Methods of Controlling the Liver Fluke of Cattle in Hawaii

by

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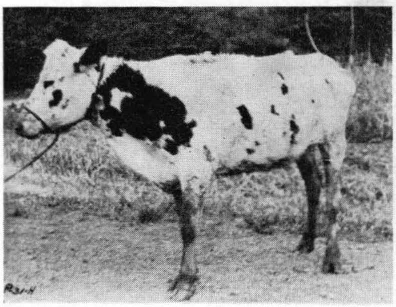

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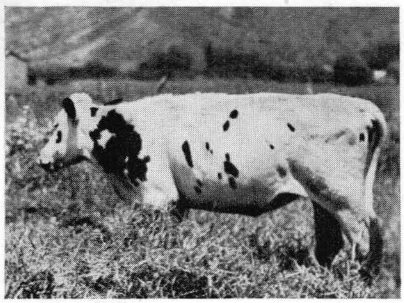

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Dr. Leonard E. Swanson left the station at the end of February 1937 to resume his post with the Bureau of Animal Industry, U.S. Department of Agriculture.

Mr. G. W. H. Goo resigned as of November 30, 1938.

METHODS OF CONTROLLING THE LIVER FLUKE OF CATTLE IN HAWAII

Introduction

Liver-fluke infection of cattle presents a serious menace to the beef and dairy industries of the Hawaiian Islands. The problem of fluke control in sheep, and to a limited extent in cattle, has received consideration in many parts of the world, particularly Europe, Australia, and the North American continent; research conducted in these areas has yielded valuable information and has offered a basis for the advocation of practical control measures. The liver-fluke problem in Hawaii is limited largely to cattle and is somewhat different from that existing elsewhere; the constant, mild temperature, the year-around rainfall, and the extensive lowland areas provide conditions conducive to the maintenance and spread of the parasite. Because of these conditions and the widespread fluke infection of cattle, studies were conducted to determine the suitability of the various known control measures under local conditions.

These studies were made possible by the sugar-processing-tax funds which were appropriated for the general benefit of agriculture in the Territory and were available from 1935 to 1938. Before the investigation was begun, the late Dr. M. C. Hall, then chief of the Zoological Division, United States Department of Agriculture, came to Hawaii for a preliminary survey of the liver-fluke situation. At the conclusion of his survey, field and laboratory investigations of the various phases of the problem were undertaken.

The purpose of this paper is to report on the control measures which have been found applicable to Hawaiian conditions. At the same time, experimental work is being continued, especially with regard to the use of drugs available in the United States for the destruction of liver flukes in cattle.

Local Fluke Infection and Maintenance

The occurrence of liver-fluke infection in the Hawaiian Islands dates back at least to 1892 when A. Lutz (*6*)[1] first reported its occurrence on Kauai, Oahu, Maui, and Molokai. At that time, examination of

[1]Reference is made by number (italic) to Literature Cited, p. 17.

cattle slaughtered in Honolulu revealed 298 calves out of 620 and 1,313 cattle out of 2,186 infected with flukes. In 1905 Smith and Van Dine (*7*) of this station published a bulletin on the control of liver flukes, in which they reported that out of 3,376 cattle slaughtered in Honolulu in 1902, during a period of 6 months, 990 showed fluke infection. In 1928 and 1931, Case (*3, 4*) reported deaths of cattle caused by liver flukes and stated that the disease was widespread throughout the Territory, especially on Oahu and Kauai.

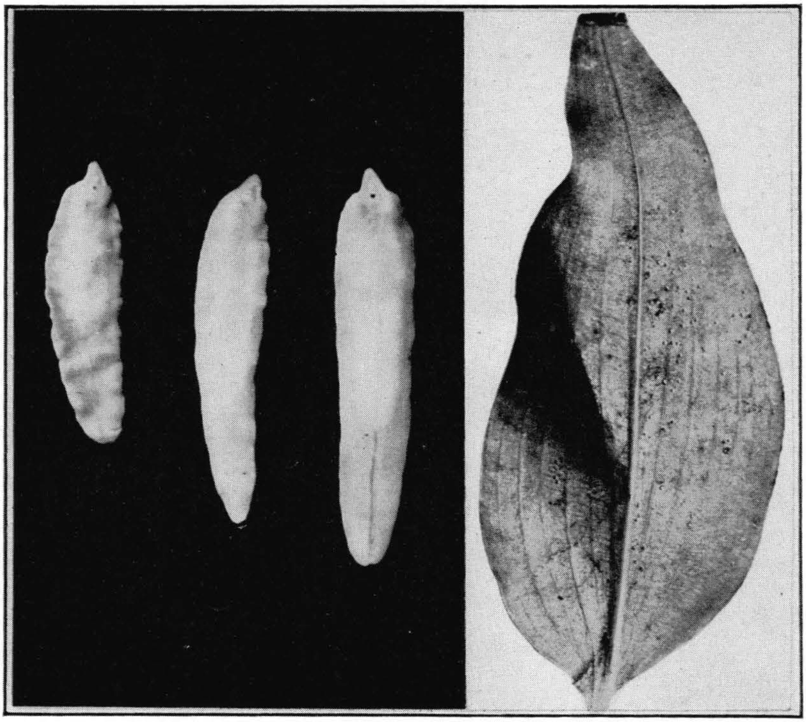
The maintenance of fluke infection in cattle is dependent largely on the environment, which makes it possible for the fresh-water snail which serves as intermediate host to live and propagate. Topography, rainfall, and temperature therefore play an important part. In the Hawaiian Islands there are relatively recent and steep volcanic mountains varying from coastal to central or eccentric in position. The contact of land with sea may be made abruptly, or may be a gradual transition over relatively flat land with very little drainage from the mountain area to the ocean. These low flat areas and valleys with high rainfall, on the windward side especially, often present extensive swampy lands. Although rainfall is most prevalent in the first or last months of the year, showers during other months are sufficient to maintain swampy areas. This constant presence of water and the ideal temperature, which varies only about 5 to 8 degrees between the coldest and warmest months, make conditions suitable the year around for snail propagation as well as for development and hatching of the fluke eggs.

Nature of the Liver-Fluke Problem

Control measures for any parasitic disease are predicated on an understanding of the life cycle of the parasite, its methods of perpetuation, and its resistance to various climatic and environmental conditions. A technical report on these factors in relation to the liver fluke in Hawaii has been published (*1*), and the pertinent points are therefore summarized briefly.

The liver fluke infecting cattle in Hawaii was at first believed to be *Fasciola hepatica,* a common parasite of sheep and cattle in the continental United States and many other parts of the world, but was later identified as a different species, *Fasciola gigantica* (*2*). This latter species measures up to about 2 inches in length, 1/2 inch in width, and 1/32 inch in thickness (see fig. 1, *a*). Figure 2 illustrates graphically the life cycle of the parasite.

The adult flukes in the bile ducts of the livers of cattle lay many eggs



(*a*) (*b*)

Figure 1.—(*a*) Adult liver flukes, *Fasciola gigantica* (natural size); (*b*) liver-fluke cysts attached to a blade of honohono plant (enlarged about 2 times).

of microscopic size. These eggs eventually pass down with the bile to the small intestine and finally are voided with the manure. In the presence of water and at a suitable temperature, the eggs develop in about 14 days and hatch into small larvae known as miracidia. The miracidia swim in the water until they find a suitable snail, which serves as intermediate host. If no such snail is found, the miracidia die. In Hawaii the fresh-water snail, *Fossaria ollula,* commonly found in swamps and streams, is the carrier of the flukes; other snails such as *Physa compacta, Melania indefinita, M. mauiensis,* and *Vivipara chinensis* (fig. 3), which are present in similar areas, have not been found to serve as hosts. The miracidia bore into the body of the suitable snail, and, in a period of about 40 days, each gives rise to a brood of larvae known as cercariae. The cercariae escape from the snail and soon encyst on surrounding vegetation or other objects submerged to various depths in water, chiefly

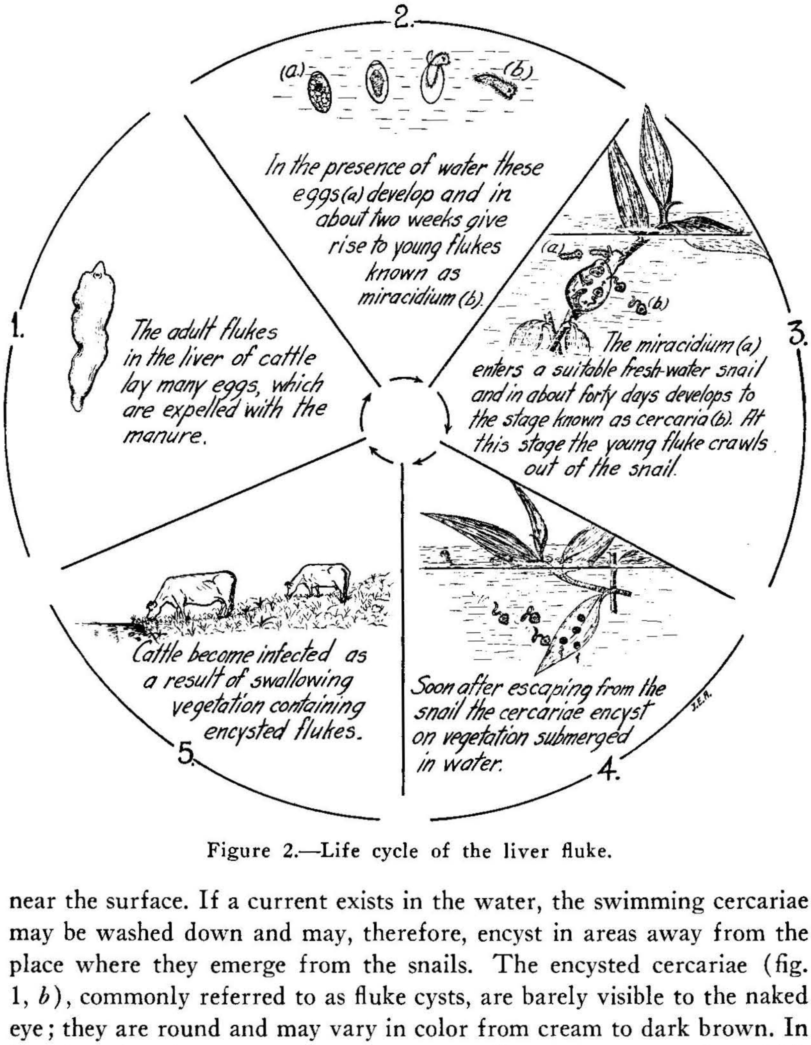
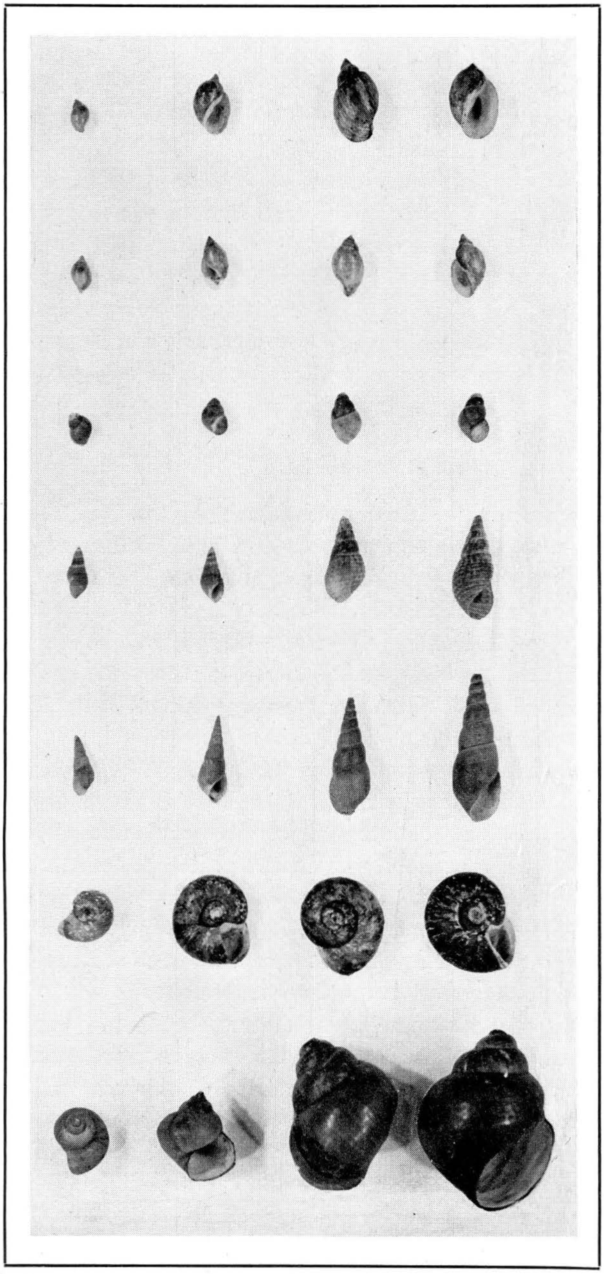


Figure 2.—Life cycle of the liver fluke.

near the surface. If a current exists in the water, the swimming cercariae may be washed down and may, therefore, encyst in areas away from the place where they emerge from the snails. The encysted cercariae (fig. 1, *b*), commonly referred to as fluke cysts, are barely visible to the naked eye; they are round and may vary in color from cream to dark brown. In heavily infested pastures, they are occasionally seen on vegetation which has emerged slightly from the water level, especially on leaves of honohono plants. In the presence of moisture, fluke cysts have been known to live for at least 7 months; there is a possibility that they remain alive longer. The cysts, however, are not able to withstand dryness or sunlight for long periods. Under experimental conditions, cysts attached to honohono plants growing outdoors in the sunlight under semi-dry conditions have been found dead after 42 days.



Fossaria ollula

Physa compacta

Bulimus robustus minor

Melania mauiensis

Melania indefinita

Planorbis sp.

Vivipara chinensis

Figure 3.—Common fresh-water snails found in local swamps and streams (natural size). Of these snails, only *Fossaria ollula* serves as intermediate host for liver flukes. (Note that the shell of *Fossaria ollula* opens on the right side whereas that of *Physa compacta* opens on the left side)

When live fluke cysts are swallowed by cattle or other susceptible animals, the young flukes eventually migrate to the liver and bile ducts. In these ducts the flukes reach sexual maturity in about 80 days, begin to lay eggs, and the life cycle is repeated.

Thus there are three definite and important phases in the life cycle of the parasite; namely, development in the snail, encystment on vegetation, and development in cattle. It follows, therefore, that control measures must be directed against (1) the snails, (2) the eating of infected vegetation by the cattle, and (3) the flukes in the livers of cattle. Although the strict application of any of these measures would help to control the parasite, it is suggested that all three be put into practice whenever possible.

Control of the Snail

Snail control offers one of the best means of breaking the life cycle of the fluke. Two of the most common methods are application of copper sulphate in snail-infested areas (swamps or streams) and drainage of swamps or areas where water accumulates for long periods.

Application of copper sulphate. Of the various chemicals known to kill fresh-water snails, copper sulphate is the one commonly used, since it is inexpensive and small quantities are very toxic to snails. This chemical is also toxic to small fish.

When the chemical is to be applied over small pools of water or swampy areas, it may be broadcast by hand; in order to facilitate broadcasting the chemical is mixed at the rate of 1 part to 4 parts of a carrier, such as sand. Under local conditions, this concentration has been found to kill snails within about 48 hours. The method is estimated to require about 20 pounds of the chemical per acre. Copper sulphate is sold on the market in several forms, varying in size from powder to small rocks; the form preferred for broadcasting is the snow-sized crystal.

When copper sulphate is to be used in streams, a more or less definite concentration is essential. In glass containers, snails may be killed in dilutions of 1 part of copper sulphate to 1,000,000 parts of water; under field conditions higher concentrations are necessary as the presence of algae and decaying organic matter renders a great deal of the chemical inert. Under local field conditions, concentrations of 1 to 200,000 and 1 to 300,000 parts of water have been found effective in destroying snails, but a concentration of 1 to 500,000 was not always adequate.

To estimate the amount of copper sulphate needed to treat the water in a stream, it is necessary to know the flow of the water in cubic feet per second. This may be determined as follows: Select a uniform portion of the stream and obtain its average width and depth. Obtain the velocity of the water by ascertaining the number of seconds required for a small piece of wood to travel a given distance (a distance of 50 feet in 25 seconds shows a velocity of 2 feet per second). Multiply width, depth, velocity, and amount of copper sulphate at the desired concentration (for a 24-hour treatment at a dilution of 1 to 250,000, 24 pounds of copper sulphate are required per second-foot flow of water). The following is given as an example.

A stream 6 feet wide and 1/2 foot deep, with a velocity of 2 feet per second, to be treated at the rate of 1 to 250,000, would require 144 pounds of copper sulphate per mile for a 24-hour treatment: i.e.,

$$\underset{(\textit{width})}{6} \times \underset{(\textit{depth})}{1/2} \times \underset{(\textit{velocity})}{2} \times \underset{(\textit{concentration of copper sulphate})}{24} = 144 \text{ pounds}$$

One method of applying copper sulphate is to place a heavy burlap sack containing crystals, pea-sized or preferably larger, at the head of the stream and allow the copper sulphate to be dissolved by the running water. This type of treatment is effective for a maximum of 1 mile and, therefore, applications will be necessary at varying intervals. In areas where coral sand is present, copper sulphate is very difficult to apply as the chemical unites with the sand, forming a hard, solidified mass. In treating a stream, it may be desirable to place several live snails in small wire-screen cages at various points in the stream, to determine whether or not they are killed. If not, a stronger concentration of the chemical must be used.

A single application of copper sulphate in streams, although effective in killing the snails, is not effective in killing the eggs of these snails. Under natural conditions, snail eggs hatch within from 6 to 10 days and the young snails reach the egg-laying stage about 26 days later; a second application of copper sulphate is desirable, therefore, about 15 days after the first.

When copper sulphate is applied in streams, the snails crawling around the edges just outside the water are often not affected. It is, therefore, desirable to broadcast the chemical by hand in powdered or "snow" form, mixed at the rate of 1 to 4 parts of a carrier.

Drainage. The presence of surface water in pastures is essential for the development and maintenance of fresh-water snails as well as for the development of the fluke eggs. Where it is possible, therefore, drainage is one of the most permanent methods of snail and fluke control.

Drainage ditches should have sufficient capacity and fall to carry off all of the water, leaving none standing. The banks of the ditches should be perpendicular so as to prevent grasses from growing. Even if drainage removes the water from only one part of a wet section, it serves to lessen the extent of the area to be treated by chemicals. These drainage ditches, when practical and economical, should be tiled. The high mauka (upper) regions, where sufficient drainage is to be had, may be controlled by surface ditching or deep ditching and tile. Such open ditches make ideal breeding ground for snails and should, therefore, be fenced off from the pasture to keep livestock from eating vegetation growing in the ditches or on the banks. It is also desirable to clean out any possible source of snail infection at the drainage head.

Complete drainage of an area will kill the snails as well as the snail eggs in about 5 days and will help to break the life cycle of the fluke, but encysted cercariae present on grasses prior to drainage may remain alive for several months.

Prevention of Infection in Cattle

One of the common methods of preventing infection in cattle is by fencing off infested pasture areas; another is by feeding vegetation which has been cut in dry areas known to be free from infestation.

Fencing is not ordinarily regarded as an economically practical method of fluke control as it takes out of production land which otherwise might be utilized for pasturage or crops. Moreover, it does not effectively control flukes if cattle are maintained where feces containing fluke eggs may be washed into the fenced area by heavy rains and serve to infect snails. Water flowing out from the fenced areas may contain fluke cercariae which will encyst on vegetation in unfenced areas or fluke cysts which have detached from infected vegetation, and these will serve to infect cattle drinking water from these outlets. In addition, if the fence does not follow the outlets of the swamp or slough throughout the pastures, cattle may become infected by consuming grasses along these outlets. Where drainage is economically impractical however, fences built in such a manner that cattle cannot reach or break through to obtain grass should be installed about 10 feet from all boggy or wet areas.

Treatment of Infection With Drugs

When drugs are properly used, the treatment of infected cattle tends to improve the general health of the animals (figs. 4 and 5) as well as

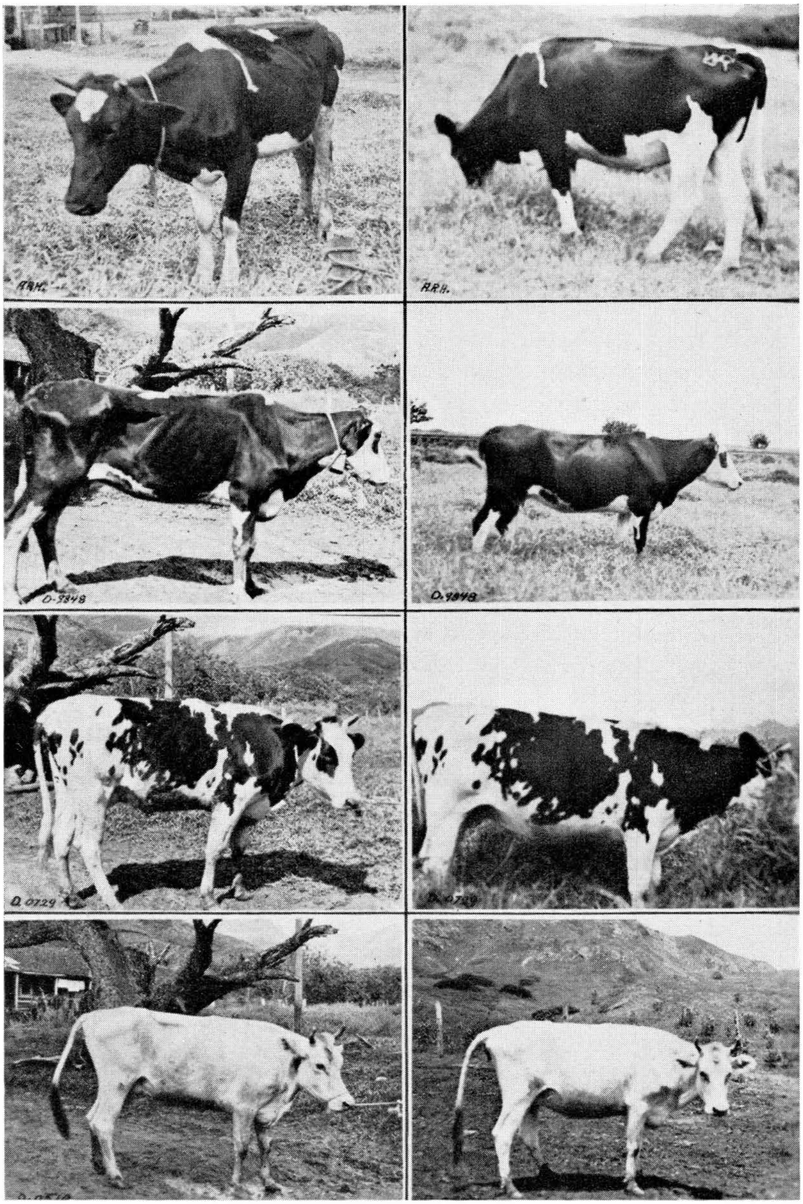


Figure 4.—Four fluky cows treated with Distol, showing, *left,* physical appearance before treatment and, *right,* about 4 months after treatment.

decrease pasture infection. Treatment does not insure against reinfection and, if this method alone is used, has considerable limitations in fluke control. Animals which have been treated should, as far as possible, be kept from reinfection; if this is not economically practical and the animals are believed to be continually reinfecting themselves, it may be essential to treat them at regular intervals, possibly once or twice a year.

The drugs which have received most consideration in this project have been Distol and kamala. Distol is a proprietary drug manufactured in Hungary. For administration to cattle, Distol is made up in soft gelatin capsules, each containing, according to the label, 1 gram aspidinolfilicic acid (conc.), 10 grams hexachloroethane, and 1.6 grams talc. This drug, according to Hutyra and Marek (5), has been used by Marek, Reisinger, and others, and has been reported as being highly effective in destroying liver flukes. Kamala is made up of glands and hairs from the capsules of a small tree *(Mallotus philippinensis)* found in the Philippine Islands, China, and Japan; this drug is obtainable in the United States.

Treatment with drugs has been conducted chiefly on beef cattle and on dairy cattle which were not in lactation, and in a few cases on dairy cattle which were near the end of their lactation period. The amount of drug administered was based on the body weight of each animal.

Records of 47 animals treated with Distol at the rate of 1 capsule to 70 pounds of body weight, the total number of capsules being divided into equal or approximately equal dosages and administered over a period of 2 or 3 successive days, indicated that the drug at this rate destroyed all or most of the flukes in the livers of infected animals. In 40 animals treated with kamala at the rate of 1 capsule (containing 10 grams of drug) to each 60 pounds of body weight administered over a period of 4 consecutive days, this drug was also found effective in destroying all or most of the flukes.

As to the tolerance of cattle to these drugs, Distol has shown no deleterious effects, whereas kamala in all cases has caused extensive diarrhea and often loss of appetite lasting from a few days to about 2 weeks. Although most of the animals recovered, two died a few days following treatment; one of these animals was in poor physical condition and the other, although in fair condition when treated, had not been very energetic for the preceding few months. These observations indicate that it is not safe to administer kamala to animals in poor condition or showing reduced vitality. There is a possibility that kamala may safely be administered to animals in poor condition at the rate of 1

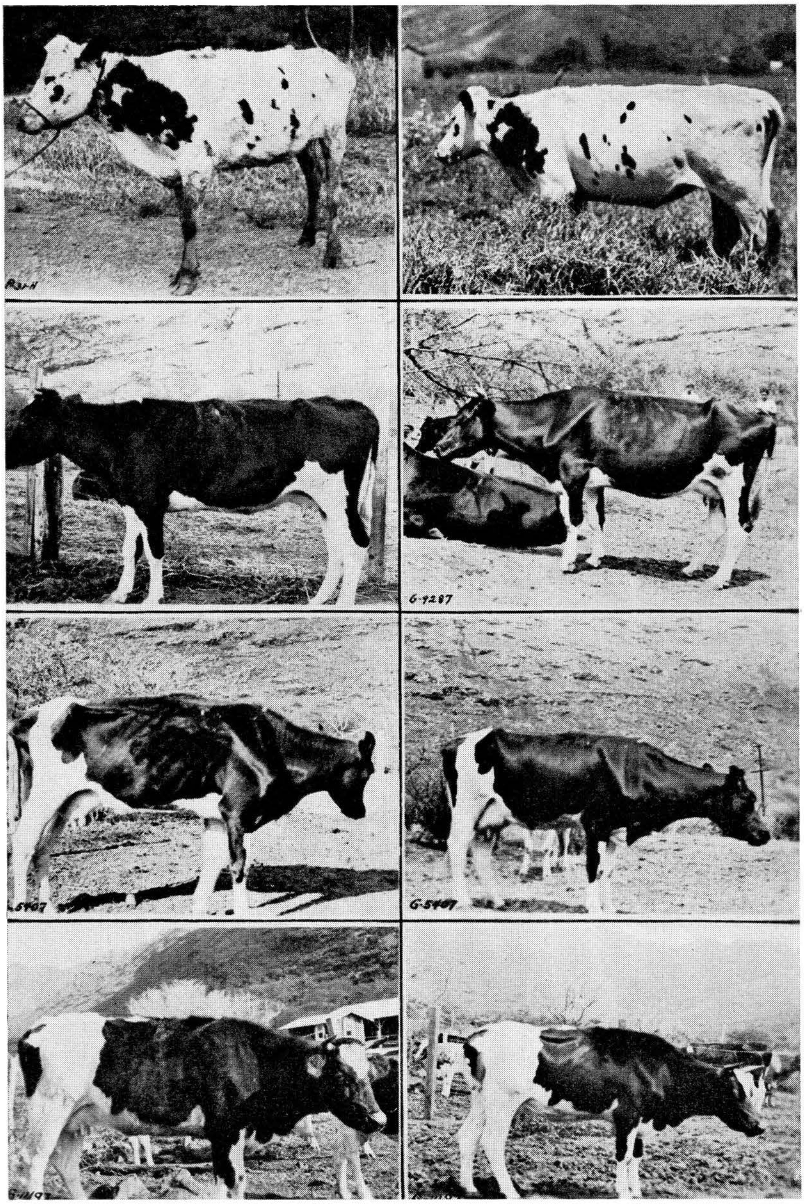


Figure 5.—Four fluky cows treated with kamala, showing, *left,* physical appearance before treatment and, *right,* about 4 months after treatment.

capsule to 70 pounds of body weight, but a few preliminary studies conducted on young animals have shown this rate in most cases to be ineffective in destroying flukes.

As to the use of drugs on cows in gestation, Distol has shown no deleterious effects on animals treated 2 months or 1 month before calving. It is, however, probably not a desirable practice to treat cows with kamala within the last 2 months of calving as this drug has a tendency to cause debilitation.

A few preliminary observations on cows in lactation treated with Distol and kamala have in all cases shown temporary decreases in milk production, but the milk output gradually increased to normal within a period of 2 weeks. The milk from cows treated with Distol usually acquired a salty, bitter taste which lasted for a few days. It is not believed desirable to use such milk for human consumption. No observations have thus far been made on the palatability of milk immediately after treatment with kamala.

Summary and Remarks

Control of the liver fluke of cattle in Hawaii may be carried out on the same bases as in other parts of the world; namely, through control of the snail carrier, prevention of grazing in swamps or the feeding on grass cut from these areas, and treatment of infected animals.

The intermediate host of the liver fluke in Hawaii is the snail *Fossaria ollula*, a common inhabitant of fresh-water streams and swamps. The snail may be controlled (1) by broadcasting copper sulphate at the rate of 20 pounds per acre, using 1 part of the chemical to 4 parts of a carrier such as sand; (2) by application of copper sulphate in streams at the rate of 1 to 200,000 or 1 to 300,000 parts of water; or (3) by drainage of swampy areas.

Cattle may be protected from infection by fencing off areas where drainage is not practical and allowing the cattle to feed only on vegetation from dry areas.

Distol and kamala have been found effective in most instances in the removal of flukes in cattle. Experimental treatment was chiefly with steers and dairy cows which were nonlactating or near the end of their lactation period. Distol was found effective in most cases when given at the rate of 1 capsule to 70 pounds of body weight over a period of 2 or 3 successive days. Kamala was effective at the rate of 10 grams of drug to 60 pounds of body weight, administered over a period of 4 days, but produced considerable diarrhea and loss of appetite lasting from a few days to about 2 weeks, and resulted in death in two instances. Additional studies are being conducted to determine the efficacy and safety of other drugs available in the United States.

For the present, therefore, Distol is considered superior to kamala because it is safer and requires less time to administer. Kamala has the advantage of costing about one-third as much as Distol, and it may be obtained in local markets. It is suggested that Distol be used for dairy cows and kamala for beef cattle and possibly for less productive dairy cows.

An appendix gives instructions for administration of the drugs.

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APPENDIX

The quantitative administration of Distol or kamala is based on body weight of infected animals. If it is not practical to weigh each animal before treatment, the weight may be estimated from measurements of heart girth, used in connection with a table prepared by the U. S. Department of Agriculture. Instructions for the procedure are given by Knapp,[1] as follows:

"To obtain a reasonably accurate measurement, the animal should be placed squarely on all four feet, with its head in the normal upright position. A steel or cloth tape, three-eighths or one-half inch wide, should be used to take the measurement. The tape should be placed around the animal at the point of smallest circumference just back of the fore legs. The tape should be pulled snugly about the animal, tight enough to make the hair lie down but not tight enough to indent the flesh. It is better to take several measurements and use the average as the true measurement. . . ."

The tables for estimating weights of beef cattle of good grade and dairy cattle follow:

[1]KNAPP, BRADFORD, JR. *A Method of Estimating the Weights of Beef and Dual-Purpose Cattle from Heart-Girth Measurements.* U. S. Dept. Agr. Bur. Anim. Ind., A.H.D. No. 24, 4 pp., 1937.

Table 1.—Estimating the weights of beef cattle of good grade by heart-girth measurements[1]

Heart girth	Weight	Heart girth	Weight	Heart girth	Weight
Inches	*Pounds*	*Inches*	*Pounds*	*Inches*	*Pounds*
30	78	50	372	70	910
30½	82	50½	382	70½	926
31	87	51	393	71	942
31½	91	51½	404	71½	959
32	96	52	415	72	977
32½	101	52½	426	72½	994
33	106	53	437	73	1,011
33½	112	53½	449	73½	1,029
34	118	54	461	74	1,047
34½	123	54½	472	74½	1,065
35	129	55	484	75	1,083
35½	135	55½	496	75½	1,100
36	141	56	508	76	1,117
36½	147	56½	520	76½	1,135
37	153	57	533	77	1,154
37½	159	57½	545	77½	1,173
38	166	58	558	78	1,192
38½	173	58½	571	78½	1,211
39	181	59	585	79	1,230
39½	188	59½	598	79½	1,249
40	195	60	611	80	1,269
40½	202	60½	624	80½	1,288
41	210	61	637	81	1,308
41½	218	61½	651	81½	1,328
42	226	62	665	82	1,348
42½	234	62½	679	82½	1,368
43	242	63	693	83	1,388
43½	250	63½	708	83½	1,409
44	259	64	723	84	1,430
44½	267	64½	738	84½	1,451
45	276	65	753	85	1,472
45½	285	65½	768	85½	1,493
46	294	66	783	86	1,514
46½	303	66½	798	86½	1,535
47	313	67	814	87	1,557
47½	322	67½	829	87½	1,578
48	332	68	845	88	1,600
48½	342	68½	861	88½	1,622
49	352	69	877	89	1,644
49½	362	69½	893	89½	1,667

[1]Source: KNAPP, BRADFORD, JR. (Cited p. 19.)

Table 2.—Estimating the weights of dairy cows by heart-girth measurements[1]

Heart girth	Weight	Heart girth	Weight	Heart girth	Weight	Heart girth	Weight
Inches	*Pounds*	*Inches*	*Pounds*	*Inches*	*Pounds*	*Inches*	*Pounds*
26	80	43½	266	61	668	78½	1,354
26½	82	44	275	61½	684	79	1,377
27	84	44½	284	62	700	79½	1,400
27½	86	45	294	62½	716	80	1,423
28	89	45½	304	63	732	80½	1,446
28½	92	46	314	63½	749	81	1,469
29	95	46½	324	64	766	81½	1,492
29½	98	47	334	64½	783	82	1,515
30	101	47½	344	65	800	82½	1,538
30½	104	48	354	65½	817	83	1,561
31	108	48½	364	66	835	83½	1,584
31½	113	49	374	66½	853	84	1,607
32	118	49½	384	67	871	84½	1,630
32½	123	50	394	67½	889	85	1,653
33	128	50½	404	68	908	85½	1,676
33½	133	51	414	68½	927	86	1,699
34	138	51½	424	69	947	86½	1,722
34½	143	52	434	69½	967	87	1,745
35	148	52½	445	70	987	87½	1,768
35½	153	53	456	70½	1,007	88	1,791
36	158	53½	467	71	1,027	88½	1,814
36½	163	54	478	71½	1,048	89	1,837
37	168	54½	489	72	1,069	89½	1,860
37½	174	55	501	72½	1,090	90	1,883
38	180	55½	513	73	1,111	90½	1,906
38½	186	56	526	73½	1,132	91	1,929
39	192	56½	539	74	1,153	91½	1,952
39½	200	57	552	74½	1,175	92	1,975
40	208	57½	565	75	1,197		
40½	216	58	579	75½	1,219		
41	224	58½	593	76	1,241		
41½	232	59	607	76½	1,263		
42	240	59½	622	77	1,285		
42½	248	60	637	77½	1,308		
43	257	60½	652	78	1,331		

[1]Source: KENDRICK, J. F., and PARKER, J. B. *Estimating the Weights of Dairy Cows from Heart-Girth Measurements.* U.S. Dept. Agr. Bur. Dairy Ind. Mimeo. 695, 2 pp., 1936.

Having determined the weight of the animal, the drug dosage may be estimated from table 3.

Table 3.—Method of estimating amount of Distol or kamala for the treatment of cattle for liver-fluke infection

Body weight of animals in pounds		Total number of capsules to be administered	Number of capsules to administer each successive day		
Rate of drug 1:60	Rate of drug 1:70		2-day period	3-day period	4-day period
60 to 90	70 to 105	1	1	1	1
91 " 150	106 " 175	2	1-1	1-1	1-1
151 " 210	176 " 245	3	2-1	1-1-1	1-1-1
211 " 270	246 " 315	4	2-2	2-1-1	1-1-1-1
271 " 330	316 " 385	5	3-2	2-2-1	2-1-1-1
331 " 390	386 " 455	6	3-3	2-2-2	2-2-1-1
391 " 450	456 " 525	7	4-3	3-2-2	2-2-2-1
451 " 510	526 " 595	8	4-4	3-3-2	2-2-2-2
511 " 570	596 " 665	9	5-4	3-3-3	3-2-2-2
571 " 630	666 " 735	10	5-5	4-3-3	3-3-2-2
631 " 690	736 " 805	11	6-5	4-4-3	3-3-3-2
691 " 750	806 " 875	12	6-6	4-4-4	3-3-3-3
751 " 810	876 " 945	13	7-6	5-4-4	4-3-3-3
811 " 870	946 " 1015	14	7-7	5-5-4	4-4-3-3
871 " 930	1016 " 1085	15	8-7	5-5-5	4-4-4-3
931 " 990	1086 " 1155	16	8-8	6-5-5	4-4-4-4
991 " 1050	1156 " 1225	17	9-8	6-6-5	5-4-4-4
1051 " 1110	1226 " 1295	18	9-9	6-6-6	5-5-4-4
1111 " 1170	1296 " 1365	19	10-9	7-6-6	5-5-5-4
1171 and up	1366 and up	20[1]	10-10	7-7-6	5-5-5-5

[1]Suggested maximum dosage.

Suggestions for Treating Fluky Cattle

1. Withhold feed from the animal for at least 12 hours before and 3 hours after each treatment. Water may be given at any time. Feed animal moderately during period of treatment, avoiding an excess of concentrates.

2. For treating animals with Distol:

   (a) For animals in good or fair condition use drug at the rate of one capsule to each 70 pounds of body weight, and administer the capsules in 2 days (i.e., give half or approximately half of the number of capsules the first day and the balance on the following day).

(b) For animals in poor condition, use drug at the rate of 1:70 and administer it over a 3-day period.

3. For treating animals with kamala:

   (a) For full-grown animals, put up the drug in large gelatin capsules (No. 10), each capsule containing 10 grams (0.32 ounce) of kamala. For calves, the drug can be administered more easily in smaller capsules (No. 11), containing 5 grams; the dosage is then double the number of capsules indicated in the table.

   (b) For animals in good or fair condition, use drug at the rate of 1 capsule to 60 pounds of body weight and administer it over a 4-day period. For animals in poor condition or showing reduced vitality, kamala is not recommended.

4. In treating dairy cows, it is preferable to treat animals not in lactation or near the end of their lactation period. Drug treatment causes a temporary drop in milk production and the milk for a few days has a bitter taste; such milk should not be used for human consumption.

5. Any drug should be administered to cattle by a veterinarian or by an individual especially trained for such work.