total of 3495 worms and an average of 28.2 worms per rat. These worms were found mainly in the anterior part of the small intestine. An excellent description of these worms is given by Yokogawa (I920) who described them for the

e under the generic name of Heligmosomum, and in I922, Yokogawa further described the development of this worm.

Nippostrongylus muris has henceforth been reported only from the United States. However, in I929, Travassos and Darriba claimed N. muris and H. braziliense to be identical and since H. braziliense has been reported from England, Australia and Brazil, this nematode may have a cosmopolitan distribution.

Luttermoser reported a 6I.5% infection from Baltimore "dump" rats.

Trichosomoides crassicauda is the bladder-worm of the rat. In all, 83 rats (55.5%) were found infected with a total number of I09 and an average of I.3 worms per rat - the greatest infection consisting of 8 worms. This worm is described by Hall, but its migratory course in the body of the rat is still not fully known. Yokogawa (I92I) attempted to elucidate the migratory course of this worm and found that the larvae must pass to the lungs as a necessary part of their life-cycle but how the larvae reach the urinary bladder is unknown. They probably are not carried in the blood vessels. This worm has been reported from Europe, Australia and the United States, and is a parasite of the urinary bladder, kidneys and ureters.

Luttermoser reported a 9I.I% infection from Baltimore "dump" rats.

Strongyloides ratti was found in I2 rats (8.0%) with an average of I.9 worms per rat, the greatest infection comprising 5 worms. These worms have been reported from Baltimore

noser and from Toulons, France where Baldassari found only one infection in 225 rats. On the other hand, Luttermoser reported a 64.7% infection with an average of 54 worms in 5 rats examined. A complete description of the worm is given by Sandground who distinguished it as a separate species from S. papillosus which Hall claimed to be identical to the rat parasite.

Capillaria hepatica is a parasite of the liver tissue of rodents, dog, the chimpanzee and man. The North American prairie dog and the European hare have also been reported as naturally infected with this worm. The life-cycle of this worm is direct. Infection occurs by eating the infected organ containing embryonated eggs, or by ingestion of the embryonated eggs from a decomposed carcass or from the droppings of carnivorous animals as contamination of food or drink.

Of the 9 rats reported as infected with C. hepatica, not one had a liver infection either of adult worms or ova. However, a zinc sulphate flotation of the contents of the large bowel revealed the presence of the characteristic eggs resembling those of Trichocephalus but having a somewhat thicker, pitted and refringent outer shell. These eggs were not embryonated , being filled with a course granular mass and measuring 29.0 — 32.I x 6I.0 — 75.$0_u$ with the average being 3I.0 x 65.$0_u$ including the polar plugs. The presence of these eggs in the large bowel of the rats suggests that a short time before being trapped, these rats may have eaten an infected rat thereby swallowing young, unembryonated eggs which were

ed to the exterior by the new host. It is interesting to note in one case when a catch of 25 rats was obtained thus extending examination time over a period of 6 days, that on the fourth day one of the rats was killed and eaten by the remaining 8. On the sixth day, 2 of the remaining 4 rats were found to harbour unembryonated eggs of C. hepatica apparently obtained from the rat they had devoured.

It is to be concluded from these observations that the percentage infection from these "dump" rats is not an accurate one and is probably far short of the actual figure. Why original infections were not found is rather surprising when chance "carriers" seemed to appear relatively often. Except for the case cited above, the chance that any two "carrier" rats could have obtained their infections from the same source is small since infections occurred at time intervals of three weeks or more.

C. hepatica has been reported from France, Italy, Australia, England, U.S.A., Japan, China and India. Hall gives a good account of this worm.

Mastophorus muris var. muris.

Syn. (Protospirura muris), was found only once in the anterior part of the small intestine bordering on the stomach. The specimin was a female measuring 36.2 mm. long.

Hall gives a good account of this worm which has a cosmopolitan distribution.

## (iii) Ectoparasites

Table 4

| (a) Lice | percent incidence |
|---|---|
| Polyplax spinulosa (Burmeister) | 7.3 |
| (b) Mites | |
| Echinolaelaps echidninus Berlese. | I.3 |
| Laelaps sp. (Koch) | 4.0 |
| Radfordia sp. | 0.66 |

Polyplax spinulosa is the common rat louse of the suborder Siphunculata or sucking lice. From the II infected rats, only 20 lice were found giving an average of I.8 lice per rat. This louse has a cosmopolitan distribution and is a vector of T. lewisi and endemic typhus from rat to rat. It does not bite man and is therefore of no direct medical importance.

Echinolaelaps echidninus was found on 2 rats in single infestations. This mite has a cosmopolitan distribution and is described by Ewing (I929) and Hirst (I9I3-I4).

Laelaps sp. was found on 6 rats with an average of 2.3 mites per infested rat. These mites were identified to genus according to Ewing.

Radfordia sp. (new genus). Only a single specimin was found and it was classified from a key given by Ewing (I938).

s has the 2 claws of tarsus 2 equal and includes the species R. ensifera, R. lemnina, R. subuliger (new species), and R. floridensis (new species). Complete identification of the mite was impossible due to damage of the body proper.

In addition to the ectoparasites mentioned above, the flour beetle Tribolium confusum Duval was found as an accidental inhabitant of the fur of a rat. This beetle was kindly identified by Dr. E. M. Whitehead, Department of Entomology, Macdonald College, and later confirmed by the author from a paper by Roth (I944).

## VI. SUMMARY AND CONCLUSIONS

(i) On examination of I50 rats, Rattus norvegicus, from the region of the "quarry" at Macdonald College, 5 protozoa, 3 cestodes, 6 nematodes, I louse and 3 mites were found, all of which had been previously reported. The percentage incidence was as follows: Protozoa: Coccidia, 28.0; Trichomonas muris, 9.0; Giardia muris, 6.0; Chilomastix bettencourti, 2.I; and Entamoeba muris, 6,7: Cestodes: Cysticercus fasciolaris, 44.6; Hymenolepis murina, I6.5; and H. diminuta, 4.0: Nematodes: Heterakis spumosa, 79.3; Nippostrongylus muris, 83.0; Trichosomoides crassicauda, 55.5; Strongyloides ratti, 8.0; Capillaria hepatica, 6.0; and Mastophorus muris var, muris, 0.66: Lice: Polyplax spinulosa, 7.3: Mites: Echinolaelaps echidninus, I.3; Laelaps sp., 4.0; and Radfordia sp., 0.66.

(ii) Over 40 percent of the rats harboured multiple infections of 4 helminths; II percent with 5 helminths; and 2 rats only with 6 helminths. These latter 2 rats harboured similar infections of 5 helminths, Cysticercus fasciolaris, Hymenolepis murina, Trichosomoides crassicauda, Nippostrongylus muris and Strongyloides ratti; the sixth in each case being Capillaria hepatica and Mastophorus muris var. muris: 4 percent had multiple infections of 3 protozoa, Giardia muris, coccidia and Trichomonas muris or Entamoeba muris, and 6 percent had double infections: only 2 rats were found to harbour the sucking louse and a mite in double infestations.

(iii) Trematodes, fleas, haematozoa, and the nematode

_____ta spiralis were not encountered at all throughout the survey.

(iv) Of the I50 rats examined, all of which were adults, 83 were males ranging in weight from II0 to 450 grams, 67 were females weighing from II0 to 380 grams excluding the 6 pregnant rats the heaviest of which weighed 385 grams with a litter of 9.

(v) The parasites found which may be transmitted to man are Hymenolepis diminuta, Capillaria hepatica, and perhaps Hymenolepis murina.

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