DECOQUINATE, LASALOCID AND MONENSIN FOR STARTER FEEDS AND THE PERFORMANCE OF HOLSTEIN CALVES TO 20 WEEKS OF AGE

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ABSTRACT: The large utilization of coccidiostats in dairy herds has raised the question regards the best product to use, based on better animal performance. Sixty-four Holstein calves were randomly assigned to four treatments at 10 (±4) d of age to evaluate calf performance when fed approved coccidiostats available on the market in Arizona, USA. Calves received a dry calf starter without (control) or with one of the following coccidiostats: lasalocid, 30 mg kg^{-1}; decoquinate, 19 mg kg^{-1}; and monensin, 30 mg kg^{-1}. Calves received 3.6 kg d^{-1} of a commercial 22% CP:20% fat milk replacer until 6 wk of age. Calves were offered starter "ad libitum" up to 2 kg d^{-1}, and calves had free access to water throughout the trial. Alfalfa hay was offered "ad libitum" after weaning. Performance and dry matter intake (DMI) were monitored for 20 weeks and broken down in different periods of measurement (0-6, 7-12 and 13-20 weeks, respectively). Despite the lower dry matter intake and weight gain for females on monensin treatment during the whole period, differences among coccidiostats were seldom observed under the conditions of this study. Good calf management and the dry, hot climate of Arizona perhaps diminished the chances for subclinical and chronic disease appearance which negated potential differences and differences in calf performances.
Key words: coccidiostats, feed efficiency, growth, ionophore, weight gain

DECOQUINATO, LASALOCIDA E MONENSINA EM CONCENTRADO INICIAL E DESEMPENHO DE BEZERROS HOLANDESES ATÉ 20 SEMANAS DE IDADE

RESUMO: A larga utilização de coccidiostaticos em rebanhos leiteiros tem levantado questões relacionadas à escolha do melhor produto baseada no suposto melhor desempenho de bezerros leiteiros. Este trabalho avaliou o desempenho de bezerros leiteiros recebendo 3 diferentes coccidiostaticos em fazenda no estado do Arizona, EUA. Sessenta e quatro bezerros holandêses foram distribuidos ao acaso em quatro tratamentos com 10 ± 4 dias de vida. Os bezerros receberam concentrado inicial sem (controle) ou com a adição de um dos seguintes coccidiostáticos: lasalocida, 30 mg kg^{-1}; decoquinato, 19 mg kg^{-1}; e monensina, 30 mg kg^{-1}. Os bezerros receberam 3,6 kg d^{-1} de substituto de leite até 6 semanas de vida. O concentrado inicial foi oferecido "ad libitum" até o consumo de 2 kg d^{-1}. Os animais tiveram acesso livre a água durante todo o período. Após a desmama foi fornecido feno de alfafa "ad libitum". O desempenho animal e o consumo de matéria seca (CMS) foram monitorados durante 20 semanas de tratamento, sendo este dividido em diferentes períodos (0-6, 7-12 e 13-20 semanas). Apesar do menor consumo de matéria seca e menor ganho de peso de fêmeas recebendo monensina durante todo o período experimental, não foram observadas diferenças entre os produtos nas condições deste experimento na maior parte das fases de monitoramento. Bom manejo e o clima quente e seco no Arizona reduziram as chances de aparecimento de cocidiose e portanto de diferenças no desempenho de bezerros leiteiros.
Palavras-chave: coccidiostaticos, crescimento, eficiência alimentar, ganho de peso, ionóforo

INTRODUCTION

Dairy calves with diarrhea have high mortality rates, resulting in significant economic losses to producers (Roy, 1990). Besides bacterial and viral infections, and conditions related to diet, diarrhea can be caused by coccidia. Coccidiosis in young calves results in decreased performance and increased morbidity and mortality (Georgi, 1985). Reduced performance can result in increased cost of raising replacement heifers and male calves. Several studies have been conducted to evaluate coccidiostats and their optimal rates for young calves (Fitzgerald & Mansfield, 1984; Heinrichs & Bush, 1991; Stromberg et al., 1986; Foreyt et al., 1986). Three coccidiostats, decoquinate (DEC), lasalocid (LAS), and monensin (MON), have been validated as effective in controlling coccidia in young bovine. Most of the studies to test effectiveness of these coccidiostats in calves raised under conditions of natural exposure have been conducted in cold, humid climates and not the dry, warm conditions found in the southwestern U.S. Another benefit of MON and LAS has been improved performance observed in older cattle, mainly through increased efficiency of feed utilization (Bergen & Bates, 1984). However, this effect has not always been shown in young dairy calves fed these ionophores (Heinrichs & Bush, 1991, Hoblet et al., 1989, Waggoner et al., 1994). The reason for less consistent benefits from ionophores in young calves than in older cattle has not been completely clarified. A possible explanation might be that the young calf is in a transition period, changing from a non-ruminant to a ruminant, and the effect of the ionophores on performance is dependent on a fully functioning microbial population in the rumen. Heinrichs & Bush (1991) suggest that it depends on starter intakes, since the calves have to consume the optimal dosage of the product. The objective of this study was to determine the effects of LAS, DEC, and MON fed in calf starter, on performance in growing Holstein calves before and after weaning.

MATERIAL AND METHODS

Animals and Diets

Sixty-four Holstein calves (32 males and 32 females), born between January and June in the University of Arizona herd, received 2 L of colostrum by 6 hr after birth and an additional two L within 12 h, and during the next 2 d, twice a day. Thereafter, a commercial milk replacer was offered to all calves in two meals of 2 L each, twice daily (0500 and 1700) until 6 wk of age, when calves were weaned. The nutrient composition of the milk replacer as specified by the manufacturer (Milk Specialties, Inc., Dundee, IL) was: CP, > 22%; crude fat, >20%; crude fiber, < 0.5%; Ca, 0.75 to 1.25%; P, > 0.7%; Vitamin A, 13,600 IU kg^{-1}; Vitamin D, 4500 IU kg^{-1}; and Vitamin E, 23 IU kg^{-1}. Calves received a commercial 16% CP calf starter "ad libitum" before being assigned to treatments. At 10 (± 4) d of age on the same day of each week, calves were randomly assigned to one of the four treatments according to sex and date of birth.

Treatments were: control (CON, no coccidiostat added to starter), lasalocid (LAS, 30 mg kg^{-1} DM), decoquinate (DEC, 19 mg kg^{-1} DM), and monensin (MON, 30 mg kg^{-1} DM) and the amounts of coccidiostats were those recommended by their manufacturers. The coccidiostats were incorporated into a commercial mineral premix, which was then mixed with other starter ingredients. The starters were formulated to meet NRC (1989) requirements for dairy calves (Table 1) when fed with milk replacer (until 6 wk) and alfalfa hay after weaning. Starter that was not eaten was discarded daily and replaced by fresh feed. Calves were housed in individual pens and were offered up to 2 kg d^{-1} of one of the four calf starters per day. From weaning until 12 wk of age, calves were moved to larger individual pens and were fed alfalfa hay "ad libitum" plus the 2 kg $head^{-1}$ d^{-1} of the same starter. Water was available free choice to all calves during the entire treatment period. After 12 wk, animals of the same sex, treatment, and close to the same age were paired and moved to single pens because of limited space. Calves in the same pen were continued on the same starter treatment and "ad libitum" hay.

Measurements

Individual feed intake (milk and starter or hay and starter) was measured daily until 12 wk on treatment. From 13 to 20 wk, intake of each pair was measured. Starter and hay were sampled weekly during the entire experiment and analyzed for dry matter and crude protein according to AOAC (1990), acid and neutral detergent fiber according to Robertson & Van Soest (1981), and starch as described by Poore et al. (1990).

Body weights of each calf were measured with a portable scale for two consecutive days every other week during the first 8 wk of the experimental period. From wk 8 to wk 20, calves were weighed on 2 consecutive days monthly on an electronic scale. Consecutive daily weights were averaged for statistical analysis. Feces from each calf were visually scored for consistency each day until 8 wk on treatment. Fecal evaluations were made after feeding on a scale of 1 (dry feces) to 4 (fluid feces). A score of 2 indicated normal calf feces.

All cases of bloat or other health problems such as increased rectal temperatures, nasal discharges, and feet and leg problems were recorded. Calves with health problems were treated according to normal herd management procedures.

Statistical Analysis

Data were analyzed as a randomized complete block design by the GLM procedure of the SAS Program (1985), according to the following statistical model:

Table 1 - Nutrient and ingredient composition of experimental calf starters[1] and alfalfa hay.

Ingredients	% DM	
Steam flaked corn	67.5	
Soybean meal	20.0	
Molasses	10.0	
Premix (mineral, vitamins, and coccidiostas)[1]	2.5	
Nutrients	Starter	Alfalfa hay
DM, %	92.9 ± 0.52	94.7 ± 0.5
DE, Mcal kg^{-3} DM	3.66	
CP, %	16.1 ± 0.8	19.7 ± 0.8
UIP, % of CP[3]	43	
NDF, %	11.5 ± 0.5	39.1 ± 1.9
ADF, %	3.8 ± 0.2	28.2 ± 1.4

[1]Experimental treatments consisted of adding the following to the starter premix (in mg kg^{-1}): Control, 0; lasalocid, 1200; decoquinate, 760; and monensin, 1200. [2]Standard error. [3]Calculated from NRC (16). DM = dry matter; DE = Digestible energy; CP = Crude protein; UIP = Undigestible intake protein; NDF = Neutral detergent fiber; ADF = Acid detergent fiber.

$$Y_{ijkl} = F + T_i + B_j + S_k + C_l + E_{ijkl}$$

Where Y_{ijkl} = response variable, F = overall mean, T_i = treatment effect (coccidiostat), B_j = block effect, S_k = sex effect, C_l = covariate, and E_{ijkl} = residual error.

Weight at birth (Table 2) was used as the covariate for the analysis of both average weight gain and DMI (Table 3). Blocks were based on time of assignment to treatment within the same sex. For the analysis of efficiency of gain (Table 3), DMI was used as the covariate. Tables present least square means for treatments and the *P* values for within sex as well as between sex comparisons (male vs. female). Orthogonal contrasts were performed as follows: Con vs LAS, DEC, and MON; DEC vs LAS and MON; LAS vs MON. For all data, differences with $P < 0.07$ were considered significant.

RESULTS

Crude protein concentration averaged 16.6%; starch content, 58.1%; and values for ADF and NDF were as expected (Table 1). Values are averages for samples taken periodically just prior to feeding and are within the expected range.

Table 2 - Body weights of calves fed the different coccidiostats at periods up to 20 wk on treatment[1].

Week of treatment	Female				Male				SE
	CON	LAS	DEC	MON	CON	LAS	DEC	MON	
	kg								
Birth	38.21	42.12	43.71	39.97	39.94	39.22	36.91	38.89	2.26
0[2]	40.43	40.62	40.88	40.52	41.15	43.27	39.90	41.21	1.60
6	63.01	62.56	61.69	59.63	60.36	59.05	60.94	60.18	2.82
12	104.00[a]	103.81[a]	98.92[ab]	93.59[b]	95.57	96.88	96.22	96.42	3.45
20	155.73[ab]	158.83[a]	155.15[ab]	147.17[b]	156.58	155.92	157.91	155.17	4.85

[a,b]Within sex, means in the same row not sharing a common superscript are different ($P < 0.07$).
[1]Treatments are abbreviated as follows: CON = control, LAS = lasalocid, DEC = decoquinate, and MON = monensin. [2] Beginning of trial at 10 ± 4 days of age.

Table 3 - Average weight gain, dry matter intake (milk, starter and hay) and efficiency of feed utilization (dry matter intake - DMI) of calves fed the coccidiostats at periods up to 20 wk on treatment[1].

Week of treatment	Female				Male				SE
	CON	LAS	DEC	MON	CON	LAS	DEC	MON	
	Averege weight gain								
	$kg\ d^{-1}$								
0 to 6	0.51	0.51	0.51	0.45	0.43[ab]	0.37[b]	0.49[a]	0.45[ab]	0.045
7 to 12[2,3]	0.95 [a]	0.99	0.93[a]	0.80[b]	0.80	0.81	0.81	0.86	0.052
13 to 20[4]	0.92	0.98	1.02	0.95	1.09	1.05	1.09	1.10	0.056
0 to 20	0.82[a]	0.84[a]	0.82[a]	0.76[b]	0.82	0.80	0.84	0.81	0.03
	Dry matter intake								
	kg								
0 to 6[5]	1.13	1.13	1.07	1.00	1.00	0.97	1.06	0.96	0.05
7 to 12[5,6]	2.25[a]	2.29[a]	2.30[a]	2.04[b]	2.10	2.11	2.11	2.01	0.07
13 to 20[6]	3.85[a]	3.77[ab]	3.60[ab]	3.52[b]	3.64[ab]	3.78[a]	3.66[ab]	3.47[b]	0.10
0 to 20[6]	2.54[a]	2.53[a]	2.46[ab]	2.31[b]	2.38[ab]	2.45[a]	2.40[ab]	2.27[b]	0.06
	Efficiency of feed utilization								
	$DMI\ gain^{-1}$								
0 to 6[7]	2.28	2.46	2.25	2.35	2.50[ab]	2.98[a]	2.26[b]	2.27[b]	0.24
7 to 12	2.37	2.38	2.64	2.60	2.63	2.57	2.56	2.72	0.15
13 to 20[8]	4.32	3.97	3.82	3.96	3.40	3.58	3.33	3.28	0.25
0 to 20	3.10	3.00	2.98	3.02	2.91	3.03	2.87	2.80	0.31

[a,b]Within sex, means in the same row not sharing a common superscript are different ($P < 0.07$).
[1]Treatments are abbreviated as follows: CON = control, LAS = lasalocid, DEC = decoquinate, and MON = monensin. [2]LAS vs MON ($P < 0.02$). [3]Females > males ($P < 0.10$). [4]Males > females ($P < 0.10$).[5]Females > males ($P < 0.09$). [6]LAS vs MON ($P < 0.01$). [7]LAS vs MON ($P < 0.10$). [8]Females > males ($P < 0.05$).

No differences among treatments were found for BW of male calves during any of the three periods (Table 2). At 12 wk, females fed MON were lower in BW than those fed LAS or the CON diet (*P* = 0.07), and at wk 20, females fed MON were lower in BW than those fed LAS (*P* = 0.06); however, females fed DEC did not differ from other treatments for any period.

During the first 6 wk on treatment, males fed DEC showed higher (P=0.07) ADG than those fed LAS (Table 3). There were no differences for males during the other periods. Females fed MON had lowest ADG (*P* < 0.05) during wk 7 to 12 and 0 to 20 (*P* < 0.06). Females gained faster than males during 0 to 6 and 7 to 12 wk (*P* = 0.10); however, during the 13 to 20 wk, males gained faster than females (*P* = 0.10).

Components of DM included in DMI were milk replacer solids, starter, and alfalfa hay (Table 4). Until weaning at 6 wk of age, all calves consumed 0.5 kg d^{-1} DM as milk replacer, with the remainder as calf starter, which was fed "ad libitum". After weaning, until 20 wk on treatment, starter was offered at 2 kg d^{-1} (1.86 kg DM) of which it was almost totally consumed. Hay was also fed at "ad libitum" intake after weaning. From wk 7 to 20, the difference between total DMI and starter DMI (approximately 1.85 kg d^{-1}) would equal the hay DMI consumed. As would be expected, hay DMI increased with age because starter DMI was restricted. During wk 13 to 20, and for wk 0 to 20, DMI for males fed LAS was higher than for males fed MON (*P* < 0.05), and there were no differences among other treatments for any of the periods. Females fed MON had lowest intakes during wk 7 to 12 (*P* = 0.05) and were lower than CON during wk 13 to 20 (*P* < 0.05). Females had significantly higher DMI than males during the first and second periods (*P* < 0.09). Considering the total period (0 to 20 wk), females fed MON had lower DMI than those fed DEC and LAS (*P* = 0.07).

Feed efficiency (DMI/gain) was greater for males fed MON and DEC than for those fed LAS during 0 to 6 wk (*P* = 0.05), with no differences between other treatments (Table 5). Females were more efficient than males during 13 to 20 wk (*P* = 0.001). Feed efficiencies from 0 to 20 wk were not different among treatments, nor between sexes.

There were no differences among treatments for the scour score (Table 4). None of the calves presented clinical symptoms of coccidiosis and even though oocysts counts were made (data not shown) there was no sign of coccidia infection in the herd. Nine cases of free-gas bloat were observed during the entire trial, mostly in the 13- to 20-wk period. There were three cases in calves fed the CON diet, four on MON, two on DEC, and none on LAS, with no differences between treatments. There were no differences between treatments in any other health problems. Overall, calves were very healthy during the entire experiment, and there were no health problems other than those normally observed in the herd.

DISCUSSION

When not inoculated, consistent induction of coccidiosis in dairy calves has been difficult to achieve (Stromberg et al., 1986). In the present study it was decided not to inoculate calves orally with oocysts so that the effect of coccidiostats under natural conditions could be studied. The opportunity to demonstrate a coccidiostat effect was negated since the lack of clinical signs and low oocyt counts reflect animals which were essentially coccidia free. The hot, dry climatic conditions of Arizona probably were not favorable for the growth of coccidia, which must have moist conditions and mild temperatures to sporulate; whereas, high temperatures and dryness impede sporulation and can destroy the sporulated oocysts (Georgi, 1985). Because inoculation was not included in this study, the major focus of the effect of the coccidiostats was shifted to calf performance.

Females fed MON exhibited slightly more diarrhea than calves receiving the two other coccidiostats. Because of the low numbers of oocysts isolated from the fecal samples in all treatments, it is unlikely that diarrhea observed in this study was caused by coccidiosis.

Ionophores have been shown to improve feed efficiency either by reducing DMI without changing gains or by increasing weight gain at similar DMI (Galyean & Hubbert, 1989). However, with diets high in readily fermentable carbohydrates such as the concentrate used in this study, ionophores generally depress feed intake with no effect on BW gains (Bergen & Bates, 1987). These effects have been related to changes in the rumen microbial population resulting in a shift towards increased production of propionic acid.

The higher ADG during wk 0 to 6 for males fed DEC than for those fed LAS was not expected, since DEC is not considered to be a growth promoter as are MON and LAS (Fitzgerald & Mansfield, 1984; Watkins et

Table 4 - Average diarrhea score for calves fed the different coccidiostats during the first 6 wk of treatment.[1]

Week of Treatment	Female				Male			
	CON	LAS	DEC	MON	CON	LAS	DEC	MON
Diarrhea score[2]	2.66	2.62	2.62	2.84	2.89	2.69	2.74	2.77

[1]Treatments are abbreviated as follows: CON = control, LAS = lasalocid, DEC = decoquinate, and MON = monensin.
[2]Scored on a scale of 1 to 4 (with 1 as dry and 4 as fluid). Females < males (*P* < 0.10). A score of 2 indicated normal calf feces.

al., 1987), and because calves were coccidia free. Females fed DEC had ADG comparable to those fed CON and LAS, and were higher than those fed MON during wk 7 to 12 and 0 to 20. Stockdale et al. (1982) showed no improvements in ADG from feeding MON at dosage of 1 mg kg^{-1} BW to dairy calves; and Foreyt et al. (1986) observed no improvement in performance of calves fed MON (33 mg kg^{-1}) over those fed DEC (33 mg kg^{-1}). Other studies conducted with LAS with different dosages (10 to 30 mg kg^{-1}) also showed no effect of this additive on the performance of young calves (Heinrichs & Bush, 1991; Hoblet et al., 1989; Stromberg et al., 1982). On the other hand, some studies have shown enhancement of performance of nonresistant or coccidia-inoculated calves fed MON over CON (Fitzgerald & Mansfield, 1984; Watkins et al., 1987) or LAS (Quigley et al., 1997). It might be speculated that the inconsistency of results among studies is a result of differences in animal age, and that young animals do not respond to MON and LAS as effectively as older ruminants. However, more data on the use of ionophores as growth promoter in young calves are needed.

Pertaining to overall growth rate of calves, females in our study were superior to standards suggested by Hoffman (1996). Males also had satisfactory rates of gain but were lower than those suggested by Roy (1990) for veal calves.

Reduction in DMI of females fed MON (13 to 20 wk) when compared to CON (7 to 12, 13 to 20, and 0 to 20 wk) is in agreement with other studies (Fitzgerald & Mansfield, 1984; Galyean & Hubbert, 1989; Goodrich et al., 1984). Nevertheless, most of these studies were conducted with beef animals that were older than the dairy calves used in this study. Calves fed LAS in this study did not show a decreased intake as compared to CON and were higher than MON in females at 7 to 12 and 0 to 12 wk, and in males at 13 to 20 and 0 to 20 wk. Reports comparing ionophores with DEC, showed no differences in feed intake (Foreyt et al., 1986), nor did calves fed DEC have lower feed intakes than those fed LAS (Waggoner et al., 1994). Moreover, intakes of calves fed DEC did not differ from those fed CON diets as reported by Heinrichs et al. (1990), but this did not occur in the present study.

After weaning, the young calf is considered a functional ruminant, so it would seem that the ionophores (LAS and MON) should have improved efficiency of gain after 2 mo when calves were weaned, but this did not occur. Also, starter (grain) intake in this study was limited to 2 kg d^{-1}, as it is done on most commercial operations. With increasing age, forage made up an increasingly greater proportion of the total DMI, which may have limited the beneficial effects of the ionophores on performance. Another possible reason that the ionophores did not appear to affect calf performance was the relatively short duration (12 wk) of the post-weaning period in this study.

No differences were observed among other treatments in feed efficiency at any age except at 0 to 6 wk, when males fed DEC and MON were more efficient than calves on LAS. Improved performance of calves fed DEC has been reported in only one other study with calves that were not inoculated with oocysts (Heinrichs et al., 1990). Because of their consistent improvement in feed efficiency in older cattle, it was expected that calves fed ionophores should have responded with better efficiency than those fed the DEC or CON diets.

No differences among treatments were shown for BW of male calves during any of the three periods (Table 2). At 12 wk, females fed MON were lower in BW than those fed LAS or the CON diet (P = 0.07), and at wk 20, females fed MON were lower in BW than those fed LAS (P = 0.06); however, females fed DEC did not differ from other treatments for any period.

During the first 6 wk on treatment, males fed DEC showed higher (P=0.07) ADG than those fed LAS (Table 3). There were no differences for males during the other periods. Females fed MON had lowest ADG (P < 0.05) during wk 7 to 12 and 0 to 20 (P < 0.06). Females gained faster than males during 0 to 6 and 7 to 12 wk (P = 0.10); however, during the 13 to 20 wk, males gained faster than females (P = 0.10).

Components of DM included in DMI were milk replacer solids, starter, and alfalfa hay (Table 3). Until weaning at 6 wk of age, all calves consumed 0.5 kg d^{-1} DM as milk replacer, with the remainder as calf starter, which was fed "ad libitum". After weaning, until 20 wk on treatment, starter was offered at 2 kg d^{-1} (1.86 kg DM) of which it was almost totally consumed. Hay was also fed at "ad libitum" intake after weaning. From wk 7 to 20, the difference between total DMI and starter DMI (approximately 1.85 kg d^{-1}) would equal the hay DMI consumed. As would be expected, hay DMI increased with age because starter DMI was restricted. During wk 13 to 20, and for wk 0 to 20, DMI for males fed LAS was higher than for males fed MON (P < 0.05), and there were no differences among other treatments for any of the periods. Females fed MON had lowest intakes during wk 7 to 12 (P = 0.05) and were lower than CON during wk 13 to 20 (P < 0.05). Females had significantly higher DMI than males during the first and second periods (P < 0.09). Considering the total period (0 to 20 wk), females fed MON had lower DMI than those fed DEC and LAS (P = 0.07).

Feed efficiency (DMI/gain) was greater for males fed MON and DEC than for those fed LAS during 0 to 6 wk (P = 0.05), with no differences between other treatments (Table 3). Females were more efficient than males during 13 to 20 wk (P = 0.001). Feed efficiencies from 0 to 20 wk were not different among treatments, nor between sexes.

CONCLUSIONS

Good calf management and hot, dry climatic conditions in Arizona diminished chances for clinical coccidiosis appearance and the need for a coccidiostat in calf rations. Despite some differences in DMI and average daily gain among treatments for the different periods, efficiency of feed utilization was generally similar among treatments. Growth of heifers fed all treatments was higher than recommended standards, which suggests that despite small differences in ADG between treatments, growth was satisfactory to sustain a good lifetime performance. These data suggest little benefit from addition of ionophores to heifer diets prior to 5 months of age.

ACKNOWLEDGMENTS

To Elanco, Inc. (Greenfield, IN) for partially support the experiment and to Dairy Nutrition Services, Inc. (Chandler, AZ) for mixing the treatment additives into the calf starter.

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Received May 21, 2001