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**STUDIES ON *CYSTICERCUS FASCIOLARIS*,  
ESPECIALLY ON DIFFERENCES OF SUSCEPTIBILITY  
AMONG UNIFORM STRAINS OF THE MOUSE**

Miyoji ORIHARA

*Department of Parasitology,  
Faculty of Veterinary Medicine,  
Hokkaido University, Sapporo, Japan*

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INTRODUCTION

As the intermediate hosts of *Taenia taeniaeformis*, some species of rodents including genus *Rattus* are well known, but no established theory has been obtained pertaining to the susceptibility of genus *Mus*. It is known, however, that strain A is susceptible and this worm develops enough to be capable of infecting cats (HUTCHISON, 1958).

The differences of susceptibility among experimental animals to the helminth parasites as well as to the bacilli or viruses must be taken always into consideration at the time of experimental studies of infection. Recently, YAMASHITA *et al* (1958) made it clear that there are differences of susceptibility to *Echinococcus* among uniform strains of the mouse, and also that apparent differences exist in developed larval echinococcus morphologically.

The present author, in this paper, describes the result of an investigation on the differences of susceptibility to *Cysticercus fasciolaris* among uniform strains of the mouse and other rodents.

MATERIALS AND METHODS

The experimental animals used were: laboratory mouse *Mus musculus*, strains A, AKR, BALB/c, CF#1, gpc, fm, C3H/He, CFW, SM, dba, dd and C57BL/6; albino rat *Rattus norvegicus norvegicus* strains Wistar and Gifu; vole *Microtus montebelli montebelli* and Mongolian gerbil *Meriones unguiculatus*.

Young animals (mostly aged 30 days but some 30~90 days) were used in considering age resistance to infection by the parasites. The author collected five *Cysticercus fasciolaris* from natural rat cases of strain Wistar and they were inoculated orally to a cat. After 45 days, proglottids were found in the feces of the cat. As to the inocula, use was made of gravid proglottids with 0.6% saline solution mainly and sometimes eggs obtained from the feces by centrifuge using 0.6% saline solution. Inoculation was conducted several times with number of eggs within the range from 200 to 400 per animal. The animals were divided into several groups, killed at certain intervals (see Table 1); their livers were examined closely with the naked

TABLE 1. *Incidence of Foci in the Liver*  
 (Number of positive cases/Number of cases examined)

STRAINS	DAYS AFTER INOCULATION																TOTAL	
	3	4	5	6	7	10	15	20	25	30	40	50	60	70	80	100		100<
Wistar	.	1/1	.	.	.	1/1	.	.	.	2/2	.	2/2	.	2/2	.	.	.	8/8
Gifu	.	.	.	.	.	2/2	.	.	1/1	.	1/1	1/1	.	.	.	.	.	5/5
A	.	.	.	.	.	.	.	5/5	.	5/5	3/3	3/3	.	.	.	.	.	16/16
AKR	3/3	3/3	.	.	.	2/2	.	5/5	.	11/11	.	4/4	4/4	3/3	4/4	3/3	2/2	44/44
BALB/c	.	.	.	.	.	.	.	7/7	.	.	.	.	.	.	.	.	.	21/38
CF #1	3/3	3/3	2/2	.	.	2/2	.	5/5	.	5/5	4/4	4/4	3/3	3/3	.	.	.	39/39
gpc	.	.	.	.	.	.	.	4/5	.	6/6	8/9	.	.	.	.	.	.	18/20
fm	.	.	.	.	.	.	.	5/5	.	.	.	.	.	.	.	.	.	5/5
C3H/He	.	.	.	.	.	3/3	.	5/5	.	7/7	4/4	3/3	4/4	3/3	5/5	.	.	34/34
CFW	.	.	.	.	.	2/2	3/3	3/4	.	2/5	5/5	3/4	2/5	.	.	.	.	20/28
SM	.	.	.	.	.	.	.	5/5	.	4/5	.	.	.	.	.	.	.	9/10
dba	3/3	3/3	1/2	.	.	.	.	4/4	.	4/4	6/6	.	.	.	.	.	.	21/28
dd	.	.	.	.	.	4/4	4/4	4/4	3/3	4/7	9/9	.	.	4/5	.	.	.	32/36
C57BL/6	.	.	3/3	2/2	0/2	2/2	.	3/3	.	5/5	.	.	.	.	.	.	.	15/17
<i>Microtus</i>	.	.	.	.	1/1	.	.	2/2	.	1/4	.	.	.	.	.	.	.	4/7
<i>Meriones</i>	.	.	.	.	.	.	.	0/3	.	0/3	0/12	.	.	.	.	.	.	0/18

eye and magnifying glass, and serial paraffin sections were stained by hematoxylin-eosin for microscopy.

## RESULTS

### A. Rat

#### 1. Strain Wistar

(4-day and 10-day cases after infection were in young animals, but the other cases were in adult).

*Macroscopicals* Four days after infection (1 ♀, dead): No focus macroscopically. Ten days (1 ♂): About 200 foci in the liver; the foci about 1 mm in diameter, round cysts with transparent fluid or minute white spots; large number of foci in the right median and left lateral lobes. Thirty days (2 ♀♀): Case 1: 50 foci, minute spots and vesicles, in each lobe, the cysts 1~4 mm in diameter and round or ellipsoid in shape, the scolex in contact with the inner surface of the wall. Case 2: A cyst sized 7×9 mm in diameter in the left lateral lobe near by the papillary process, strobilated worm developed thought to be a naturally infected case). Fifty days (2 ♀♀): Case 1: 18 spheroidal cysts sized 3~4 mm in diameter in each lobe but not in the papillary process, and foci vesicular with scolex and strobila as dark-white part. Case 2: Two foci 5 mm in diameter, the one in the left lateral lobe near by the papillary process and the other in the right median; the cyst surface protuberant. Seventy days (2 ♀♀): Case 1: A focus, 6 mm size in the right median lobe, strictly demarcated by hepatic parenchyma. Strobilated cysticercus in the cyst. Case 2: 11 protuberant cystic foci clearly demarcated, mostly strobilated.

*Microscopicals* Four days: The parasites round or ellipsoid, 40~65  $\mu$  in diameter, and mostly parasitic underneath the hepatic capsule. Mostly larval membrane clear, some parasites vesicular, but some in pre-vesicular stage; the nucleus of germinal cell large with a distinct nucleolus. Host tissue reaction slight. Ten days: The average size of parasites 850×750  $\mu$ , the largest one 1000×850  $\mu$ . Cuticular layer of the parasites thin but clear; germinal layer composed of several cell layers arranged vertically to the wall. Most of the parasites gourd-shaped; the germinal layer thickened partially (20  $\mu$  in thickness). Host tissue reactions slight, but detrited cells in contact with the portion of scolex formation accompanied by slight histiocytic accumulation. Thirty days: The parasites round-shaped and vesicular, 2.5~3 mm in diameter. Advanced stage of scolex formation, most parasites invaginated with immature rostellum, hooks and suckers; some, however, remained in the stages of scolex anlage. Cuticular layer of scolex thicker than that of the other part. The parenchyma of the caudal vesicle reticular. In adventitious tissue at the scolex portion, eosinophile cell accumulations; the outer connective tissue layer not so thick. Fifty days: The cyst-shape round, 3~5 mm size. The scolex completed and strobila formation advanced. Muscular tissue of strobila developed. Osmoregulatory canals in caudal vesicle and strobila. Adventitious connective tissue thin and containing eosinophile leukocytes. Seventy days: The shape of parasites round, 3~5 mm in diameter. The parasites well developed, the cuticular layer thickened and adventitious connective tissue thin but compact.

In cases of 4 days after the inoculation, the focus was 40~65  $\mu$  in diameter and vesicular. In 10-day cases, the focus was 850  $\mu$  in size, a part of germinal layer

thickened (cephalic rudiment). In 30-day cases, the parasites were 2.5~3 mm in diameter, invaginated scolex with immature suckers were found and the cuticular layer was thick at the portion of scolex formation. In 50-day cases, the cyst was 3~5 mm in diameter and strobilation developed. Muscular tissue, osmoregulatory system and other tissue structures were fully established. Throughout all stages, adventitious connective tissue reaction was slight and finally became thin connective tissue layer. But at the time of scolex formation, degenerative cell masses appeared restrictedly.

## 2. Strain Gifu

*Macroscopicals* Ten days (2 ♀♀): Cases 1 and 2: 150 and 120 cystic foci respectively, shaped round and ellipsoid. The foci especially densely distributed, in the right and left median and the lateral hepatic lobes. In portion where foci were densely, the size was generally minute such as 0.5 mm. Twenty five days (1 ♀): The parasites aggregated densely, the liver swollen, 10×6×2.5 cm in size. More than 300 cystic foci sized 3~5 mm on the surface of the liver, and also in the left lateral and caudate lobes; in the other lobes, liver tissues remained like islands. On cut surface, the cysts closely aggregated; shape of cysts various under mutual pressure. Transparent fluid within the cysts; scolex formation at a portion of inner surface. Forty days: The liver swollen, cysts distributed in almost same density; liver tissues remained like islands. The majority of cysts were 4~7 mm in size and irregular round through dense aggregation. The scolex 2 mm in length and 1.8 mm in breadth. Forty-five days (1 ♂, dead): Swelling of the liver remarkable. Foci similar to those of the above.

*Microscopicals* Ten days: A large number of cysts gourd-shaped, 750~950  $\mu$  in diameter. The cuticular layer apparent; linear germinal cells, 10~15  $\mu$  in length, arranged in several layers vertically to the cyst wall. Tissue reactions slight, but necrotic cell mass with polymorphonuclear leukocytes (mainly eosinophile leukocytes) and immature granulation tissue remarkable in contact with the portion of scolex anlage. Some cysticerci dead and organized to the state of nodular foci; in the center of these foci regressive cell mass surrounded by granulation tissue with histocytes and giant cells. Twenty-five days: Formation of scolex and distinct anlage of the hooks, rostellum and the suckers. Attached to the hooks there are eosinophile materials, so-called "hair-like bodies". Adventitious connective tissue with almost regular thickness and considerably thick. Necrotic change in tissues in contact with the portion of scolex formation: within these foci detritus mass conspicuous. Cuticular layers of scolex parts 3~5  $\mu$  in thickness and crumpled. At the caudal vesicle, the cuticular layers thin and osmoregulatory system observable. Forty days: Proglottids still unobservable, but wrinkles appeared in the cuticle. Most hooks completed, but some immature. Suckers yet immatured. Detrited cell mass close to the scolex part. Adventitious tissue fibrous and thin. Forty-five days: In comparison with 40-day cases, muscular tissue more developed.

In 10-day cases, the parasites were 750~950  $\mu$  in diameter, cuticular layer was very thin but distinct. At a portion of the cyst wall, formation of scolex anlage was detected. In 25-day cases, the parasites were 3~5 mm in size, the scolex formation was advanced, and an anlage of the attachment organs of scolex had begun develop-

ment. In contact with the hooks, so-called "hair-like bodies" grew densely. In 40-day cases, the parasites were 4~7 mm in size, strobilation was about to be formulated.

## B. Mouse

### 1. Strain A

*Macroscopicals* Twenty days (3 ♂♂, 2 ♀♀): Respectively 84, 32, 52, 17 and 17 foci were found. Those cysts distributed with almost uniform density. Foci about 2 mm in size; the largest 3.5 mm. On the surface of the liver, cysts protuberant. Where a large number of cysts existed, hepatic tissue scarcely seen. By pressure of cysts against each other, their shapes are changed to ovoid or gourd-shape. In large cysts small protuberant structure observable at the inner surface of wall. Thirty days (2 ♂♂, 3 ♀♀): Each 20, 113, 62, 60 and 50 cysts, 2 mm size. Of these cases, especially in cases 3, 4 and 5 numerous white opaque foci. Among cystic foci, some of which contained scolex anlage, foci filled with gray mass were found. Forty days (3 ♀♀): Fifty-two, 24 and 80 cystic foci respectively. In cases 1 and 2, large and minute cysts mingled, the large ones 5 mm in size with transparent fluid and minute 2 mm with opaque fluid. In case 2, the average size of foci 4~5 mm; the largest 6 mm. Foci developed uniformly, the wall comparatively thin and the scolex anlage observable on the inner surface. In some foci, however, the wall thick; the center minute vesicular. Fifty days (3 ♀♀): All cases with about 50 foci each, the size of cyst 1~4 mm. In large foci, the scolex, about 15 mm length, existed. The minute foci white and opaque, the cavity very minute.

*Microscopicals* Twenty days: The cyst ellipsoid, 1.4~2.2 mm in diameter. The parenchyma of parasite generally thin and monolayer, but sometimes few or several layers. Numerous parasites with initial scolex formation: in this portion the parenchyma thickened. In most foci, eosinophile leukocytes in the innermost vesicle. Adventitious connective tissue comparatively thick, more than 200  $\mu$  in thickness. In contact with the portion of scolex formation, at inner layer of adventitious tissue, detrited cell mass existed; it sometimes occupied 300 $\times$ 400  $\mu$  areas. Giant cells, sometimes LANGHANS type, often mingled with the outer adventitious tissue and also with lymphocyte accumulation. Some foci regressive. Thirty days: Initial stage of scolex formation. The parasites large, round and vesicular, 2 mm in diameter. The cyst wall generally thin. Adventitious tissue with regular thickness, composed of circular fibers with slight histiocytic and eosinophile cell accumulation. Detrited cell mass in contact with the portion of scolex formation. Some foci dead, fallen into degeneration and organization progressed. Forty days: Scolex with immature hooks and suckers. The cuticular layer of scolex thickened, the caudal vesicle with thin parenchyma. Osmoregulatory system formulated, but muscular tissue still immature. The adventitious layer with giant cells and lymphocyte masses in demarcation area between hepatic tissue and this layer. Fifty days: Attachment organs of the scolex incomplete except a few foci. Caudal vesicle wall thin, 10~15  $\mu$  in thickness. Adventitious tissue apt to become connective tissue layer (encystment).

In 20~30 day cases, foci were about 2 mm in diameter. Parasites were vesicular, and initial stage of scolex formation was observable. Tissue reactions were found locally, and accumulated cells had fallen into degeneration. Adventitious reaction

was accompanied by cell mass with intermingling giant cells. In 40-day cases, the large foci were 6 mm in size, scolex had been already formulated, and attachment organs of parasites were constructed, but incompletely. Adventitious reaction was apt to become encystment. Fifty-day cases were similar to those of above noted, but in some foci parasites were dead and organized.

## 2. Strain AKR

*Macroscopicals* Three days (3 ♂♂): No focus macroscopically. Ten days (2 ♂♂): One hundred-thirty and 63 foci respectively. The liver enlarged. Some foci round and vesicular, about 1 mm in diameter, and the others very minute, white in color. The latter conspicuous in case 2. In both cases many minute white foci in the left lateral lobe and a few in the papillary process. On cut surface, many foci like minute round or ellipsoid holes. Twenty days (5 ♂♂): Respectively 85, 78, 8, 5 and 50 foci. In case 1, foci conspicuous in the right and left median lobes; absent in the papillary process. In case 2, foci in each lobe. In case 3, only 2 and 6 foci in the left median and left lateral lobes respectively. In case 4, foci in each lobe, and especially rich in the left median lobe. In case 5, foci in each lobe except the papillary process in the same degree. Of these cases, where foci aggregated densely, the parenchyma of the liver scarcely remained. Cyst round and filled with transparent fluid; an initial scolex at a portion of inner surface of the wall. Some cysts minute and the wall slightly thickened. Thirty days (8 ♀♀, 3 ♂♂): Seventeen to 100 foci in each hepatic lobe; but few in the papillary process (absent in five cases). The majority of foci 3~5 mm in size; the largest 6 mm. In general, in cases with many foci the cyst size smaller than in cases with a few foci; These cases often with white foci of indistinct cystic structure or dark colored foci. Fifty days (4 ♀♀): Eleven to 18 foci, 1.5~6 mm in size. Scolex formation in large cysts; in some small, however, structure of the parasites indistinct. Foci rare or absent in the papillary process (lacking in cases 2 and 4). Sixty days (3 ♀♀): The distribution of cysts almost similar to those of the above cases. Large foci about 6 mm in diameter; strobilated cysticercus distinct and enveloped by thin wall. Minute cysts also observable. Sixty-two days (1 ♂, dead): The liver enlarged, 7×5×2 cm. Many large cysts; the largest 8 mm in size. Seventy days (3 ♀♀): A few small cysts, 2~3 mm in each lobe. The cysts semi-transparent; the central vesicle minute or indistinct. Eighty days (4 ♀♀): Numerous small cysts. One hundred days (3 ♂♂): Case 1: A large cystic focus, 8 mm in size, with a cysticercus of 12 mm length in the right lateral lobe. Case 2: Twenty one large foci with strobilated cysticerci sporadically in each lobe, and also many minute white foci. Case 3: A large focus in left lateral lobe, and foci aggregated densely in the other lobes. One hundred-nineteen days (1 ♂): On account of dense distribution of cysts, the liver parenchyma remained visible only at a portion of the left lateral lobe. Foci similar to the above cases. One hundred twenty-six days (1 ♀): About 200 foci, 5 mm in diameter (often 8 mm). Most of foci with strobilated parasites.

*Microscopicals* Three days: Parasites round or ellipsoid, about 50  $\mu$  in diameter, already vesicular or in its initial state. Larval membrane conspicuous. Perifocal liver cells slightly degenerated, but other reactions slight. Ten days: In general, parasites ellipsoid-shaped, 800~1000  $\mu$ . The cuticular layer thin; germinal layer 15~30  $\mu$  in thickness, arranged in several

layer. A portion of germinal layer thickened as an anlage of scolex, and some scolices at the beginning stage of invagination. In adventitious tissue, marked histiocytic accumulation, mingled with some giant cells. Foci of dead parasites often detected where organization observable; central degenerated part became narrower and surrounded by granulation tissue with eosinophile leukocytes. Nodular foci also observable. Twenty days: Parasites large and ellipsoid, 1.3~1.7 mm in diameter, partial thickening of germinal layer, an anlage of scolex, conspicuous and expanded to an area 250~300  $\mu$  in diameter. Many parasites began invagination. The cuticular layer at the portion of invagination thickened where spindle-shape parenchyma cells arranged densely. The caudal vesicle wall thin (germinal layer 1~5  $\mu$  thickness). Adventitious tissue generally thick accompanied by cell accumulation and detrited cell mass. Pressure atrophy of perifocal hepatic cells. Considerable number of parasites dead and degenerated. Thirty days: Similar to 20-day cases. Considerable number of degenerated foci surrounded by granulation tissue with detrited cell mass and polymorphonuclear leukocytes. Organization advanced in some foci. Fifty days: Scolex formation developed. Rostellum, suckers and hooks formed; hooks nearly completed. In the parasite parenchyma, osmoregulatory system and muscular tissue existed. At scolex invagination, wrinkles formed as initial stage of strobilation. In some foci, lntal process of parasite observable; parasites just before detrition and tissue reaction conspicuous. Sometimes a parasite at a corner of cyst cavity floated in fluid and cell elements; this changed structure can be called a "pseudocyst". Sixty days: Strobilation advanced with evagination of scolex. Adventitious tissue thin and compact. Sixty-two days: Parasite 12 mm in length. Calcareous corpuscles appeared. Seventy to 119 days: Foci similar to the 60- and 62-day cases. Calcareous corpuscles of parasites stained by hematoxylin. Some parasites degenerated and became pseudocyst or exhibited nodular lesion.

In 3-day cases, no focus was found macroscopically. The size of cyst was as follows: Three days: 40~50  $\mu$ . Ten days: 800~1000  $\mu$ . Twenty days: 1.3~1.7 mm. Thirty days: foci almost same size as in 20-day cases, and 50 days 4~5 mm. The size of parasites more than 60-day was similar to that of 50-day cases. In 3-day cases, the parasite was vesicular and larval membrane was conspicuous. In 10 day cases, thickening of germinal layer as an anlage of scolex occurred. In 20 and 30-day cases, scolex formation of invaginated type developed, but the walls of caudal vesicle were thin. In parasites of 50 days, the attachment organs of scolex were near to completed; osmoregulatory systems and muscular tissue appeared and strobilation began. In 60-day cases, scolex evaginated, the formation of strobila progressed and calcareous corpuscles were observed. Throughout all stages examined, adventitious connective tissue was slightly formed, although detrited cell mass was detected in contact with the portion of initial scolex development, compact connective tissue layers completed as parasites developed to be completed. But from 10 days after inoculation, some parasites turned to degeneration, pseudocyst formation and nodular formation; proliferation of granulation tissue was conspicuously found in foci with organization.

## 3. Strain BALB/c

*Macroscopicals* Ten days (3 ♀♀): Forty five, 35 and 5 foci respectively. The size of cyst less than 1 mm. Twenty days (7 ♂♂): One focus in one case, and 10~16 foci in other cases; the foci minute. In case 1, a white focus with central cavity, 2 mm in diameter. Twenty-five days (6 ♀♀): No focus in 3 cases, and 2, 2 and 1 cyst respectively in the others. Foci were similar to 20-day cases. Thirty days (5 ♀♀): No, 1, 1, 5 and 7 foci respectively. Foci less than 1 mm in diameter and opaque with white color. Forty days (4 ♂♂, 3 ♀♀): Three cases without focus, 3 cases with one focus each and one case with 3 foci. These cysts minute and white. Fifty days (4 ♀♀, 1 ♂) and 62 days (3 ♂♂, 2 ♀♀): All cases without focus.

*Microscopicals* Ten days: Adventitious tissue comprised outer layer of granulation tissue with giant cells and outer necrotic layer with polymorphonuclear leukocytes; degenerated parasite and detrited cell mass in the cavity surrounded by these layers. Twenty, 25 and 30 days: Reactive changes followed by degeneration of parasites were recognized. Therefore, characteristics of foci were similar to those of above noted cases. Forty days: Findings were also similar to the above, namely organization against degenerated parasites was found. Central cavity contained fluid elements with detrited cell elements and parasites (picture of pseudocyst), and adventitious tissue (wall tissue) was composed of inner degenerated layer and outer granulation layer. In periphery of foci, cell accumulation was conspicuous.

A few foci were found throughout all cases, organization process was shown accompanied by dead parasites and tissue reaction was conspicuous.

## 4. Strain CF #1

*Macroscopicals* Three days (3 ♀♀) and 4 days (3 ♀♀): No focus visible to the naked eye. Five days (2 ♀♀): White minute 70 and 150 foci respectively, distributed in each hepatic lobe. Ten days (2 ♀♀): About 200 and 300 foci, 0.5~0.8 mm in diameter in almost same density. Minute vesicle in the center of focus. Twenty days (5 ♂♂): Out of 5 cases, 2 cases with 10 and 19 ellipsoid foci respectively, 3~4 mm in diameter. The other 3 cases with minute foci (the number of foci: 29, 36 and 81 respectively), however, almost all foci less than 2.5 mm in size; the central cavity of focus narrower, cyst fluid turbid and adventitious layer thick. Thirty days (5 ♂♂): Thirty-seven to 62 foci, some of which 3~3.5 mm in size but generally smaller. Size of central vesicle and thickness of the wall not uniform; cyst fluid somewhat white and floccular. Forty days (4 ♂♂): Three to four hundred foci in 3 cases, but a few in one case (20 foci); The liver conspicuously enlarged. In some foci, the central vesicle invisible. Fifty days (4 ♂♂): All cases with 300~400 foci and conspicuous enlargement of the liver. Characteristics of foci similar to the 40-day cases, but in most foci central vesicle with opaque-white substance. One cyst focus 4 mm in diameter but scolex formation absent. Sixty days (3 ♂♂): Number of foci 42, 40 and 20 respectively. Small cysts about 1~2.5 mm in diameter, without any vesicle in general, white nodular and considerably hard. Eighty days (4 ♀♀) and 100 days (4 ♀♀): All cases with 300~400 cysticercus foci. The liver enlarged. Most foci 1~3 mm in diameter, faint brown in color.

*Microscopicals* Three days: Some parasites vesicular but the others not yet. Size 50  $\mu$ , round or gourd-shaped; cells of parasite possess basophilic cytoplasm, comparatively large

nucleus and distinct nucleolus. Reaction against parasite scanty. Four and 5 days: Almost the same appearance as 3-day cases. Parasite vesicular, 0.8~1.0 mm in size and ellipsoid or gourd-shape. In general, partial thickening of germinal layer as an anlage of scolex. Detrited cell mass in adventitious layer in contact with the scolex part. In some cysts, regressive changes and severe tissue reaction. Adventitious tissue composed of inner necrotic layer and outer granulation tissue layer with some giant cells. The wall of parasite thinned, the parasites filled the focus cavities. In dead foci, the parasite had fallen into collapse, floated in cyst fluid at a corner of cavity (pseudocystic change). Twenty and 30 days: Almost all foci organized. Histology similar to that of 10-day cases, but the reaction more severe. Inner necrotic layer of adventitious tissue 70~100  $\mu$  in thickness; circumscribed cell accumulation conspicuous. Forty days: organization process more advanced than in the earlier stages. Foci with fluid, cell elements and degenerated parasite (pseudocystic organization) still observable, but most foci nodular. Fifty and 60 days: Histologically, foci similar to the above stage, but adventitious layers became fibrous. Eighty days: Most foci nodular with central necrotic lesion. Calcification of necrotic parts with cholesterol crystals recognizable. Pseudocystic state also found. Vesicular parasites rarely seen, but the cyst wall very thin. Without scolex formation.

Considerable number of foci were found, but the development of parasites stopped before or after the period of vesiculation and thereafter parasites were fallen into degeneration and turned to organization. The size of cysts increased to some extent but the cyst wall was very thin, most of germinal layer was of one layer of cells. Adventitious layer was a granulation tissue layer accompanied by accumulation of histiocytic cells with some giant cells, but in contact with the parasite, the necrotic layer existed which was composed of detrited cell mass of necrotic adventitious layer. Some parasites kept the state of thin-walled cysts, but a great number of cysts fell into collapse, and floated in fluid (pseudocystic change). Finally, they were organized and became to be nodular.

#### 5. Strain gpc

*Macroscopicals* Twenty days (5 ♀♀): Respectively, 0, 2, 9, 11 and 22 foci, 1~3 mm in size; white in color and cyst cavity non-recognizable in most foci. Thirty days (6 ♀♀): Six to 13 foci respectively, about 2 mm in size. Characteristics of foci similar to the above. Forty days (9 ♂♂): Of 9 cases, 8 cases with 3~15 foci. Some foci 2 mm in diameter, but many foci only about 0.5 mm.

*Microscopicals* Twenty days: Foci, 0.9~1.5 mm in size, with degenerated parasite. Surrounding the parasites, inner necrotic and outer granulation tissue layers; the former composed of shadowy picture of necrotic liver cell cords and the latter having accumulation of polymorphonuclear cells, round cells and giant cells. Thirty days: Foci similar to those in the 20-day cases. Some parasites still vesicular, with very thin wall. Forty days: Most parasites organized, but some foci still cystic with slightly darkened degenerated parasite.

Number of foci was not very large, and because the parasite was dead in early stage, necrotic liver tissue could be recognized in surrounding reactive layers. Organization process was advanced and finally the focus had become nodular.

## 6. Strain fm

*Macroscopicals* Twenty days (5 ♂♂): All cases with foci, 60~100 in number. Generally, opaque and white foci, about 1 mm and rarely more than 2 mm in size. In portion of dense aggregation, foci conglutinated like a map. Cyst cavity very small or scarcely found.

*Microscopicals* Twenty days: The cyst wall very thin. Adventitious tissue constituted inner necrotic layer (20~100  $\mu$  in thickness) and outer thick granulation tissue layers. Conspicuous histiocytic cell accumulation in granulation tissue.

Considerable number of foci established, but parasites were dead had commenced degeneration. Foci were surrounded by thick necrotic layers and granulation tissue.

## 7. Strain C 3H/He

*Macroscopicals* 10 days (1 ♀, 2 ♂♂): One, 19 and 40 foci respectively, about 1 mm in diameter. Thin adventitious tissue wall and distinct central vesicle. Twenty days (1 ♂, 4 ♀♀): Fourteen to 26 foci, 1~1.5 mm in diameter. Considerable number of cysts with central vesicle but some without. Thirty days (5 ♀♀, 2 ♂♂): One case with 6 foci, the others 25~78 foci, average size 1.5~2 mm in diameter. Many cysts with thin wall and distinct central vesicle. Forty days (4 ♀♀): Eighteen, 28, 39 and 66 respectively, generally round in shape. Eleven large foci 1.8~2 mm in diameter; large vesicle with thin wall on cut surface. Fifty days (3 ♂♂): Thirty, 40 and 50 foci, some large cysts 2~3 mm in diameter, but generally minute and yellow in color; considerable number of foci without central vesicle. Sixty days (2 ♀♀) and 62 days (2 ♂♂): About 20~60 foci, some foci more than 2 mm, while the greater number less than 2 mm; many nodular foci. Seventy days (2 ♀♀, 1 ♂): Five, 15 and 15 foci respectively. Foci similar to those of 60-day cases. Eighty days (5 ♀♀): Five to 15 nodular foci, about 1.5 mm in diameter.

*Microscopicals* Ten days: Parasites already vesicular, 0.8~1 mm in diameter. Local thickening as an anlage of scolex in some foci. The cuticular and adventitious tissue layers generally thin. Cell accumulation slight. Sometimes the wall of parasite thin with detrited cell mass in contact with the cyst wall. Twenty days: Size of parasites 1~1.5 mm, the cyst wall thin (5~7  $\mu$  in thickness). Parasites surrounded with a thick necrotic layer (sometimes more than 70  $\mu$  in thickness); in some foci there occur detrited cell mass and thick granulation tissue layer with conspicuous polymorphonuclear cell infiltration. Giant cells (LANGHANS type) sporadically in granulation tissue layer. Sometimes pseudocystic foci observable; parasite degenerated (collapsed), floated in the cavity together with degenerated polymorphonuclear leukocytes. Thirty days: In large foci (1.5 mm size), cyst wall thin, necrotic layer not very thick surrounded by granulation tissue layer. In small foci, however, organization progressed. Forty days: Characteristics of foci similar to those of 30-day cases. Large foci (about 2 mm in diameter) with slight tissue reaction rarely observable; the germinal layer was thin and simple, without scolex anlage and cell accumulation found in granulation tissue. Fifty days: Foci similar to above noted. In granulation tissue near to necrotic layers there were sometimes cholesterol crystals. Sixty days: Organization more advanced than in preceding cases.

The average number of foci was about 30. Parasites were vesicular and in some

parasites growth was recognizable which had developed until formation of scolex anlage, but thereafter parasites kept the structure in this stage, and cyst wall became thin. Reaction against parasites was not very severe. Meanwhile, parasites degenerated one after another, course of organization advanced by granulation tissue with necrotic layer. After all, foci of all parasites turned to organization.

#### 8. Strain CFW

*Macroscopicals* Ten days (2 ♂♂): Round and white foci with minute central cavity, 18 and 20 in number respectively. Each focus minute and white, about 1.5 mm in size. Twenty days (3 ♀♀, 1 ♂): Thirteen, 0, 13 and 27 foci respectively in almost same density. Each focus made a white spot, about 2 mm in diameter. Thirty days (3 ♂♂, 2 ♀♀): One male and one female case with minute vesicle. Forty days (4 ♂♂, 1 ♀): All cases with 3~6 foci. Foci minute white spots excepting 1 nearly white focus of 2 mm size. Fifty days (2 ♀♀, 2 ♂♂): Respectively 0, 2, 7 and 15 foci. One cyst with vesicles 1.5 mm in diameter, but the others minute white spot. Sixty days (5 ♀♀): No focus in 3 cases, while in the others 6 and 7 foci, small and white.

*Microscopicals* Fifteen days: Parasites degenerated and floated in a recess of vesicle. Hematoidin crystals scattered. The adventitious tissue composed of inner necrotic layer (20~50  $\mu$  in thickness) and outer granulation tissue layer possessed conspicuous cell accumulation. Twenty days: Similar to 15-day cases. Necrotic layer thick (130~150  $\mu$ ) and often composed of degenerated liver tissue. Granulation tissue thick accompanied by giant cells. Thirty days: Foci generally small and organized. The majority of foci with collapsed parasites floated in small vesicle and with cavity filled by degenerated leukocytes. Forty days: Foci similar to the above. Exceptionally, foci with large vesicle; cyst wall thin, necrotic and adventitious tissue layer not very thick. Fifty and sixty days: Foci not advanced from stage next above described. Both large foci, about 2 mm in diameter, and minute nodular ones, about 1 mm occurred. Necrotic layer consisted of necrotic liver tissue. Cell elements in granulation tissue decreased in amount.

Number of foci is small (average 6 foci per case). Parasites fell into degeneration in comparatively early stage of development and organization advanced. Adventitious tissue divided into inner necrotic layer and outer granulation tissue layer. The former was composed often of necrotic liver tissue whilst, in the latter, cell accumulation was observed. Rarely, even though parasites remained, foci kept the state of simple cyst with thin wall, and before long they fell into degeneration and turned to organization.

#### 9. Strain SM

*Macroscopicals* Twenty days (4 ♀♀, 1 ♂): Respectively 90, 3, 20, 4 and 42 foci, the largest 2 mm in diameter, but generally smaller than 1.5 mm. Almost all cysts gray and nodular, but central vesicle recognizable clearly in large foci. Thirty days (5 ♂♂): Respectively 0, 41, 17, 53 and 4 foci. Generally, foci small and white, while a few large foci, 1.5~2 mm, with or without distinct central vesicle.

*Microscopicals* Twenty days: At a portion of dense population, foci confluent with each other and liver tissues remained only like islands. All foci in state of organization. Although in some foci parasite with thin wall, most parasites in a state of pseudocystic organization; parasites collapsed, vesicle filled with cell elements or in state advanced of absorption. Regressive cells observed in the inner necrotic layer. Granulation tissue reaction severe accompanied by polymorphonuclear leukocytes and histiocytes; giant cells always appeared, the inner layer of granulation tissue sometimes replaced by epithelioid cells. Thirty days: Foci similar to the above, but parasite with thin wall were observed.

Parasites were surrounded with adventitious layer of granulation tissue accompanied by thick necrotic layer; they had fallen into degeneration and turned to organization.

#### 10. Strain dba

*Macroscopicals* Three days (3 ♀♀): No foci. Four days (3 ♀♀): Respectively 5, 16 and 25 foci, very minute and white. Five days (2 ♀♀): One case without any focus, the other with very minute white foci, about 120 in number. Twenty days (4 ♂♂): Respectively 31, 49, 25 and 42 foci. Almost all foci minute and white, but some about 2.5 mm in diameter, with thin-walled vesicle. 30 days (2 ♀♀, 2 ♂♂): Number of foci 32, 16, 6 and 15 respectively. The size of foci similar to those of 20-day cases, but in many cases walls thicker and color changed to yellow. Forty days (6 ♀♀): Six to 48 foci in all cases, size similar to those of above cases. Almost all foci white and clearly demarcated from the liver parenchyma. On cut surface, some foci irregular-shaped, and some without central cavity surrounded by adventitious tissue.

*Microscopicals* Three and four days: Parasites ovoid with larval membrane, 37  $\mu$  in size. No vesiculation. Cells of parasites composed of faint nucleus, distinct nucleolus. Periparasitic reaction conspicuous. Foci occupied an area 200  $\mu$  in diameter through accumulation of histiocytic elements and polymorphonuclear leukocytes. Five days: Irregular round foci of necrotic liver cells, about 100  $\mu$  in diameter. In periphery of the foci, masses of histiocytes and polymorphonuclear leukocytes. No parasites. Twenty days: Irregular-shaped small vesicles with fluid element and contractile dead parasite; surrounded by necrotic area, a mass of regressive eosinophile leukocytes. In outer layer of necrotic layer, thick granulation tissue layer, rich in cell elements, especially eosinophile leukocytes. Thirty days: Findings similar to those in above cases, but reactive layer often contained liver cells. Forty days: Resembled the cases of 20 and 30 days, but vesicle narrower in many foci. Accumulated cells in outer granulation tissue decreased in number; foci became nodular. In a few of the foci, reactive layer thin without necrotic layers.

Even when 3 days had elapsed after the inoculation, parasites showed still non-vesiculation and peripheral reactions were severe. In early stage of development, necrosis of liver tissues also occurred. In 20-day cases, parasites fell into degeneration; they floated in a cavity of foci with cell and fluid elements. Necrotic layer appeared at inner adventitious layer. Granulation tissue was rich in cell elements, and eosinophile leukocytes were conspicuous. Before long, foci were organized.

## 11. Strain dd

*Macroscopicals* Ten days (2 ♀♀, 2 ♂♂): Respectively 100, 110, 37 and 43 foci. Many foci irregularly round-shaped and surrounding tissue thick. Large number of foci very minute and white in color. Fifteen days (2 ♀♀, 2 ♂♂): Very minute 14, 85, 23 and 84 foci respectively. Twenty days (2 ♀♀, 2 ♂♂): Respectively 6, 3, 1 and 1 foci. In general, size of foci about 1 mm and most foci white and minute, but some large with thin wall. Twenty-five days (3 ♀♀): One case with 7 foci, other 2 cases with each about 100 foci; foci very minute and nodular. Thirty days (5 ♂♂, 2 ♀♀): Three cases without foci. The others with 6, 5, 4 and 12 minute foci, partly vesicular, about 1.5 mm in diameter. Forty days (6 ♂♂, 3 ♀♀): Five to 78 foci, mostly white or light yellow, less than 2 mm in diameter, but some large foci vesicular. Seventy days (5 ♀♀): Number of foci 17, 6, 6, 1 and 0; small and white.

*Microscopicals* Ten days: Parasites already vesicular and not seldom more than 1 mm in diameter. Parasites generally irregular-shaped, degenerated and surrounded by degenerative necrotic layer. In outer portion, proliferation of granulation tissue accompanied by epithelioid cells. Twenty and 25 days: A few parasites attached to inner surface of necrotic layer with thin wall, but the most collapsed, round or ellipsoid in shape and floated in cavity together with degenerative polymorphonuclear leukocytes. At outer portion of thick necrotic layer, granulation tissue presents with cell elements, especially polymorphonuclear leukocytes, proliferated. Forty days: Absorption process of degenerated parasite advanced and some foci nodular. Many foci, however, similar to those of above cases. Where foci occurred densely, the liver tissues remained like islands.

Number of foci varied from case to case, but the foci exhibited similar characters. In 10-day cases, parasites were large and vesicular, but they were dead or nearly so. Parasites at 20 and 25 days fell into collapse, and floated in the central cavity (pseudocyst). In 40-day cases, organization process had progressed and parasites had become nodular or similar to that of the above cases.

## 12. Strain C 57BL/6

*Macroscopicals* Five days (3 ♀♀): Very minute white spots in each hepatic lobe, respectively 44, 34 and 30 in number. Six days (2 ♀♀): Twenty and 80 miliary foci. Seven days (2 ♀♀): No focus. Ten days (2 ♀♀): Forty-five and 26 foci, very minute white spots. Some foci with central cavity. Twenty days (2 ♂♂, 1 ♀): Respectively 2, 23 and 12 foci, cystic foci 1.5 mm in diameter and minute white spotted foci. Thirty days (1 ♂, 4 ♀♀): 17, 6, 2, 8 and 16 foci. Generally minute foci, but some more than 2 mm in diameter.

*Microscopicals* Five days: Foci about 400  $\mu$  in size not seldom more than 500  $\mu$ . Parasites already vesicular, 100~200  $\mu$  in diameter, with larval membrane of 3~4  $\mu$  thickness. Thin cystic wall. Severe reaction against parasite; wide necrosis of liver tissues with surrounding cell accumulation, above all polymorphonuclear leukocytes. Six days: Foci similar to those of the above cases. The wall of parasite thin and simple monolayer, nuclei found sporadically. Ten days: Some parasites vesicular, about 1 mm in diameter, the wall 5~10  $\mu$  in thickness; adventitious tissue comparatively thin and cell reactions slight. In most foci, however, degeneration of parasites observed; the wall had become thinner or had fallen

into collapse. Reaction severe with necrotic layer accompanied by proliferation of granulation tissue. Twenty days: Thick necrotic layer often included mass of liver tissues; adventitious granulation tissue thick, with giant cells. Thirty days: Similar to 20-day cases. Frequently pseudocystic organization; the wall of parasite thin, necrotic tissue in limited portion, cell accumulation conspicuous.

In 5- and 6-day cases, vesicular structure was visible even to the naked eye. Generally, germinal layer had become thin and was simple mono-layered; cell nuclei existed sporadically. After 10 days, foci showed picture of organization according to death of parasites. Twenty and 30-day cases were similar to the above, namely organization foci were detected.

#### C. *Microtus montebelli montebelli*

*Macroscopicals* Seven days (1 ♀, dead): Eight very minute foci in all the lobes, white in color. Twenty days (1 ♂, 1 ♀): Four and 7 foci respectively; foci similar to those of the above case. Thirty days (4 ♀♀): One case with 2 minute foci and the others negative.

*Microscopicals* Seven days: Organized foci, 350  $\mu$  in diameter. Parasites indetectable. Detrited cell mass in the center of foci. Necrotic liver tissues surrounded foci and initial formation of granulation tissue with polymorphonuclear leukocytes in periphery. Twenty days: Organized foci, similar to 7-day case. Granulation tissue and polymorphonuclear leukocytes increased. Surrounded by histiocytic layer. Thirty days: Organized foci, parasite absent. Foci 350~400  $\mu$  in size. In the center of foci, detrited cell mass surrounded by epithelioid and giant cells and polymorphonuclear leukocytes. In outer layer, connective tissue accompanied by histiocytes.

Remarkable differences were not to be seen among foci of 7-, 20- and 30-day cases; the parasite died in initial stage of development and foci fell into organization. Foci manifested similar size. The center of focus was a detrited cell mass which was enveloped by a thick granulation tissue layer with giant cells and polymorphonuclear leukocytes (eosinophile); at the outermost layer histiocytic cell accumulation was observed.

#### D. *Meriones unguiculatus*

Examining the cases at 20 days (2 ♂♂, 1 ♀), 30 days (3 ♂♂) and 40 days (4 ♂♂, 8 ♀♀): all cases negative.

### DISCUSSION

It can be said without saying that in rat strain Wistar and Gifu, the parasite *Cysticercus fasciolaris* develops well in the liver in agreement with many investigators' reports in the past. Among uniform mouse strains, AKR and A are also suitable intermediate hosts for the parasites. Especially, development of bladder worm in the former is similar to that in the above rat strains. In the latter, strain A, however, the development is delayed. In other mouse strains and *Microtus montebelli montebelli*, the bladder worm develops to some extent in the early stage.

But the worm dies and thereafter falls into degeneration and turns to organization, even though the time of death is different by strain. In *Meriones unguiculatus*, formation of the focus cannot be recognized at all.

As to histogenesis of *Cysticercus fasciolaris*, many investigations have been carried out by many investigators. KAN (1933) using rats clarified the histogenesis. Namely, he published pictures showing almost all stages of development of this cysticercus from the time of inoculation by eggs to completion of bladder worm. Summarizing his investigation: 1 day after infection, the parasite appears in the veins belonging to portal system or periphery of the hepatic lobes near to interlobular connective tissue; 2~3 days, the parasite becomes vesicular; 8 days, a portion of germinal layers thickens (an anlage of scolex); 13~19 days, scolex invaginates; 22 days, rostellum is about to be formulated; 24~27 days, so-called "hair-like body" grows; 28~30 days, an anlage of suckers appears; 45 days, scolex evaginates and sucking organ of the scolex fully develops; 50 days, so-called "hair like body" is reduced; 50~60 days, calcareous corpuscles appear.

Recently, HUTCHISON (1958) reported an investigation on experimental infection in strain A mice. According to his investigation, on the 30th day after infection, an invaginated cysticercus develops. This evaginates on the 42nd day, and by the 48th day a strobilocercus is formed. The youngest strobilocercus capable of infecting cats has a fresh weight of 20 mg; strobilocerci are recovered from mice after 60 days.

The author would like to compare the investigation reported in literature with the present investigation. The rat strains Wistar and Gifu in the present paper showed similar findings except minute differences in speed of development. The author, therefore, concludes that the parasite develops normally in the liver of these hosts. In mouse strain AKR, development of cysticercus was delayed, but on the 62nd day, conspicuous number of strobilae with calcareous corpuscles were already formulated; the author considers that parasite is capable of infecting cats. It is necessary to make observation for a longer period in mouse strain A, but judging from the investigation up to this time, the scolex has been already formed, so the parasite will be capable of infecting cats even if it needs more time than in mouse strain AKR.

As to the time when the cysticercus is able to infect the cat, the author would like to call attention to the time of appearance of the calcareous corpuscle in strobilae. Such corpuscles are found in large quantity in the parenchyma of the parasite and also a few in the part of the caudal vesicle. As soon as the corpuscles appeared, they stain well with haematoxylin, thereafter their state of staining changes often; therefore the author would comment on the physiological role of this structure. These corpuscles, in the present experiment, are detected

on the 62nd day after inoculation in the mouse strain AKR for the first time. As compared with the above A and AKR strains, in the liver of the other mice, 10 strains, and *Microtus montebelli montebelli*, interesting results were obtained from observations on the state of the parasites and tissue reaction against the parasites. In the liver of these experimental animals, the parasite fell into degeneration at the stage of vesiculation or earlier stage of development, and turned to organization. Although a detrited cell mass appeared in contact with the portion of scolex formation, in cases of normal development of the parasite, adventitious tissue itself which accompanied cell reaction was inconspicuous, and it changes to a capsule of a connective tissue composed of compact circular fibers; the parasite continues development within this capsule. When degenerative changes appeared in the parasites, reactions are different from the above-noted and changes of the parasite can be divided into two types, in vole and mouse cases except strains AKR and A. The first is that the parasites a vesicle composed of a very thin wall; the wall is simple monolayered, nuclei are distributed sporadically or are scarcely found, and the local swelling (scolex anlage) is difficult of discovery. The shape of the vesicle is usually irregular and somewhat similar to the shape of *Echinococcus polymorphus*. The cuticular layer is often not clearly seen. As to reactions, necrotic layer exists in attachment to the parasites; this layer comprises a cell accumulation, mostly eosinophile leukocytes, or a stratiform necrosis of granulation tissue. The necrotic layer, however, is marked off by surrounding liver tissue when regressive change of the parasite takes place in an early stage of infection; in such case, the liver cell cords are observed shadily. Sometimes, the parasite continues the above state for a comparatively long period, but after all it turns to the following second type.

The parasite shrinks to round or ellipsoid shape owing to decrease in the internal pressure of the vesicle. The parasite itself falls into necrobiotic or necrotic state. The construction of adventitious tissue is similar to that of the first type, but tissue reaction is more severe in degree. As the central cavity of focus exists, the parasite floats in the fluid content; at the same time cell elements especially eosinophile leukocytes appear. To this state of a focus was given the name "pseudocyst" by the author. In company with progress of organization of foci the central cavity is filled up with cell mass and dead parasites, thereafter absorption process by granulation tissue from the peripheral portion takes place. Finally the focus is replaced by granulation tissue and becomes nodular. It is not seldom that in the center of nodular foci a necrotic structure exists and, at the same time, calcification is often found. Accumulation of histiocytes in reactive tissue is conspicuous and the appearance of epithelioid cells and giant cells is also recognized as a characteristic of this type of lesion. Even in mouse strains AKR and A these changes can be

found, but very rarely.

The above-noted findings of tissue reaction have been apt to be neglected in the past investigations of experimental studies, because the subjects of these matters are based upon the development of parasite. The author would like to call attention to the above changes. In any case, it may be concluded that marked tendencies of susceptibility are noticeable among mouse strains in the present work. Moreover, although negative assertions with regard to the susceptibility of the mouse have been made in the past, it is clarified that at least strains AKR and A are susceptible to the parasite just as rats are.

It is known with certainty that the suitable intermediate hosts for *Cysticercus fasciolaris* are animals belonging to genus *Rattus*, and the fact is reaffirmed by the present investigation. Reports pertaining to the parasitism of this parasite in rodent animals other than genera *Rattus* and *Mus* were published by STILES & HASSAL (1894), LINTON (1915) and NELSON (1923) in the muskrat, by MAHON (1954) in the American rabbit *Lepus americanus* and recently by DOLLFUS & SAINT GIRONS (1958) in *Apodemus flavicollis flavicollis*. The present author also conducted an experimental infection about vole *Microtus montebelli montebelli* and Mongolian gerbil *Meriones unguiculatus*. Results obtained are that in the former the foci are produced in the liver, but the parasite dies in an earlier stage of development than in mice cases and falls into organization. In the latter, even an initial focus is not formulated at all.

KAN (1933) reported that cysticercus foci became visible to the naked eye on the 6th and 7th day after infection in rat cases while in mice, however, the foci were already visible as white spots on the 2nd and 3rd day. In the present experiment the focus was invisible to the naked eye in the 4th day case in the rat, but, in mice, the days of the first discovery of foci by the naked eye were respectively the 4th and 5th in strains CF #1 and dba. In C57BL/6, the foci already existed as an area of  $500 \times 600 \mu$  on the 5th day. In AKR cases, however, the foci were unrecognizable by the naked eye on the 3rd day or 4th day. As for a reason why the foci in strain dba were detectable on the 4th day irrespective of negative findings in CF #1 and AKR on that day, the author can point out the existence of marked cell reactions surrounding the parasite in dba strain. It, therefore, is considered that the first discovery of foci by the naked eye is delayed in cases of suitable intermediate host as compared with the unsuitable.

Age resistance of host animals to infection of *Cysticercus fasciolaris* was demonstrated by GREENFIELD (1942) using the rat strain Sherman. According to his investigation, infection begins in rats on the 25th day when they have the most living cysticerci in proportion to the total number of cysticerci. Comparatively young animals were used in the present work, considering the age resistance, but

the rat cases of strain Wistar from which the data of more than 30 days post infection were obtained were those of adult animals of unknown age. The conclusions, already described above, were as follows; In young rat cases of 10 days elapsed after the infection, of which the age was less than 30 days, about 200 foci were found respectively; but number of foci was 13 in average. Accordingly, it can be concluded that in rat experiment of the present study age resistance was proved.

In one case, 30th day case of rat strain Wistar in the present study, there were no foci except for a fully developed cysticercus so the case was thought to be a naturally infected one. On the basis of this fact, it can be said that immunity against re-infection exists similar to the conclusion reached by MILLER (1931), KAN (1933) and others.

#### SUMMARY AND CONCLUSION

*Cysticercus fasciolaris* is the larval form or the bladder worm of *Taenia taeniaeformis* and is parasitic usually in the liver of animals of genus *Rattus*. In the literature up to this time, however, no established theory has been formulated regarding the susceptibility of genus *Mus* to this larval parasite.

The present author conducted an investigation on the susceptibility of experimental animals. The animals used were: laboratory mouse *Mus musculus*, strains A, AKR, BALB/c, CF #1, gpc, fm, C3H/He, CFW, SM, dba, dd and C57BL/6; albino rat *Rattus norvegicus norvegicus*, strains Wistar and Gifu; vole *Microtus montebelli montebelli* and Mongolian gerbil *Meriones unguiculatus*. Young animals were used in view of the age resistance to infection by the bladder worm. They were inoculated orally with the eggs of *Taenia taeniaeformis* obtained from experimentally infected cats. After the inoculation the animals were divided into several groups and were killed at certain intervals to be examined macro- and microscopically for the development of the parasite and host tissue reactions.

The conclusion reached were as follows:

1. In rat strains Wistar and Gifu, the bladder worm developed enough to be capable of infecting cats. The same results were obtained in the experiment with the mouse strains A and AKR.
2. In the other mouse strains examined, the bladder worm developed to some extent in the early stage of infection, and thereafter turned to degeneration and organization. Similarly, the parasite which developed in the liver of voles manifested degeneration and organization in the same manner.
3. Mongolian gerbils did not show any susceptibility to the parasite.
4. The author, therefore, concluded that the strains A and AKR should be listed as suitable intermediate hosts of *Taenia taeniaeformis* and that there are

differences of susceptibility among uniform strains of the mouse examined.

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## EXPLANATION OF PLATES

All photographs are those of hematoxylin-eosin stained sections.

## PLATE I.

- Fig. 1. Strain Wistar, 4 days after the infection  
Magnification  $\times 400$ . Initial stage of parasite with distinct larval membrane;  
no vesiculation
- Fig. 2. Wistar, 10 days,  $\times 75$ . Local thickening of germinal layer (scolex-anlage)
- Fig. 3. Wistar, 30 days,  $\times 170$ . Transverse section of the portion of scolex-invagination; so-called "hair-like body" around the rostellum
- Fig. 4. Wistar, 50 days,  $\times 50$ . Completion of scolex; advanced strobilation; muscular tissue formation; thick cuticular layer
- Fig. 5. Gifu, 25 days,  $\times 75$ . Initial stage of scolex formation
- Fig. 6. Gifu, 40 days,  $\times 50$ . Parasite just before the evagination of scolex; wrinkles appear in cuticular layer; attachment organs completed

## PLATE II.

- Fig. 7. Gifu, 45 days,  $\times 50$ . Evagination of scolex
- Fig. 8. AKR, 3 days,  $\times 350$ . Initial stage of vesiculation
- Fig. 9. AKR, 10 days,  $\times 64$ . A few layers of germinal cells; distinct cuticular layer; thin adventitious layer
- Fig. 10. AKR, 20 days,  $\times 75$ . Initial invaginated scolex; at the portion of scolex-invagination, eosinophile leukocytes

- Fig. 11. AKR, 60 days,  $\times 50$ . Nearly completed parasite with muscular tissue distinct  
Fig. 12. A, 40 days,  $\times 75$ . Advanced scolex formation; nearly completed hooks and incomplete suckers

## PLATE III.

- Fig. 13. CF #1, 3 days,  $\times 640$ . Initial stage of parasite; tissue reaction scarcely observable  
Fig. 14. CF #1, 10 days,  $\times 60$ . Thin germinal layer  
Immature granulation tissue with local detrited cell accumulation  
Fig. 15. CF #1, 20 days,  $\times 70$ . Degeneration at the time of scolex anlage formation; parasite with thin wall, necrotic granulation tissue in contact with the cyst wall and outer granulation tissue rich in cell elements  
Fig. 16. CF #1, 40 days,  $\times 70$ . Parasite fell into degeneration at the time of scolex formation; In central cavity fluid elements contained  
Fig. 17. gpc, 30 days,  $\times 160$ . Contactile parasite, surrounded by thick necrotic liver cells  
Fig. 18. C 57BL/6, 5 days,  $\times 160$ . Degeneration of vesiculated parasite; perifocal degeneration of liver cells and accumulation of eosinophile leukocytes

## PLATE IV.

- Fig. 19. C 3H/He, 20 days,  $\times 50$ . Pseudocystic focus  
Degenerated contactile parasite in fluid of cavity; eosinophile cell mass at a corner  
Fig. 20. CF #1, 20 days,  $\times 70$ . Nodular focus, central cavity becomes narrower and in it float the contactile parasite and cell elements  
Fig. 21. BALB/c, 40 days,  $\times 160$ . Organized focus with degenerative materials in the center; surrounding portion is granulation tissue  
Fig. 22. dd, 40 days,  $\times 70$ . Nodular focus with degenerative cell mass in the center  
Fig. 23. CFW, 60 days,  $\times 65$ . Nodular focus with necrotic substances in the center; scattered hematoidin crystals  
Fig. 24. CF #1, 80 days,  $\times 50$ . Nodular focus with a calcificated parasite in the center; parasite embedded in necrotic cell mass







