Bovine Fascioliasis: Economic Impact and Control in Gulf Coast Cattle Based on Seasonal Transmission

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INTRODUCTION

Fasciola hepatica, the common bile duct fluke of cattle and sheep, occurs throughout much of the world as a cause of liver condemnations and decreased livestock production efficiency (Boray, 1969; Foreyt et al., 1976; Price, 1953; Roncalli, 1971). In the United States, *F. hepatica* is found primarily in gulf coast and western states in regions where seasonally high annual rainfall, large areas of poorly drained pasture, and certain soil types provide suitable habitats for the lymnaeid snail intermediate hosts required for fluke transmission. There is evidence that the prevalence of *F. hepatica* is increasing in the US, particularly in western states where irrigated pastures are increasingly utilized (Malczewski et al., 1978).

In 1981, liver flukes were responsible for the condemnation at slaughter of 1,444,027 cattle livers in the US. This number represents 22.4% of cattle livers condemned for all causes (6,184,679) or 4.4% of all cattle slaughtered (32,898,968). Assuming an average value of $5 per liver, the annual "direct" loss due to liver condemnations in 1981 was $7.2 million. Economic loss due to the "indirect" effects of fascioliasis is less clear. Liver flukes and other internal parasites fall into the category of "production diseases" along with certain metabolic, reproductive, toxic, genetic or nutritional maladies. As a group, production diseases (vs epidemic diseases) are complex epidemiologically, often result from several etiologic factors acting in concert with environmental and management factors, and usually cause their greatest reduction in productivity without causing clinical signs of disease (Pond et al., 1980). Although accurate quantitation of indirect losses due to liver flukes in the US is consequently difficult, recent reports suggest that losses due to fascioliasis as a sub-clinical and clinical disease in cattle may be greater than has previously been recognized.

Production losses in fluke infected livestock have been reported in terms of poor feed conversion or inappetance in beef cattle (Hope-Cowdery et al., 1977; Ross, 1968, 1970; Liddell, 1972; Bell, 1979) and reduced milk production in dairy cows (Black and Froyd, 1972; Horschner et al., 1970; Leinati, 1961; Koopman, 1969; Randell and Bradley, 1980; Ross, 1970). Less information is available on the effect of *F. hepatica* on economically important production indexes in cow-calf operations. It has been estimated that significant production losses may occur in the cattle herds with over 25% prevalence of infection, and that rate of gain in feeder calves may be reduced by 8-28% in animals infected with 40-140 *F. hepatica* (Hope-Cowdery et al., 1977, Horchner et al., 1970). These moderate to heavy infection levels are commonly encountered in cattle in fluke-endemic areas of the US. Olson (1947) reported that appreciable weight gain did not result after treatment with the fasciolicide hexachloroethane in Texas cattle. More recently, Bradley and Sand (1982) and Sand, et al. (1981) reported improved reproductive performance and calf weaning weights for first calf heifers in Florida receiving twice annual treatment with ABZ vs. twice annual treatment with hexachloroethane for flukes and either phenothiazine, levamisole, or thiabendazole for nematodes. Treatments were begun when heifers were 3-6 months of age. In a South Texas study on replacement heifers affected by the related fluke *Fascioloides magna* (but not *F. hepatica*) improved conception rates, increased mature cow body weights, and higher calf weaning weights were observed over a three-year period in animals treated semiannually with ABZ (Foreyt, 1982). In a separate study in which experimental infections with both *F. hepatica* and *F. magna* were given to Eastern Washington brood cows, Foreyt (1982) reported reduced reproductive performance in fluke-infected animals (80% vs. 95% calf crop).

The primary method used to control liver fluke losses in the US has traditionally been chemotherapy. Since the 1940's, the standard drug used to control liver flukes in the US was hexachloroethane (Olson, 1947). It was routinely used once or twice a year in fluke endemic areas, especially in gulf coast states. In early 1979, hexachloroethane was found to be a carcinogen by the National Cancer Institute. The US Food and Drug Administration (FDA) banned use and sale of the drug shortly thereafter. This left cattlemen without an effective, legal means of protecting herds against fluke parasitism. The FDA agreed in early 1980 to permit emergency use of albendazole (Norden Laboratories) on a restricted investigational basis after formal petition by the state veterinarian of fluke infested states. Although all required testing is not complete, albendazole (ABZ) is presently available in 14 states. Under present emergency restrictions, ABZ is subject to a 6-month withdrawal period before slaughter for human consumption, it is not for use in lactating dairy animals, it is not for use in the first 45 days of pregnancy, and it is available only from a veterinarian who must maintain accurate pre- and post-treatment records.

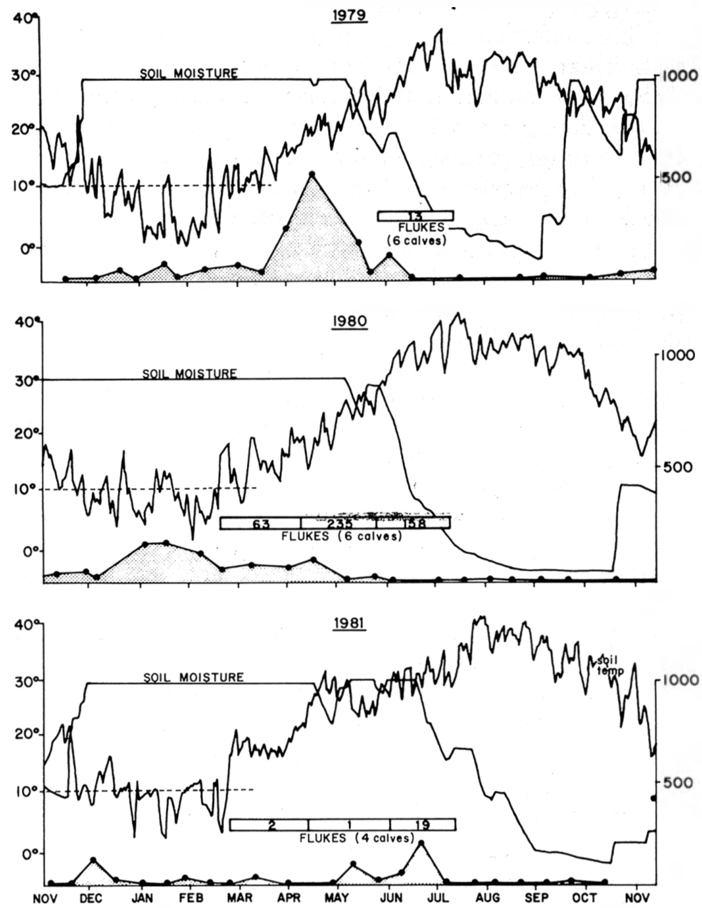
We review here the results of recent studies done under Southeastern U.S. conditions: 1) to determine whether the cost of treatment of cattle for *F. hepatica* with ABZ can be justified by improved herd performance; and 2) to develop improved treatment strategies for use of flukecides in the context of seasonal fluke transmission patterns and management methods typical of the Gulf Coast region of the U.S.

SEASONAL TRANSMISSION OF F. HEPATICA IN LOUISIANA

The relationship of climate to yearly variation in potential losses due to *Fasciola hepatica* in cattle was studied as part of a 3-year seasonal transmission study on a herd in the Red River Basin in Louisiana (Malone et al., 1982). Methods involved correlation of treatment times to data on fluke-free sentinel calves (45-day grazing periods), quarterly herd infection prevalence (20 fecal samples) and bi-weekly snail population studies at 10-meter plots in *Fossaria bulimoides* habitats. Yearly variation in snail population was related to the suitability of snail habitat microclimate as measured by a computer model for soil moisture and soil temperature. Results are summarized in Figure 1.

In 1979, a total of 13 flukes were found in 2 of 6 sentinel calves that were grazed during the mid-May to July grazing period. In 1980, a total of 456 flukes were recovered from 14 of 18 calves (3 groups of 6 calves) that were exposed to pastures during 3 grazing periods between late February and early July. In calves exposed to pasture during the same time span in 1981, only 22 flukes were found in 5 of 12 calves (3 groups of 4 calves). The marked difference in *F. hepatica* risk between years was correlated with the relative abundance of snail intermediate host populations during the winter-early summer months and the relative suitability of climate for snails during this period. In the "high risk" year, 1980, soil moisture levels had been recharged by rains at least 2 months earlier than in 1979 or 1981 and standing water was thus consistently present in snail habitats for a longer period. The winter of 1979-80 was also relatively mild, with a significant number of days in which maximum soil temperatures reached above the critical 10°C required by both the snail and *F. hepatica* life cycles for development (Boray, 1969). A massive reproductive effort and the emergence of a new generation of snails in abundant numbers began in December 1979 and was sustained through the first major drought in May 1980. Summer drought resulted in the killing of large num-

Figure 1 — Relationship of numbers of *F. hepatica* found in sentinel calves to lymnaeid snail numbers, maximum daily soil temperatures, and soil moisture 1-6 inches below the soil surface for November, 1978 to November, 1981. The dotted line represents the critical 10° C temperature required for development of the snail and *F. hepatica* life cycles.



bers of snails on the soil surface and aestivation within the soil survivors. Metacercariae of *F. hepatica* are short-lived in hot, dry conditions, thereby interrupting further transmission in the summer months (Olson, 1944). In the relatively "low risk" years of 1979 and 1981, abundant snail populations and suitable climatic conditions were available over a shorter period, reducing the chance of snail infection and subsequent transmission of *F. hepatica*.

Cows maintained in the same pastures that sentinel calves grazed were monitored for changes in herd *F. hepatica* infection prevalence by examining fecal samples from 20 or more animals at quarterly intervals. In January, 1979, *F. hepatica* eggs were found in only 3% of random fecal samples and the mean epg count was 0.03. By October of 1979, herd prevalence had increased to 42% of cows shedding *F. hepatica* eggs and a mean epg value of 0.9. In 1980, the year in which 456 flukes were found in sentinel calves, herd prevalence was 31% (0.6 epg) in January and then increased dramatically to 96% prevalence (13.2 mean epg) by October. Herd flukecide treatment had not been given in 1978. In October, 1979, half of the cows were given ABZ; the other half served as untreated controls for performance studies on the effect of fascioliasis control on production. In October, 1980, whole herd ABZ treatment was given.

Herd infection patterns observed in 1979 and 1980 illustrate the dramatic ability of *F. hepatica* to mushroom in numbers from low or moderate infection rates in spring to very high infection rates by fall if climatic conditions favor transmission. The increased prevalence in both years was attributed to maturation of *F. hepatica* burdens picked up on pastures during the prior spring and early summer. By contrast, herd egg shedding did not increase between January 1981 (38% prevalence; 1.0 epg) and November 1981 (16% prevalence; 1.7 epg). This was apparently due to low infection risk during the prior spring-early summer, lesser egg production by older flukes (Dixon, 1964) or spontaneous rejection of pre-existing fluke burdens by immune mechanisms (Kendall et al., 1978).

LONG-TERM CONTROL BY ALBENDAZOLE

To further study the long term efficacy of ABZ under various flukecide treatment schedules, prevalence data was gathered from 4 herds in the coastal marsh region of Louisiana in which ABZ was given by producers once, twice or three times per year. Results are compared to data from the Alexandria herd (fall only treatment) for the period of July 1980 to April 1982 (Table I). In one herd in the Mississippi basin (Baton Rouge), no flukecide was given. Twenty or more fecal samples were taken at each date to determine *F. hepatica* epg levels. Results suggest that fall treatment reduced *F. hepatica* burdens dramatically whereas additional winter, spring or early summer treatment in 1980-81 had little effect in terms of herd epg counts. In the herd receiving no flukecide, herd prevalence remained relatively stable (40-60%; 0.6-3.0% epg) from July 1980 - July 1981 and then dropped to low levels by October, 1981. The high epg counts in all herds in the late summer and fall of 1980 support the con-

Table 1 - EFFECT OF ALBENDAZOLE (ABZ) TREATMENT ON FLUKE PREVALANCE AND MEAN EGG PER GRAM COUNTS (EPG) AND PREVALENCE (%) IN LOUISIANA CATTLE OPERATIONS

	1980						1981												1982			
	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr
TRANSMISSION TO TRACER CALVES																						
TREATMENT REGIME																						
Fall Only — Herd 1 (150)† Alexandria	0.8* (40%)**			ABZ 13.2 (96%)			1.0 (38%)			1.0 (47%)			0.6 (50%)				1.7 (16%)		ABZ 2.1 (57%)	0.2 (25%)		
Herd 2 (75) Grand Chenier				ABZ 16.2 (90%)††						Levamisole§§ 0.5 (48%)							ABZ 0.3 (27%)					
Fall-Spring — Herd 3 (75) Grand Chenier				ABZ 15.8 (88%)§						ABZ 0.2 (16%)							ABZ 0.5 (45%)					ABZ 0.5 (13%)
Fall-Summer — Herd 4 (175) Cameron					ABZ 14.5 (88%)			1.9 (44%)					ABZ 0.1 (15%)				ABZ 0.7 (44%)				0.3 (32%)	
Winter-Spring-Summer — Herd 5 (75) Cameron		ABZ 4.2 (93%)					ABZ 0.9 (20%)			ABZ 1.4 (57%)				ABZ 0.6 (32%)					ABZ 0.3 (17%)			
No Treatment — Herd 6 (400) Baton Rouge	1.3 (44%)					0.6 (40%)				3.0 (69%)			1.6 (64%)			0.3 (24%)			0.4 (25%)			

* Mean fluke eggs per gram
** Prevalence %
† Approximate number of cattle in herd in parenthesis
†† Based on 10 fecal samples
§ Based on 15 fecal samples
§§ Levamisole is effective against stomach and intestinal roundworms and lungworms but not against liver flukes.

TABLE II - EFFECT OF ALBENDAZOLE IN CALVES ON WINTER PASTURE AND IN FEEDLOT

	No.	Initial weight 12-20-77	162 day Winter grazing gain - ADG*	98 day feedlot gain - ADG	Total 260 day gain - ADG	Liver Condem-nations	Feed/100 Kg gain in feedlot
Albendazole	33	237	122 - 0.75	103 - 1.05	225 - 0.86	3%	1025
Control	31	227	113 - 0.70	93 - 0.95	205 - 0.79	32%	1110

* Average daily Gain

clusion based on seasonal transmission studies that 1980 was a high risk year for fascioliasis statewide. Similarly, the low prevalence levels in both treated herds and in the untreated herd in late 1981 and early 1982 support the conclusion that 1981 was a low risk year in terms of *F. hepatica* transmission.

A single treatment with ABZ was not as effective in long term reduction of herd prevalence during years of higher fascioliasis risk and semiannual treatment was needed. Results are presented below as part of treatment and performance studies in feedlot calves during 1978 and in cow-calf operations in 1980.

FEEDLOT STUDIES

In a winter pasture-feedlot study on Louisiana calves (Loyacano, et al., 1979), sixty-four crossbred steers were divided into 2 groups to assess the efficacy of ABZ in controlling losses in calf performance due to *F. hepatica*. Treated calves received ABZ paste (10 mg/kg) on December 20, 1977, prior to winter grazing on wheat and ryegrass pasture for 162 days and again on May 31, 1978, prior to a 98 day feedlot period. Control calves were treated with thiabendazole (TBZ) paste (50 mg/kg). Treated calves gained more than controls (Table II) on winter pasture (122 kg vs 113 kg) and in feedlot (103 kg vs 93 kg). Total average gain for the two periods was 225 kg for calves receiving ABZ and 205 for control calves. Feedlot conversion values were 1025 kg of feed per 100 kg of grain for treated calves and 1110 kg per 100 kg of grain for controls. Liver condemnation rates at a commercial slaughterhouse were 3% for treated calves and 32% for control calves. Liver lesions were minimal in both groups, however, and most condemnations were due to finding flukes rather than pathologic changes.

The effect of flukecidal treatment on *F. hepatica* fecal epg counts is summarized in Table III. Mean numbers of eggs shed by treated calves decreased substantially after both ABZ treatments. After initial treatment, counts gradually increased until the treatment prior to entering feedlot, apparently due to spring re-infection and/or increases in egg production by residual flukes. There is evidence that normal *F. hepatica* egg production is impaired by ABZ (Lang et al., 1980). Fluke epg counts in control calves remained relatively stable on pasture but decreased during the feedlot period.

The above trial was designed to test for production effects due to flukes only. Drug treatment was given to remove stomach and intestinal worms in both test and control groups. While both TBZ and ABZ are effective against gastrointestinal nematodes, the possibility that results were partly attributable to a greater efficacy against nematodes by ABZ cannot be excluded, particularly in light of the reported efficacy of ABZ against the inhibited larval forms of *Ostertagia* which begin accumulating in spring and emerge from the abomasal wall in the fall (Williams et al., 1981). Epidemiologic evidence (Williams, 1982) indicates that *Ostertagia* populations in cattle would be expected to consist primarily of the adult stage in December, however, and any differential effect against inhibited stages would thus be minimal at that time. Mean nematode epg counts were determined on 15 or more calves from each group prior to the initial treatment, 51 days later, and at the time of slaughter at 231 days. Respective mean epg counts were 1,264; 13.0; and 14.6 for the TBZ treated control group and 873, 0.5 and 2.1 for the ABZ treated test group.

Other recent studies performed under U.S. conditions suggest that performance of *F. hepatica* infected feedlot calves can be improved in terms of average daily gain and feed conversion by use of ABZ (Bell, 1979; Bradley, pers. comm.; Armstrong and Rinker, pers. comm.) and are summarized and compared to the present study in Table IV.

TABLE III - LEVEL OF FASCIOLA HEPATICA INFECTION IN ALBENDAZOLE TREATED CALVES ON WINTER PASTURE AND IN FEEDLOT

	No.		12-20-77*	1-3-78	3-9-78	4-26-78	5-31-78*	6-19-78	9-6-78
Albendazole	33	F. hepatica EPG	1.73	.03	.30	.36	.73	.21	.24
		Range	0-13	0-1	0-3	0-5	0-7	0-2	0-3
		No. infected	13	1	4	7	10	6	4
Control	31	F. hepatica EPG	4.3	2.48	3.21	1.67	1.70	.70	.58
		Range	0-60	0-30	0-19	0-5	0-20	0-8	0-3
		No. infected	15	10	15	11	12	9	9

* Treatment dates

TABLE IV - SUMMARY OF RECENT STUDIES ON THE EFFECT OF ALBENDAZOLE TREATMENT ON AVERAGE DAILY GAIN AND FEED CONVERSION RATIOS IN FEEDLOT CATTLE

Study	No. Treated/ Control Calves	Days in Feeding Period	Initial % of Cows Shedding F. hepatica eggs	Performance Improvement in ABZ - Treated Cattle: Average Daily Gain	Feed Conversion Ratio
Florida, 1977	75/75	74	N/A	+ 6%	+ 7%
Louisiana, 1978	33/31	98	34%	+10%	+ 8%
Oklahoma, 1978	64/64	134	N/A	+ 8%	NA
Texas, 1979	30/19	140	73%	+14%	NA

COW-CALF STUDIES

Studies were initiated at a commercial cow-calf operation in the coastal marsh region of Southwest Louisiana: 1) to determine the economic benefit of twice a year flukecide treatment in a herd with a history of heavy exposure to *F. hepatica* and 2) to determine the long-term reduction of herd prevalence and mean epg values for *F. hepatica* in ABZ treated cattle. Cows were randomly assigned to treatment groups in July, 1979 by administering either ABZ (10 mg/kg,) levamisole (8 mg/kg), or both hexachlorethane (220 mg/kg) and levamisole (8 mg/kg) to every third animal as they came through a working chute. Some of these cows had calves, some were pregnant, and some were open. In February, 1980, cows received a second treatment. Since hexachloroethane had been removed from the market by the FDA at the time of the second treatment, ABZ was given to cows previously treated with hexachloroethane and levamisole. ABZ has broad spectrum efficacy against liver flukes, gastrointestinal nematodes, lungworms and tapeworms of cattle (Theodorides, 1976). Hexachloroethane is effective against *F. hepatica* only (Olson, 1947). Levamisole is effective against a broad spectrum of gastro-intestinal nematodes and lungworms but is not effective against *F. hepatica.* ABZ and hexachloroethane are thought to have inconsistant or no efficacy against immature liver flukes (Malone, 1980; Olson 1947).

Response to treatment (Table V) was assessed by determining *F. hepatica* epg counts by fecal sedimentation examination of feces collected per rectum from 20 or more randomly selected cows from each group. Results suggest that flukecidal treatment with ABZ or hexachloroethane was effective in both July, 1979 and February, 1980, but that the winter treatment was somewhat more effective than the summer treatment in the degree of reduction in epg and *F. hepatica* herd prevalence two months later. Mean epg counts and percent prevalence increased to high levels in all groups by 7-9 months after each flukecide treatment. Assuming *most* infections with *F. hepatica* are contracted between March and July of each year in Louisiana, July treatment results can be explained by the maturation of immature worms not affected by ABZ or hexachloroethane. After the February treatment, re-exposure to *F. hepatica* in the spring-early summer would be expected to produce new fluke burdens that mature and begin shedding large numbers of eggs in the feces by the following fall.

The effect of treatment on performance of each group is presented in Table VI. The Louisiana Cooperative Extension Service Herd Performance Testing System was used. Although cows were exposed to bulls from February 27, 1979 to August 4, 1979, the subsequent calving season was arbitrarily divided in half to allow calves to be evaluated by performance testing criteria (205 days ± 45 days at weighing). Calves from groups receiving two ABZ treatments or hexachloroethane and levamisole followed by ABZ had a 10.1 kg and 7.7 kg advantage in 205-day adjusted weaning weight, respectively, and a higher grade (11 vs 9 on a 15 point scale) as compared to calves from cows treated with levamisole only on the same dates. Results suggest that flukecide treatment had a positive effect on cow productivity by increased milk production, resulting in heavier weaning weights. Other effects are less clear. While more calves were raised from cows receiving flukecide than from the group receiving levamisole only, the July, 1979 treatment was given after most cows had conceived. In these cows drug treatment therefore could not have had an effect on conception rates.

Table V. Mean EPG counts and prevalence (%) in cows treated with albendazole only, levamisole only or hexane -levamisole and albendazole

GROUP	NO. COWS	JULY '79 RX	EPG	%	SEPTEMBER' 80 EPG	%	FEBRUARY' 80 RX	EPG	%	APRIL' 80 EPG	%	NOVEMBER' 80* EPG	%
I	41	ABZ	5.8	70	2.0	67	ABZ	15.4	95	1.3	44	19.7	88
II	38	HEX/LEV	4.7	67	1.2	70	ABZ	8.4	95	1.5	44	11.7	88
III	41	LEV	4.2	36	12.1	80	LEV	19.3	95	8.6	75	12.2	88

* Experiment terminated; all cattle treated with albendazole

Table VI. Adjusted Weaning Weight Data* on Calves Produced by Cows Treated With Albendazole only, Levamisole only, or Hexane-Levamisole and Albendazole

GROUP	TREATMENT††	NO. COWS	1980 CALVES NO.	%	205 DAY ADJUSTED WEANING WEIGHT	DAYS OF AGE	GRADE	WPDA†	CONDITION SCORE OF DAM AT CALF WEANING	% PREGNANT AT PALPATION 9/29/80
I	ABZ	41	24	59	334	197	11	1.60	5.0	42
II	HEX-LEV	38	25	66	327	185	11	1.69	5.0	39
III	LEV	41	18**	44	310	193	9	1.51	4.8	58

†† July 1979 and February 1980
* Weigh Dates Aug 30, 1980 and November 29, 1980.
† Weight per day of age
** One cow died at calving; one calf died at birth

In the remaining cows, extrapolation from calving dates indicated that 2 cows from the levamisole group conceived between treatment on July 6, 1979 and removal of bulls on August 4, 1979. In the same time period, 5 cows in the ABZ treated group and 6 in the hexachloroethane-levamisole group had conceived. Pregnancy diagnosis by rectal palpation on September 29, 1980 indicated that a greater number of cows in the levamisole treated group became pregnant during the next breeding season (58%) when compared to the ABZ tested group (42%) and the hexachloroethane-levamisole tested group (39%). This result suggests that there was no difference in inate fertility in the levamisole group, but that fertility was impaired in cows not receiving flukecide, possibly because of heavy parasite load and attendant loss of condition. Taken together, calving data, cow condition scores, and palpation data support the hypothesis that flukecide treatment can contribute to improved body condition of cows, and that this may result in more regular ovarian cycles, earlier conception, and a lesser percentage of barren cows each year. The relationship of poor body condition to lowered reproductive performance is well known. It is relevant to note that the second treatment of anthelmintic was not given until February, 1980, thus allowing fluke and/or nematode burdens to have a depressing effect on performance during the winter period. It is not uncommon in Louisiana coastal marsh cattle operations to encounter low annual calving percentages as a result of cows calving in alternate years.

While performance data suggest that major benefits can result by flukicidal treatment of cattle under heavy infection pressure by *F. hepatica* (1980 was a high risk year), it is generally recognized by animal scientists that long term studies over several years in the same herd are necessary to conclusively demonstrate significant effects on performance. Unfortunately, the private producer-cooperator who owned the study herd was reluctant to undertake additional studies in light of first year results. Results of the above study are in contrast with the negative results obtained in a concurrent cow-calf performance trial done at the Alexandria study herd in 1980 (Loyacano, unpublished data). ABZ was given to half the cows in the herd. Cows in the other half served as controls and were treated with TBZ. No significant differences in performance were observed. Study animals were part of an experiment station herd in which nutrition and management were superior for the area, however. This may have compensated for detrimental effect on performance by *F. hepatica* and underscores the complexity of evaluating economic losses for production diseases such as bovine fascioliasis.

STRATEGIC CONTROL PROGRAMS

Future improvements in control programs for *F. hepatica* in cow-calf operations are dependent on fundemental information on seasonal transmission patterns and the climatic variables that determine yearly variation in infection pressure. While these factors determine the number of flukes present, it is management variables such as forage availability, nutritive requirements of breeding stock related to reproduction, and periods of nutritional and climatic stress that often determine whether economic effects actually occur due to fascioliasis as a production disease. It is well known that serious helminth parasite problems seldom occur when cattle are on a good plane of nutrition. However, economical beef cattle production implies maximum stocking rates in relation to forage and other resources, and the most efficient producers must therefore operate on a thin margin of resources for at least part of the year. Winter nutritional and environmental stress is commonly experienced by cattle extensively maintained on open pastures in the southeast. The synergism of poor nutrition and parasitism becomes most prominent during the winter months and the number of cattle in poor body condition often peaks just before spring forage regeneration. The effects of this period and the role of mixed parasite infections on body weight maintenance, milking ability, the length of anestrus, and brood cow livability may affect herd productivity during this period and in subsequent months. Evaluation of the "sparing" effect of parasite control measures therefore requires evaluation of the entire annual management cycle.

In Figure II, an example of a fluke control program is diagrammatically represented that is applicable to many extensively managed commercial beef herds in Louisiana that experience winter nutritional stress. Major management variables depicted are representative of a winter - spring calving period and winter conditions in which nutritional requirements are met by hay and/or by planting cool season annual pastures such as ryegrass. Since cattlemen are unlikely to give

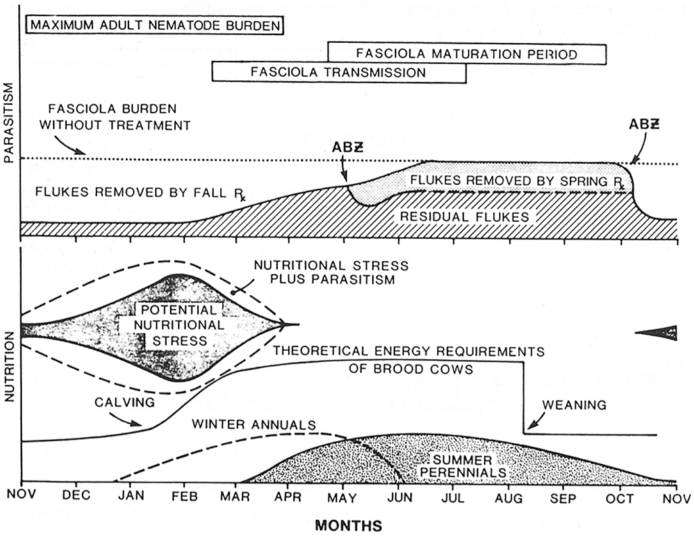


Figure 2 — Diagrammatic representation of expected *F. hepatica* control in a typical gulf coast beef cattle operation by May and October albendazole herd treatment in relation to brood cow energy requirements, pasture availability, and potential winter nutritional stress. Maximum adult fluke populations, maximum adult nematode populations, and the greatest potential nutritional stress coincide during the winter period without anthelmintic control measures.

anthelmintics at times other than when herds are collected and worked for other purposes in the spring and fall, a May - October treatment schedule is illustrated. Based on data presented in this paper on transmission dynamics and ABZ treatment results, the fall treatment (when most flukes are mature) would be expected to be more effective than the spring treatment (when a mixed mature-immature population is present) because ABZ has little effect against immature flukes. Perhaps more importantly, fall treatment removes fluke burdens prior to potential winter nutritional stress. In the absence of fluke control, the presence of large fluke burdens in the fall and winter months could lead to fluke-related anemia and protein loss at the time of maximum nutritional stress. The effect on herd productivity of this period would be correspondingly amplified. In addition, recent epidemiologic studies on the transmission dynamics of *Ostertagia* and other gastro-intestinal nematodes have shown that winter conditions favor transmission and that maximum populations of adult ostertagia and other nematodes typically occur during this period (Williams, 1981, 1982). Maximum fluke populations, maximum nematode populations, and potential winter nutritional stress thus coincide under Louisiana conditions.

Additional information on the relationship of herd performance to parasite control is needed to provide hard evidence for development of better, more cost-effective strategic control programs for fluke-endemic areas in the Southeastern US. As presented in the above scheme, May ABZ treatment would remove only part of fluke burdens at a time of maximum forage availability. If it were possible to provide this treatment in late winter (February-March,) it may enhance recovery of body condition of cows by removing residual flukes and heavy winter nematode burdens at a time when warm season forages are regenerating. Less pasture contamination with fluke eggs would occur, thereby reducing potential infection of the massive spring snail population and subsequent transmission to cows and the new calf crop. An added benefit may result from reduction of *Ostertagia* burdens before spring, when larvae become inhibition prone (Williams, 1982).

Based on presently available information and available drugs, it is proposed that herd treatment strategies for flukes and other internal parasites in fluke-endemic areas of the Southeast include special attention to reducing parasite burdens during the winter period. A routine preventive fall and late winter semiannual treatment schedule is recommended, with an optional third treatment in late spring-early summer. While management realities in many herds presently limit anthelmintic use to times when herds are ordinarily collected and handled for other purposes, future improvements in drug formulation and mass treatment methods for inaccessible herds (i.e. range cubes, rumen boluses) may add substantial flexibility to the timing of treatment in parasite control programs.

SUMMARY

Recent studies on the epidemiology of *F. hepatica* transmission in Louisiana revealed that most transmission to cattle occurred in the spring and early summer and that annual variation in the number of flukes transmitted was correlated with climatic variables that determine the numbers of snail intermediate hosts available for infection. Herd prevalence and sentinel calf data suggest that annual fall treatment with albendazole (ABZ) was effective for sustained reduction of fluke burdens in "low risk" years such as 1982, but that at least two ABZ treatments (spring and fall) are needed in moderate risk (1979) and high risk years (1980). Feedlot studies indicate that ABZ treatment may result in improved average daily gain and feed efficiency of feeder calves infected with *F. hepatica*. A one-year herd performance study in a coastal marsh cattle operation suggests that increased beef herd performance can result after flukecidal treatment directed at reducing loss of cow condition during winter nutritional and environmental stress. The implications of these findings on treatment strategies for flukes and other internal parasites in fluke-endemic regions of the Southern US are discussed.

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Acknowledgements

Supported in part by the U. S. Department of Agriculture, Agriculture Research Service, Special Grant No. 59-2221-0-2-057-0 and funds from the Louisiana Commissioner of Agriculture and Smith Kline Animal Health Products, West Chester, PA.