FASCIOLIASIS IN JAMAICA: EPIDEMIOLOGIC AND ECONOMIC ASPECTS OF A SNAIL-BORNE PARASITIC ZOONOSIS[1]

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Fascioliasis is endemic in Jamaica. This study uses survey and livestock production data to assess the animal health, veterinary public health, and economic impact of the disease.

Introduction

Fasciola hepatica, the etiologic agent of fascioliasis in the Caribbean region, occurs throughout the major islands of the Greater Antilles and in foci on two islands (Martinique and Saint Lucia) of the Lesser Antilles.

According to a study conducted by the Pan American Health Organization *(1),* fascioliasis is recognized as causing prodigious losses to the food animal industries of Cuba, the Dominican Republic, Haiti, and Jamaica. The extent of these losses may be partially quantified by examining the prevalence of bovine liver condemnations, an indicator of morbidity produced by liver-fluke infestation. In this regard, Dobsinsky *(2)* found liver condemnation rates ranging from 10.7 to 32.9 per cent in Cuba in 1968; Barnish et al. *(3)* found rates ranging from 9.8 to 23 per cent on Saint Lucia in 1978; and Gentilini et al. *(4)* found 60 per cent of the livers were condemned at one Haitian abattoir in 1964. Also, Frame et al. *(5, 6)* have cited a liver condemnation rate on Puerto Rico of 3.18 per cent. The economic consequences of these animal protein losses have been investigated on Puerto Rico, where the direct monetary loss in carcass retail value due to offal condemnation rose from US$24,400 in 1948-1949 *(7)* to US$2,270,000 in 1976 *(6).*

Human fascioliasis also has a long history of occurrence in the Caribbean region *(8),* but has been considered of minor public health significance. Recently, however, findings from Cuba and Puerto Rico have indicated that clinical cases are more common than was suspected, and that an even larger number of asymptomatic human infections remain unrecognized *(9, 10).*

Bovine hepatic distomiasis has been recognized on Jamaica since the early part of this century *(11, 12).* Preliminary studies on the epidemiology of the disease have identified the intermediate host as *Lymnaea (= Fossaria) cubensis (13),* and have demonstrated the occurrence of the infection in Jamaican sheep *(14)* and goats *(15).*

Because of the potential economic and public health significance of fascioliasis for Jamaica, the study reported here was undertaken by the University of the West Indies, the Government of Jamaica (Veterinary Division), and the Pan American Health Organization. That study sought to quantify epi-

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demiologic variables relating to the occurrence and morbidity of fascioliasis, and to estimate the current economic losses attributable to persistence of the disease.

Materials and Methods

The national prevalence of ruminant fascioliasis on Jamaica was assessed by analyzing fecal specimens obtained from cattle, sheep, and goats from November 1979 to April 1980. Specimens were collected from all parts of the island except from Cockpit Country in the west and the Blue and John Crow mountain ranges in the east, due to the inaccessibility of these areas.

With regard to cattle and goats, 48 animals of each kind were sampled in each of Jamaica's 13 parishes. Each parish was divided into quadrants of equal area, and a total of 12 specimens were collected from a minimum of four different farm units in each area.

Sheep were sampled in the six parishes where sheep-raising was a significant activity. The sample size was adjusted in each area covered to include approximately 10 per cent of the whole flock.

Equal numbers of samples were collected from cattle in the age ranges of 3-9, 10-15, 16-21, and 22-27 months, and from sheep and goats in the age ranges of 9-15, 16-21, 22-27, and 28-30 months.

The specimens were collected by the Veterinary Division of the Ministry of Agriculture through its national network of parish veterinarians and animal health assistants. A proforma history was completed for each animal, and a 4-5g rectal fecal specimen was collected and submitted to the Central Veterinary Laboratories in Kingston within 24 hours for fecal analysis. These specimens were airfreighted from the western parishes.

All the specimens analyzed (see Table 1) were examined within 36 hours of collection using a modified double flotation technique *(16)*. The detection of a single *F. hepatica* egg after zinc sulfate flotation was considered indicative of infection.

Results and Discussion

Epidemiologic Study

The relative size of the sampled ruminant populations is shown in Table 1. Goats and cattle that had received anthelminthic treatment less than six weeks before specimen collection were excluded from the study. The total proportions excluded, 16.7 and 12.4 per cent, respectively, were homogeneously distributed and did not generate geographic or age bias in the sample. Data from all the sampled sheep were included in the study be-

Table 1. The numbers of cattle, goats, and sheep included in the survey; the estimated size of the respective national herds; and the percentage of each national herd included in the survey.

Livestock type	Fecal specimens: No. collected	Fecal specimens: No. analyzed	Estimated size of national herd (in thousands)	Percentage of national herd sampled
Cattle	624	520[b]	358.9[c]	0.14%
Goats	587[a]	514[b]	368.6[c]	0.14%
Sheep	268	268	2.2[d]	12.2%

[a]Incomplete data for Hanover Parish.

[b]Specimens from cattle and goats receiving antihelminthics less than six weeks before the specimen collection were excluded from the study.

[c]PAHO extrapolation based on Ministry of Agriculture census data for 1958-1968.

[d]Estimate made during the survey.

cause the majority of the sheep had recently received anthelminthics, making exclusion impractical.

The geographic distribution of sampling sites with infected goats and cattle is shown in Figure 1. Infected herds were identified in four different types of ecologic zones: the irrigated alluvial plains of central Clarendon and southern St. Catherine parishes; the rainy lowland plateaus; the high-rainfall (200 cm per annum) coastal areas of St. Thomas and Portland parishes; and the marshlands (morass) of St. Elizabeth and Westmoreland parishes. These zones are characterized by the existence of persistent or frequently replenished aquatic habitats.

Infected sheep were confined to coastal areas in the parish of Portland. The relative rarity of fascioliasis in this species may reflect widespread anthelminthic use, but it could also be a consequence of the species' present geographic distribution. That is, Jamaica's sheep population declined from 6,200 animals in 1967 *(17)* to 2,200 in 1981, and most flocks are now confined to arid, well-drained areas. In all, 83 per cent of the sheep population is currently situated outside the endemic zones shown in Figure 1, perhaps reflecting intentional exclusion of flocks from areas associated with acute ovine fascioliasis.

Figure 2 shows the prevalence of fascioliasis in goats and cattle by parish, as indicated by the analysis of fecal specimens, and compares these prevalences to data on bovine liver condemnation. In this regard, it should be noted that meat inspectors do not ordinarily condemn the entire liver of an infected animal, but instead excise the visibly affected portion. Accordingly, offal condemnations are recorded as the total weight condemned in a particular parish each month, providing no direct indication of the number of slaughtered animals infected. For our purposes, figures providing a basis for inter-parish comparison were derived by dividing the total weight (in kg) of the infected condemned liver by the number of cattle slaughtered; this yielded a rough composite measure of the intensity of infection.

Nationally, the prevalence of bovine fascioliasis indicated by the coprologic survey was 22.2 per cent. Moreover, parish-by-parish comparison of these results and the offal condemnation data indicate a correlated geographic distribution, with the disease appearing most prevalent in the eastern and far-western parishes.

The parish distribution of fascioliasis in goats, as indicated by the survey, somewhat resembled that of fascioliasis in cattle; nationally, the observed prevalence of infestation among goats was 17.2 per cent. Records of goat offal condemnations were not ade-

Figure 1. The parishes of Jamaica, showing the location of unsurveyed areas and the portions of each parish found to harbor endemic fascioliasis.

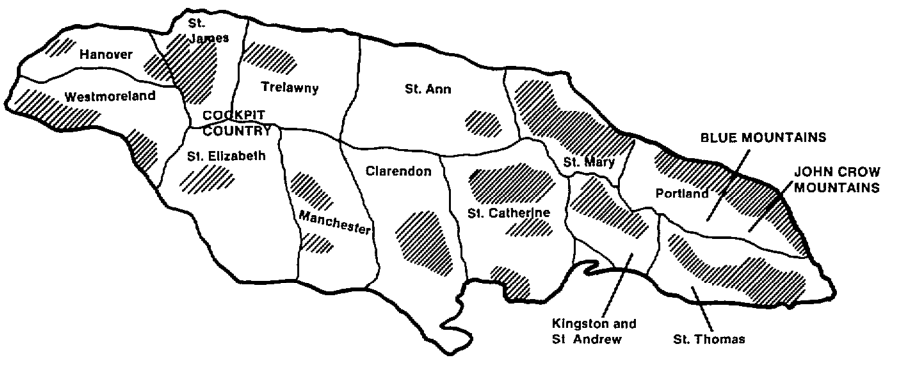
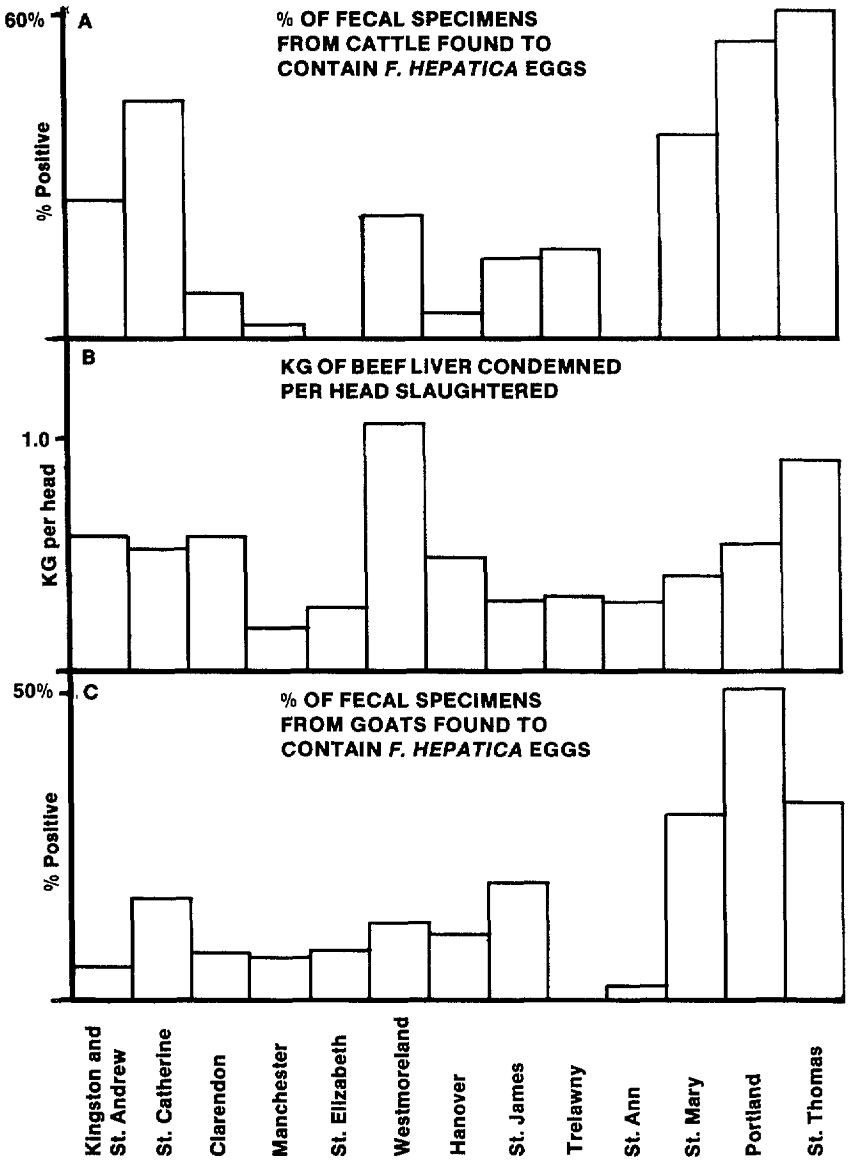


Figure 2. Data from the study survey and reference 22 indicating the occurrence of *F. hepatica* infection in the parishes of Jamaica. The top and bottom charts (A and C) show the percentages of goat and cattle coprologic survey specimens yielding positive results. The middle chart (B) shows the average amount of beef liver condemned (in kg) per slaughtered animal.



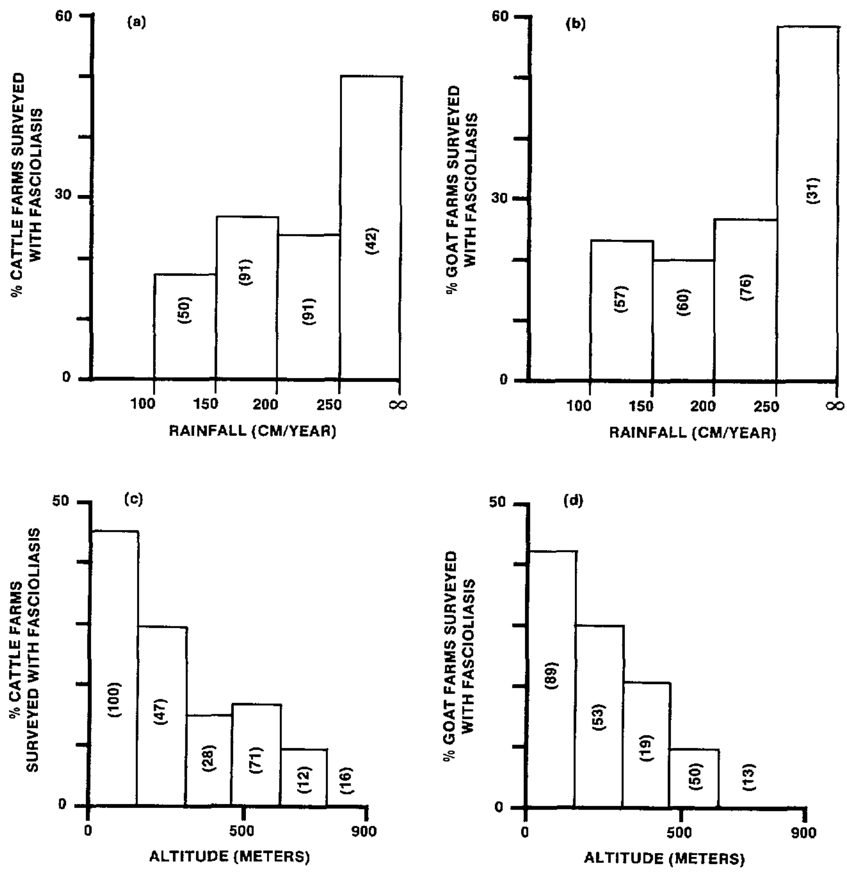
quate to provide a basis for comparison with these data.

Infected sheep were only observed in one parish, the indicated national prevalence of fascioliasis in sheep being a mere 0.72 per cent. This result probably reflects the virtual exclusion of sheep from fluke-endemic areas and the extensive use of anthelminthics by local sheep-raisers.

The data for cattle in Figure 2 show that the method of fecal analysis used failed to detect infections in some areas proved positive by slaughter inspection. That is presumably because the zinc sulfate technique, while appropriate for mass-surveys under conditions where technological services are limited, sacrifices sensitivity for convenience and yields results that tend to underestimate the prevalence of low-grade infections.

The influence of climatic conditions (rainfall and altitude) were assessed by examining the distribution of farm units with "endemic" fascioliasis—an "endemic" farm being defined as one where the infection was detected in at least one member of a cattle or goat herd. As Figure 3 shows, farms in all of Jamaica's rainfall zones (areas receiving between 100 and 500 cm of rain per year) were found to

Figure 3. Relationships between rainfall and farm elevation in Jamaica and the prevalence of fascioliasis among goats and cattle. The number of farms surveyed in each case is shown in parentheses.



harbor the infection. However, the prevalence of endemic farms was highest in places that received over 250 cm of rain per year. No infections were detected in cattle herds kept at altitudes above 750 meters or in goat herds kept above 600 meters. Moreover, the percentage of farms with infected goats and cattle was inversely associated with altitude, being highest below 150 meters.

A rough assessment of the interaction between rainfall and altitude was made with the data shown in Table 2. Predictably, the percentage of "endemic" cattle and goat farms was found to be highest in places situated below 300 meters that received over 200 cm of rain a year. This percentage declined as altitude increased; and finally, at altitudes above 600 meters only one of the 44 cattle and goat herds surveyed was found to be infested.

The positive correlation between the occurrence of fascioliasis and rainfall is readily explained, because the parasite's semi-aquatic intermediate host snail populations maintain themselves most efficiently in areas with persistent aquatic habitats. The negative correlation between fascioliasis and altitude, leading eventually to exclusion of *F. hepatica* at high altitudes, is harder to explain. Average temperatures do tend to be lower at higher altitudes. For example, data provided by Jamaica's Meteorological Service indicate that the St. Catherine plains (altitude below 30 meters) experience temperatures ranging from 10.1 to 35.6°C, the average annual minimum and maximum temperatures being 15.3 and 31.9°C. Considerably higher, at a place named Cinchona in St. Andrew Parish (altitude 1,500 meters), the temperatures range from 8.3 to 27.2°C, the average annual minimum and maximum being 11.7 and 23.0°C. Despite such lower temperatures, however, even the Cinchona ranges equal or exceed those of southern parts of the U.S., where a *F. hepatica* cycle sustained by *Fossaria cubensis* is endemic. It thus appears unlikely that low temperatures exclude *F. cubensis* from elevated areas of Jamaica, although the indigenous snail strain could conceivably be differentially adapted to the higher temperatures found at low elevations.

Another possibility is that Jamaica's uplands fail to provide enough persistent aquatic habitats for the host snail. This seems likely, since the island's limestone hills are both steep and permeable, thereby tending to prevent formation of such habitats and to encourage runoff. Paradoxically, the uplands' high annual rainfall areas, characterized by young fast-flowing streams, seem especially unlikely to provide suitable habitats for the host snail. It thus appears, within the Jamaican context, that the rainfall level alone is a poor indicator of fluke endemicity.

The seasonality of fascioliasis in Jamaica

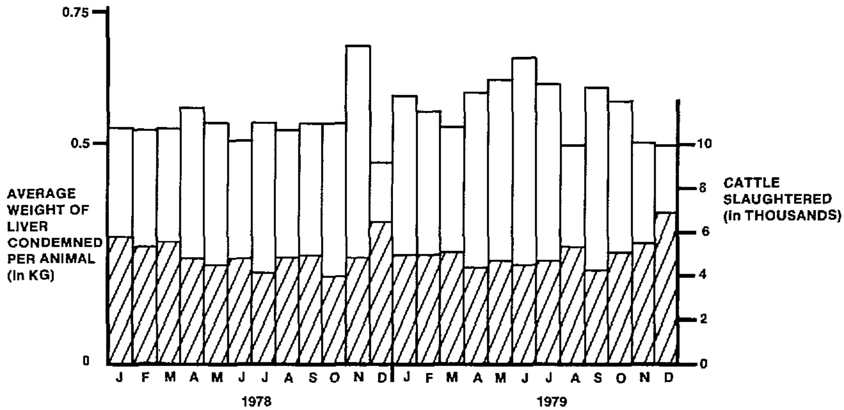
Table 2. Percentages of farms raising cattle and goats with fascioliasis under varying conditions of altitude and rainfall.

Altitude[a]	Farms with cattle				Farms with goats			
	Annual rainfall ≤200 cm[b]		Annual rainfall >200 cm		Annual rainfall ≤200 cm		Annual rainfall >200 cm	
	Farms surveyed	% with fascioliasis	Farms surveyed	% with fascioliasis	Farms surveyed	% with fascioliasis	Farms surveyed	% fascioliasis
<300 meters	90	32.2	57	52.6	75	18.7	67	44.8
300-600 meters	45	13.3	55	20.0	38	5.3	31	22.6
>600 meters	12	8.3	16	0	10	0	6	0

[a]Farm altitudes were estimated from a map made by the Directorate of Overseas Surveys Ordinance Survey Office, United Kingdom, 1976 (DOS 410, Series E 721, 1:50,000, 1976)

[b]Farm rainfall levels were determined on the basis of rainfall data supplied by the Government Meteorological Service of Jamaica.

Figure 4. The number of cattle slaughtered in Jamaica (shaded bars) and the amount (in kg) of bovine liver condemned, 1978-1979, by month.



was investigated using monthly bovine liver condemnation data for the years 1978-1979 (Figure 4). The weight of the condemned offal did not vary significantly throughout the year. This finding, consistent with a pattern of chronic bovine fascioliasis, gives no indication of either the incidence or seasonality of infection.

The Economic Impact

Direct Losses

Mortality. No deaths due to intra-hepatic migration of *F. hepatica* in cattle have been described in Jamaica, although anecdotal reports indicate that the liver dysfunction associated with chronic infection may be an accessory factor in some deaths. Acute fascioliasis, in which liver function is compromised by massive simultaneous infection, has been observed in both sheep and goats *(13, 18)*. In fact, an entire herd of goats in one high-rainfall area succumbed in a single season, effectively dissuading local farmers from keeping small ruminants.

As the latter chain of events demonstrates, acute small ruminant fascioliasis involves two kinds of loss: damage to the stock and its potential progeny, and future exclusion of small ruminants from high-risk pastures. This latter component is especially important on small islands where pasturage is limited; but neither loss component has been adequately quantified on Jamaica.

Offal condemnations and morbidity. The average number of mature flukes found in the bile ducts of cows from one St. Andrew abattoir was 51 ± 13 per cow (n = 15), plus an undetermined number of migrating juveniles. This intensity of infection compares with 24 ± 7 per cow (n = 49) found among dairy cattle in Australia's Macalister irrigation area *(19)*, and 67 (n = 900) found among cattle in Belfast, Northern Ireland *(20)*. Mature infections were associated with fibrosis and calcification of major bile ducts, and with parenchymal fibrosis.

Table 3 shows the total losses due to recorded bovine liver condemnations on Jamaica during the period 1978-1980, losses that appear due almost entirely to fluke-induced lesions. These losses are expressed in terms of the weight of liver trimmed off and discarded. In all, the average annual retail value of the liver lost is estimated at J$257,000 (US$1 = J$1.78).

During the same three-year period, registered abattoirs slaughtered an average of 26,000 goats per annum. Curried goat meat is

Table 3. An assessment of the worth of beef liver condemned as a result of fascioliasis in Jamaica. This assessment is based on 1978-1980 cattle slaughter statistics *(21, 22)* and upon the assumption that 22.2 per cent of the slaughtered cattle were infected.

	Year			Three-year average
	1978	1979	1980	
No. of cattle slaughtered	59,308	59,995	63,995	61,099
Weight of liver condemned (in kg)	32,147	33,037	30,399	31,861
Estimated value (J$1.78 = US$1)	J$259,000	J$266,000	J$245,000	J$257,000
Estimated loss per infected head	J$19.7	J$20.0	J$17.2	J$19.0

the traditional fare at Jamaican social gatherings, the animals being purchased on the hoof and slaughtered and butchered at the site. An estimated 80 per cent of all goats slaughtered are dispatched in this manner, the total number of goats slaughtered annually on the island thus being on the order of 130,000 head. In 1980, 1,400 kg of liver were "trimmed" from the 29,600 goat carcasses that were officially inspected. Approximately 50 per cent of this trimming was due to *F. hepatica* lesions; and so, if one extrapolates these data to cover the estimated annual slaughter population of 130,000 goats, it would appear that roughly 3,250 kg of goat liver with a retail value of some J$29,000 was rendered unfit for consumption each year.

In contrast, sheep-liver losses were relatively slight. Registered abattoirs slaughtered an average of 1,230 sheep per year in 1978-1980. The tourist industry, which is almost entirely supplied through regulated dealers, currently provides the major market for mutton. This fact, together with the very small size of the sheep population, lends veracity to this estimate. Extrapolating from this figure, the nationwide cost of sheep offal condemnations appears trivial, amounting to something on the order of J$280.

If the current practice of "trimming" were replaced with whole-organ condemnation, this would substantially increase the cost of the disease. For instance, if one assumes an average liver weight of 5.0 kg per head for cattle and 1.5 kg per head for goats *(23, 24)*, then the cost of condemning the livers of infected cattle (22.2 per cent of the national herd) would amount to some J$546,000 per year, while the cost of condemning the livers of infected goats (17.2 per cent of the herd) would amount to some J$303,000 per year.

Milk production. Before considering the effects of fascioliasis on milk production, it is necessary to clarify the contribution of local dairy production to the Jamaican dairy industry. National dairy-product consumption is estimated at 160 million liters of Fresh Milk Equivalent (FME) per year, of which 75 per cent is imported *(25, 26)*. Butter and cheese are not manufactured by local commercial establishments, but are processed and repackaged locally. Imported milk solids are the major component of locally produced ice cream, flavored milk, malted milk, and aseptic (UHT)[5] milk.

Both total and per capita milk consumption increased during the period 1960-1974, condensed milk retaining its dominance of the local market (Table 4A). Estimates of domestic fresh milk production (Table 4B) indicate some slight improvement during that period, although the accuracy of these data has been questioned; for example, 1967 production has been variously estimated at 42.29 million liters *(30)*, 33.12 million liters *(28)*, and 17.51 million liters *(25)*.

There appear to be four major outlets for domestic fresh milk. As indicated in Table 4B, in 1981 some 9 per cent was retained on the farm for feeding calves and general purposes;

[5]UHT = Ultra-high-temperature.

Table 4A. Domestic milk consumption in Jamaica, in millions of liters of Fresh Milk Equivalent.

Year	Milk category				Total consumption	Per capita consumption (in liters)
	Liquid	Condensed	Dry skimmed	Dry whole		
1960[a]	24.7	31.2	27.3	0.9	84.1	51.9
1967[c]	35.0	52.1	21.1	7.0	115.3	60.7
1974[b, d]	46.6	61.4	22.0	23.7	153.7	101.7

[a]*Sources:* Department of Statistics *(27)* and Atsu *(28)*.
[b]*Source:* Food and Agriculture Organization *(25)*.
[c]*Source:* Division of Economic Statistics *(29)*.
[d]Estimated data.

Table 4B. Domestic milk production in Jamaica, in millions of liters.

Year	Milk distribution					Total production
	Farm use[b]	Calf feed[b]	Conden-sary	Proces-sor[c]	Raw milk[d]	
1960	1.5	1.9	13.2	17.0	4.4	38.0[a]
1974	2.0	2.4	3.2	21.9	19.3	48.8[b]
1981[d]	1.8	2.2	2.0	16.6	22.1	44.7

[a]*Sources:* Department of Statistics *(27)* and Atsu *(28)*.
[b]*Source.* Food and Agriculture Organization *(25)*.
[c]*Source:* Division of Economic Statistics *(29)*.
[d]Estimated data.

roughly 40 per cent was pasteurized and packaged by ''processors'' for the commercial liquid milk market; an inaccurately known but significant proportion was sold through irregular channels as raw milk; and a steadily decreasing proportion was supplied to the condensary.

This distribution pattern is associated with a multi-tiered pricing system in which grade ''A'' milk sells to the processors at J$0.83 per liter, grade ''B'' sells to the condensary at J$0.58 per liter, and raw milk sells at prices that tend to exceed those of grade ''A'' without attendant processing costs. It is thus apparent that over 80 per cent of the local milk sold attracts a minimum farm-gate price of J$0.83 per liter.

Chronic fascioliasis is known to reduce the quality and amount of milk produced by infected dairy animals *(31, 32)*. In general, the positive effect of anthelminthic treatment on national milk production can be shown by the relationship

$$M_t = Y_m \cdot N \cdot P_m \cdot P_i \cdot P_t$$

where M_t = the improvement in national yield due to anthelminthic treatment (in liters); Y_m = the milk yield per lactating cow per annum (in liters); N = the number of animals in the national dairy herd; P_m = the proportion of the herd lactating at one time; P_i = the proportion of the herd with fascioliasis; and P_t = the proportional increase in the average infected animal's milk yield due to treatment.

Two estimates of Y_m are used. One of these, 1,775 liters per cow per annum, approximates the present average yield. The other, 2,420 liters per cow per annum, is the

Ministry of Agriculture's projected yield for "improved" herds and represents the anticipated output of cattle in an upgraded national dairy herd.

As of 1976, N was estimated at 36,000 head, of which approximately 80 per cent were Jamaica Hope cattle of all grades and the remainder were mainly Holsteins. The Ministry of Agriculture estimates that 70 per cent of the national herd is lactating at any one time, making P_m equal to 0.7.

For these calculations, P_i (the proportion of the dairy herd with fascioliasis) is considered equal to 22.2 per cent (the percentage of all cattle infested). However, this figure may underestimate the prevalence of fascioliasis in dairy cattle, since the major dairy producers are located in the infested alluvial plains of south-central and southeastern Jamaica, and 60 per cent of the dairy farms use flood irrigation to improve the pasture.

P_t (the percentage improvement of milk yield that results from treatment) is estimated at 8 per cent. This estimate is based on a report by Ross *(31)* that found a "low-grade" infection with approximately 100 flukes reduced a cow's milk yield by 8 per cent, while "heavy" infections could reduce her production by over 20 per cent.

As Table 5 indicates, if these various figures

Table 5. Projected increases in the milk yields of infected dairy cattle following anthelminthic intervention.

	Milk yields:		Value of total actual and projected production, in J$ millions:	
	Per cow (in liters per year)	Total (in millions of liters per year)	At grade A prices	At grade B prices
At current national herd's productivity level:				
Pre-treatment	1,775 liters	44.70 m. liters	37.10	25.93
Post-treatment	1,806 liters	45.52 m. liters	37.78	26.40
Projected benefit		0.82 m. liters	0.68	0.47
At an "improved" national herd's projected productivity level:				
Pre-treatment	2,420 liters	60.98 m. liters	50.61	35.37
Post-treatment	2,463 liters	62.07 m. liters	51.52	36.00
Projected benefit		1.09 m. liters	0.91	0.63

Table 6. Average annual meat production in Jamaica during the period 1978-1980.

		Slaughter weight	
Type of livestock	No. slaughtered per year	Live weight (million kg)	Dressed weight (million kg)
Cattle	59,779	11.66	9.72
Goats[a]	26,083	0.33	0.27
Goats[b]	130,000	1.63	1.36
Sheep	1,234	0.02	0.02

Source: Data Bank and Evaluation Division *(21)*.

[a]Goat slaughter at regulated abattoirs.

[b]Estimated goat slaughter (80 per cent outside of regulated abattoirs).

are entered into the above formula, the results suggest that successful anthelminthic treatment of the herd could improve dairy output by somewhere between 0.82 and 1.09 million liters per year, an amount of milk valued at between J$470,000 and J$910,000.

Meat production. Infection intensities of less than 50 flukes per head may temporarily reduce weight gains in beef cattle up to 8 per cent and suppress their feed conversion efficiency by up to 11 per cent *(33, 34)*. Together, these effects produce a significant reduction in dressed carcass weight at slaughter age. Table 6 shows Jamaica's mean annual meat production statistics for cattle, goats, and sheep over the period 1978-1980 *(21)*. Using those figures, even a 1 per cent reduction in the mean carcass weight of these animals would result in an economic cost to the industry on the order of J$825,000.

Indirect Losses

Treatment costs. Table 7 shows the proportion of farms with sheeps, goats, and cattle using anthelminthics active against *F. hepatica*. The proportion is directly related to herd size, with higher percentages of large herds receiving treatment. Table 8 extrapolates from these data to estimate national fasciolicide expenditure in the cattle industry at J$560,700 per year. This represents a mean expenditure of about J$2.00 per head, with relatively larger average expenditures per head being made by farmers with large herds. These treatment costs do not include the cost of labor needed to administer the anthelminthics, the cost of buying and transporting the drugs, and opportunity costs.[6]

Existing estimates of amounts spent on veterinary services for Jamaican cattle are confined to dairy animals. In 1969 Atsu *(28)* calculated that the average cost of artificial insemination, medicines, and services came to J$6.40 per dairy cow, representing 3.3 per cent of total production costs. More recently, the Ministry of Agriculture has estimated that this cost had risen to J$49.00 in 1982, which still represented about the same share (3.8 per cent) of production costs.

Regarding the cost of goat treatment, it should be noted that goat ownership is ubiquitous in both rural and urban Jamaica, the typical stock consisting of two breeding does with progeny. On farms varying in size from 1 to 200 hectares the mean goat density is only 2.76 head per farm unit *(17)*. Herds of more than 10 animals are unusual, and probably less than 10 herds have over 100 head. This relative independence of goat herd size and farm area stands in marked contrast to the situation regarding cattle, in which 54 per cent of the national cattle population is found on 0.2 per cent of the farms (see Table 8).

For present purposes, it is therefore assumed that all goats are maintained in herds of less than 10 animals and (as the data in Table 7 suggest) that the flukicide oxyclosanide is administered to 0.6 per cent. On this basis, the current national cost of anthelminthics administered in a four-dose regimen appropriate for treating acute caprine fascioliasis can be estimated as being on the order of J$11,600.

As indicated in Table 8, it appears reasonable to estimate the current overall cost of treating sheep for fascioliasis at about J$1,300. However, there is some evidence that rafoxanide, the most popular drug used, is selected primarily because of its activity against the bot fly *Oestrus ovis (35)*.

Current and Projected Losses

Table 9 summarizes the estimated losses due to fascioliasis. As shown, the total monetary cost of the disease is estimated as being approximately J$2,400,000. It should be

[6] Where financing has to be used to maintain the status quo (e.g., ensuring herd health) it is not available for expansion or development. The cost of treatment therefore has two components: the actual monetary cost and the loss of an exactly equivalent amount from the capital funds available for development. The latter is referred to as "opportunity cost."

Table 7. Percentages of cattle, goats, and sheep receiving anthelminthics active against *F. hepatica* in Jamaica, and the average cost of the various drugs administered, 1979-1980.

Type of livestock	Herd size	No of farms surveyed	% of national herd receiving the following drugs:			
			Oxyclosanide[a] %	Albendazole[b] %	Rafoxanide[c] %	Any flukicide %
Cattle	1-10 animals	162	0.6	0	0	0.6
	11-50 animals	80	5.0	0	1.5	6.5
	>50 animals	20	10.0	5.0	0	15.0
	Cost per dose:		J$5.69	J$6.47	J$1.89	
Goats	1-10 animals	161	0.6	0	0	0.6
	11-50 animals	46	0	2.2	4.3	6.5
	>50 animals	8	12.5	12.5	0	25.0
	Cost per dose:		J$0.91	J$1.62	J$0.31	
Sheep	1-10 animals	18	0	0	0	0
	11-50 animals	18	5.6	0	22.2	27.8
	>50 animals	9	0	11.1	0	11.1
	Cost per dose:		J$0.91	J$1.62	J$0.31	

[a]3 per cent oxyclosanide, 1.5 per cent levamisole (Nilzan; Imperial Chemical Industries, Ltd.).
[b]2.5-10 per cent albendazole (Valbazen; Smithkline Animal Health, Ltd.).
[c]2.3 per cent rafoxanide (Ranide; Merck, Sharp, and Dohme, Ltd.).

Table 8. Current expenditures (at 1980 prices) on fasciolicides for treating cattle and sheep in Jamaica.

	Herd size (No. of animals)			Total cost (in J$ thousands)
	0-10	11-50	>50	
Cattle expenses:				
No. of farms >0.4 hectares	134,620	700	295	
Mean no. of cattle per farm	0.80	29.8	514.3	
Anthelminthic cost for 3 doses per treated animal per year (in J$ thousands):				
oxyclosanide	*14.2*	*22.9*	*328.5*	
albendazole	*0*	*0*	*193.1*	
rafoxanide	*0*	*2.0*	*0*	
total	*14.2*	*24.9*	*521.6*	*560.7*
Cost per head (in J$)	0.21	1.86	5.37	
Sheep expenses:				
No. of farms	83	23	9	
Mean no. of sheep per farm	2.65	24.0	160.1	
Anthelminthic cost for 4 doses per treated animal per year (in J$ thousands):				
oxyclosanide	*0*	*0.1*	*0*	
albendazole	*0*	*0*	*1.0*	
rafoxanide	*0*	*0.2*	*0*	
total	*0*	*0.3*	*1.0*	*1.3*
Cost per head (in J$)	0	0.48	0.72	

Source: Department of Statistics, Agricultural Census Unit *(17)*.

Table 9. Summary of estimated economic losses due to fascioliasis in Jamaica (1980 prices).

	Cost (in J$)	
	Current cost	Projected cost
Direct losses:		
Edible offal condemnation	286,300	849,000
Suboptimal milk production	680,000	910,000
Suboptimal meat production	825,000	825,000
Indirect losses:		
Cost of anthelminthics	573,600	573,600
Total losses	2,364,900	3,157,600

noted, however, that projected improvements in dairy industry productivity and stricter controls on meat inspection procedures could increase the projected loss to J$3,200,000. These estimates assume no concomitant increase in the national herd or in meat production, nor do they include the potentially major costs due to mortality, reduced carcass quality, and the need for animal health care services. Moreover, even though this study has assigned no special value to foreign exchange, it is true that a substantial proportion of the estimated losses involve foreign exchange drains—because foreign exchange must be used to purchase anthelminthics and cattle feed, and to import substitutes for local meat and dairy products.

Public Health Considerations

There have been no recorded cases of human fascioliasis in Jamaica, although zoonotic infection of man is known to occur in Cuba, the Dominican Republic, and Puerto Rico. The prevalence of human fascioliasis in the northern Caribbean and the morbidity it produces have not been adequately quantified, although there is some evidence that records of overt disease underestimate the prevalence of subclinical infections. For example, a single Cuban clinic observed 27 clinically apparent cases in the course of a three-year study during the period 1973-1976 *(9)*, while a recent survey of 184 asymptomatic subjects from an endemic region of Puerto Rico revealed that 7.1 per cent had *Fasciola hepatica* eggs in their stools *(10)*. Thus, even though the Cuban data constitute the most complete recent record of human fascioliasis in the Caribbean region, those data do not suggest anything, like the 7.1 per cent prevalence of asymptomatic cases found in the Puerto Rican study.

It has been suggested that zoonotic infection of man is genuinely absent from Jamaica, and that its differential distribution within the Caribbean region is a function of local dietary patterns that may themselves reflect the different ethnic origins of the island's population *(36)*. That does not suggest grounds for complacency, however, since changes in irrigation techniques, particularly for salad vegetables, could result in the occurrence of the human disease in Jamaica, with its attendant social and economic costs.

Conclusions

The study reported here has shown that fascioliasis is endemic in Jamaica below 500 meters and exists at prevalences and levels of intensity that reduce livestock productivity. The monetary cost of this constraint, which is proportional to the size and efficiency of the livestock industry, has been estimated for existing livestock production and population levels. Improvements in productivity and increases in the national herd will therefore cause an increase in the absolute monetary losses produced by this disease. The importance of this point can be brought out by considering two proposed developments in the Jamaican livestock industry.

First, it has been proposed that the national herd of Jamaica Hope dairy cattle be increased. A similar expansion of the Puerto Rican cattle industry from 1948-1976 was paralleled by an increase in the prevalence of fascioliasis, which rose from 7.5 to 31.7 per cent *(5, 6)*; and the disease is now approaching hyperendemic proportions *(10, 37)*. Direct monetary losses due to bovine liver condemnations increased tenfold over the same period *(5, 7)*. Expansion of the Jamaican dairy herd could have similar undesirable sequelae.

Second, it has also been proposed that a sheep-rearing industry be reestablished with Barbados Black-Belly or St. Elizabeth flocks. It must be recognized, however, that the detrimental effects of acute fascioliasis on sheep industries are much more severe than the effects of chronic fascioliasis on cattle production *(38)*. The current trivial losses due to sheep fascioliasis on Jamaica reflect the insignificant size of the Jamaican sheep population, but incautious expansion of sheep husbandry could rapidly result in that industry becoming the major single source of fascioliasis-induced losses.

In order to avoid such increased losses, development of the livestock industry should be paralleled by development of a locally appropriate fascioliasis control strategy. Current animal health practices, based on salvage and remedial treatment, are inefficient and expensive, and make no contribution to controlling the incidence of infection. Furthermore, strategic control is generally more cost-effective than sporadic treatment, since it confines treatment to the periods and localities at greatest risk and uses animal management techniques to reduce the incidence of infection. This approach is particularly applicable to developing countries because it minimizes expenditures on anthelminthics and hence helps to conserve scarce foreign exchange.

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SUMMARY

This study attempts to quantify the animal health, veterinary public health, and economic impact of fascioliasis in Jamaica. A coprologic survey conducted for this purpose in late 1979 and early 1980 revealed an overall fascioliasis prevalence of at least 22.2 per cent (n = 520) in cattle and 17.2 per cent (n = 514) in goats. In general, the prevalence of the disease was found to be directly correlated with rainfall and inversely correlated with altitude. Four ecological zones of endemicity were identified and related to the epidemiology of the intermediate host, *Fossaria cubensis*.

The economic cost of the disease was estimated from production statistics and a questionnaire survey. Losses were categorized as being either direct (due mainly to liver condemnation and suboptimal dairy or beef production) or indirect (due mainly to treatment costs). The estimate did not include the less quantifiable costs associated with mortality, provision of veterinary services, and lost opportunities for development. The total economic cost of fascioliasis in Jamaica, as indicated by the above data, appears to be on the order of J$2.4 million (J$1.78 = US$1.00); and if anticipated improvements in Jamaica's livestock industry are allowed for, this total rises to J$3.2 million. It is

noteworthy that a significant share of this cost would be in scarce foreign exchange spent on drugs and on imported substitutes for local meat and dairy products.

It should also be recalled that fascioliasis is a zoonosis producing significant numbers of human cases in the Greater Antilles, and that inappropriate changes in vegetable cultivation practices could cause it to become a significant human health problem in Jamaica.

Finally, there is a very real danger that proposed increases in Jamaica's cattle and sheep herds could enormously increase the prevalence of the disease, as has happened elsewhere. It is therefore recommended that development of the country's livestock industry be paralleled by development of an appropriate fascioliasis control strategy. Such a planned approach to fascioliasis control, which tends to be relatively cost-effective, confines treatment to the periods and localities at greatest risk and uses animal management techniques to reduce the incidence of infection.

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SMALLPOX ERADICATION SURVEILLANCE

In conformity with the 1980 recommendations of the Thirty-third World Health Assembly for post-eradication surveillance of smallpox, the World Health Organization is continuing to coordinate and participate in the investigation of suspected smallpox cases throughout the world.

Between January 1979 and July 1983, 143 reports of suspected smallpox cases were received from 58 countries. These rumors were investigated by national health authorities or joint national/WHO teams and, when required, specimens were tested by a WHO collaborating center for laboratory confirmation of the diagnosis. Results of the investigation of 142 reports (one is still under investigation) showed that none of the cases involved were smallpox. Most of them were actually misdiagnosed cases of other diseases such as chickenpox or measles. These results further augment confidence in the absence of smallpox worldwide.

Source: World Health Organization, *Weekly Epidemiological Record* 58(29):226, 1983.