SUPPLEMENTAL FEEDING OF MOOSE DURING WINTER: CAN HAY SERVE AS AN EMERGENCY RATION?

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ABSTRACT: When severe winters result in starvation of moose (*Alces alces*) in the proximity of human development, people often demand emergency feeding programs. In spite of the controversy surrounding such programs, political decisions may dictate that resource agencies feed starving moose. Consequently, we tested the feasibility of using locally grown grass hay as an emergency ration. In two concurrent experiments (trial 1), 16 captive moose were maintained on either hay or a pelleted ration. In a separate experiment (trial 2), 8 moose calves were fed grass hay for the duration of winter and their health and mass dynamics recorded. Over the 11 weeks of trial 1, adults eating the hay lost an average of 53.0 kg, whereas those consuming the pellets gained 36.3 kg. Calves eating hay maintained body mass, whereas those eating pellets gained 29.5 kg. Calf moose in trial 2 showed no adverse physiological effects from the diet and maintained body mass throughout the winter. Mean urinary urea:creatine rations (U:Cr) differed ($P = 0.004$) between moose fed hay and pellets, but not among periods in trial 1. These results indicate a difference in intake of nitrogen, but consistency among nitrogen balance over time. Phosphorus:Cr (P:Cr) ratios were not different between treatments ($P = 0.42$) but differed among periods ($P = 0.06$), corresponding to a decline in dry matter intake which is typical for moose during winter. Cortisol:Cr (C:Cr) ratios did not differ between treatments ($P = 0.82$) or among periods ($P = 0.19$), indicating that the level of physiological stress experienced by the moose did not change. We conclude that although the pellets served as a more complete ration for emergency feeding, locally grown grass hay can serve as an emergency food for moose in reasonably good physical condition. We also tested seven new flavors to improve the palatability of our formulated ration. Moose consumed significantly more feed flavored with milky whay when compared to the standard ration and the other 6 flavors tested. Recommendations concerning emergency feeding are discussed.

ALCES VOL. 29 (1993) pp.135-147

As human settlements expand into the northern environments, people come in contact with moose. Community developments generally occur along water courses, in valleys, or other areas that traditionally represent moose winter range. As these settlements develop, the boreal forest is cleared for roads, subdivisions, and other human habitation. When land is cleared but not permanently altered (i.e., paved), seral vegetation rapidly recolonizes many sites. Road rights-of-way, power line easements, driveways, and house lots, represent some of these areas of disturbance. These revegetated areas are a sources of high quality food that attract moose and keep them in close proximity to humans (Child *et al.* 1991, Del Frate and Spraker 1991, McDonald 1991).

Severe winters, those with snow in excess of 90 cm that persist for several months, tend to concentrate moose on their winter range. When severe winters occur and moose starve in town and other settled areas, the public witnesses first hand the physical plight of dying animals. They often demand emergency winter feeding. Most biologist recognize winter starvation as a natural part of the population cycle and do not condone human intervention. Such differences of opinion between biologists and well meaning citizens can generate controversy about the biological impacts of winter feeding and its usefulness in population management. However, in spite of such differences, strong public sentiment can generate politically motivated programs that dictate resource agencies "feed moose".

During the winter of 1989-90 in south central Alaska, extreme snowfall precipitated high moose mortality associated with railroad (Modafferi 1991) and automobile collisions (Del Frate and Spraker 1991), and starvation of calves and adults. This high death rate of moose resulted in a politically motivated program to feed moose.

The winter of 1989-90 not only generated controversy about the wisdom of an emergency feeding program, but there was also disagreement about what to feed. There is virtually no information available in the literature concerning winter feeding programs for moose. Supplemental feeding of hay to mule deer (*Odocoileus hemionus*) has failed to prevent starvation (Carhart 1943, Doman and Rasmussen 1944), and can result in acute digestive problems (Schoonveld *et al.* 1974). At the other extreme, feeding high energy concentrates to ruminants adapted to a poor roughage diet can cause ruminal acidosis and death (Wilson *et al.* 1975, Wobeser and Runge 1975). Consequently, a special ration has been formulated specifically to feed starving deer during winter (Baker and Hobbs 1985).

Anecdotal information suggested that moose eat hay during winter (Denniston 1956), and they are capable of digesting it (Hjeljord et al. 1982, Renecker *et al.* 1982, Renecker and Hudson 1990). We know that moose are seasonally adaptive concentrate selectors (Kay *et al.* 1980, Hofmann 1985, 1989). Moose choose foods that are of relatively high nutrient value, readily fermentable, and passed through the system rapidly (Schwartz 1992*a*). Moose accomplish this by eating mainly woody browse. Food passes rapidly through the digestive system because highly lignified browse when masticated (Renecker and Hudson 1990), shatters into large cuboidal particles (Mertens 1973, Milchunas *et al.* 1978). These particles pass rapidly from the rumen (Renecker and Hudson 1990).

Renecker *et al.* (1982) and Renecker and Hudson (1990) compared the efficiencies of cattle (a grazer), wapiti (*Cervus elaphus*)(a mixed feeder), and moose (a concentrate selector) to digest browse, grass hay, and alfalfa. They concluded that moose were most sensitive to diet, propelling browse more rapidly than cattle, but retaining grass hay and alfalfa longer than either wapiti or cattle.

For a ruminant to maximize energy utilization, it must balance the time food is retained in the rumen for digestion with the time it takes to pass material through the system. Retention of food in the rumen allows for more complete digestion, whereas rapid passage allows for more food to be processed. Evolutionarily, the moose employs a strategy of retaining forage just long enough to digest the soluble components and then passes the fibrous material through the system rapidly. This strategy contrasts to that of a roughage eater (cattle) which consumes a poor quality diet and retains the food in the rumen for a long period of time to ensure adequate digestion of the fiber. Hence cattle are efficient at processing hay, whereas moose are efficient at processing browse. The ability of cattle to process browse or moose to process hay is compromised by the chemical nature of the foods and the differences in physiological adaptions of the digestive system.

Moose in captivity which were fed hay for several years developed chronic digestive upset and eventually died (Schwartz *et al.* 1980, Schwartz 1992*a*). This fact led to the development of a formulated ration which contained wood fiber and is currently used to successfully keep moose in captivity (Schwartz *et al.* 1985, Schwartz 1992*b*).

During the severe winter of 1989-90 there was a public outcry to feed starving moose on the Kenai Peninsula and in the Matanuska-Susitna Valley. The typical feed offered to moose by the public was locally grown grass hay, which we believed to be nutritionally inadequate for moose in poor condition. Responsible members of the public, following our recommendations, attempted to feed our commercially available moose ration. Some people reported success, but many indicated that starving moose refused to eat the diet even though it was a nutritionally complete (Schwartz *et al.* 1985). Similarly, anecdotal accounts from the public and ADF&G staff suggested that some moose readily ate hay and outwardly exhibited signs of nutritional recovery, while others refused it and ultimately starved to death.

The major objectives of our study was to determine if hay could be successfully use as an emergency ration during winter for moose. We specifically were interested in determining if: 1) moose fed hay could survive the winter, 2) moose eating hay met their minimum maintenance energy requirement, 3) moose consuming hay for an extended period developed chronic digestive upset and died, and 4) either the formulated ration or hay might be used as a practical emergency rations for winter feeding.

METHODS

We conducted our studies over 2 winters with captive moose at the Moose Research Center (MRC), located on the Kenai Peninsula in southcentral Alaska. Moose were obtained from wild stock on the Kenai Peninsula, interior Alaska (Fairbanks area), or Matanuska Valley north of Anchorage. All were of the subspecies *A. a. gigas*. Most animals were hand-reared and trained to accept handling (Regelin *et al.* 1979). Others were raised by tame cows and were habituated to confinement, and trained to accept handling for weight determination and human presence.

Trial 1.

During the first winter, sixteen moose (8 cows and 8 calves) were assigned to one of 2 treatments and fed either a pelleted ration (4 cows, 4 female calves) (Schwartz *et al.* 1985) or locally grown mixture of brome grass (*Bromus inermis*) and timothy (*Phleum pratense*) hay (4 cows, 4 male calves) during winter. All cows were pregnant. Animals were fed the pellets from a self-feeder, whereas hay was placed on the ground at several locations. Each treatment group was fed *ad libitum*. To simulate an emergency feeding program, free water was not offered; animals obtained their moisture by eating snow.

We conducted trials to determine intake, weight change, and physiological status as measured by snow-urine analysis for treatment (hay) and control (MRC ration) groups. Each group consisted of 8 moose: 4 adult and 4 female calves in the control group, and 4 adult female and 4 male calves in the hay group. The trials began on 17 January and continued through 6 April, 1992 (11 weeks). Control and treatment moose were housed in a 4 and 3 ha enclosure, respectively.

We monitored weight change of each animal once a week throughout the trial. Animals were trained to walk onto a cattle scale that was accurate to 1 kg (Schwartz *et al.* 1987). Differences in gain or loss of body mass over the duration of the trial were determined with a t-test (Dixon and Massey 1969). Calves and adults were analyzed separately.

We measured dry matter intake during week 5 and 10. Animals were housed in individual holding pens and offered *ad libitum* quantities of either hay or pellets for a 7 day period. Intake during these periods was expressed on a dry matter basis, with feed samples dried at 60 C for 48h. Moose fed hay often dropped some on the ground. Consequently we estimated the loss of hay offered by simulating a 24 hour feeding. We placed a known quantity of hay in the feeder, and removed it in a fashion to simulate a feeding moose. Uneaten hay was cleaned from both the feed bunk and the ground, following the protocol used during the regular experiment. The amount of mass not accounted for as eaten and orts, was considered experimental error. We replicated this experiment 3 times. Differences in intake between treatments, time periods, and age class were tested using ANOVA (Dixon and Massey 1969).

Urine was collected approximately bi-weekly by either maneuvering a container attached to a pole into the urine stream during urination (most samples) or collecting freshly deposited urine in snow. Samples collected during 3 arbitrarily-defined periods: 1 (Weeks 1-2), 2 (Weeks 4-7) and 3 (Week 11) were submitted for analysis for urea, phosphorus, cortisol, and creatine. Nutritional status of moose was evaluated by expressing U and P as ratios to Cr (DelGiudice *et al.* 1989, Hundertmark *et al.* 1992). Cortisol:Cr ratios were used to assess physiological stress levels which can be elevated during nutritional deprivation (Saltz and White 1991). Caution must be used when interpreting cortisol data since stress can be associated with factors other than nutrition (i.e., social, weather etc.). Since the experimental animals were maintained under similar conditions, non-nutritional effects were similar so comparisons should represent treatment effects. Ratios were $\log_e$ transformed before being subjected to ANOVA with period (1-3) and trial (hay vs. MRC) as categorical variables.

Trial 2.

During the second winter, seven moose calves (4 males and 3 females) were fed a locally grown mixture of brome grass and timothy hay *ad libitum.* Animals obtained their moisture by eating snow. The trials began on 25 December and continued through 5 May, 1993 (19 weeks). We weighed calves weekly to track mass dynamics and monitored average daily consumption of hay throughout the winter. We conducted 2 trials to determine intake. Moose were housed in a bare 30 X 30 m enclosure.

We monitored daily consumption of the group by weighing the hay offered daily and estimating the amount remaining after 24 hours. These data was used to monitor consumption rates and evaluate wastage.

We measured dry matter intake during week 10 and at the end of the trial in week 19. Hay consumption was measured by providing *ad libitum* amounts of hay to all 7 animals together in the holding pen. After 24 hours, the uneaten hay was collected and weighed. Average daily consumption was calculated for all animals.

Rump fat was measured in 5 calves using the ultrasound technique described by Stephenson *et al.* (1993).

Evaluation of Flavor Additives.

In the summer of 1991, 8 adult female moose were used in a trial to determine preferences for the MRC ration containing 8 different flavor enhancing additives. Each animal was offered all 8 feeds *ad libitum* for a 24-hr period, with the different flavored feeds being placed in separate compartments in a feed bunk. Assignment of animals to pens and feeds to compartments was randomized with a Latin Squares design. Each animal was offered 9 kg (fresh weight) of each flavored feed, and in certain cases some animals were supplemented with an additional 5 kg of certain feeds to assure that they had an *ad libitum* supply. Refused food was collected and weighed. Difference between fresh weights of feed offered and feed refused was considered feed consumed. Rank transformations of amount consumed (response variable) were subjected to ANOVA for Latin Squares (Conover and Iman 1981, Hora and Conover 1984, Akritas 1990) with animals and feed placement being blocking variables.

Feed flavors tested included: apple, anise-molasses, horse, milky whay, mineral (Crest Flavor Co., Kansas City, Mo.), caramel (Far-Mor Inter., Dolton, Ill), dairy krave (Feed Flavors, Inc., Wheeling, Ill.) and our standard ration flavored with anise (Don Chemical, Anchorage, AK.).

RESULTS

Chemical composition indicated that the MRC ration contained more protein and less fiber but was equally digestible when compared to the hay samples. The hay contained more moisture and less ash than the pellets (Table 1).

Trial 1

Moose in the hay treatment took over 10 days to begin eating the hay. This was probably due to two things, (1) like wild moose, our animals did not recognize hay as a food source, and/or (2) our moose were more accustomed to eating the MRC ration and found hay unpalatable. However, once hungry, they ate hay. Two cows, one in each treatment, were removed from the study after they aborted their fetuses. Both abortions were associated with systemic infections not associated with the feeding trial.

We estimated that 1.1-2.5% of the hay offered during intake trials was lost on the ground. Consequently, our estimates of hay intake were slightly inflated. Analysis of variance of intake data revealed a non-significant month effect ($P = 0.864$), so we pooled measurement of intake over the two periods. Regardless of treatment, calves (69.8 g/kg $BW^{0.75}$/d) consumed significantly ($P = 0.002$) more dry matter than adults (53.6 g/kg $BW^{0.75}$/d)(Table 2). Similarly, regardless of age, moose eating MRC ration consumed (73.7 g/kg $BW^{0.75}$/d) significantly more ($P < 0.0001$) dry matter than moose eating hay (51.9 g/kg $BW^{0.75}$/d). There was also a significant treatment by age interaction ($P = 0.03$) because adult cows in the hay treatment consumed about half the dry matter of moose eating pellets, whereas calves in both treatments ate similar amounts.

Changes in body mass reflected differences in dry matter intake (Fig. 1.). Cows consuming the pelleted ration gained an average of 36.3 kilograms (SD = 5.9) during the 11 weeks of study, whereas cows consuming hay lost an average of 53 kg (SD = 7.5)($t = 16.2$, $P = 0.001$, df = 3.8). The 4 calves eating hay maintained body mass during the trial ($\overline{X}$= 5 kg, SD = 2.4), whereas calves feeding on MRC ration gained mass ($\overline{X}$= 29.5 kg, SD = 14.9) ($t = 3.2$, $P = 0.04$, df = 3.2).

Mean U:Cr ratios differed ($F_{1,37} = 9.71$; $P = 0.004$) between moose feeding on hay ($\overline{X}$= 2.96, SE = 0.50) and on MRC ration ($\overline{X}$= 5.48, SE = 0.46) but not among periods ($F_{2,37} = 0.033$; $P = 0.90$), suggesting that nitrogen intake, but not nitrogen balance differed between hay and pellet fed moose. One observation was deleted from analysis due to anomalous ratios (Fig. 2).

Phosphorus:Cr ratios did not differ between trials ($F_{1,37} = 0.65$; $P = 0.42$) or among periods ($F_{2,37} = 3.08$; $P = 0.06$), but declined

Table 1. Chemical composition (%) of the pelleted ration and grass hay fed to moose at the Moose Research Center, Alaska. Moose were fed during the winters of 1991-92 and 1992-93.

Nutrient	Hay		
	1991-92	1992-92	Pellets
Dry matter	84.0-86.3	84.0	92.7
Gross energy (kcal/g)	4.4-4.5	4.6	4.5
Dry matter digestion	59.0	65.7	59.0
Neutral-detergent fiber	65.1-67.0	57.8	33.8
Acid-detergent fiber	36.9-39-7	30.4	18.1
Lignin	4.8-4.9	4.0	2.8
Crude protein	7.9-9.5	9.5	10.5
Ash	4.5-4.7	6.6	7.4
In vitro digestion	57.6-59.8	65.7	67.9

Table 2. Dry matter intake of hay and a pelleted ration fed to adult cow and calf moose during winter 1991-92 at the Moose Research Center, Alaska.

Treatment	Mass (BM)		Intake			
Age	(kg)	SD	g/kgBM$^{0.75}$/d	SD	%BM	SD
Pellets						
Cows	529	44	70.5	12.2	1.5	0.2
Calves	196	24	76.1	17.2	2.0	0.5
Hay						
Cows	430	44	36.6	9.8	0.8	0.2
Calves	215	26	63.4	5.7	1.6	0.1

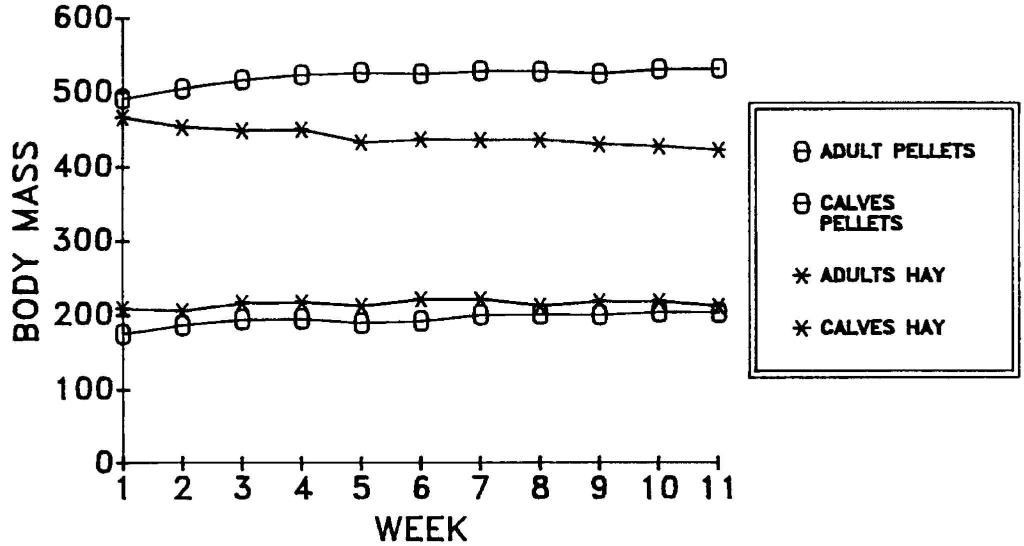

Fig. 1. Body mass of cow and calf moose fed either hay or a pelleted ration during winter. The trial began on 17 January (week 1) and continued through early April, 1992.

over time (Fig. 3). This decline reflected the decrease in intake observed (DelGiudice *et al.* 1989). Moose feeding on hay were sampled (Period 1) within 1 week of being weaned from MRC ration, which would account for the similar P:Cr ratios between the trials for Period 1. As moose continued to feed on hay their P:Cr ratios declined and remained noticeably lower than those of moose fed the formulated ration for the remainder of the study.

Cortisol:Cr ratios did not differ between moose in the 2 trials ($F_{1,37} = 0.05$; $P = 0.82$) or among periods ($F_{2,37} = 1.73$; $P = 0.19$).

Trial 2.

The calf moose consuming only grass hay from late-December through April were able to maintain their body mass throughout the winter (Fig. 5). All animals appeared healthy at the end of the experiment although ultrasound measurements indicated no measurable rump fat. Average daily consumption of hay ranged from 3.8-4.4 kg/day/calf. This equates to 70-84 g/kg BW$^{0.75}$/day.

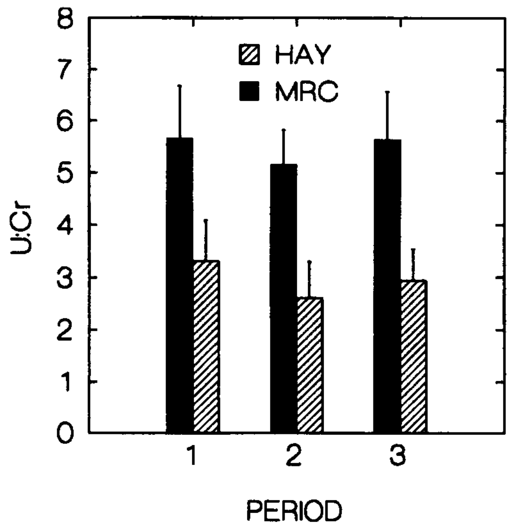

Fig. 2. Mean U:Cr ratios of moose on 2 different diets, for each of 3 periods (see text) during an 11-week feeding study. Error bars represent 1 SE. The mean ratio for moose feeding on hay during period 2 is presented with and without an anomalous datum.

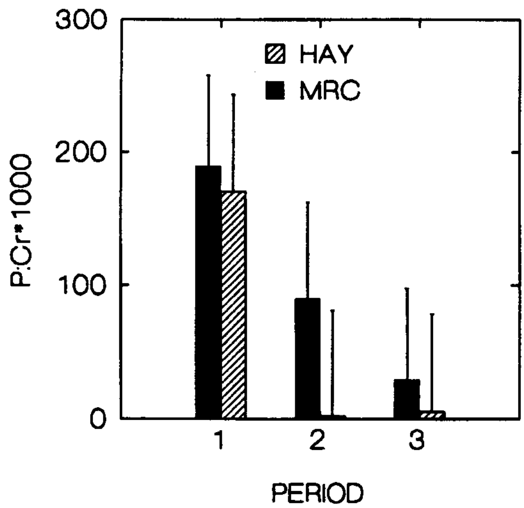

Fig. 3. Mean P:Cr*1000 ratios of moose on 2 different diets, for each of 3 periods (see text) during an 11-week feeding study. Error bars represent 1 SE.

Evaluation of Flavor Additives

Amounts of feed consumed differed among the 8 types of flavored feed offered ($F = 2.57$; $P = 0.027$), but were not affected by animal ($F = 0.97$, $P = 0.47$) or location ($F = 0.95$, $P = 0.48$). The mean rank for milky

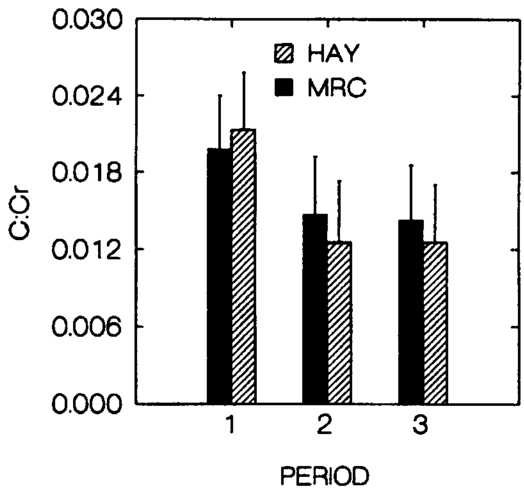

Fig. 4. Mean C:Cr ratios of moose on 2 different diets, for each of 3 periods (see text) during an 11-week feeding study. Error bars represent 1 SE.

whay differed from those of flavors 2-6 (Table 3). Flavor 8 (MRC ration) was not included in the multiple comparison because we wanted to evaluate new flavors only. However, the MRC ration ranked 2nd in amount consumed, indicating that only 1 flavor tested exceeded the taste preference for the standard ration.

DISCUSSION

Based on changes in weight and urine chemistry we concluded that moose feeding on hay were in poorer condition after 11 weeks than moose consuming the MRC ration. However the moose eating hay were still relatively healthy at the end of the experiment. Although differences in weight dynamics between the 2 groups were obvious, the magnitudes of the differences were less than expected. The adult cows feeding on hay lost between 8-10% of their body mass over the course of the trial. They probably did not lose more weight because they were in excellent condition entering the trials. In this respect, we believe that our experiment did not reflect conditions which wild moose would experience in a severe winter prior to being

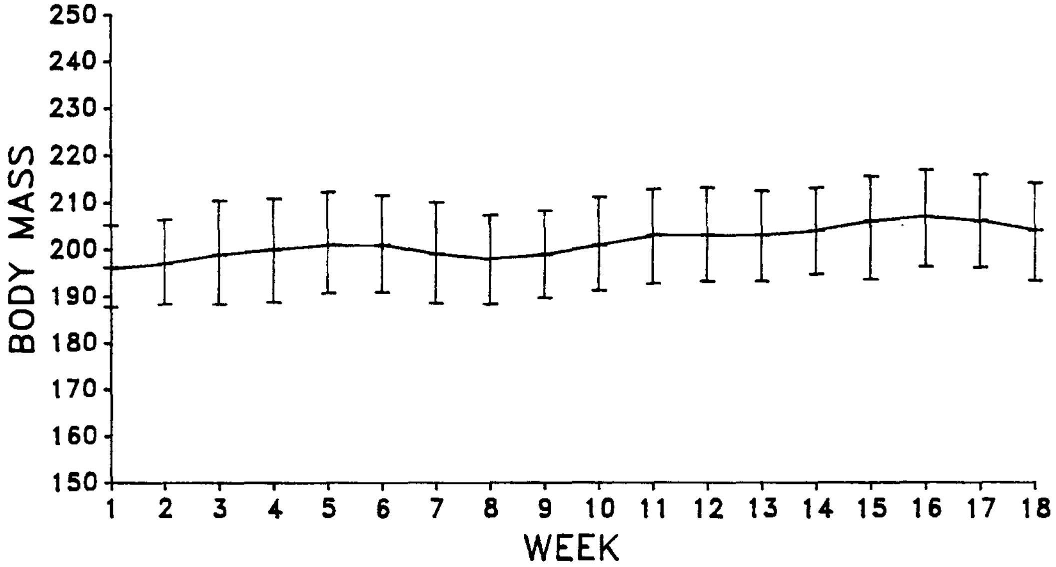

Fig. 5. Body mass of calf moose fed hay during winter. The trial began on 25 December (week 1) and continued through early May, 1993.

Table 3. Mean ranks of feed flavorings used in a test of flavor preference by moose. Higher mean ranks indicate a greater amount of feed was consumed.

Number	Mean Rank	Flavor	Manufacturer
1	43.75[b]	Milky Whay	Crest Flavor Co.
2	38.69[a]	Apple	Crest Flavor Co.
3	34.75[a]	Caramel	Far-Mor
4	34.31[a]	Anise-molasses	Crest Flavor Co.
5	29.88[a]	Dairy Krave	Feed Flavors, Inc.
6	22.94[a]	Horse	Crest Flavor Co.
7	14.56[a]	Mineral	Crest Flavor Co.
8	41.13	MRC CONTROL	Don Chemical

[a,b] Means with different superscripts are significantly different ($P < 0.05$); the mean for the control ration was not included in the comparison

fed. Consequently, we conducted trial 2 where we fed calves for the entire winter. Based upon this hay feeding trial, we can conclude that *ad libitum* quantities of good quality grass hay can meet the maintenance requirements of calf moose during winter.

There is one important part of our studies which differed from what normally occurs in the wild. Moose in both of our trials were in good body condition at the start of the feeding experiment. Moose in the wild are usually close to death before emergency feeding programs commence. Ruminant animals generally require days to weeks to adapt to new feeds. The rumen bacteria may need up to 2 weeks to adjust population numbers and gut morphology and physiology may require as long as 6 weeks to adapt (Hofmann 1982). Animals in good physical condition are more likely to adjust to diet changes than those near starvation.

During the severe winter of 1989-90 on

the Kenai Peninsula calves were in negative energy balance in late autumn, and winter-related mortality was widespread by January 1990. Attempts to feed moose during this time often failed either because wild moose refused to eat emergency rations or because their physical condition had already deteriorated beyond the point of recovery.

Cows, particularly those with nursing calves, rely on autumn and early winter ranges to accrue fat for the winter, gaining weight into early winter (Schwartz *et al.* 1987). Bulls also rely on post rut foods to replenish some of their fat reserves lost during the breeding season. Early, deep snows would inhibit this critical fat deposition in both sexes, thus accelerating nutritional decline. Consequently, when deep snows precluded movements of wintering moose, some starved.

Emergency rations fed to moose must contain adequate digestible energy to meet maintenance requirements, particularly for animals with depleted fat reserves. Both rations we tested met this criteria, at least for calves. In addition, an emergency ration must be palatable to wild moose. Neither hay nor pellets met this requirement in all cases, although moose tended to eat hay more readily.

An emergency ration must be easy to handle and feed. The pellets came in 50 pound bags and were easily fed from a self feeder. There was little waste. Hay was also easily handled and additionally could be thrown from an aircraft. However, hay placed on the ground was often wasted. We estimated that in excess of 50% of all hay fed, during trial 1, remained uneaten. Animals often bedded, defecated, or urinated on it. We eliminated this during trial 2, by placing the hay in a trough. Wastage was reduced to less than 25%. Using conventional hay feeding devices developed by the agriculture industry would reduce waste, but make deployment of hay from the air impractical.

An important consideration of any emergency feeding program is the economics. Although we do not have actual measures of the costs associated with the 1989-90 winter, we can make projections based on the known intakes of our animals (Table 4). The grass hay fed to our moose cost $350/ton, and the pellets cost $480/ton. It cost about $4.75 and $4.02 per day to feed a cow and calf moose hay, whereas feeding pellets cost $3.77 and $3.20, respectively.

During the winter of 1989-90, calves began showing signs of nutritional stress by mid-December, and cows by mid-January, and deep snows remained through late-April. Consequently, to feed animals during this critical winter period, the cost of the program would be between $396 and $543 per animal depending upon feed used and animal age (Table 4).

Feed costs can be lowered by reducing waste or by feeding less food (i.e., below ad libitum). However, it is our experience at the MRC that dominant individuals tend to eat to fill and prevent submissive animals from feeding. Consequently, the emergency ration must be deployed in a dispersed fashion.

It might also be assumed that emergency fed animals will consume some natural foods in addition to the emergency ration, thereby reducing the total feed requirement. We did observe the cow moose on the hay diet consuming spruce. Spruce is not a good food source, and we suspect that these animals were stressed from eating hay. During very extreme winters, deep snow generally restricts animals to small areas. Once emergency food is made available, we suspect that the animals using this food will travel very little to obtain browse.

There is also a question about the benefits to the population of feeding and justification of its costs. As stated by Baker and Hobbs (1985), there are insufficient data to access many of the potential biological costs of feeding. They state that emergency feeding can increase the potential for disease transmission. It may reduce wildness or cause detri-

Table 4. Estimated cost of emergency feeding an adult cow and calf moose during winter either hay or a pelleted ration.

Assumptions	Diet	
	Hay	Pellets
Intake of feed (% body mass)		
Cow	1.0	1.0
Calf	2.0	2.0
Feed dry matter (%)	85	93
Efficiency of feed use (%)	50	80
Cost of feed (cents/kg)	0.39	0.53
Feeding costs (cents/d)	0.35[a]	0.35[a]
Feed time (days)		
Cow	105	105
Calf	135	135
Body mass (kg)		
Cow	480	480
Calf	200	200
Cost/day ($)		
Cow	4.75[b]	3.77[b]
Calf	4.02[b]	3.20[b]
Cost/winter ($)		
Cow	499.24	395.78
Calf	542.78	431.93

[a] Estimate from Baker and Hobbs (1985).

[b] Cost of feeding per day was calculated as follows: (body mass X daily intake / feed dry matter / efficiency of usage X cost of feed) + feeding costs.

mental effects on spatial distribution. By preventing the culling effects of winter on weak animals, feeding may harm the genetic quality of a population. Concentrating moose may also concentrate their predators making them more vulnerable to predation.

Emergency feeding of moose can also compromise moose population management. Maintaining high stocking densities on depleted ranges through winter feeding programs can exacerbate range depredation. Sound moose management programs should include objectives for herd management that encompass the potential need for emergency feeding. A policy should be established dealing with use of emergency feeding as a possible management tool. The program should include a discussion of when, where, and how such a program might be implemented thus reducing the potential for crises management and political intervention.

Feeding moose definitely reduces their wildness and often exacerbates moose/human conflicts. Wild moose that are habituated to humans often become aggressive and mean. For example, of 201 nuisance animal calls recorded by Fish and Wildlife Protection (FWP) in Anchorage in 1990 (Lt. T. Ruddell, pers. comm.), over 80 percent dealt with moose. An estimated 50 percent of the moose calls resulted from people feeding moose. Of significance was: (1) all 15 reported animal attacks were moose, not bears, (2) 40 percent of 25 defense of life and property cases dealt with moose, (3) human/animal conflicts were twice the rate of injured animal calls, and (4)

100 percent of the aggressive animals destroyed (n = 5) were moose. The decision to destroy a moose only occurs after numerous contacts with the animal posing significant threat to humans, utilizing all available deterrents, and consulting with the ADF&G. In Soldotna, in 1992, there were 132 nuisance moose calls. Members of the public killed 14 and FWP killed 4. The number of calls received by FWP does not reflect the number of calls received by ADF&G since both agencies deal with moose problems.

Finally, are the costs of feeding moose offset by the benefits? As stated by Baker and Hobbs (1985) clearly, economic justification of feeding depends on estimating the dollar value of each animal saved—a difficult estimate to make. If our estimates are accurate, then the break-even point is between $396 and $543.

The economic value of moose is a complex issue and has several components. There are direct use values that reflect benefit derived from specific activities involving moose like hunting and viewing. There are also indirect use values like option values that reflect an individual's perception that he or she might want to use moose in the future. There are also nonuse values like existence value reflecting the benefit derived simply from knowing that moose exist. Values and types of value relative to wildlife and natural resources are discussed elsewhere (McCollum *et al.* 1992).

There is some controversy regarding the relevance of and ability to measure some components of value like existence value or option value, but a conservative and generally accepted approach to valuing wildlife is to value the direct use components. Using surveys of resident and nonresident hunters and resident voters in Alaska, McCollum and Miller (pers. comm.) estimated comsumptive and nonconsumptive use value of wildlife in Alaska. For trips by resident hunters naming moose as a target species the net trip value (over and above all costs of the trip) ranged from $181 to $429, depending upon success and trophy quality. For non-resident hunters the net trip value ranged from $393 to $508. McCollum and Miller (in press) also focused on primary "wildlife viewing" trips, where "wildlife viewing" was the term used to include all nonconsumptive use. Primary trips were defined as overnight trips on which wildlife viewing was the single most important purpose of the trip. The average net value of trips where moose were sought or seen ranged from $101 to $123.

The decision to feed moose becomes a balance sheet between cost and benefits. The economic value of a moose varies with human use, rareness, sex and age, contribution to population biology, and many other factors. Thus the decision to feed is not simply made when the cost side of the equation is smaller than the value of a moose. For example, the economic value of a bull moose ($181-$508) to a sport hunter may exceed the cost of feeding it during the winter. But winter feeding programs are not selective about which animals get fed. Cows and calves predominate in any hunted population. Consequently, the economics of feeding must consider population biology, the relationship of the population to carrying capacity, harvest strategies, habitat quality, and an array of other factors. On well stocked ranges, there is a surplus of animals produced each year. Moose saved from starvation will likely die from compensatory causes. Emergency feeding moose on well stocked ranges is wasting resource dollars that would be better spent managing habitat. Decisions to implement emergency feeding programs should be based upon biological and economical considerations laid out in advance in a well designed management plan. Emergency feeding programs should not be based on emotion.

ACKNOWLEDGEMENTS

We especially thank C. C. Shuey, J. Carnes, and J. Latimer for assistance with feeding experiments. We wish to thank E. F. Becker for providing the experimental design and data analysis for the evaluation of flavor additives and for statistical help with data analysis, E. Rolph for performing dry-matter determinations and data entry for the hay feeding trials, and D. Anderson, L. Renecker, P Karns, and W. L. Regelin reviewed the manuscript. We also thank Dan McCollum and SuzAnne Miller for providing us data on the economic value of moose.

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