AN ABSTRACT OF THE THESIS OF

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Title MERIONES UNGUICULATUS, A NEW EXPERIMENTAL HOST FOR FASCIOLA HEPATICA

Abstract approved (Major professor)

The literature relating to fascioliasis in experimental hosts, and the clawed jird (Meriones unguiculatus) as an experimental host was reviewed.

Four experiments were conducted using experimental hosts for Fasciola hepatica. The first two experiments were done using Swiss mice, B. P. laboratory albino strain; the third and fourth experiments involved the clawed jird.

The metacercariae of F. hepatica used in the first three experiments were obtained from Weybridge, England, and from Lymnaeid snails maintained by the Department of Veterinary Medicine, Oregon State University, Corvallis, Oregon. Metacercariae from the latter source were used in experiment number four.

An individual dose of 20 and 10 metacercariae proved fatal to mice 26 to 29 and 27 to 31 days following infection, respectively. A similar fatality pattern was observed in experiment number three.
from day 27 through 33, when the clawed jird was infected with 20 metacercariae. In experiment number four, the dosage of metacercariae given to five groups of clawed jirds was as follows: 1, 2, 4, 8, and 16. Similar death losses were observed in animals receiving 4, 8 and 16 metacercariae from day 26 through 36. No lesions were observed in the two groups receiving one and two metacercariae, or the controls. The absence of lesions in the two infected groups was attributed to the administration of nonviable metacercariae.

Necropsy of infected animals that died revealed hemoperitoneum, fibrinous peritonitis, and severe hepatic necrosis. Histological examination of liver sections from these animals revealed necrosis, infarction, and organized hemorrhages. Evidence of inflammatory response was observed around the fluke's burrows and the hepatic trinities. Biliary hyperplasia was evident and flukes were observed in the hepatic parenchyma.

Flukes recovered from the liver and from peritoneal washings compared favorably in size with previous reports in mice.

The mouse as an experimental host for fascioliasis has been established by others. This study confirmed this finding. Although *F. hepatica* was not observed to complete its life cycle in the clawed jird, the susceptibility of this host for *F. hepatica* was demonstrated.
MERIONES UNGUICULATUS, A NEW EXPERIMENTAL HOST FOR FASCIOLA HEPATICA

by

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MERIONES UNGUICULATUS, A NEW EXPERIMENTAL HOST FOR FASCIOLA HEPATICA

INTRODUCTION

Laboratory animals as experimental hosts are desirable for several reasons in research involving the biological sciences. Economically, they are less expensive and more readily obtainable than other animals, and the facilities required for their care, feeding, and shelter are correspondingly less. Administration of infective materials or drugs, and the collection of blood or fecal samples is easily accomplished in experimental animals. Their smaller size permits 24 hour collections of excreta rather than a sample. Likewise, for parasitological studies, their entire alimentary tract can conveniently be examined. Laboratory animals also permit experimental designs having less variation with regard to size, sex, age, and genetic origin.

As early as 1893, Lutz used rats, rabbits, and guinea pigs as hosts for Fasciola gigantica (13, p. 99). Several animals have been shown to be valuable hosts for experiments with Fasciola hepatica. These include the rabbit (27), guinea pig (37), mouse (41), albino rat, syrian hamster, and cotton rat (22).

Meriones unguiculatus, the clawed jird (34) also called the Mongolian gerbil (35), (Figure 1 and Appendix I) and known by the native
Figure 1. *Meriones unguiculatus*, the clawed jird.
names of sand rat, desert rat, and jird (35) seems to incorporate many advantages of other laboratory animals with few of the disadvantages. It is a clean, odorless and docile animal that readily adjusts to laboratory conditions. Unlike some laboratory species the jird rarely bites when being handled.

Found naturally in arid regions, its water intake is low, consequently its daily output of urine is lower than most laboratory animals. This results in reduction of ammonia odor and simplifies maintenance.

Although the jird is more expensive than other laboratory animals, its research value lies in its unique susceptibility to a wide variety of experimentally-induced disease agents.

In 1933, Leiper announced the use of this animal as an experimental host for *Hymenolepsis sp.* (24). Studies on bilharziasis, cited by Schwentker (35), using the jird were done in 1948 in Egypt by Watson et al., and in England in 1950 by Abdel and Cowper. The jird has also been shown to be an excellent experimental host for *Echinococcus multilocularis* (31, 45). Since then, it has been demonstrated as a host for *Trichostrongylus axei* (18, 25), *Dipetalonema witei* (44), *Ascaris suum* (4), *Angiostrongylus cantonensis* (19), *Nanophyetus salmincola*, and *Trichinella spiralis* (20).

Cross (6) reported the jird to be susceptible to primary infection with *Nematospiroides dubius*, but this animal failed to pass eggs in
the feces longer than 32 days, as compared to control mice which passed eggs for eight months. The jird was also completely refractory to reinfection.

One other possible disadvantage of the jird as an experimental host for rickettsial disease agents is the presence of *Haemobartonella* sp. (30) in a high percentage of animals. This infection is apparently prenatally transmitted.

The purpose of the present study was to determine whether *Meriones unguiculatus*, the jird, would serve as an experimental host for *Fasciola hepatica*. 
REVIEW OF THE LITERATURE

The literature related to experimental fascioliasis, and the jird as an experimental host for parasitic disease, has been discussed. The following review of the literature will be divided into disciplines dealing with histopathology, hemopathology, and route of infection, in experimental fascioliasis.

**Histopathology**

The pathogenesis of fascioliasis may be divided into an acute and a chronic phase.

**Acute Fascioliasis**

The penetration of the liver capsule by immature liver flukes initiates the acute phase and is characterized by localized peritonitis and traumatic hepatitis (42, 43). As the immature fluke burrows through the hepatic parenchyma an inflammatory tissue response is manifest by leukocytic accumulations and granulation tissue around the tracts (43). The damage produced increases with time because of the rapid growth of the fluke. Upon entering the liver of the mouse, the fluke is 0.3 mm in length, and 11 days later it is six times as large (8). Infarction with resultant necrosis appears during this phase as a result of vessels having been severed, by thombus formation, and possibly by inflammatory changes within the vessel walls.
(43). The burrows, or tracts contain debris from excavation, erythrocytes and leukocytes, macrophages, and a proteinaceous mass that stains in a manner similar to the cytoplasm of the hepatic cells (7). Also, the hepatic cells immediately adjoining the narrow connecting channels of the burrow show a marked similarity in staining to that of the epithelium of the fluke's ceca. This similarity was attributed to action of an intestinal enzyme from the fluke acting upon the aforementioned cells. As the immature fluke continues to burrow, the granulation process that will ultimately end with scar tissue formation, results (7).

Biliary hyperplasia has been described in fascioliasis (11, 42). In mice, hyperplasia developed while the young fluke was still in the hepatic parenchyma. This occurred before the third week of infection (11). In some cases, as the disease progressed, the tall columnar epithelium was thrown up into folds which resembled compound epithelium (29). A cytoplasmic change involving swelling of the epithelial cells with cytoplasmic fluid which resembled goblet cells of the intestinal epithelium has also been reported (11, 29). Fibrosis and submucosal edema may occur with the epithelial hyperplasia. This results in a thickened, laminated appearance; in cattle, calcification occurs (29, 39). Finzi reports bile duct dilation in rabbits which may result in cyst formation and atrophy of the wall, rather than stenosis (14).
Chronic Fascioliasis

The chronic phase of fascioliasis is characterized by the presence of liver flukes in the bile ducts. This may take eight to nine weeks in the rabbit (43) although flukes have been observed in the bile duct of the mouse 24-32 days following infection (8, 9, 21, 23). Dawes has suggested that the hyperplastic reaction was perpetuated by mechanical irritation of the cuticular spines of the fluke, aided perhaps by the suckers, and that hyperplasia of the biliary epithelium was a host defense mechanism. This reaction may provide the parasite with "a readily available pasture" upon which to feed after entering the biliary system (12).

Though the liver and bile ducts are the usual habitat for *F. hepatica*, it has been found in the lungs of rats (42); cattle (5); and sheep by Mychlis, as cited by E. M. Pantelouris (32, p. 124). In this abnormal location the parasite apparently was not reported to reach sexual maturity (32, p. 124).

This trematode has also been found in lymph nodes (7) and cited by E. M. Pantelouris (32, p. 124) where, histologically, hyperplasia of the elastic tissue of the capsule and trabeculae was seen (5). Pantelouris reported that Thom found this fluke in the uterus of cattle (32, p. 124), and that it caused endometritis and sterility. This suggests a possible explanation for fascioliasis in animals under
three months of age (32, p. 125).

**Hemopathology**

_Fasciola hepatica_ has been suggested as a primary cause of anemia in parasitized animals, however this has been disputed by Dawes (12).

Considerable work has been done on the hemopoietic response to infection with _F. hepatica_. The two most consistent findings reported were anemia and eosinophilia. Jennings _et al._ (16, 17) using $^{32}$P-labeled erythrocytes and $^{131}$I-labeled serum albumin, demonstrated in rabbits a $^{32}$P/$^{131}$I ratio in flukes, consistently higher than that of the circulating blood. They calculated that this host lost 0.2 ml of blood per fluke per day. The resultant anemia produced was comparable to the anemia induced by daily removal of 3.5 ml of blood from the ear vein of the rabbit, demonstrated by Steele and Oberg as cited by E. L. Taylor (40, p. 27). Morrill and Shaw (29) reported decreasing erythrocyte counts in cattle, through eighteen weeks of infection. This was followed by a period of fluctuating counts, and later by a gradual increase in total erythrocytes. They also demonstrated an eosinophilic increase two to three weeks postinfection, followed by fluctuating counts. A seasonal eosinophilic increase was coincidentally noted in the control animals during December and January. Balian obtained similar results with sheep and cattle, but he expressed the opinion that the anemia may have
resulted from toxins produced by the fluke (1). Holman, as cited by E. L. Taylor (40, p. 138), has suggested that the anemia observed might result simply from massive liver destruction. The eosinophilia described was further corroborated by Sinclair, in E. M. Pantelouris (32, p. 133) and Moroshkin et al., (28) in sheep and calves respectively.

A study of bone marrow in bovine fascioliasis revealed increased production of granulocytic and erythroblastic series (26). A similar response was observed in ovine fascioliasis (2). Pautrizel et al. reported a transient rise in eosinophils in sheep, 7 and 24 hours following intradermal injection of adult F. hepatica extracts (33).

Dawes (12) has contended that F. hepatica is primarily a tissue feeder, and erythrocytes observed in the ceca of the fluke were ingested along with the cellular material of the liver. Photomicrographs showing the burrow of the fluke turning away from blood vessels would indicate that they avoid these readily available sources of blood.

**Route of Infection**

There is general agreement by previous investigators that the liver and its bile ducts appear to be the organ and structure of choice for F. hepatica. There does exist, however, some dispute over the route this parasite takes to reach the liver.
The three most probable routes for movement from the intestine to the liver are the hepatic portal vein, the common bile duct, and peritoneal migration.

Cited by Ben Dawes and D. L. Hughes (13, p. 99) are Lutz, supported by Railliet et al., Compes, Nöller, Nöller and Schmidt, Marek, and Bugge, who believed the route of migration to be through the portal vein.

Leuckart, as cited by Ben Dawes and D. L. Hughes (13, p. 99) and Shirai (38) thought the fluke reached the liver by means of the common bile duct.

The majority of evidence would indicate that the migration involves penetration of the intestinal wall where the immature fluke then wanders about over the abdominal viscera until it encounters and penetrates the liver. This route was confirmed by Sinitzin, as cited by Ben Dawes and D. L. Hughes (13, p. 99), and others (10, 37, 38, 42, 43).

Immature flukes have been found in the abdominal cavity of experimental hosts 2 to 3 hours following ingestion of viable metacercaria (13, p. 99, 103; 7, 38). The time interval between entry into the peritoneal cavity and penetration of the liver is variable. Flukes have been found in the liver parenchyma three days following infection, and they may penetrate the liver earlier (7).

The left lobe of the liver has been found to be more severely
affected in acute fascioliasis than other lobes (20, 39). This finding, when associated with the statement by D. C. Blood and J. A. Henderson (3, p. 140) that blood from the gastroplenic area and lower part of the large intestine tends to enter the left half of the liver, while blood from the intestines tends to enter the right half, may reopen the question as to the exact route of migration.
MATERIALS AND METHODS

Four experiments were done using experimental hosts for fascioliasis. The first two involved the mouse, the latter two, the clawed jird, (Meriones unguiculatus).

The materials and methods section was divided as follows: experimental design, administration of metacercariae, collection of ante-mortem data and necropsy.

In all four experiments the animals were maintained at an ambient temperature in individual Number 10 cans with screen covers, secured by rubber bands. The animals were kept on commercial litter,¹ and fed a commercial ration,² and potatoes.

The metacercariae used in experiment numbers 1, 2, and 3 originated from two sources. Part of these were collected from experimentally infected snails (Lymnaea columella) maintained by the Department of Veterinary Medicine, Oregon State University ("OSU" strain). The others were part of a shipment of metacercariae sent to the Department of Veterinary Medicine from Weybridge, England by Dr. C. B. Ollerenshaw ("British" strain). In experiment number four, "OSU" metacercariae were used. All metacercariae had been encysted for three weeks or longer.

¹PEL-E-CEL, laboratory animal waste absorbent, produced by Laurel Farms, Inc., White House Station, New Jersey.

²Purina laboratory chow for mice, rats and hamsters, produced by Ralston Purina Co., St. Louis, Missouri.
Experimental Design

Experiment Number 1

Swiss mice, B-P laboratory albino strain, were purchased commercially. Eighteen mice were divided, according to weight into three groups of six animals each, using the latin square method (15). Group A, the controls, were not infected. Each animal in groups B and C received 20 "OSU" and "British" metacercariae, respectively. Body weights for individual animals were recorded three times a week.

Experiment Number 2

Thirty mice of the strain used in experiment number one were divided according to weight into three groups of ten each. Group A were noninfected controls. Each animal in groups B and C received ten "British" and "OSU" metacercariae, respectively. The experiment was designed so that two randomly selected mice from each group would be killed and examined at 1, 2, 4, 8 and 16 weeks post-infection. Individual mice were weighed weekly.

Experiment Number 3

Six male jirds, five months old, were purchased commercially.  

3Berkeley-Pacific Laboratories, Berkeley 10, California.  
They were divided into three groups of two each by weight. Group A were noninfected controls. Each animal in groups B and C received 20 "British" and "OSU" metacercariae, respectively. Individual animals were weighed weekly.

**Experiment Number 4**

Twelve, eight-week-old male jirds were purchased. Upon arrival they were weighed and divided into six groups of two each, with approximate weights. A day later they were individually infected with metacercariae as follows: group 1, 1 cyst; group 2, 2 cysts; group 3, 4 cysts; group 4, 8 cysts; group 5, 16 cysts; and group 6, noninfected controls. Individual weights were recorded weekly.

**Administration of Metacercariae**

The mice used in experiment number one were placed in a restraining device and orally given metacercariae from a rubber bulb controlled Pasteur pipette.

For the other three experiments light ether anesthesia was used prior to administration of the metacercariae by stomach intubation. The stomach tube apparatus consisted of a syringe, a one-inch 20-gauge needle and an attached three-inch length of Clay-Adams Intramedic Poly-Tubing, P. E. 100 (I. D. 0.034", O. D. .060"). Care was taken to limit the volume of water containing the metacercariae
so the entire dose could be contained in the tubing. The apparatus was examined under a dissection microscope following dosing, to assure all metacercariae had been administered.

Collection of Data (Ante-Mortem)

No data, other than body weights, were recorded for experiments 1, 2, and 3.

In experiment number four, packed cell volumes were determined by microhematocrit. Wright's stained blood smears were examined bi-weekly. Fecal examinations by sedimentation technique were done every two to three days starting 25 days postinfection.

Necropsy

Experiment Number 1

Animals that died were promptly necropsied. Gross lesions were described and photographed. The affected tissues were preserved in 10 percent buffered formalin solution for histological sectioning and study. The remaining animals were killed 35 days post-infection and similarly examined.

Experiment Number 2

Two animals, randomly selected from each group, were scheduled for necropsy at 1, 2, 4, 8, and 16 weeks following infection.
Any animals that died prior to these dates were promptly necropsied. In addition, the peritoneal cavities of the exposed animals were thoroughly washed with cold water and the washings examined microscopically for flukes.

**Experiment Number 3**

Dead animals were immediately necropsied and the peritoneal washings examined for flukes. Significant lesions were photographed and the livers preserved in 10 percent buffered formalin solution for histological study.

**Experiment Number 4**

The clawed jirds were handled in a similar fashion to those in experiment number three, except that the livers, rather than being preserved for histological study, were teased apart under a dissection microscope to attempt recovery of flukes.

The remaining jirds were killed and necropsied 55 days postinfection.
RESULTS

The results of the four experiments were divided as follows: pathogenicity, necropsy (gross and histological findings).

Experiment Number 1

Pathogenicity

All mice used in experiment number one appeared normal for 23 days following infection. On day 24, one mouse from the "British" group was dull and anorexic. On day 26 four mice in the "British" and "OSU" groups showed signs of malaise. From day 26 through day 29, eight of the 12 infected mice died (Table I).

The body weights among the three groups remained approximately equal until day 27 when the average weights of both groups of infected mice was 2.8 gm less than the controls, (Figure 2). The weight data from day 27 on, was discarded because the high mortality left too few, and uneven numbers in the groups.

Necropsy

Gross. Hemoperitoneum and or ascites of varying degrees was observed in all infected mice that died. On day 36, the four remaining infected mice and the six controls were killed. The findings for all infected mice were similar, merely varying in intensity.
TABLE I. MORTALITY OBSERVED FROM DAY 25 THROUGH DAY 36 IN THE FOUR EXPERIMENTS.

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*Moribund, killed.

The primary site of pathological change appeared to be the liver and biliary system. Evidence of focal fibrinous peritonitis was seen on the surface of the liver, and in some mice the lobes of the liver were adhesed. Numerous anemic infarcts were observed, and in some instances, an entire liver lobe appeared necrotic. Several mice were seen to have gross evidence of biliary hyperplasia.

No lesions were observed in the control mice.
Figure 2. Experiment number 1: average weights of mice infected with 20 "British" or "OSU" metacercariae and noninfected controls.
Histology. Histological study of liver sections prepared and stained with hematoxalin and eosin, revealed extensive destruction of the liver parenchyma. Massive hemorrhage and necrosis were evident, and inflammatory response was seen involving the burrows of the flukes and hepatic trinities. The bile ducts were hyperplastic, and the underlying submucosa was edematous and infiltrated with fibroblasts. A fluke was observed in the liver parenchyma of one mouse from the "OSU" group.

Experiment Number 2

Pathogenicity.

No deaths occurred until 27 days following infection, when a mouse from the "OSU" and "British" groups died. Singular deaths followed on days 28, 29, 30, and 31. Mice from the "OSU" group died on days 28 and 30, and mice from the "British" group died on days 29 and 31.

The weight loss observed in the infected mice paralleled approximately, the weight losses of the mice in experiment number 1 (Figure 3).

Necropsy

Gross. No visceral lesions were observed in the four infected
Figure 3. Experiment number 2: average weights of mice infected with 10 "British" or "OSU" metacercariae and noninfected controls.
mice killed eight days postinfection. Two immature flukes were recovered from the peritoneal washings of one mouse in the "OSU" group.

Areas of necrosis and infarction were seen in the livers of three of the four infected mice killed 15 days following infection. No flukes were recovered. The control mice were normal.

The lesions observed in the mice that died on days 27, 28, and 29 were similar to those observed in the mice from experiment number 1.

The four infected mice killed 29 days postinfection revealed similar pathological change, except the degree of liver involvement and hemoperitoneum was less in one mouse from each of the "OSU" and "British" groups. The control mice were normal.

Since a single mouse remained in each of the infected groups at the end of eight weeks, these, and the remaining controls were killed.

Necropsy of the mouse from the "British" group revealed ascites, and one 3 mm foci of necrosis. The bile duct however, was markedly hyperplastic (Figures 4 and 5) and a fluke was visible through the wall of the duct. The mouse from the "OSU" group revealed less pathological change, and no evidence of biliary hyperplasia. The control mice were normal.

**Histology.** Histological study of similarly prepared liver
Figure 4. Mouse from "British" group. Note the involvement of the left lobe of the liver and biliary hyperplasia.

Figure 5. Visceral surface of the mouse from "British" group. Note hyperplastic bile duct.
sections revealed essentially the pathological changes observed in the mice in experiment number 1.

Experiment Number 3

Pathogenicity

The fatality pattern in the jirds followed closely the pattern seen in mice. Deaths occurred on days 27, 31, and 33 for 1, 2, and 1 infected animals respectively. A weight loss similar to that observed in the first two experiments with mice was observed in the jirds starting at day 23. The small number of animals involved had a wide weight variance at the beginning of the experiment, so graphical evaluation of the weight change observed was not done.

Necropsy

Gross. Necropsy findings included ascites and hemoperitoneum, (Figure 6) fibrinous peritonitis, biliary hyperplasia, focal necrosis and traumatic hepatitis. No flukes were recovered from the peritoneal washings, however, a single fluke measuring 2.5 x 1.0 mm in length and width, respectively, was observed in the bile duct of one jird (Figure 7).

Histology. Histopathological changes in the livers included organized hemorrhage, fibrosis and vacuolar degeneration, with
Figure 6. Hemoperitoneum.

Figure 7. Fasciola hepatica in the bile duct of a clawed jird 31 days postinfection. (X 25)
large areas of necrotic infarction. These lesions were similar to those observed in mice. Other similarities were evidence of inflammatory response around the tracts and vessels of the liver. Bile duct proliferation was also evident. A fluke was observed in the liver parenchyma of one animal (Figure 8).

Experiment Number 4

Pathogenicity

The first mortalities occurred on day 26 and included one jird from each of three groups. These were groups 3, 4, and 5 that had received 4, 8, and 16 metacercariae, respectively. On day 29 the remaining jird in group 5 (16 metacercariae) appeared moribund and was killed and necropsied. The remaining jird in group 4 (8 metacercariae) died on day 30. The last jird in group 3 (4 metacercariae) appeared moribund on day 36 and was killed. During the bleeding process on day 41, one jird from group 2 (2 metacercariae) was accidentally suffocated. The remaining animals lived until the experiment was terminated on day 55.

The weight losses observed paralleled those seen in the previous experiments.

Some difficulty was encountered in obtaining adequate amounts of blood for microhematocrit determinations due to clotting. The
Figure 8. *Fasciola hepatica* in the liver parenchyma of the clawed jird 27 days postinfection. (X 80)
packed cell volume ranged from 36 to 53 on day 2, in 11 of 12 jirds. The PCV recorded for a moribund animal in group 5, day 29; and group 3, day 36, was 24 and 30, respectively. The range observed on day 55 in the remaining animals was from 46 to 48. The normal PCV range stated for mice is 39.5 to 50, and for rats 35 to 51 with a mean of 45 (36, chap. 5).

Results of differential blood counts showed an increase in eosinophils on day 13 for one animal in groups three and four, and both animals in group five. The controls and principals in groups one and two remained normal.

All 12 animals were observed to be infected with Hemobartonella sp. as described by Najarian (30).

Fecal examinations, by sedimentation technique were negative for fluke ova.

Necropsy

Gross. Severe hemoperitoneum was found in the jird in group five that died on day 26 (Figure 6). The left lobe of the liver was grossly enlarged and congested with blood (Figure 9). Fibrinous peritonitis involving the lobes of the liver and the duodenum were observed. The liver was removed, teased apart under a dissection microscope, and two flukes found the parenchymatous tissue.

The jirds from groups three and four that died on day 26 had
Figure 9. Involvement of the left lobe typically seen in experiments three and four.
similar lesions. The right lung of the jird from group 3 was completely ecchymotic but no flukes were found in the lung. One fluke measuring 5.3 mm x 1.9 mm in length and width, respectively, was recovered from the peritoneal washings and preserved in AFA solution. Lesions similar to those seen in preceding animals were observed in the jird from group four. No flukes were found.

On day 28, one jird in group five (16 metacercariae) appeared cachectic, and was killed on day 29. Severe left lobe involvement of the liver was observed, along with hemoperitoneum and fibrinous peritonitis. The liver was examined carefully for parasites, and one fluke measuring 6.0 mm x 2.0 mm in length and width was recovered and preserved. A second fluke that measured 5.2 mm x 1.9 mm in length and width was recovered from the peritoneal washings and preserved.

The jird remaining in group four that died on day 30, had lesions similar to the preceding animals. One fluke that measured 5.0 mm x 1.6 mm in length and width was recovered from the peritoneal washings.

On day 36 the moribund jird remaining in group three was killed. Similar lesions were seen, but no flukes were recovered.

No lesions were found in the jird from group two that was

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5 85 parts 85 percent alcohol, 10 parts 10 percent formalin, and 5 parts glacial acetic acid.
accidentally suffocated.

On day 55 the remaining infected principals were killed. No lesions were observed in these animals.
DISCUSSION AND CONCLUSIONS

The pathogenic reactions observed in mice were similar to those reported by other workers (9, 21, 23). The most critical period for mice occurred between days 26 to 31, (Table I). The hemoperitoneum reported in these experiments was described by Dawes (9), Lagrange and Guttman (21). Hemorrhage into the peritoneal cavity might be expected to occur at the time of penetration of the liver capsule early in fascioliasis, but it has been suggested that the hemoperitoneum seen during this later stage is perhaps the result of flukes leaving the liver and re-entering the peritoneal cavity. Dawes suggests the flukes may leave the liver during this critical period in search of better nutrition (13, p. 113).

During experiments with mice, no fecal examinations for fluke ova were made. Ova have been reported in mice 36 days following infection (9), and in rabbits at 63 days (27).

The individual dosage level of 20 metacercariae was selected as a result of Dawes work (8). This dosage proved an overwhelming parasite burden for this host, as evidenced by the high mortality. The individual dosage was therefore reduced in experiment number two to ten metacercariae. Noninfected control mice were killed concurrently with infected principals to serve as standards by which to judge the degree of pathological change evidenced in the principals.
This dosage also proved to be fatal to a high percentage of animals, and resulted in the experiment being concluded at the end of eight weeks.

Apparently the mouse can sustain an infection of from one to five flukes (9, 23) for up to 150 days (21).

Study of histological sections prepared from livers of infected mice revealed lesions described by others (7, 8, 9, 11, 23).

The degree of liver destruction appears to be directly related to the dosage of metacercariae and the age of the infection at the time of examination.

Undoubtedly the high incidence of mortality observed in experiments one and two was related to the severe liver damage and resultant hemorrhage associated with such a massive invasion in such a small host. The absence or lack of severity of lesions noted in several of the mice might have been the result of a low percentage of viable metacercariae having been administered.

Advantages of the mouse as an experimental host for Fasciola hepatica include its susceptibility to infection, and the rapid maturation of the fluke within this host.

The pathogenicity of Fasciola hepatica in the clawed jird closely parallels that seen in mice. The mortality observed reached its peak from day 26 through day 33 in experiment number three. In experiment number four the effect of the higher doses of metacercariae was
manifest by deaths on days 26 and 29 in the group receiving 16 metacercariae. The animals receiving the lower dosages died over a longer period of time.

The jird apparently can sustain approximately the same number of flukes as the mouse.

Again, it appeared that there was a direct correlation between dosage level and fatalities observed. Certainly, there was a definite relationship between the degree of liver destruction observed and the number of metacercariae administered.

The histopathology in liver sections from the jirds paralleled that seen in mice. Grossly however, the appearance of the liver closely resembled acute fascioliasis in lambs (Figures 10 and 11).

The size of the flukes recovered from the livers and peritoneal washings were within the stated range for this parasite in mice (8). This would indicate an adequate nutrition level for the development of this parasite in the jird.

The complete absence of lesions in the principals in groups one and two in experiment number four was attributed to the administration of nonviable metacercariae. This would account also for their normal blood studies and negative fecal examinations.

The mouse as an experimental host for *F. hepatica* has been established, and the susceptibility of the jird to infection with this parasite has been demonstrated.
Figure 10. Gross appearance of the burrows made by immature *Fasciola hepatica*, in the liver of the clawed jird.

Figure 11. Lamb liver with acute fascioliasis. Note resemblance to the liver of the clawed jird.
In this study the parasite was not observed to complete its life cycle. This failure has been attributed to administration of nonviable metacercariae. Possible future studies using larger groups of jirds receiving lower individual doses of metacercariae (1 to 4) may result in successful completion of this life cycle.

The similarity of lesions observed in the jird's liver to those of the lamb with acute fascioliasis was described. This similarity, in conjunction with the severity of left lobe involvement may be of future value in anthelmintic mode-of-action studies.
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Meriones unguiculatus is a relatively new experimental laboratory animal in the United States. Dr. Victor Schwentker of Brant Lake, New York is credited with the establishment of the first commercial colony in 1954. The parent stock for this colony originated from the Kitasato Institute, Tokyo, Japan.

Since its introduction some confusion regarding the common name for this animal has developed. The most commonly used name has been "Mongolian gerbil," although recently Dr. Sigmund T. Rich, of the University of California at Los Angeles, California has suggested that the name "clawed jird" is more appropriate.

The taxonomic classification adopted by Dr. Rich was compiled by J. R. Ellerman and is as follows:

Genera of Subfamily Gerbillinae

I. Gerbillus . . . . . . . . . . (77 species)
II. Microdillus . . . . . . . . . . (1 species)
III. Tatera . . . . . . . . . . . . (90 species)
IV. Taterillus . . . . . . . . . . . . (20 species)
V. Desmodillus . . . . . . . . . . . . (2 species)
VI. Desmodilluscus . . . . . . . . (2 species)

VII. Pachyuromys . . . . . (3 species)
VIII. Ammodillus . . . . . (1 species)
IX. Meriones . . . . . . (75 species)
X. Psammomys . . . . . . (8 species)
XI. Brachiones . . . . . . (3 species)
XII. Rhombomys . . . . . (7 species)

The classification adopted by Dr. Schwentker was compiled by G. G. Simpson and lists 10 genera, omitting the genus Microdillus and Desmodilliscus.

It has been suggested by Dr. Rich that the name gerbil be used only for animals belonging to the genus Gerbillus, and that animals belonging to the genus Meriones be designated as the "clawed jird" (34).

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