STUDIES ON THE PARASITIC HELMINTHS OF KOREA II. PARASITES OF THE RAT, RATTUS NORVEGICUS ERXL. IN SEOUL, WITH THE DESCRIPTION OF CAPILLARIA HEPATICA (BANCROFT, 1893) TRAVASSOS, (1915)

Byong Seol Seo, Han Jong Rim, Chan Wuk Lee, and Joo Soo Yoon.

Department of Parasitology and Institute of Endemic Diseases, College of Medicine, Seoul National University.

Many studies of rat parasites have been made in different parts of the world. Balfour (1922) reported the occurrence of parasites in 478 rats in England. Fielding (1927) reported the parasites of 222 rats in Townsville, Australia; Cram (1928) and Price and Chitwood (1931) contributed to the information of the wormburdens in the Rattus norvegicus and R. r. rattus of Washington, D.C. U.S.A. Luterns (1936) conducted a similar study on 2,638 Baltimore house rats, R. norvegicus. In Asia, Tubangui (1931) reported the parasites of almost 1,000 rats in Manila, Philippine Islands; and Wu (1930), of 69 rats in Soochow and Chen (1933) of 89 rats in Canton, China. Recently Ash (1962) reported helminth parasites of 75 rats in Hawaii.

Oldham (1931) compiled his work which gives an excellent summary of work on rat parasites in different parts of the world up to date. According to him, total number of helminth parasites reported in his paper from common rat is 109 species, comprised of 27 trematodes, 11 cestodes, 40 nematodes and 1 acanthocephalid. Out of 109 species, 69 species were found from Rattus norvegicus.

There have been several previous reports of rat parasites in Korea. Nakamura and Kobashi (1935) found Cysticercus fasciolaris and Capillaria hepatica on the liver of 1,251 house rats, and also Obara (1936) found Hymenolepis diminuta and H. nana from 70 rats examined in Seoul. On the other hand, Park (1938) reported the trematode, Echinostoma hortense Asada 1926 from R. norvegicus in Seoul. In the most recent, Seo et al. (1964) reported several trematodes of rodents. They found Echinostoma hortense and E. cinetorchis from R. norvegicus and other rodents in Seoul and other localities of Korea, and also they reported a new species of Fasciola scutellata from R. norvegicus in Seoul.

An investigation of the helminth parasites of house rats in the Seoul has been carried out in October to December 1956, January to May 1958 and July 1963 to March of 1964. A total of 325 rats were examined.

This study was carried out for the purpose of securing information on the helminths of Korean house rats and more additional informations on Capillaria hepatica which is the most common parasite of the brown rat in Korea.

MATERIALS AND METHODS

The rats were trapped from the Campus, in Seoul and its vicinity, and a total of 325 rats were secured for examinations during the survey. All the rats were autopsied in the laboratory. The organs were opened separately and helminths were isolated in normal saline solution. Trematodes and cestodes were fixed in hot alcohol-formol-acetic solution and stained in Semichon's aceto-carmine, and permanent mounts were prepared. Nematodes were fixed in hot Travassos fixative and cleared in lactophenol or glycerine and studied unmounted.

To obtain the adult worms of Capillaria hepatica, embryonated eggs cultured in laboratory, fed to white rats experimentally. Infected animals were examined at several day intervals. The resulting infections from the series of animals were examined in gross and then samples of the livers were pressed between slides and examined.
microscopically. The liver were next washed and placed in petri dishes and covered with normal saline solution at 37°C. After several hours, the worms recovered were examined for their stage of development, then fixed in hot Travassos fixative, and cleared in glycerine.

RESULTS

Helminths were found in 304(93.4 per cent) of 325 house rats. A list of the different parasites encountered and their incidence are given in Table 1. Each species is discussed with the incidence of other investigators in different parts of the world.

Table 1. Parasites encountered in 325 house rats.

<table>
<thead>
<tr>
<th>Name of Parasites</th>
<th>Infestation Number</th>
<th>Per cent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trematoda:</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Echinostoma hortense</em></td>
<td>4</td>
<td>1.2</td>
</tr>
<tr>
<td><em>Fibricola scouleri</em></td>
<td>2</td>
<td>0.6</td>
</tr>
<tr>
<td>Cestoda:</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Taenia taeniaformis</em> (Larval for m)*</td>
<td>65</td>
<td>20.0</td>
</tr>
<tr>
<td><em>Hymenolepis diminuta</em></td>
<td>52</td>
<td>16.0</td>
</tr>
<tr>
<td><em>Hymenolepis nana</em></td>
<td>4</td>
<td>1.2</td>
</tr>
<tr>
<td>Nematoda:</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Heterakis siphonura</em></td>
<td>162</td>
<td>49.9</td>
</tr>
<tr>
<td><em>Syphacia obvelata</em></td>
<td>55</td>
<td>17.0</td>
</tr>
<tr>
<td><em>Nippostrongylus muris</em></td>
<td>160</td>
<td>49.2</td>
</tr>
<tr>
<td><em>Trichosomoides crassicauda</em></td>
<td>79</td>
<td>24.3</td>
</tr>
<tr>
<td><em>Capillaria hepatica</em></td>
<td>286</td>
<td>88.0</td>
</tr>
</tbody>
</table>

TREMATODA

Genus *Echinostoma* Rudolphi, 1809
*Echinostoma hortense* Asada, 1926

This species was collected from 4 (1.2 per cent) of the 325 brown rats. Asada (1926) found this parasite experimentally in white rats fed with cysts from tadpoles which had been infected with cercariae from *Lymnaea japonica* and *L. periova*. Yamaguti (1933) found in the small intestine of a naturally infected *Rattus norvegicus* in Japan. The first report of this parasite from Korea was reported by Park (1938) in the area of Seoul. Seo et al (1964) have found this species from small intestine of *R. norvegicus*, *R. r. alexandrinus*, *Mus musculus yamashinai*, and *Microtus fortis pelleceus* in several districts in Korea.

Genus *Fibricola* Dubois, 1932
*Fibricola scouleri* Seo, Rim and Lee, 1964

This species was collected from 2 (0.6 per cent) of the 325 *Rattus norvegicus* in the present survey. This was reported by Seo et al (1964) as a new species in their studies of trematodes of rodents. The occurrence of the species of Diplostomidae is very rare from rats. The only one previous report of *Fibricola caballeroi* have found by Zerecero (1943) from *Rattus norvegicus* in Mexico.

CESTODA

Genus *Taenia* Linneaus, 1758
*Taenia taeniaformis* (Batsch, 1784)
Wulffügel, 1911

The larval stage of this tapeworm is commonly known as *Cysticercus fasciolaris* Rudolphi, 1808. It is practically cosmopolitan in distribution and one of the common parasite of the brown rat. *C. fasciolaris* was found on the liver of 65 (20 per cent) of 325 rats examined. The adult stage has been found only in cats.

Tubangui (1931) found it in 94 per cent of 950 brown rats examined at Philippine Islands, while Wu (1930) and Chen (1933) found 44.8 per cent and 41.7 per cent in Soochow and Canton, China respectively. In Korea, Nakamura and Kobashi (1935) found 41.3 per cent of 1,251 rats from Seoul.

Genus *Hymenolepis* Weinland, 1858
*Hymenolepis diminuta* (Rudolphi, 1819)
Blanchard, 1891

This species was found 16.0 per cent in the present survey. This is the tapeworm occurring most frequently in rats all over the the world. It has been reported rather infrequently from man. Ogura (1936) found 10(14.9 per cent) instances from 70 rats examined in Seoul. Tubangui (1931) reported a 64.0 per cent infestation of rats examined in the Philippine, and in China, Chen (1933) reported it 1.19 per cent of Canton rats and Wu (1930), 16.8 per cent of Soochow rats. Luttermoser (1936), 16.6 per cent of Baltimore house rats in United States.

*Hymenolepis nana* (Siebold, 1852)
Blanchard, 1891

This, the dwarf tapeworm, is common parasite of rats
and of human beings in many parts of the world, especially in tropical and subtropical countries. Chandler (1927) concluded from his observations that rats are an important epidemiological factor in the dissemination of *H. nana*. Ogura (1936) reported that rat strain of *H. nana* found to be transmissible to children through his experimental infection of two children, and also human strain of *H. nana* found to be transmissible to albino rats and mice. Otherwise Shorb (1933) found that mice and rat strains were physiologically different from the human strain. Stoll (1947) estimated the world incidence to be 20.2 millions mostly in the U.S.S.R. and Asia. The occurrence of this parasite in human beings in Korea has been recorded by Ogura (1936) who found 2 cases from 3,000 school children in Seoul, and by Soh et al. (1961), who found 32 (0.2 per cent) *H. nana* infections from 14,682 fecal samples obtained from Severance Hospital outpatients. Rim (1963) reported 0.6 per cent of its infection from 1963 fecal samples from Korean army soldiers.

*H. nana* was found in only 1.2 per cent of the series of 325 rats in the present survey. Ogura (1936) found 3 (4.3 per cent) instances of *H. nana* from 70 rats examined in Seoul. Tubangui (1931) found also the worm in 1.7 per cent of rats examined in Philippine. Wu (1930) and Chen (1933) found 6.0 and 4.76 per cent of rats examined in China respectively. In the United States, Luttermoser (1936) found 11.4 per cent of Baltimore rats, Harkema (1936) found 28 per cent of 55 North Carolina’s brown rats.

**NEMATODA**

**Genus Heterakis** Dujardin, 1845

*Heterakis spumosa* Schneider, 1866

This nematode parasite of the cecum of the rats is cosmopolitan in distribution. A rather high incidence of 49.9 per cent of this parasite were found in the present survey. While in Philippine and China, it was found very low incidence 0.4 and 1.19 per cent respectively. In the United States, Luttermoser (1931) found 1.6 per cent, but in Hawaii Ash (1962) reported 46 per cent of his 75 house rats examined.

**Genus Syphacia** Seurat, 1916

*Syphacia obvelata* (Rudolphi, 1802)

Seurat, 1918

The nematode, which occurs in the cecum and large intestines of rats and mice, is cosmopolitan in distribution (Hall, 1916). Its occurrence in the house rats from Seoul is 17.0 per cent. Chen (1933) found this parasite 2.38 per cent of Canton rats, Luttermoser (1936) reported 1.6 per cent of Baltimore house rats, Ash (1962), on the other hand found 44 per cent of 75 house rats from Hawaii.

**Genus Nippostrongylus** Lane, 1923

*Nippostrongylus muris* (Yokogawa, 1920)

Lane, 1923

This worm was usually in great abundance, and was found especially in the upper part of the intestine. In the present survey, it was found 49.2 per cent. Tubangui (1931) found it 58.0 per cent from Philippine house rats and Chen (1933) found 23.8 per cent of Canton rats. While in the Baltimore and Hawaii rats show 16.8 and 17.0 per cent of its incidence respectively.

**Genus Trichosomoides** Railliet, 1895

*Trichosomoides crassicaudata* (Bellingham, 1840) Railliet, 1896

This nematode occurs in the urinary bladder of the rat, and is cosmopolitan in distribution. The incidence of this worm is 24.3 per cent. Luttermoser (1936) found the parasite in 90.4 per cent of Baltimore house rats. Tubangui (1931) reported 57.0 per cent of brown rats from Philippine. Chen (1933) reported 11.9 per cent of Canton rats. Ash found 17.0 per cent of Hawaii house rats.

**Genus Capillaria** Zeder, 1800

*Capillaria hepatica* (Bancroft, 1893)

Travassos, 1915

This worm appears to be one of the commonest parasites of the brown rat in Korea, it could be recognized easily by the presence of irregular white or yellowish appearances on the surface of the liver, which is due to the presence of eggs deposited by the adults which live inside of the liver. Worms or ova of this species have been recorded from a variety of mammals, chiefly rodents. In the present survey heavy infestations with the eggs of this parasite were found 283 rats, *Rattus norvegicus*, of 325 examined, an incidence of 88.0 per cent in Seoul. Nakamura and Kobaishi (1935) found this worm 36.0 per cent of house rats from Seoul. Tubangui (1931) reported 90.0 per cent of
the brown rats in the Philippines. Luttermoser (1936) reported 85.6 per cent of the Baltimore house rats. In the China, Wu (1930) and Chen (1933) found 30.4 and 7.1 per cent in Soochow and Canton respectively. Momma (1930) found 1,272 (57.2 per cent) out of 2,222 house rats examined in Osaka, Japan.

In the human beings, up to present time, eleven cases were reported in several parts of the world; the first case was reported by MacArthur (1924) the British soldier who died after three years of service in India, five cases were reported from United States (McQuown, 1950; Otto et al., 1954; Ewing et al., 1956; Ward et al., 1959; and Calle, 1961), two cases from South Africa (Cochrane et al., 1957; Kallichurum, 1961), and each one case from Turkey (Turhan, 1954), Mexico (Romero Garcia et al., 1962) and Brazil (Piazza et al., 1963).

Capillaria hepatica was formerly placed in a separate genus Hepatolca (Halls, 1916), because it was believed to lack bacillary bands and a copulatory spicule, but Baylis (1931) showed that both structures are present and hence the species belongs in Capillaria, and also he described in detail on the structure of C. hepatica obtained from woodmice (Apodemus sylvaticus) in England. However, he measured with only the fragments of the worm, therefore it seems desirable to provide a more complete description of this worm based on Baylis.

Description: Body capillary divided into anterior esophageal and posterior portions. Esophageal portion apparently shorter than the posterior portion, which is only slightly thicker. The length of the anterior portion of esophagus free of surrounding cells, is 0.43 to 0.46 mm long; the rest passes through a chain of 27 to 28 large esophageal cells. Cuticle delicately striated, dorsal and central bacillary bands are present especially conspicuous in the esophageal portion, these are longitudinal tracts of minute projections that constitute the outlets of subcuticular glands. The mouth is simple, without lips; the arrangement of the head papillae is not known.

Male: 23.2 to 35.9 mm long and 0.046 to 0.063 mm thick at esophago-intestinal junction; esophagus, 5.18 to 7.00 mm long, which is equal to one-third of total body length. A quite well developed spicule is present, it appears to be rather slightly chitinized; 0.336 to 0.396 mm length, and slightly expanded at the root, cylindrical for the greater part of its length; and lightly fusiform thickening towards its distal end. Its tip tapers to a fine point. The spicule is contained in a protrusible membranous sheath (0.231 to 0.297 mm by 0.050 to 0.066 mm), the distal end of this sheath is capsule of expansion to form a large funnel-shaped dilatation. The cloacal aperture is subterminal, and is overhung posteriorly by a very short projection, showing a faint indication of division into a pair of lobes and bearing a pair of papillae on its ventral surface.

Female: 74.5 to 81.1 mm long and 0.116 to 0.154 mm thick at esophago-intestinal junction; esophagus 6.72 to 7.81 mm, which is equal to between one-ninth and one-tenth of total body length. The vulva is provided with a protrusible, membranous, funnel like structure at closely behind the esophago-intestinal junction. Tail very short, blunt and conical. Eggs lemon-shaped, with polar opercula, 0.053 to 0.059 mm by 0.030 to 0.033 mm in size, double walled, outer eggshell pitted, inner shell homogeneous.

DISCUSSION

Ten species of helminths have recorded from house rat, Rattus norvegicus in Seoul; viz. Echinostoma hartense, Fibricola soudensis, larval form of Taenia taeniaformis, Hymenolepis diminuta, H. nana, Heterakis spumosa, Syphacia obvelata, Nippostrongylus muris, Trichosonodes crassicaudata and Capillaria hepatica. All the species except two of the trematode are practically cosmopolitan in distribution and common parasites of the brown rat.

Several workers have mentioned the occurrence of Clonorchis sinensis and Paragonimus sp. in the common rats. However those parasites are not found in this survey. Muto (1920) and Ando (1922) found a specimen of C. sinensis from R. norvegicus captured on the shores of Lake Biwa. Wu (1930) reported 5.2 per cent of C. sinensis from 69 rats in Soochow, and Chen (1932) found a single individual of C. sinensis from Canton rats. On the other hand Chen (1933) found two of immature form of Paragonimus sp. from lungs of two rats, however species was not determined at that time. Chen (1935, 1936) has made several reports on the life history of Paragonimus from rats, and then he established Paragonimus iloktsuensis as a new species. (Chen, 1940)

The three species of Euparyphium were reported in the Philippines by Tubangui (1931), but Soco et al (1964) found E. murinum from wild rat, Apodemus agrarius at
Kumwha district of Korea.

An attempt to find *Trichinella spiralis* and *Angiostrongylus cantonensis* in the rats, examination of diaphragm and lungs were made during the present survey. All the examinations persistently show negative results. Luttermoser (1936) found 1.2 per cent of *T. spiralis* larvae encysted in striated muscles of brown rat, however Balfour (1922) had never found it in any of 444 brown rats examined in England. (1933) Chen also had never found the parasite after the thorough examination of all diaphragms of collected Canton rats.

*Angiostrongylus cantonensis* was originally described under the genus *Pulmonema* by Chen (1935) but Dougherty (1946) placed in synonym with *Angiostrongylus*. The species has been reported from China, Formosa, Australia and Hawaii (cited from Ash, 1963).

*Strongyloides ratti*, which is quite common parasite of rats, has previously been recorded in 74 per cent of Manila, 11.9 per cent of Canton, 20.2 per cent of Baltimore, and 59 per cent of Hawaii, but we could not find this worm in the present survey.

In order to find *C. sinensis*, *Paragonimus sp.*, *A. cantonensis*, *S. ratti*, and others, the further studies are required from various localities particularly in rural areas.

**SUMMARY**

An investigation of the helminth parasites of house rat, *R. norvegicus* Erxl. in Seoul has been carried on for four years. A total of 325 rats was examined. Ten species of helminths were considered, of which 4 species were recorded for the first time from Korea.

The adult worms of *Capillaria hepatica*, the most common parasite of house rats in Seoul, was observed experimentally, and provided a more complete description of this worm.

**REFERENCES**

1. Andu, A. (1922): Studies on the intestinal trematodes as that find the final host in the rat. Aichi Izukokwai Zasedi, 29 (1).
3. Ash, L.R. (1962): The helminth parasites of rats in Hawaii and the descriptions of *Capillaria traveera*, sp.n.
39. Tubangui, M.A. (1931): Worm parasites of the brown rat (Mus norvegicus in the Philippine Islands, with special reference to these forms that may be transmitted to human beings. Philippine Jour. Sc. 6, 637~587.
이 제목의 '寄生蠕蟲類에 關한 研究 II.'

서울市內의 家鼠, Rattus norvegicus Erxh.의 寄生蠕蟲,
及 Capillaria hepatica (Bancroft, 1893)
Travassos (1915)의 形態學的 補遺

서울大學校 醫科大學 寄生蠕蟲學教室 及 常病研究所
徐丙高・林漢鎬・李燦旭・尹順鐘

韓國의 寄生蠕蟲類研究의 一部로서 서울市內에 時常出入의 家鼠의 蠕蟲類을 調査 하였다. 家鼠는 1956年부터 1964
年 3月까지 補獲한 325匹을 調査對象으로 하였다.
蠕蟲感染率은 93.4% (304匹)이고 發見된蠕蟲類는 다음과 같다.

吸虫類: Echinostoma hortense (1.2%), Fibricola seoulensis (0.6%)

營虫類: Taenia taeniaformis의 幼虫(Cysticercus fasciolaris) (20.0%), Hymenolepis diminuta (16.0%); Hymenolepis
nana (1.2%)

線蟲類: Heterakis spumosa (49.9%), Syphacia obvelata (17.0%) Nippostrongylus muris (49.2%), Trichosomoides
crassicauda (24.3%); Capillaria hepatica (88.0%).

以上発見된 10種의 線蟲類 4種 (H. spumosa, S. obvelata, N. muris, 및 T. crassicauda)은 韓國에서 처음으로 記錄
される것이다.

서울市內의 家鼠에 가장 많이 時常出入하고 있는 Capillaria hepatica는 그 細長한 成蟲이 肝組織內에 爲지어 있어 完
全한 成蟲発育を 分離하기 困難하다. 蠕蟲의 形态 및 完全한 形態學의 記載가 되어있지 않은 故로 著者들은 實驗的
으로 C. hepatica의 幼虫無害性을 白鼠에 感染시켜 完全한 雄雌発育을 肝組織으로 부터 分離하였다. 蠕蟲発育 및 食
道周圍細胞 交換 및 蠕蟲陰門에 面하여 細密한 形態學의 検討를 하여 過去에 報告인 Baylis의 記載를 補遺하였다.
EXPLANATION OF PLATE

Fig. 1. Infected rat liver with *Capillaria hepatica*, showing the presence of the adults in the liver.

Fig. 2. Egg of *C. hepatica*. (360×)

Fig. 3. A complete female specimen of 20 days old. (32×)

Fig. 4. A osophagal cell of worm embayed in liver from stained section. (400×)

Fig. 5. Posterior part of a male worm showing a spicule and spicule sheath. (100×)

Fig. 6. Oesophago-intestinal junction of a female worm showing a vulva provided with a protrusible membranous funnel like structure and eggs in a uterine tubule. (100×)