

CYSTICERCUS FASCIOLARIS AND CAPILLARIA HEPATICA IN RATTUS NORVEGICUS

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Borrel (1907, 1909; see also Roux, 1906), one of the first investigators to test the parasitic hypothesis of the etiology of cancer, examined the livers of wild rats, *Rattus norvegicus* and *Rattus rattus*, for the presence of *Cysticercus fasciolaris*, the larval stage of the cat tapeworm, *Taenia taeniaformis*, and found a wide variation in the incidence of this parasite in different localities. The frequency of occurrence of liver sarcoma in infected wild rats was consistently low. Since all wild rats as well as experimental rats thus infected did not develop cancer of the liver, Borrel proposed the idea that a virus carried by some cysticerci but not others was responsible for the initiation of the sarcomatous condition. Further evidence indicating that *C. fasciolaris* may act as a sarcoma-virus-carrying parasite was obtained by Borrel and Larrouse (1931) and these workers (1932) demonstrated the development of both dendritic and diffuse adenoma in rats infected with *C. fasciolaris*. Bridre and Conseil (1909) examined 2000 wild rats, *R. norvegicus* and *R. rattus*, in Tunis and found 800 (40%) infected with *C. fasciolaris* but only 5 liver tumors were found, 4 of which contained strobilocerci. Further studies by Bridre and Conseil (1910) of 3800 wild rats from Tunis and 1970 wild rats from Algiers revealed, respectively: 760

(20%) infected with *C. fasciolaris* but only 2 showing liver sarcomas and 614 (31%) infected with *C. fasciolaris* but only 4 showing liver sarcomas. McCoy (1909) reported on autopsies of 100,000 American wild rats, *R. norvegicus*, at the Federal Plague Laboratory in San Francisco and stated that 22 primary tumors of the liver were seen, in 12 of which he found *C. fasciolaris*. The number of rats parasitized by this form in McCoy's study unfortunately is not mentioned. Due to the large numbers of animals examined and the speed deemed necessary the search was at best a cursory one. This worker claimed that where there was distinct tumor formation the parasite was almost invariably dead and partly disintegrated. In this connection, Hiyeda and Oiso (1929) in a study of wild rats, *R. norvegicus* and *R. rattus*, infected with *C. fasciolaris* claimed that polymorphous sarcoma of the liver resulted from dead or inactive worms while spindle cell sarcomas were developed around cysts containing live, active larvae. In another study during the attempt to eradicate the plague in San Francisco, Woolley and Wherry (1911-1912) reported 22 spontaneous tumors of the liver in *R. norvegicus* observed in routine autopsy of 23,000 animals. Again, a count was not made of rats parasitized with

C. fasciolaris and only 3 of the 22 tumors noted were sarcomas containing *C. fasciolaris* strobilocerci. More recently Tsuchiya and Rector (1936) found 72 out of 100 *R. norvegicus* from the St. Louis area infected with this liver parasite, but no sarcomas were noted. Brumpt (1934) encountered *C. fasciolaris* in 288 of the 750 *R. norvegicus* examined in Caracas. From 1 to 5 cysts were observed in individual rats but in none was there evidence of liver sarcoma. More recently Calera *et al.* (1950) found 40 of 400 *R. norvegicus* in Panama City and suburbs infected with *C. fasciolaris* and Li and Hsu (1951) recorded 165 cases of *C. fasciolaris* infection in 358 rats, *R. norvegicus* and *R. rattus*, from the Taiwan area in Formosa. No reference was made to liver sarcomas in either of these latter two studies.

Examination of 532 *R. norvegicus* obtained from the city dump area of Bloomington, Illinois, revealed the livers of 428 animals (80.5%) infected with *Cysticercus fasciolaris* strobilocerci and the livers of 127 animals (23.9%) infected with the nematode, *Capillaria hepatica*. It was not the original intention of the authors to examine rats for this roundworm. However, since nests of eggs (Fig. 1) of this parasite were observed along with cysticerci in the livers of some of the first animals examined, the decision was made to record its incidence. It is interesting to note that only 10 of the 127 animals harboring this liver nematode were found infected with it alone; the rest (117) showed livers infected with both *C. fasciolaris* and *C. hepatica*. While no particular significance relating to this

association of a cestode and a nematode parasite in the liver of the wild rat has been definitely established, it is entirely possible that trauma of the liver caused by invasion by *Taenia* oncospheres could facilitate a portal of entry for the larvae of *C. hepatica*. According to Luttermoser (1936) the incidence of this nematode in wild rats varied considerably in different areas and has been found to be as high as 77% in the District of Columbia and 85.6% in Baltimore, Maryland. Fullborn (1924) and Luttermoser (1938a, 1938b) have shown that the life cycle of *C. hepatica* is direct from rat to rat without an intermediate host. However, according to these workers, the eggs to be infective must first be exposed to air until embryonated. Upon ingestion of embryonated ova, larvae are hatched in the intestine, pass through the wall of the caecum into the blood stream, and are carried to the liver. There is no evidence that the parasite is capable of inciting sarcoma of the liver.

The livers of all wild rats obtained for the study reported here were examined within two to four hours after the animals were killed. Gross inspection of each liver for cysts was followed by careful slicing of the liver with a sharp scalpel to locate cysticerci and egg nests of *C. hepatica*. Infected tissue was preserved in Bouin's, sectioned, and stained with Delafield's hematoxylin and eosin.

Cysts containing *C. fasciolaris* found in individual rats varied from 1 to 13 in number and ranged from 2 to 9 mm. in diameter (Fig. 2). Mode and mean of numbers of cysts in infected rats were, respec-

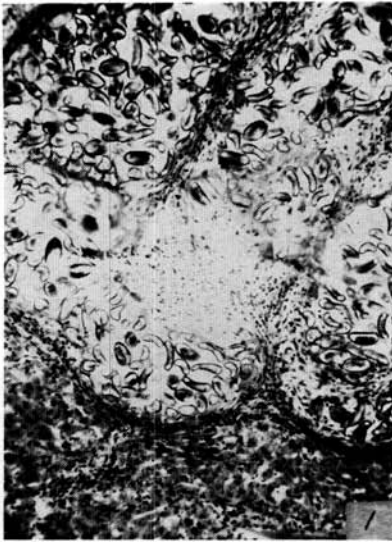


FIG. 1.—Photomicrograph of nests of *Capillaria hepatica* ova in liver of wild rat. 85x.

tively, 5.0 and 5.03. Strobilocerci when expelled from cysts measured from 2 to 8 cm. in length (Fig. 3). Specimens exhibited the characteristic scolex with 4 suckers and a rostellum bearing a double row of 32 to 44 hooks. *Taenia taeniaformis* developed in 6 experimental cats in 70 to 90 days following the feeding of cysticerci from captured wild rats. With reference to the life cycle of this organism it is interesting to note that the number of adult worms found in 50 cats in this area varied from 1 to 7 per cat with an incidence of 80% infection. Mode and mean of number of worms in infected cats were, respectively, 3.0 and 3.2. In this connection, Cross and Allen (1948) found 19 of 51 cats in Chicago infected with this tapeworm. Mann and Fratta (1952) found 8 of 100 cats in northern New Jersey harboring *T. taeniaformis*,

and Miller (1932) found the rather astounding number of 22 mature and 2 immature *T. taeniaformis* in one cat.

None of the 428 wild rats found infected with *C. fasciolaris* in this study had developed liver tumors, such as were found in any of the studies referred to above, or polymorphous and spindle cell sarcomas as described by Bullock and Curtis (1920, 1925, 1928) and Curtis, Dunning and Bullock (1934) in experimental rats. Histological evidence of cellular and tissue changes which apparently do lead in some cases to liver sarcoma in regions adjacent to encysted larvae (Curtis and Bullock, 1924) were observed in 5 of the 428 infected rats. Areas of fibrosis in and near the cyst wall with abnormal cells proliferating from, and in both close and remote association with, the capsules surrounding strobilocerci together with

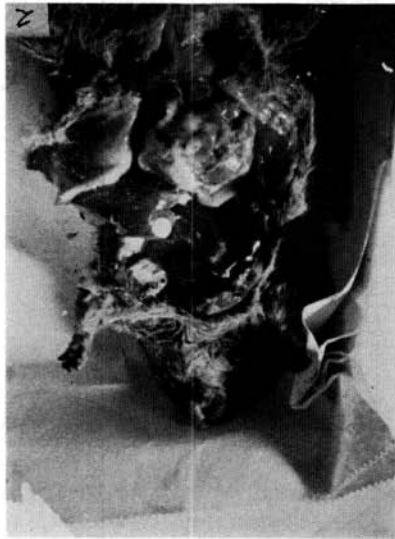


FIG. 2.—Photograph of *Cysticercus fasciolaris* cysts in liver of wild rat. 0.5x.



FIG. 3.—Photomicrograph of *Cysticercus fasciolaris* strobilocercus. 8x.

pronounced eosinophilic necrosis were observed in these few animals but no definite sarcomas had developed. It may be that because of the close cat and rat association in this area, rats do not live long enough after acquiring the infection to develop liver sarcoma. The results of this study are in agreement with the early work of Borrel (1907, 1909) and with other studies in that, while *C. fasciolaris* may occur in a fairly high percentage of wild rats, the incidence of cysticercus sarcoma is very low.

Bullock, Curtis and Dunning (1920, 1925, 1928, 1934) over a period of about 14 years infected thousands of laboratory rats with *C. fasciolaris* and observed the progression of liver tumors in many of these animals. Various types of malignant tumors were studied and in most instances were found during the 6-month period between the 11th and 17th months following infection. These investigators mentioned the strong probability of a sarcoma-inciting agent associated only with certain individual larvae, which is in agreement with the earlier contention of Borrel (1909). However, no virus or other cancer-inciting agent has ever been demonstrated to be in association with cysticerci. The problem of why liver sarcomas develop in some rats infected with *C. fasciolaris* but not in others harboring the same parasite has not been solved.

Studies on the details of progressive tissue changes in the livers of white rats experimentally infected with *C. fasciolaris* and attempts to infect golden hamsters in this laboratory are nearly completed. Findings thus far in white rats have revealed: 1) a remarkably high tolerance of extremely heavy infections; 2) further evidence of early pre-sarcomatous tissue changes; 3) additional data on early developmental states of the parasite; and 4) several liver sarcomas associated with *C. fasciolaris*. One accidental infection has been reported in the golden hamster, *Mesocricetus auratus*, by Wantland (1953). These rodents are refractory to this parasite.

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SUMMARY

Examination of 532 wild rats, *Rattus norvegicus*, showed the livers of 428 animals (80.5%) infected with *Cysticercus fasciolaris* strobilocerci and the livers of 127 animals (23.9%) infected with *Capillaria hepatica*. Cysticerci found in individual rats varied from 1 to 13 in number (mean 5.03) and ranged from 2 to 9 mm. in diameter. The livers of five of the animals infected with *C. fasciolaris* showed cellular and tissue changes which may lead in some cases to liver sarcoma, but no definite liver tumors were observed. *Taenia taeniaformis* devel-

oped in experimental cats after feeding cysticerci from captured rats. White rats fed large numbers of *T. taeniaformis* ova developed extremely heavy infections which were tolerated very well.

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