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Simulation of the Effects of Parasite Infestation on the Performance of Goats in Northeastern Brazil

by

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INTRODUCTION

Parasite infestation is a global problem which impairs productivity of goats. Effective control of parasites is difficult due to a large number of interacting variables (e.g.; plane of nutrition, breed resistance, precipitation pattern, drenching frequency and drug efficacy). Internal parasitism due to helminths can be expressed as an acute disease or as a subclinical chronic condition (Williams, 1981). Within a particular environment, determining the optimal strategy for helminth control is difficult. A primary problem is the re-infestation of the treated goat. A multitude of plans have been developed for specific situations; e.g., a combination of drenching and pasture rotation. However, with differing environments and production systems, preformulated plans of treatment may not be as effective in a different environment as they were in the environment of origin. Furthermore, as seasonal or yearly conditions change within a location, the need for flexible response to the helminth situation may be necessary.

Systems analysis is a technique used to evaluate the effect of alterations in input and output of a system and the interaction between its component parts. The Systems Analysis project of the Small Ruminant Collaborative Research Support Program (SR-CRSP) and the Texas Agricultural Experiment Station (TAES), developed a computer simulation model for goat production (Blackburn et al., 1987). The objective of the simulation model is to allow scientists of different disciplines to evaluate production alternatives (nutritional, management, breeeding and health). With the model it is possible to

evaluate many more alternatives than would be possible in the physical world. Not only can the interaction of components contained within the system be evaluated (e.g., body condition and reproduction), but also how the system (or goat) responds to external stimuli (e.g., improved nutrition) can be examined. With the model, simulations can be performed which help locate optimal combinations of production practices.

The objectives of this study were: 1) to utilize H. contortus data collected by parasitologists at the Centro Nacional de Pesquisa de Caprinos (CNPC) for evaluating the parasite component of the TAES Goat Simulation Model in projecting animal response, in terms of trend and magnitude, to worm burden and treatment; 2) to locate knowledge voids related to modeling helminth effects on goats so that real world experiments can be designed to provide answers; and 3) perhaps the most important, to design effective drenching programs which raise the productivity of goats while remaining within economic constraints.

MATERIAL and METHODS

The Texas A&M Goat Simulation Model (Blackburn et. al., 1987) was parameterized to simulate a SRD (undefined local race) goat in north-eastern Brazil. Parameterization included four types of information: genetic parameters, which enable the model to simulate a particular breed; forage parameters, which specify the nutritional environment; management practices, which exist or are imposed upon the system; and helminth intake across time. To simulate an SRD, the genetic potentials for a mature doe were set at: size of 35 kg, milk production at peak day lactation of 2.0 kg, worm resistence of 35% and

ovulation rate of 2.0 ova (Figueiredo et. al., 1987). Forage parameters specified in terms of crude protein, digestibility and availability (kg/hd/day) were derived from Kirmse (1984) and Pfister (1983) and have previously been used in the TAES model for this environment by Figueirdo (1986). Management practices were those found normally in the area; breeding in November, kidding in March and weaning at 105 d of age.

Simulations were performed for 80 periods (3.3 years). This length of run was considered desirable from the aspect of examining doe growth and productivity from 5 mo of age to 3.7 yr of age.

The main focus of this experiment was to evaluate four drenching programs in two different types of years with does producing singles or twins. The four drenching programs tested were: control, with no drench; the recommended drenching pattern which includes four drenches per year (RD); three drenches which occur only in the wet season (WSD); and an altered system of four drenches per year (4D); drenching times are given in table 1. The two years in this study refer to the two levels of worm burden specified, forage parameters remained the same for both years. These two levels were actual estimates obtained from a normal year (NY), in terms of rainfall and a drier than normal year (DY). Worm intakes per 15-day period are presented in figure 1.

The parasite component of the Texas A&M Goat Simulation Model was designed to simulate the effects of H. contortus load, or number, on the productivity of the goat. Simulating the effects of worm burden are based upon two major factors: the number of worms infesting the animal and the resistence that the animal can mount to respond to the

TABLE 1. DRENCHING PATTERN FOR A YEAR

TREATMENT	MONTH											
	J	F	M	A	M	J	J	A	S	O	N	D
Control	0	0	0	0	0	0	0	0	0	0	0	0
RD	0	0	.9	0	0	.9	0	.9	0	0	0	.9
WSD	.9*	0	.9	0	.9	0	0	0	0	0	0	0
4D	0	0	.9	.9	0	.9	0	0	0	0	0	.9

RD = Recommended drenching

WSD = Wet season drenching

4D = 4 drenching per year

*9 = Efficacy of drench

challenge. Incorporated into resistence are a genetic level (expressed as a percent, where 100% would imply total resistence to worm infestation), body condition, maturity, pregnancy and lactation. All of these factors range in value from 0 to 1. Worm intake is based on actual worm counts obtained from field data. The closer the animals resistance factors are to 1 the less impact the worm burden will have on animal performance. If there is a worm burden its effects are mediated on animal performance by increasing the maintenance costs for the simulated animal. Also as worm burden becomes extremely large and animal resistence lowers a reduction in feed intake is imposed upon the simulated animal. Most of the parasite functions contained in the model are based on the expert opinion of a parasitologist (T. Craig). Expert opinion had to be used in constructing parasite component functions because quantitative experimental data documenting the influence of parasite load on animal performance is locking. Because of the manner in which this portion of the model was constructed, it is felt that the weights simulated may not be of the appropriate magnitude, but the trends simulated are a reflection of physical world results.

RESULTS

Results from the simulated drenching strategies are reported in terms of worm burden and animal performance which included: doe body weight, kid weight and milk production. Simulated doe worm burdens are presented in figures 2 and 3. From these figures, fluctuations in worm numbers can be observed across treatments. The drench given the does had an efficacy of 90%, therefore at no time were worms

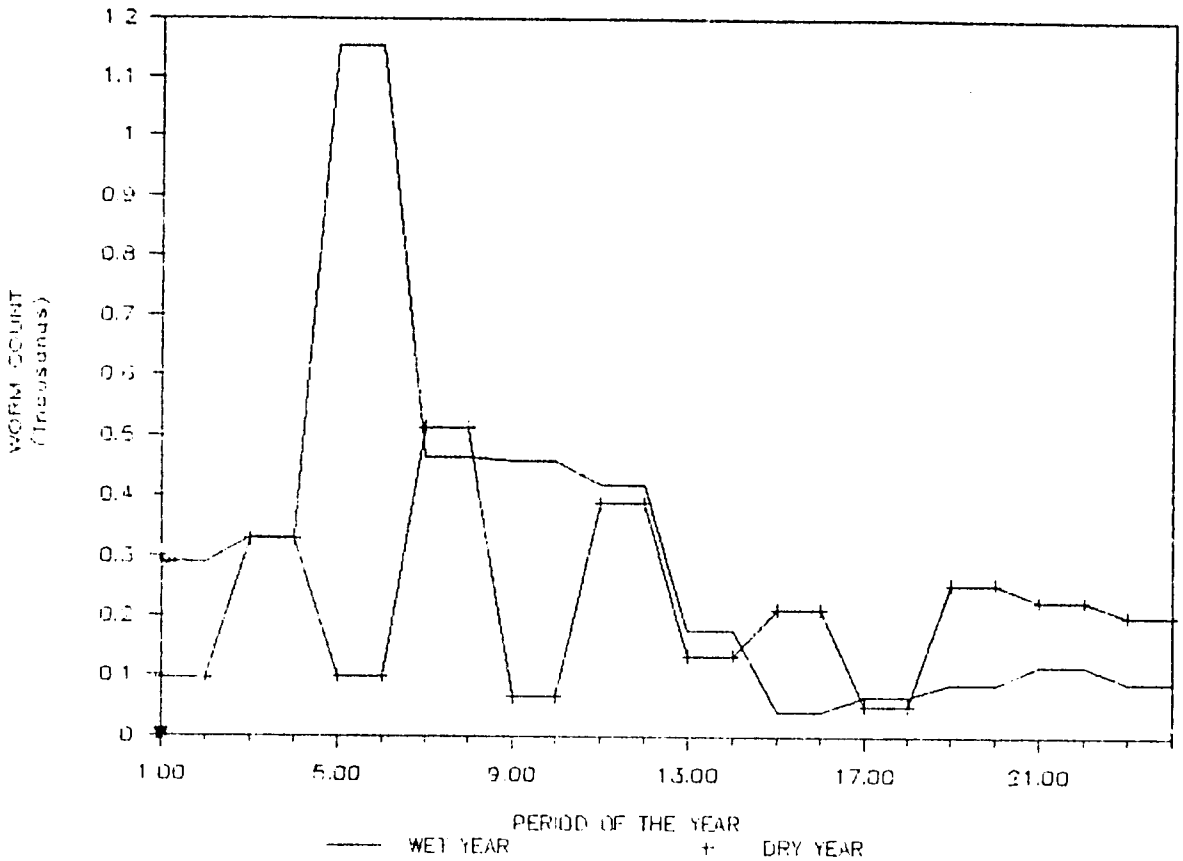

Figure 1. Wet and dry year worm intake levels per 15-day period used as model input.

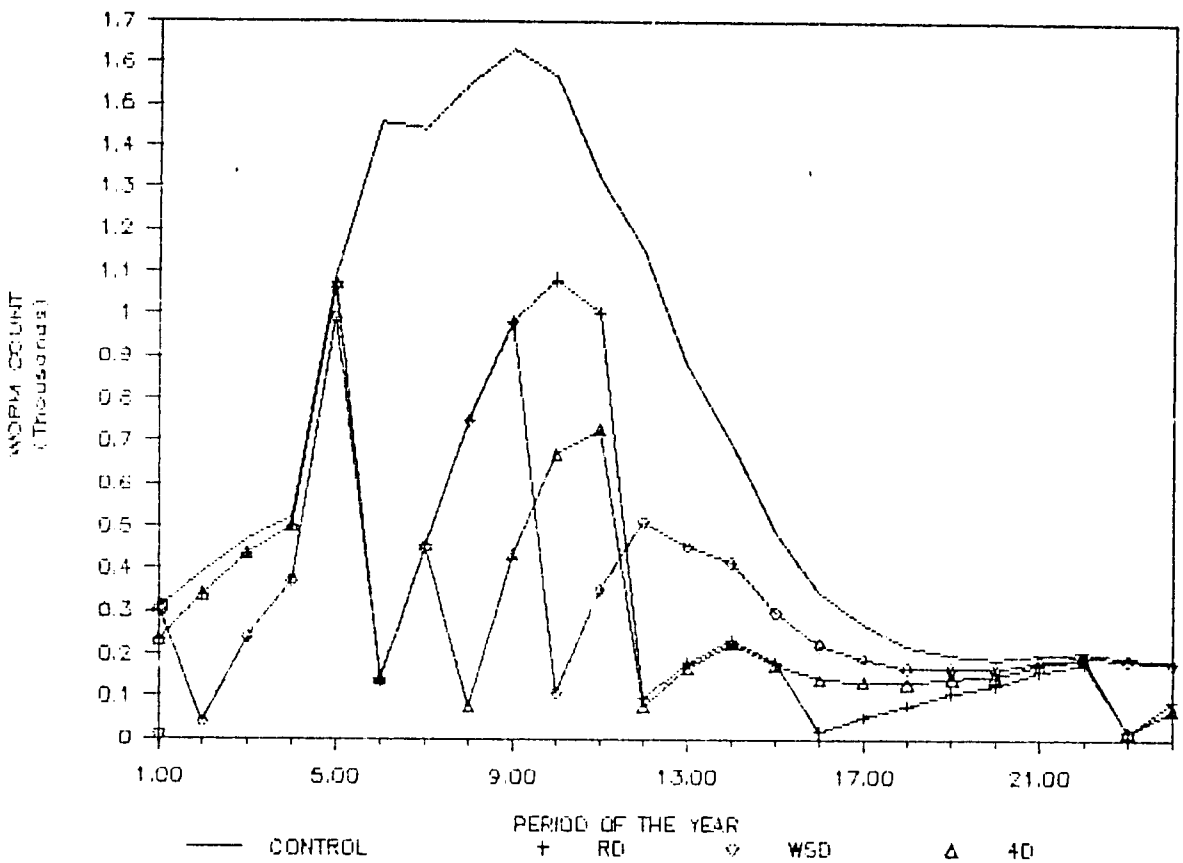

Figure 2. Wet year worm burden for each drenching treatment for the last simulated year.

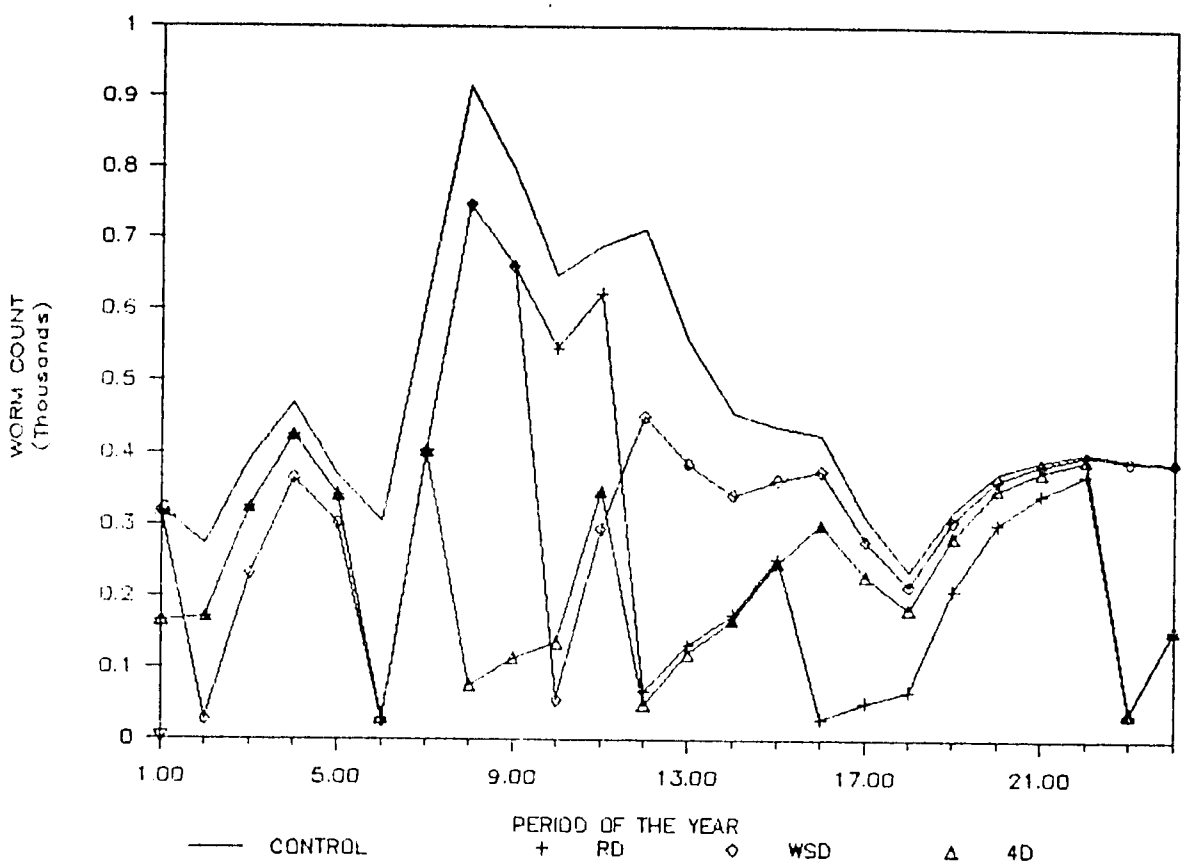

Figure 3. Dry year worm burden for each drenching treatment for the last simulated year.

TABLE 2. PERFORMANCE OF SIMULATED DOES, BEARING SINGLES, WITH NO PARASITE INFESTATION, NORMAL YEAR AND DRY YEAR LEVELS OF INFESTATION

Category	No worm burden Body wt, kg	Normal year burden Body wt, kg	Dry year burden Body wt, kg
Year 1			
Initial wt	13.0	12.9	12.9
Breeding wt	15.7	15.0	14.7
Kidding wt	23.2	18.5	17.8
Wt at weaning	28.4	18.7	20.2
Year 2			
Breeding wt	30.0	22.4	23.6
Kidding wt	31.2	23.9	26.5
Wt at weaning	27.9	24.3	26.0
Kid birth wt	2.8	1.45	2.7
Kid weaning wt	13.0	4.4	7.4
Year 3			
Breeding wt	31.4	28.0	28.5
Kidding wt	32.3	27.1	29.1
Wt at weaning	28.1	26.6	27.3
Kid birth wt	2.8	2.8	2.8
Kid weaning wt	13.8	6.6	9.1

completely removed from the goats. The major difference between years is evident by comparing figures 2 and 3. The NY has a higher peak and average number of worms; the DY worm numbers are more constant and have lower peaks and averages.

Simulated responses of does with and without a worm burden are compared in table 2. Does with worm burden were not drenched. Across time there existed large differences between no infestation and the two levels of infestation. Also, differences in performance between the two levels of infestation were simulated. Obviously, the kids weaned from parasite infested does in year 2 would not have survived to weaning (table 2). In figures 1 through 3, levels of worm intake and fluctuation in parasite load are given. Clearly there are differences in the magnitude of worm burden; the model translated these differences in worm burden into effects on animal performance. Therefore it appears that the model does have the capability to evaluate animal performance as worm burden and drenching practices change.

Animal performance for NY is given in tables 3 and 4 for single and twin producing does. All drenching schemes produced heavier doe and kid weights than the control. Within the drenching treatments minor differences existed for doe weight. However, kid weaning weights were higher for WSD and 4D. Although the model simulated a kid for the control doe in year 2, a kid this small at weaning would be extremely unthrifty and probability of death would be quite high. Twin bearing does followed the same pattern in terms of body weight and kid weaning weight for drenching treatments. However, differences

TABLE 3. SIMULATED DOE PERFORMANCE WITH A SINGLE BIRTH DURING THE NORMAL YEAR.

Category	Worm Number				Weight, kg			
	C	RD	WSD	4D	C	RD	WSD	4D
Year 1								
Doe								
Initial	44	44	44	44	12.9	12.9	12.9	12.9
Breeding	157	157	157	157	15.0	15.0	15.0	15.0
Kidding	1249	145	139	145	18.5	20.1	20.3	20.1
Weaning	554	166	430	160	18.7	24.3	24.3	24.8
Year 2								
Doe								
Breeding	190	160	184	174	22.4	27.8	27.5	27.7
Kidding	1443	145	140	145	23.9	28.2	28.5	28.2
Weaning	862	178	450	166	24.3	27.5	27.1	27.5
Kid								
Birth	---	---	---	---	1.45	2.8	2.8	2.8
Weaning	13	3	7	3	4.4	8.1	9.2	9.4
Year 3								
Doe								
Breeding	199	160	184	174	28.0	30.5	30.1	30.3
Kidding	1459	145	139	145	27.1	29.9	29.9	29.8
Weaning	880	180	454	167	26.6	27.9	27.6	27.9
Kid								
Birth	---	---	---	---	2.8	2.8	2.8	2.8
Weaning	13	3	7	7	6.6	9.1	10.1	10.4

TABLE 4. SIMULATED DOE PERFORMANCE WITH A TWIN BIRTH DURING THE NORMAL YEAR.

Category	Worm Number				Weight, kg			
	C	RD	WSD	4D	C	RD	WSD	4D
Year 1								
Doe								
Initial	44	44	44	44	12.9	12.9	12.9	12.9
Breeding	157	157	157	157	15.0	15.0	15.0	15.0
Kidding	1454	145	139	145	18.4	20.1	20.3	20.1
Weaning	674	166	430	160	18.7	24.3	24.3	24.8
Year 2								
Doe								
Breeding	190	160	184	174	22.4	27.8	27.5	27.7
Kidding	1458	145	139	145	23.8	27.0	27.3	27.0
Weaning	864	179	453	167	24.1	27.1	26.8	27.2
Kid								
Birth	---	---	---	---	1.1	2.1	2.0	2.1
Weaning	13	3	7	3	3.1	5.4	5.8	5.9
Year 3								
Doe								
Breeding	199	160	184	175	28.0	30.4	30.0	30.2
Kidding	1456	145	139	145	26.6	29.0	29.0	28.9
Weaning	891	181	457	168	26.6	27.5	27.2	27.6
Kid								
Birth	---	---	---	---	2.1	2.2	2.2	2.2
Weaning	13	3	7	3	4.6	6.1	6.5	6.7

C = Control, RD = Recommended drench, WSD = Wet season drench, 4D = four drench per year.

in weaning weights were not as great between treatments as they were for single producing does.

When worm burden was altered to that of the DY, the 4D treatment doe weaned heavier single and twin kids. The WSD and RD yielded similar weaning weights (tables 5 and 6).

Comparing NY and DY conditions with no worm control, does subjected to the DY worm burden performed at higher levels. This result was due to the absence of the high peak worm burdens the does were exposed to in the NY.

Doe body weights tended to be similar for the treatments, but kid weaning weights were different. This difference reflected in weaning weight implies that does weaning larger kids were able to produce more milk. Examination of the doe lactation performance (table 7) confirms that certain (e.g., D4) drenching practices enabled does to produce more milk; however, the additional milk produced supressed doe weight gain. Does given the 4D treatment had a more persistent lactation than the RD and WSD; this effect illustrates the importance of drenching lactating does. Drenching the doe early in lactation (Costa, 1983; Blackburn et al., 1987) counters the decrease in natural resistence of lactating does so that higher levels of milk production can be achieved. Also apparent in table 9 is the influence of increasing nutritional quality and quantity of the diet during lactation. By period 5 of lactation, an increase across all groups was observed. The increase in nutritional quality and quantity are due to the initation of the rainy season.

TABLE 5. SIMULATED DOE PERFORMANCE WITH A SINGLE BIRTH DURING THE DRY YEAR.

Category	Worm Number				Weight, kg			
	C	RD	WSD	4D	C	RD	WSD	4D
Year 1								
Doe								
Initial	33	33	33	33	12.9	12.9	12.9	12.9
Breeding	339	339	339	339	14.7	14.7	14.7	14.7
Kidding	302	29	26	29	17.8	20.1	18.3	20.1
Weaning	457	123	367	117	20.2	24.9	23.7	25.5
Year 2								
Doe								
Breeding	387	345	387	377	23.6	27.2	26.2	26.9
Kidding	306	29	26	29	26.5	29.0	28.8	29.9
Weaning	547	132	383	120	26.0	27.6	27.1	27.6
Kid								
Birth	---	---	---	---	2.7	2.7	2.8	2.8
Weaning	8	2	6	2	7.4	9.3	9.7	10.9
Year 3								
Doe								
Breeding	391	344	386	376	28.5	29.9	29.3	29.6
Kidding	305	29	26	29	29.1	30.6	30.3	30.5
Weaning	559	132	386	120	27.3	28.0	27.6	28.0
Kid								
Birth	---	---	---	---	2.8	2.8	2.6	2.8
Weaning	8	2	6	2	9.1	10.3	10.5	11.7

C = Control, RD = Recommended drench, WSD = Wet season drench, 4D = four drench per year.

TABLE 6. SIMULATED DOE PERFORMANCE WITH A TWIN BIRTH DURING THE DRY YEAR.

Category	Worm Number				Weight, kg			
	C	RD	WSD	4D	C	RD	WSD	4D
Year 1								
Doe								
Initial	33	33	33	33	12.9	12.9	12.9	12.9
Breeding	339	339	339	339	14.7	14.7	14.7	14.7
Kidding	302	29	26	29	17.8	20.1	19.4	20.1
Weaning	457	123	367	117	20.2	24.9	23.7	25.5
Year 2								
Doe								
Breeding	387	345	387	377	23.6	27.2	26.2	26.9
Kidding	305	29	26	29	25.9	27.8	27.6	27.8
Weaning	550	132	385	120	25.6	27.2	26.8	27.3
Kid								
Birth	---	---	---	---	2.0	2.1	2.1	2.1
Weaning	8	2	6	2	5.8	5.9	6.0	6.6
Year 3								
Doe								
Breeding	392	344	386	377	28.4	29.8	29.2	29.4
Kidding	304	29	26	29	28.3	29.7	29.4	29.6
Weaning	565	133	389	121	26.9	27.7	27.3	27.7
Kid								
Birth	---	---	---	---	2.1	2.2	2.2	2.1
Weaning	8	2	6	2	5.9	6.6	6.7	7.3

C = Control, RD = Recommended drench, WSD = Wet season drench, 4D = four drench per year.

TABLE 7. MILK PRODUCTION FOR SINGLE BEARING DOES IN NORMAL AND DRY YEARS.

Period	Normal year				Dry year			
	C	RD	WSD	4D	C	RD	WSD	4D
1	.32	.73	.73	.72	.62	.80	.77	.78
2	.11	.34	.34	.48	.29	.40	.36	.52
3	.14	.21	.21	.32	.25	.28	.27	.41
4	.13	.21	.41	.28	.28	.30	.43	.40
5	.30	.33	.42	.36	.36	.37	.43	.42
6	.12	.26	.23	.29	.18	.30	.24	.34
7	.05	.13	.13	.15	.10	.16	.14	.18

C = Control, RD = Recommended drench, WSD = Wet season drench,
4D = four drench per year.

The apparent superiority of the 4D treatment in both NY and DY raises biological and model structure questions. The model is structured so that resistence of lactating does to parasites is lowest between 30 and 45 days of lactation and increases after 45 days; this alteration in resistence corresponds to the "self-cure phenomenon" observed in sheep and goats. The 4D treatment purposely treats the lactating doe 30 days after kidding. By reducing the worm burden when the does were more susceptable to infestation, productivity was increased. If the assumptions contained in the model concerning resistence during lactation are correct, the 4D treatment is promising. However, if this is not the case, 4D may convey no advantage and this portion of the helminth subroutine should be re-structured. In a review Courtney (1982) reported several incidences where parasite infestation increased during lactation. The cause of depressed resistence appears to be related to increased lactogenic hormone production which inhibits differentiation of sensitized lymphocytes to effector cells needed for worm expulsion. This evidence strengthens the rationale for the 4D treatment as an effective drenching strategy.

DISCUSSION

Primary differences associated with both treatments and years were for kid weaning weight. Differences in kid weight were large enough to have an impact on kid mortality. However, two questions are suggested. Are the simulated differences of large enough magnitude to be of practical importance? Are the simulated performance levels valid? Controlled experiments with goats infested with known levels of H. Contortus could provide important information in this regard.

(Such an experiment is currently being conducted at CNPC collaboratively with the Texas A&M SR CRSP System Project.)

The model provides useful insight as to strategic treatment of the animals by allowing researchers to evaluate body weight, milk production and kid growth according to forage availability during the year, peak nutritional requirements and worm infestation. Because these factors interact and influence animal production, trade-offs can be considered; e.g., in this environment, is it more economical to supplement a high quality concentrate to does during lactation or to drench them? Therefore, the next step in this evaluation of the production system in northeastern Brazil will be to experimentally evaluate the trade-offs between supplementation and drenching; for example, in extremely wet years or seasons it could be more economical to provide better levels of nutrition to lactating does than to provide repeated drenchings.

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