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ABSTRACT

A rather unique systems analysis approach has been made to simulate the utilization of dry matter by ruminant animals, and the natural breeding and reproduction process within a herd. Physiological factors occurring over time and the time related effects of these factors are simulated.

INTRODUCTION

A simulation model for assessing alternate strategies of beef production with land, energy, and economic constraints has been developed by a multidisciplinary research team at the University of Kentucky (Walker et al., 1977; Loewer et al., 1978). This model provides a method of simulating different production strategies and determining their consequences before time, energy, resources, and capital are invested in any proposed strategy. Accordingly, the objectives of the study were to:

1 Present an overview of some of the key factors influencing the interaction of plant growth, animal growth and animal reproduction,

2 Show how these and other factors have been integrated in a dynamic simulation model,

3 Provide an analysis of the results of a particular set of recommended management decisions involving the plant-animal interaction.

REVIEW OF LITERATURE

Grasslands are the primary land resources which are used to produce beef animals. The quantity and nutritive value of grassland plants have a significant effect on beef animal growth and reproduction. However, the quantity of dry matter which grass plants will produce is directly related to the availability of nitrogen fertilizer. Missouri (Garner, 1977) reported an increase in dry matter production when the amount of nitrogen fertilizer applied on Fescue 31 pastures was increased from 0 to 224 kg of nitrogen/ha. However, when a spring calving cow-calf program was conducted with the Fescue 31 pastures and hay, a decrease was reported in the conception rate of cows. The weaning weights of calves also decreased as did the weights of dry pregnant cows during the winter months when the amount of nitrogen fertilizer applied on the Fescue 31 was increased.This would indicate the important interactions among dry matter availability, nutritional composition of the plant, and the growth and reproduction of beef animals.

This can also be illustrated by interseeding legumes into existing grasslands. The interseeding results in a grass-legume mixture that is a better feed for beef animals than grass plants alone. For example, Lechtenberg et al. (1975) reported significantly better performances of beef animals when they were grazing fescue-clover mixtures than when they were grazing fescue alone.

In addition to improved nutritional content, grass-legume mixtures yield more dry matter than grass alone, thus increasing the potential for beef animal growth and reproduction. Taylor et al. (1977) reported a 296 percent increase in dry matter yield from bluegrass-clover as compared with bluegrass alone, and a 242 percent increase from fescue-clover as compared to fescue alone. The nitrogen concentration in the harvested dry matter was greater in grass-legume mixtures than in grasses alone that had received 336 kg of nitrogen fertilizer/ha. In addition, dry matter availability may be increased by interseeding legumes into existing grasslands without destroying the grass plants (Smith et al., 1976b; 1977a; Bucher et al., 1975). Smith et al. (1976a) also stated that nitrogen fertilization of grasslands requires an energy input 55 times greater than interseeding legumes into the grasslands with the grassland renovation seeder, and the grass-legume mixture yielded 1.59 times more beef per unit area than the fertilized grass alone.

The growth and reproduction of beef animals are also influenced by the energy content of the feed ration in addition to its nutritive content and the quantity available for consumption. Generally, relatively high energy intakes have been associated with reduced dry matter demand, larger calves at weaning, earlier weaning times, quicker rebreeding of cows and higher conception rates (Hart, 1972; Willoughby; Dickie, 1973; Hill, 1974; Brown et al., 1972; Dinius and Baumgardt, 1970; Sanbidet and Verde, 1976; Campling, 1964; National Academy of Science, 1976; Wiltbank et al., 1962). Likewise, grazing pressure alters the composition of the feed that is available for beef animal consumption (Mott, 1960; Bryant and Blaser, 1967; Cooke et al., 1973). Related references also used in this study are given by Walker (1977).

OVERVIEW OF THE MODEL

A simulation model has been constructed to simulate plant growth and animal growth and reproduction as functions of time and to compute accumulative accountings of energy use, cash flow, and net worth for a farm

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TABLE 1. CATEGORIES OF ANIMALS USED IN BEEF MODEL

	Description	Age (where applicable)
1.	Mature Bulls	over 24 mos
2.	Mature Steers	over 24 mos
3.	Yearling Bulls	12 - 24 mos
4.	Yearling Steers	12 - 24 mos
5.	Non-Lactating Non-Pregnant Cows	over 24 mos*
6.	Yearling Heifers, Non-Pregnant	12 - 24 mos
7.	Pregnant Non-Lactating Cows	over 24 mos*
8.	Lactating Non-Pregnant Cows	over 24 mos*
9.	Lactating Pregnant Cows	over 24 mos*
10.	Female Calves	0 - 12 mos
11.	Bull Calves	0 - 12 mos
12.	Steer Calves	castration - 12 mos
13.	Unborn Calves	conception - 9.34 mos after conception

*May include pregnant heifers who are not yet 24 mos old.

which encompasses the land resources used to grow the plants and animals (Walker et al., 1977, Loewer et al., 1978; Smith et al., 1977b; Smith et al., 1977c). User input information includes detailed descriptions of land, labor, machinery, buildings, fences, roads, fertilizer, chemicals, seed, animals, feed, and money resources; and detailed descriptions of when, how, and where the following operations will be performed during the time span of the simulation: tilling, planting, applying lime, fertilizer and chemicals, maintaining pastures, moving animals for grazing, harvesting, feeding, breeding, caring for animal health, castrating, dehorning, implanting growth stimulants, purchasing, and selling operations. A complete description of the BEEF model (achronym for Beef Energy and Economic evaluator for Farms), including a listing of the program, sample input forms and sample output is given by Walker et al. (1977).

Output information from the model includes the current status of land resources; crops growing on each field; the number, age, sex, and weight of each category of animals on each field; stored feed; stored supplies; machinery; net worth and money accounts; the change in net worth since the beginning of simulation; the accumulated amount of energy for each of nine different categories used on each field and the total of all fields; the accumulated amount of stored feed of each kind and each crop that has been fed, sold, and purchased; the accumulated quantity of each kind of stored supplies that has been used, purchased, and sold; the accumulated amount of interest paid on borrowed money; the performance of selected fields with respect to crop production; feed consumption by animals; beef production; energy use; and the performance of selected categories of animals on selected fields with respect to feed consumption, daily gain or loss of weight, and total weight. These outputs can be selected as to specific information desired and time interval between printouts. For example, it might be desirable to print out the current net worth and the change in net worth annually while the performance of animals might be given each simulated day. The income statement tabulates all expenses and all income which occurred during the previous calendar year. It closely approximates the form that would be prepared for an income tax return.

BEEF is a FORTRAN model that utilizes the GASP IV simulation language (Pritsker, 1974). The growth of plants and animals is programmed as a continuous function while the effects of management activities are initiated as discrete events. BEEF contains approximately 4500 source statements. Core requirements exceed 600K for the IBM 370-165.

ANIMAL GROWTH AND REPRODUCTION

Beef animals have been identified by 12 different categories for purposes of simulating their growth and reproduction (Table 1). These categories serve to group the animals according to age, sex, and reproductive status. Fractional numbers of animals are considered. BEEF maintains an accounting of the number of animals and the average weight per animal in each category on each field. The number of animals in each category on each field can change because of age; for example, calves reach 12 months of age and become yearlings; breeding, for example, non-pregnant cows that are bred and become pregnant cows; moving animals onto or away from the field; birth of calves; death; and castration of male animals. BEEF changes animals from one category to another based on its accounting of the age of each category and the instructions given in the input information concerning breeding, animals moving and castration. The number of animals in each category is adjusted each time a change is made.

BEEF maintains an accounting of the average age of the animals in each category on each field by chronologically updating the age each day. The average age of the animals in each category on each field can also be changed owing to animals being moved into categories by birth of calves, breeding, moving animals from one field to another, castrating male animals, reaching an age which moves the animals to another category, and death of animals. When animals are moved into or out of each category on each field BEEF computes a new weighted average age for each category on each field and continues the chronological updating of age.

Breeding is initiated when yearling and/or mature bulls are scheduled by the input information to be moved onto a field with non-pregnant heifers and/or cows, or when artificial insemination is scheduled. Each category of bulls and method of artificial insemination has a characteristic breeding rate; i.e., number of females serviced per day. BEEF computes a daily breeding rate based on the relative number of bulls and eligible cows of each category on each field. A time delay is considered after calving and before lactating cows are available for breeding. Yearling heifers have to reach a certain weight before they are considered available for breeding. The weight change is computed each day on each field for each category of animal. If the female animals are losing weight, their rate of conception is reduced in proportion to the rate of weight loss. For each field, BEEF uses the bull breeding rate and the weight change of females in each category that are available for breeding to compute a conception rate. The females that conceive are moved into the pregnant non-lactating or the pregnant lactating category. When this occurs, BEEF creates an unborn calf category and maintains an accounting of the weighted average age of this category. When the age of the unborn calf category is equal to the gestation period, the calves are born and moved into one of the calf categories.

Animal growth is represented by the live weight per animal, and the growth rate by the rate of change in live weight as a function of time; i.e., gain or loss of weight per animal per day. The weight change of an animal

TABLE 2. COEFFICIENTS FOR THE NORMAL WEIGHT-AGE RELATIONSHIPS OF THE EQUATION FORM:

$$\text{Normal wt (Kg)} = \text{Wt. into category} + \binom{\text{Daily grain}}{\text{(Kg/Day)}} * \binom{\text{Days in}}{\text{category}}$$

Category	Normal Weight when entering the category (kg)	Normal Daily gain in the category, kg/Day	Maximum attainable weight, kg
1. Mature Bulls	847.0	0.73	998.8
2. Mature Steers	810.5	0.65	908.0
3. Yearling Bulls	500.0	0.95	NA*
4. Yearling Steers	284.17	0.373	NA*
5. Non-lactating non-pregnant cows	475.0	0.06	541.0
6. Yearling heifers	266.0	0.51	NA*
7. Pregnant non-lactating cows	475.0	0.06	541.0
8. Non-pregnant lactating cows	475.0	0.06	541.0
9. Pregnant lactating cows	475.0	0.06	541.0
10. Female calves	28.0	0.652	NA*
11. Bull calves	29.5	0.736	NA*
12. Steer calves	29.5	0.697	NA*

*NA - not applicable

category is based on dry matter demand, the quantity of dry matter consumed, the nutritional content of the feed supply in the form of metabolizable energy and digestible protein, and utilization of the dry matter for body maintenance, lactation, and gain.

The dry matter demand is based on the average age of the animals in each category and the normal weight per animal for animals of this age. Normal weight-age relationships for each category of animals are given in Table 2. BEEF maintains an accounting of the average age of the animals in each category on each field and selects the weight per animal from the normal weight-age relationship for each category. This weight is used to compute the dry matter demand for each category of animals on each field each day by multiplying it times a percentage that varies with animal age. For example, animals up to 6 mo in age have a daily dry matter demand equal to 2.88 percent of their expected normal weight. This decreases to 2.75 percent for ages between 6 and 18 mo, 2.50 percent for ages between 18 and 24 mo, and 2.20 percent for animals over 24 mo of age.

The dry matter intake by each category of animals on each field is based upon the dry matter demand and the quantity of dry matter available. User input information describes the type and amount of dry matter fed from storage on each field. BEEF simulates the growth of plants on the field along with beef animals. The quantity and energy and protein composition of the growing dry matter is added to the dry matter being fed to reflect the total feed supply that is available to the animal. The dry matter intake by each category of animals on each field is computed by the following procedure:

1 If the amount of dry matter available is equal to or greater than the dry matter demand, the dry matter intake is equal to the demand. When several different kinds of dry matter are available, the amount of intake of each kind is based upon the quantity and metabolizable energy content of each kind.

2 If the amount of dry matter available is less than the dry matter demand, the dry matter intake is equal to the amount available.

The dry matter consumed by each category of animals on each field is utilized by the animals for maintenance of body functions, lactation, and gain in body weight. The quantity of dry matter needed by each category of animals is determined for each of these physiological processes each day and compares the need with the amount consumed. The dry matter needs are based on metabolizable energy, digestible protein, and the metabolic body weight of the animals (Cullison, 1979). If the needs for body maintenance and lactation are satisfied, any excess available energy and protein are utilized to provide gain in body weight. Conversely, failure to satisfy the needs for body maintenance and lactation results in loss of body weight.

SIMULATION OF A RECOMMENDED MANAGEMENT SYSTEM

A multidisciplinary team of specialists in the Cooperative Extension Service used the results of research conducted at the University of Kentucky to develop recommendations for a beef-forage system (Absher et al., 1975) to be used by cow-calf producers. The model was used to simulate this recommended system.

The recommended beef-forage system requires that the beef brood cows be kept on pasture all of the time. When the pasture growth does not satisfy the needs of the animals for dry matter, hay is fed to make up the deficiency. The brood cows are bred in early summer and give birth to calves in early spring of each year. The calves are weaned in early winter and sold as feeder calves.

The pastures in the recommended beef-forage system include red clover-fescue mixtures for late spring, summer, and fall grazing; and nitrogen fertilized fescue for winter and early spring grazing. Rotation grazing is practiced so that when pasture growth exceeds the needs of the animals for dry matter, the excess growth can be harvested for hay.

The red clover-fescue pastures are established by interseeding red clover into existing fescue (Smith et al., 1976a, 1976b). The red clover has to be reseeded every other year, and the quantity of dry matter produced per unit of land area is less during the year when the clover is seeded than during the following year. This non-uniform production requires that the farmer do a good job of planning and carrying out management decisions to coordinate the need of animals with pasture production.

The BEEF model was used to simulate this recommended system. The tabular output in Fig. 1 shows the results of the simulation of animal reproduction and is copied directly from the computer printout. On March 2, 1977, there are 64.88 pregnant, non-lactating cows (Category ID No. 7) on Field No. 2. Each one of these pregnant cows is carrying an unborn calf (Category ID No. 13), and the average age of the unborn calves is updated each day of simulation. When the average age reaches 9.34 mo (the gestation period for beef cows), BEEF will schedule the calves to be born. This occurs on March 23, and the cows and nursing calves are moved from Field No. 2 to Field No. 3, on March 24. Field No. 3 is the red clover-fescue pasture, and the animals will graze on this pasture until July 2.

On April 2, 1977, there are 64.78 lactating non-pregnant cows (Category ID No. 8) on Field No. 3. These are the same cows that are present on March 2, except they have been moved from the pregnant non-lactating category (Category ID No. 7) to the lactating, non-pregnant category (Category ID No. 8) due to the birth of their calves. The difference in the number of cows in the two tables is due to a death rate function in the model. This table also shows that there are 32.40 female calves (Category ID No. 10) and 32.40 bull calves (Category ID No. 11) on Field No. 3. The average age of these calves is 0.34 mo. These calves have replaced the unborn calves (Category ID No. 13) that are shown on March 2. The bull calves are castrated on April 9, and on May 2, 1977, Fig. 2 shows that BEEF has moved these bull calves (Category ID No. 11) into the steer calf category (Category ID No. 12).

The model also moves animals from one category to another because of age. On April 2, 1977 (Fig. 1), there are 4.99 female calves (Category ID No. 10) on Field No. 4, and the average age of these calves is 12 mo. These female calves are from the calf crop of the previous year, and they will be moved onto Field No. 3 with the lactating non-pregnant cows (Category ID No. 8) where they can be bred as replacement heifers and added to the breeding herd. On May 2, 1977 (Fig. 2), there are 4.98 non-pregnant yearling heifers (Category ID No. 6) on Field No. 3, and the average age of these heifers is 13 mo. These heifers are the same animals that were listed as female calves (Category ID No. 10) in the table for April 2, 1977 (Fig. 1), on Field No. 4. BEEF moved these female calves from Category ID No. 10 to Category ID No. 6 when they reached an average age of 12 mo plus one day.

The tabular output in Fig. 2 shows the results of the simulation of animal breeding. In the table for May 2, 1977, there are 4.98 yearling heifers (Category ID No. 6) and 64.67 lactating, non-pregnant cows (Category ID No. 8) on Field No. 3; and there are three mature bulls (Category ID No. 1) on Field No. 5. The three bulls were moved from Field No. 5 to Field No. 3 on May 20 and began breeding the heifers and cows that were on the field. The results of breeding from May 20 to June 2 are shown on June 2, 1977 (Fig. 2). There are now only 3.87 yearling heifers (Category ID No. 6) on Field No. 3 because 1.11 of them have been bred. The BEEF model moved the bred heifers into the pregnant non-lactating category (Category ID No. 7). The number of lactating, non-pregnant cows (Category ID No. 8) on Field 3 has been reduced to 50.17 because 14.39 of them have been bred. BEEF moved the bred cows into the lactating pregnant category (Category ID No. 9). There are now 15.50 unborn calves (Category ID NO. 13) on Field No. 3, which reflects the total number of female animals that

BEEF SIMULATION UPDATE
MAR. 2,1977 JULIAN DATE 60.8 SIMULATION DATE 60.8

CATTLE	FIELD ID	CATEGORY ID*	NUMBER OF ANIMALS	AVERAGE AGE(MO)	AVERAGE WT.(KG)	MRKT.VALUE ($/100 KG)	NUMBER SOLD	NUMBER PURCHASED	SALES ($)	PURCHASES ($)
	2	7	64.88	45.05	435.69	50.69	0.0	40.00	0.0	13200.00
	2	13	64.88	8.67	0.0	0.0	0.0	40.00	0.0	0.0
	4	10	4.99	11.00	245.29	79.34	0.0	0.0	0.0	0.0
	5	1	1.00	50.00	617.00	50.69	0.0	0.0	0.0	0.0

*1.MATURE BULLS;2.MATURE STEERS;3,YEARLING BULLS;4.YEARLING STEERS;5.NON-LACTATING NON-PREGNANT COWS;6.YEARLING HEIFERS NON-PREGNANT;7.PREGNANT NON-LACTATING COWS; 8.LACTATING NON-PREGNANT COWS;9.LACTATING PREGNANT COWS;10.FEMALE CALVES; 11.BULL CALVES;12.STEER CALVES;13.UNBORN CALVES.

BEEF SIMULATION UPDATE
APR. 2,1977 JULIAN DATE 91.2 SIMULATION DATE 91.2

CATTLE	FIELD ID	CATEGORY ID*	NUMBER OF ANIMALS	AVERAGE AGE(MO)	AVERAGE WT.(KG)	MRKT.VALUE ($/100KG)	NUMBER SOLD	NUMBER PURCHASED	SALES ($)	PURCHASES ($)
	2	7	0.0	0.0	0.0	50.69	0.0	40.00	0.0	13200.00
	2	13	0.0	0.0	0.0	0.0	0.0	40.00	0.0	0.0
	3	8	64.78	46.05	429.44	50.69	0.0	0.0	0.0	0.0
	3	10	32.40	0.34	40.61	79.34	0.0	0.0	0.0	0.0
	3	11	32.40	0.34	43.93	68.32	0.0	0.0	0.0	0.0
	4	10	4.99	12.00	263.48	79.34	0.0	0.0	0.0	0.0
	5	1	3.00	33.07	578.19	50.69	0.0	2.00	0.0	1368.00

*1.MATURE BULLS;2.MATURE STEERS;3,YEARLING BULLS;4.YEARLING STEERS;5.NON-LACTATING NON-PREGNANT COWS;6.YEARLING HEIFERS NON-PREGNANT;7.PREGNANT NON-LACTATING COWS; 8.LACTATING NON-PREGNANT COWS;9.LACTATING PREGNANT COWS;10.FEMALE CALVES; 11.BULL CALVES;12.STEER CALVES;13.UNBORN CALVES.

FIG. 1 Simulated tabular output of cattle status on March 2 and April 2, 1977.

have been bred since May 20 when the bulls were moved onto Field No. 3. About 22 percent of the heifers and cows on Field No. 3 are bred in the 13 day interim from May 20 to June 2. The average age of the unborn calves (Category ID No. 13) is 0.26 mo, and when their average age reaches 9.34 mo, BEEF will schedule their birth and move them into the female calf category (Category ID No. 10) and the bull calf category (Category ID No. 11).

The plotted output of variables related to animal performance is shown in Fig. 3 for steer calves (Category ID

BEEF SIMULATION UPDATE
MAY 2,1977 JULIAN DATE 121.6 SIMULATION DATE 121.6

CATTLE FIELD ID	CATEGORY ID*	NUMBER OF ANIMALS	AVERAGE AGE(MO)	AVERAGE WT.(KG)	MRKT. VALUE ($/100 KG)	NUMBER SOLD	NUMBER PURCHASED	SALES ($)	PURCHASES ($)
2	7	0.0	0.0	0.0	50.69	0.0	40.00	0.0	13200.00
2	13	0.0	0.0	0.0	0.0	0.0	40.00	0.0	0.0
3	6	4.98	13.00	302.87	66.12	0.0	0.0	0.0	0.0
3	8	64.67	47.05	453.52	50.69	0.0	0.0	0.0	0.0
3	10	32.37	1.34	66.95	79.34	0.0	0.0	0.0	0.0
3	12	32.37	1.34	73.75	96.97	0.0	0.0	0.0	0.0
5	1	3.00	34.07	614.64	50.69	0.0	2.00	0.0	1368.00

*1.MATURE BULLS;2.MATURE STEERS;3.YEARLING BULLS;4.YEARLING STEERS;5.NON-LACTATING NON-PREGNANT COWS;6.YEARLING HEIFERS NON-PREGNANT;7.PREGNANT NON-LACTATING COWS; 8.LACTATING NON-PREGNANT COWS;9.LACTATING PREGNANT COWS;10.FEMALE CALVES; 11.BULL CALVES;12.STEER CALVES;13.UNBORN CALVES.

BEEF SIMULATION UPDATE
JUNE 2,1977 JULIAN DATE 152.0 SIMULATION DATE 152.0

CATTLE FIELD ID	CATEGORY ID*	NUMBER OF ANIMALS	AVERAGE AGE(MO)	AVERAGE WT.(KG)	MRKT. VALUE ($/100 KG)	NUMBER SOLD	NUMBER PURCHASED	SALES ($)	PURCHASES ($)
2	7	0.0	0.0	0.0	50.69	0.0	40.00	0.0	13200.00
2	13	0.0	0.0	0.0	0.0	0.0	40.00	0.0	0.0
3	1	3.00	35.07	651.20	59.51	0.0	0.0	0.0	0.0
3	6	3.87	14.00	338.95	66.12	0.0	0.0	0.0	0.0
3	7	1.11	14.00	338.42	70.52	0.0	0.0	0.0	0.0
3	8	50.17	48.05	475.77	50.69	0.0	0.0	0.0	0.0
3	9	14.39	48.05	475.77	77.14	0.0	0.0	0.0	0.0
3	10	32.34	2.34	89.95	79.34	0.0	0.0	0.0	0.0
3	12	32.34	2.34	98.91	96.97	0.0	0.0	0.0	0.0
3	13	15.50	0.26	0.0	0.0	0.0	0.0	0.0	0.0
5	1	0.0	0.0	0.0	50.69	0.0	2.00	0.0	1369.00

*1.MATURE BULLS;2.MATURE STEERS;3.YEARLING BULLS;4.YEARLING STEERS;5.NON-LACTATING NON-PREGNANT COWS;6.YEARLING HEIFERS NON-PREGNANT;7.PREGNANT NON-LACTATING COWS; 8.LACTATING NON-PREGNANT COWS;9.LACTATING PREGNANT COWS;10.FEMALE CALVES; 11.BULL CALVES;12.STEER CALVES;13.UNBORN CALVES.

FIG. 2 Simulated tabular output of cattle status on May 2 and June 2, 1977.

PLOTTED OUTPUT OF VARIABLES RELATED TO ANIMAL PERFORMANCE

THE FOLLOWING TABLE AND/OR PLOT IS FOR FIELD NUMBER 3, AND CAT. NUMBER 12.

EACH PLOTTED SYMBOL HAS THE FOLLOWING MEANING:
G=ACTUAL WEIGHT GAIN FOR CAT.#12 IN KILOGRAMS PER ANIMAL PER DAY
L=WEIGHT LOSS FOR CAT.#12 IN KILOGRAMS PER ANIMAL PER DAY
D=TOTAL DRY MATTER DEMAND FOR CAT.#12 IN KILOGRAMS PER ANIMAL PER DAY
I=ACTUAL TOTAL INTAKE FOR CAT.#12 IN KILOGRAMS PER ANIMAL PER DAY
W=TOTAL ANIMAL WEIGHT FOR CAT.#12 IN KILOGRAMS PER ANIMAL PER DAY
M=TOTAL MILK INTAKE FOR CAT.#12 IN KILOGRAMS PER ANIMAL PER DAY
NOTE: SYMBOLS G & L ARE PLOTTED TO ONE SCALE; D, I, & M TO ANOTHER; AND W TO A THIRD.

TABLE NUMBER 7
RUN NUMBER 1

TIME 7	GAIN		LOSS		DEMAND		INTAK T		ANIM WT		INTAK M	
MINIMUM	0.0		0.0		0.0		0.0		0.0		0.0	
MAXIMUM	0.1103	01	0.0497	01	0.0544	02	0.0531	02	0.2099	03	0.0740	01

PLOT NUMBER 7
RUN NUMBER 1

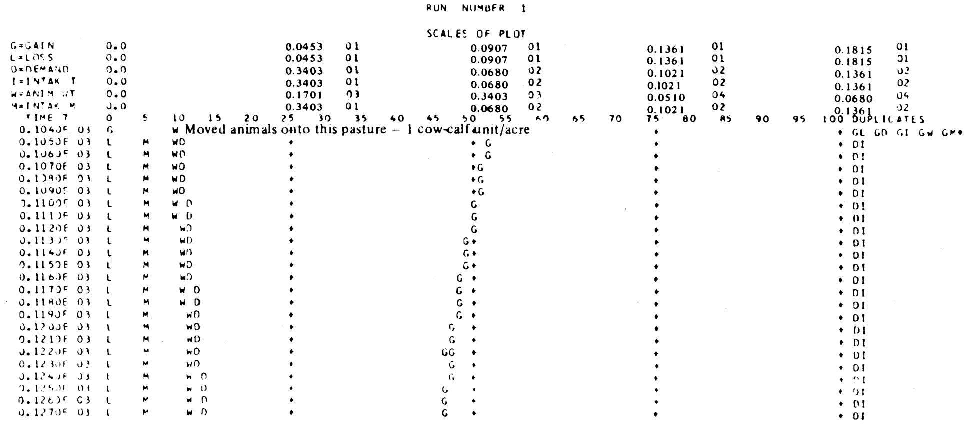

FIG. 3 Simulated performance of steer calves on pasture over a two year period.

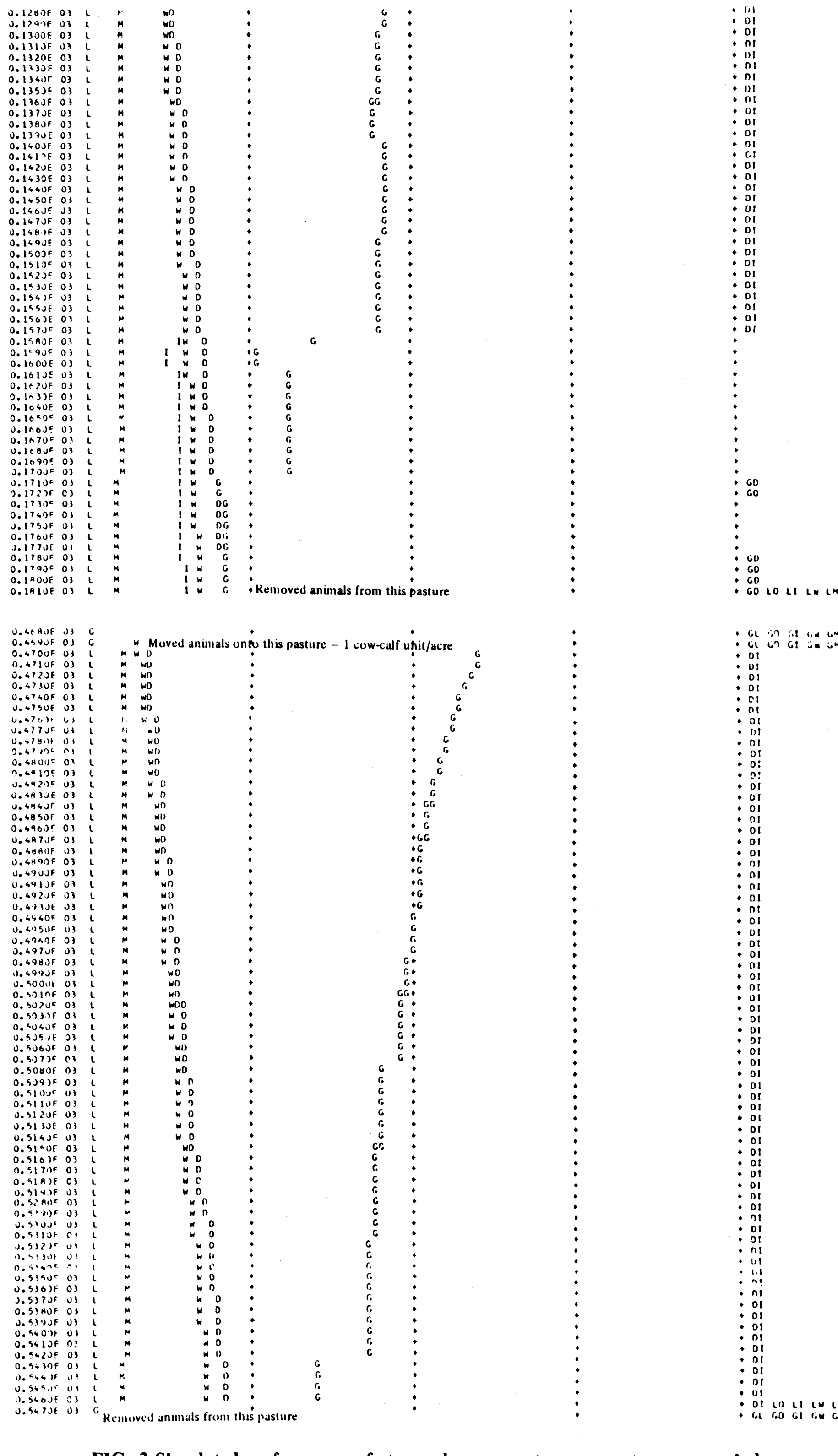

FIG. 3 Simulated performance of steer calves on pasture over a two year period.

No. 12) which are nursing and also grazing on a red clover-fescue pasture (Field ID No. 3) during the year when the red clover is seeded into the fescue, i.e., the first production year for the red clover-fescue pasture. The average age of the calves is 22 days, and their average weight (W) is about 62 kg/calf when they are moved onto this pasture on April 15 (Julian Day No. 104). The calves and their mothers remain on this pasture until July 1 (Julian Day No. 182) when they are moved to another pasture in a rotation system.

On April 16 (Julian Day No. 105) milk (M) accounts for 52 percent, and red clover-fescue pasture accounts for 48 percent of the total feed intake (I) by the steer calves. The rate of gain (G) is computed to be 0.94 kg/calf per day. However, the rate of gain (G) decreases as the proportion of milk (M) in the total feed intake (I) decreases. On June 6 (Julian Day No. 157), 52 days after the calves are moved onto this pasture, milk (M) accounts for 31 percent and red clover-fescue pasture accounts for 69 percent of the total feed intake (I) by the steer calves, and the rate of gain (G) decreases to 0.82 kg/calf per day. Each unit of dry matter in milk contains more metabolizable energy and digestible protein than does a unit of dry matter in red clover-fescue forage; consequently, a higher daily gain (G) results when milk (M) accounts for a higher proportion of the total feed intake (I). The average weight (W) of each steer calf on June 6 is 103 kg, and the average daily gain is 0.78 kg/calf during the period from April 16 (Julian Day No. 105) to June 6 (Julian Day No. 157).

From June 7 (Julian Day No. 158) to June 30 (Julian Day No. 181) the red clover-fescue pasture doesn't furnish enough feed, in addition to milk (M), to satisfy the demand (D) of the steer calves, so the total feed intake (I) is less than the demand (D). The rate of gain (G) is reduced to 0.57 kg/calf per day for the period from June 11 (Julian Day No. 161) to June 20 (Julian Day No. 170), and after June 20, when the intake of milk (M) is also reduced, the rate of gain (G) drops to 0.38 kg/calf per day. The average weight (W) on June 30 (Julian Day No. 181) is 116 kg/calf, and the average daily gain is 0.54 kg/calf during the period from June 6 (Julian Day No. 157) to June 30 (Julian Day No. 181). The average daily gain is 0.70 kg/calf for the period from April 15 to June 30 during the first production year of the red clover-fescue pasture.

The plotted output of variables related to animal performance is also shown in Fig. 3 for steer calves (Category ID No. 12) which are nursing and also grazing on a red clover-fescue pasture (Field No. 3) during the year which follows the year when the red clover was seeded into the fescue i.e., the second production year for the red clover-fescue pasture. The average age of the calves is 17 days, and their average weight (W) is about 49 kg/calf when they are moved onto this pasture on April 15 (Julian Day No. 469). The calves and their mothers remain on this pasture until July 1 (Julian Day No. 547), when they are moved to another pasture in a rotation grazing system.

On April 16 (Julian Day No. 470) milk (M) accounts for 57 percent, and red clover-fescue pasture accounts for 43 percent of the total feed intake (I) by the steer calves, and the rate of gain (G) is 1.08 kg/calf per day. The rate of gain (G) decreases as the proportion of milk (M) in the total feed intake (I) decreases. On June 25 (Julian Day No. 542) milk (M) accounts for 28 percent of the total feed intake (I), and the rate of gain (G) decreases 0.77 kg/calf per day. When the proportion of milk (M) in the total feed intake (I) decreases to 22 percent on Julian Day No. 543, the rate of gain (G) drops to 0.63 kg/calf per day. The average weight (W) on June 30 (Julian Day No. 546) is 116 kg/calf, and the average daily gain is 0.87 kg/calf for the period from April 15 (Julian Day No. 469) to June 30 (Julian Day No. 546). This compares with an average daily gain of 0.70 kg/calf for the same period, Julian Day No. 104 to Julian Day No. 181, during the first production year for the red clover-fescue pasture.

FUTURE MODIFICATIONS AND INVESTIGATIONS

Additional development and validation of the BEEF model is being conducted by the NC-114 Regional Research Committee. The influences of breed differences, environmental stresses, parasites and diseases are being added to better reflect the growth and reproduction of both plants and animals. Presently, the model has been validated to the extent that it does reasonably well in reflecting observed animal and plant performance. Future investigations are being designed especially for purposes of extended validation.

SUMMARY AND CONCLUSIONS

A dynamic simulation model has been developed to simulate a total farm operation and evaluate different production strategies in light of the resources available to and management decisions made by the farmers who produce beef animals. This model was used to simulate a beef-forage strategy which is recommended for use by cow-calf producers in Kentucky.

Tabular outputs are presented which demonstrate the ability of the model to simulate breeding and reproduction of beef animals. The simulation takes into account the management decisions made by the farmer, as well as the physiological factors that affect breeding and reproduction.

The BEEF model indicated that the rate of gain for steer calves which are nursing and also grazing on a red clover-fescue pasture decreased as the proportion of milk in their total feed intake decreased. The first production year for a red clover-fescue pasture gave lower average daily gains than did the second production year. The grazing pressure during both years was one cow-calf unit/acre of pasture; however, the feed produced during the first production year was not enough to satisfy the demand by the grazing animals.

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