Basic Nutrition of Bison

Saskatchewan
Agriculture

TABLE OF CONTENTS

LIST OF TABLES ii
FEED INTAKE, DIGESTIVE SYSTEM, AND SEASONAL PHYSIOLOGY 1
- Introduction 1
- Dry Matter 1
  - Dry Matter Intake 1
- Factors Affecting Nutrient Requirements 1
  - Digestive System 1
- Growth and Seasonal Physiology of Bison 2
  - Growth and Development of Calves 2
  - Seasonal Weight Changes of the Mature Cow 2
  - Seasonal Weight Changes of the Mature Bull 4
  - Metabolic Winter Weight Loss 4

THE BASIC NUTRIENTS 5
- Water 5
  - Dugouts 5
  - Sloughs, Creeks and Springs 6
  - Snow 6
  - Wells 6
  - Water Quality 6
- Energy 8
  - Energy Requirements of Mature Cows 9
  - Mature Bulls 9
  - Juveniles and grower/feeder calves 9
- Crude Protein 10
- Minerals 10
  - Macro Minerals 11
  - Micro Minerals 11
- Vitamins 12
  - Effects of Stress 12

PRACTICAL FEEDING FOR BISON 13
- Adults 13
- Replacement Heifers 13
- Breeding Bulls vs. Feeder Bulls 13
- Differences between Cereal Grains 14
- Mineral / Vitamin Supplementation 14
- Summer Grazing 15
  - Pasture Supplementation and Flushing 16
- Winter Feeding 16
  - Winter Swath Grazing of Annuals 17
  - Moldy Forages 17
  - Nitrates in Forages 18

REFERENCES 19
ACKNOWLEDGMENTS .... back cover

LIST OF TABLES

Table 1. Dry matter intake of beef cows consuming high to low quality forages. 1
Table 2. Comparison of total tract retention time and dry matter digestibility of forages between bison and cattle. 2
Table 3. Winter vs. summer with respect to daylength, metabolism, dry matter intake and body weight status. 5
Table 4. Water quality guidelines for livestock use. 7
Table 5. Estimated energy, crude protein, calcium and phosphorus requirements of bison. 8
Table 6. Macro mineral function, deficiency and toxicity symptoms. 10
Table 7. Micro mineral function, deficiency and toxicity symptoms. 11
Table 8. Mineral and vitamin requirements for stressed beef calves and unstressed beef cattle. 12
Table 9. Acres/1000 lb. bison (or Animal Unit) based on 7 month grazing season, 30% carryover, 30% creep-rooted alfalfa and 70% meadow bromegrass pasture in good condition. 16
Table 10. Acres/1000 lb. bison (or Animal Unit) based on 7 month grazing season, 50% carryover, and season long use of native range (Loam or Clay range sites). 16
Table 11. Nutrient levels of forages available to bison in sward sites, grazed patches, and actual feeding stations. 16
Table 12. Variation in forage quality for alfalfa hay and grass hay. 17
Table 13. Common nutrient values for feeds in Saskatchewan. 18

FEED INTAKE, DIGESTIVE SYSTEM, AND SEASONAL PHYSIOLOGY

Introduction

Most of the information available on bison nutrition has been extrapolated from beef cattle requirements, bison forage selectivity, current knowledge of the bison digestive system and growth and seasonal adaptations. Specific energy, protein, mineral and vitamin requirements have yet to be fully developed. **When feeding bison, several concepts must be understood: a) bison are ruminants, and all diets must be forage based prior to considering the use of grain supplementation and b) weight loss will happen at certain times of the year and planning is required prior to such periods.** Finally, it is important to read through this entire document prior to making any decisions on a year round feeding program.

Dry Matter

Dry matter (DM) is the weight of the feed once all moisture is absent. For example, alfalfa hay containing 10% moisture (as fed basis) will have a dry matter value of 90%. This is calculated by subtracting the moisture level in the feed from 100 (e.g. 100 - 10 = 90). Therefore, a bale of alfalfa hay weighing 1,000 lb. at 10% moisture (90% DM) has a total of 900 lb. hay on a dry matter basis. The value of 900 lb. was achieved by multiplying 1,000 lb. x 90%. Conversely, 900 lb. of alfalfa hay dry matter would equal 1,000 lb. as fed basis (900 lb. ÷ 90% = 1,000 lb.). Conversions between as fed and dry matter are necessary, not only for estimating nutrient levels consumed but also for estimating actual as fed feed amounts required on a daily, monthly or yearly basis. Finally, all nutrient requirements for ruminants are expressed on a dry matter basis.

Dry Matter Intake

Dry matter is important for other reasons. Total dry matter intake for ruminants can be estimated as a percentage of body weight. For beef cattle, dry matter intake will vary when consuming forages ranging in quality (Table 1). As the forage fiber level increases, the digestibility of that feed decreases. This results in a reduced level of feed intake as the rumen requires a longer period of time to digest the fiber. Thus, the rumen stays full longer, reducing feed intake. While Table 1 refers to cattle and cannot be directly related to bison, it does show that predicted dry matter intake changes with changing forage quality.

Table 1. Dry matter intake of beef cows consuming high to low quality forages.

Feed	Dry Matter Digestibility (%)	Per cent ADF [z] (100 % DM)	Dry Matter Intake (% of body weight)
Excellent Quality Hay	65	29	3.0
Silage	60-65	36	2.5 - 3.0
Very Good Hay	60	36	2.5
Medium Quality Hay	55	39	2.0
Poor Hay, Barley Straw	45	49	1.5
Wheat Straw	35-50	54	1.0

[z] ADF = Acid Detergent Fiber

SOURCE: Saskatchewan Feed Testing Laboratory, 1990.

Factors Affecting Nutrient Requirements

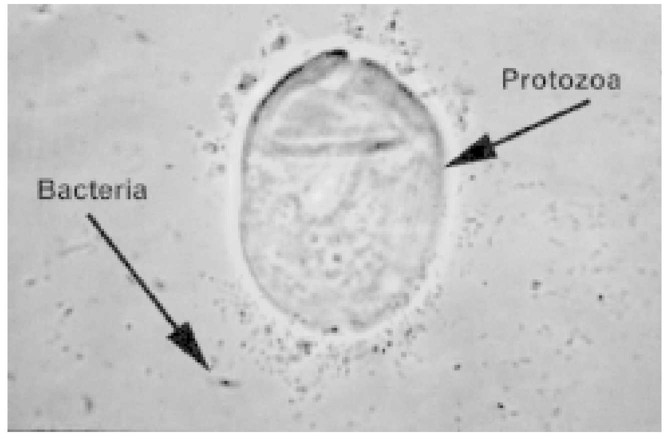
Digestive System

Bison are grazing ruminants that have a four chambered stomach for feed digestion. The first two stomach chambers are the rumen and reticulum. A bison's rumen is very structured, ensuring that forage based feeds are retained for long periods of time. As a result, bison only feed four to nine times a day, consuming large quantities of forage per feeding. In comparison, deer consume smaller quantities of feed more frequently throughout the day. Bison also retain feed in their digestive system longer than cattle (Table 2). Longer feed retention means that bison have more time to digest the fiber in feeds such as sedges and grasses. However, when consuming alfalfa or alfalfa brome hay, there is virtually no difference in digestibility between bison and cattle because the fiber level in alfalfa based forages is typically lower than in grasses and sedges. Forages with lower fiber levels do not need to stay in the digestive tract as long to be fully digested as compared to forages with higher fiber levels.

The rumen and reticulum are populated with microorganisms such as bacteria and protozoa. These microorganisms utilize the fibers in forages and starches in grains to produce acetic, propionic and butyric acids. These acids are absorbed through the wall of the rumen into the blood stream to be converted into energy by the liver. Forages contain higher levels of fiber and lower levels of starch than grains and when utilized by the microorganisms, the amount of acid produced can easily be absorbed.

When suddenly introduced to high grain diets, the microorganisms produce higher levels of acid. Higher acids levels can potentially result in liver abscesses, rumen ulcers, acidosis (otherwise known as feedlot bloat), founder and even death.

The microorganisms also break down feed protein and nitrogen to create their own protein. This microbial protein, as well as minerals and vitamins, are passed down the digestive tract for absorption in the large and small intestines.



Picture of protozoa (large circle) surrounded by smaller bacteria in the rumen. Photo: Dr. G. Jones.

Table 2. Comparison of total tract retention time and dry matter digestibility of forages between bison and cattle.

	Bison	Cattle
Total Tract Retention Time (h)	78.8	68.7
Dry Matter Digestibility (%)		
Sedge hay	64	58
Grass hay	74	62
Alfalfa/brome hay	50	52

SOURCE: Schaefer, A. L., Young, B. A. and Chimwano, A. M. 1978

Growth and Seasonal Physiology of Bison

Growth and Development of Calves

When born, most calves have a mid-May birth weight of 40 to 75 lb. and can gain 1.2 to 2.0 pounds per day until weaning at 7 months of age (Figure 1). At weaning, an average weight of 400 pounds for heifer calves and 500 pounds for bull calves should be achievable under normal feeding and feed management conditions. From January to April, calf growth rate will vary depending on the feeding program. If fed a grain supplement with a grass or legume hay, it is possible for bison calves to gain approximately 0.75 to 1.5 pounds per day. Dry matter intake levels for calves will range from 2.0 to 2.4% of body weight from December to 18 months of age. Upon reaching 18 months of age, a lifetime cycle of reduced dry matter intake and weight loss in the winter followed by higher dry matter intake and weight gain in the spring/summer will occur.

Growth rate of calves depends on the feeding program.

Seasonal Weight Changes of the Mature Cow

Once bison reach 18 months of age, they begin a lifetime cycle of winter weight loss followed by spring/summer weight gain. Figure 2 shows a typical weight cycle and estimated dry matter intake for bison cows throughout the course of a year. From December to April, it is not uncommon for mature bison to lose 10 to 15% of pre-winter body weight. For example, a 1,000 lb. cow in December will weigh 900 lb. in April, a loss of 10% of body weight. Dry matter intake at this time would be 1.4 to 1.8% of body weight. **If greater than 20% of pre-winter body weight is lost, there is an increased risk for abortions, stillborn calves, or if calves are born, smaller and weaker calves.**

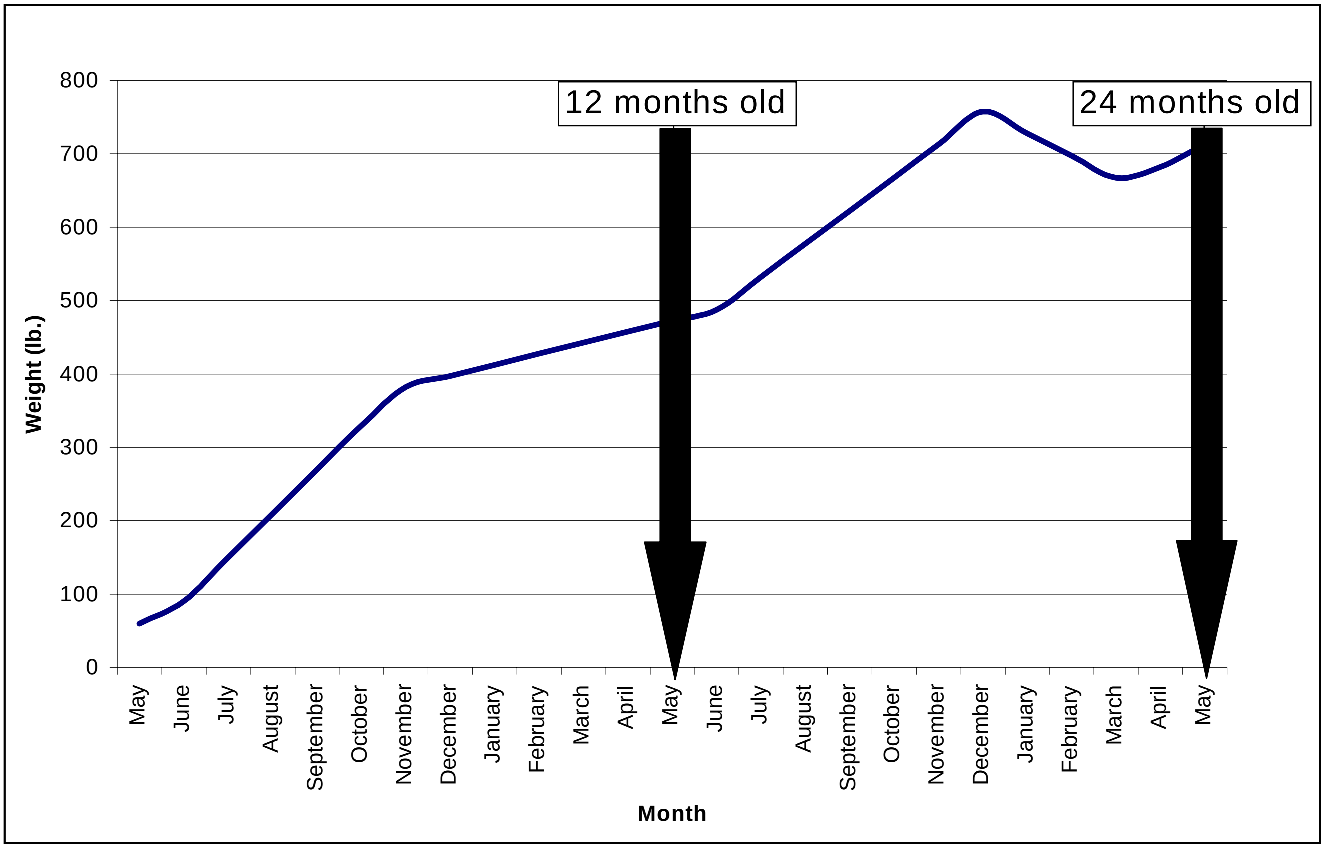


Figure 1. Weight curve for female bison from birth to 24 months of age.

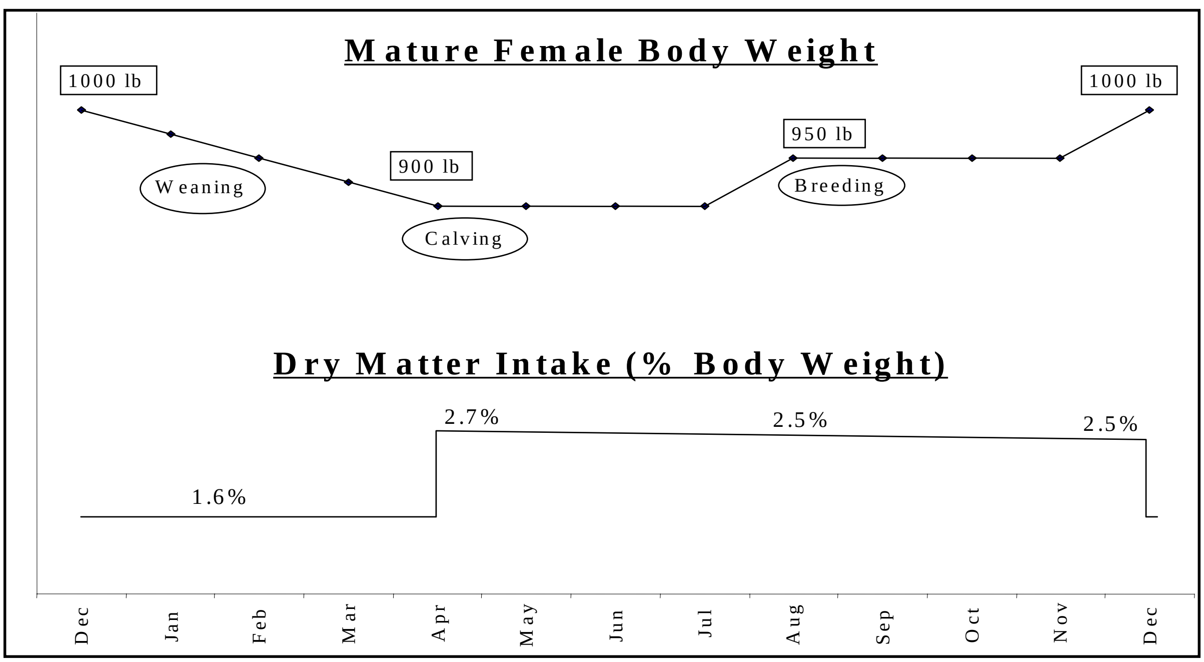


Figure 2. Seasonal weight changes of mature female bison.

In the last 2 to 6 weeks prior to the calf being born, the fetus is rapidly gaining weight. This increases the nutritional requirements of the cow. Dry matter intake will increase to 2.7 to 3.0% of body weight and will remain high to support the growth of the fetus. Once the calf is born in May or June, the weight of the cow will be reduced by another 100 lb. (calf weight, placenta and fluids). Dry matter intake will remain high to support lactation.

From May to August, lactation demands on the cow are slowly decreased. This is due to the calf becoming less dependant on the cow's milk and more dependant on pasture forages or creep feed. This reduced demand is timely as it allows the cow to partition more feed nutrients into her own body to gain weight. A steady rise in body weight and condition is necessary to enable the cow to begin its estrous cycle in August for breeding. Breeding in August ensures that calves are born at an optimal time in May.

Thin or poorly conditioned cows most likely will not conceive. In contrast to thin cows, cows that are too fat may not conceive either. This reflects the importance of winter weight loss followed by a rising plane of body weight and condition.

Once bred, the cow has from August to December to regain her original weight or heavier to allow for a safe level of winter weight loss. Thin or poorly conditioned cows entering the winter will still lose weight and be more expensive to feed.

This weight loss in the wintering period is a result of a reduced metabolic rate and cannot be changed, hence the importance placed on prior planning for autumn weight gain.

Seasonal Weight Changes of the Mature Bull

A bison male at 18 months of age will begin a lifetime cycle of winter weight loss followed by spring/summer weight gain. Mature bulls will also lose weight during the breeding season, followed by a final period in the fall to allow for weight gain. **It is important to plan a feeding program prior to these periods of weight loss.** Much like mature females, bison bulls can lose 10 to 15% of their pre-winter body weight from December to April due to a slower metabolism. During this winter period, dry matter intake will range from 1.4 to 1.8% of body weight. If grass hay diets are supplemented with grain, winter weight loss will be minimized, but compensatory gains in the spring and summer will not be as great. During the breeding season, bulls can potentially lose 10 to 15% of body weight again. Therefore, it may be necessary to provide extra energy through supplementation to prevent too much loss of body condition. Excessive loss of body weight during breeding makes it more difficult for the bulls to regain a proper weight status prior to the start of the wintering period. It is important to ensure the bulls are of adequate body condition prior to the winter and breeding seasons. Much like the cows, thin or poorly conditioned bulls entering the winter will still lose weight and be more expensive to feed.

Metabolic Winter Weight Loss

Changes in body weight and dry matter intake by bison 18 months of age and older is directly related to season, or more specifically, daylength. Daylength affects the pineal gland located near the base of the brain.

Body weight and feed intake varies according to the season.

This gland secretes a hormone (melatonin) which inhibits secretions of hormones such as growth hormone (IGF-1) and a metabolism controlling hormone (thyroxin). High levels of growth hormone and thryroxin are related to a faster metabolic rate, whereas low levels are related to a lower metabolic rate.

Bison metabolism in the winter is at a maintenance level due to higher concentrations of melatonin inhibiting the secretions of growth hormone and thyroxin. A maintenance metabolic rate does not require much fuel in the form of feed energy. This is one reason for dry matter intake to range as low as 1.4 to 1.8% of body weight. Another reason for lower dry matter intake in the winter is the longer feed retention time in the bison's digestive tract. This reduces stomach capacity and gives a feeling of "fullness." Bison also have a thick layer of fat, a thick hide and a wooly hair coat, providing sufficient insulation to keep bison warm for temperatures to -30°C.

With an increase in daylength, there is a decrease in melatonin secretions from the pineal gland. Lower melatonin levels allow for an increased growth hormone and thyroxin secretion, resulting in an increased metabolic rate. Because daylight hours are longer in the spring, summer and autumn, there is an increase in metabolic hormones. The summer metabolic rate is estimated to be nearly double the winter metabolic rate, thus requiring more fuel from feed energy. Therefore, dry matter intake from spring to autumn is higher, ranging from 2.0 to 3.0% of body weight. Increased feed intake results in more rapid weight gain for yearlings, two year olds and bulls. Rapid weight gain in post-partum cows is not observed, as feed energy is partitioned into maintaining weight and milk production. Higher feed intake levels are necessary to support lactation and body weight gains. Table 3 summarizes winter versus summer daylengths, metabolic rates, dry matter intakes and body weight status.

In conclusion, bison are seasonal ruminants. The metabolic rate, dry matter intake and body weight changes are linked to the seasons, daylength, hormone fluctuations and forage quality. It is not uncommon for bison older than 18 months of age to lose 10 to 15% of pre-winter body weight from December to April. Dry matter intake during the winter period tends to range from 1.4 to 1.8% of body weight depending on forage quality, fiber levels, metabolism and total tract retention time. In the spring to autumn, dry matter intake can be expected to range from 2.0 to 3.0% of body weight.

Because mature bison will experience two periods of weight loss (controllable = lactation, breeding; uncontrollable = slower metabolism in winter), it is extremely important to plan a proper yearly feeding program.

Table 3. Winter vs. summer with respect to daylength, metabolism, dry matter intake and body weight status.

	Daylight Hours	
	Short (Winter)	**Long (Summer)**
Metabolism	Slow (maintenance)	Fast (maintenance, weight gain, lactation, fat deposition)
Dry Matter Intake	Low (1.4-1.8% Body Weight)	High (2.2-3.0% Body Weight)
Body Weight Status	Maintain or lose weight	Maintain or gain weight

The Basic Nutrients

Water

Water is the first limiting nutrient. Without water, dry matter intake will be restricted, resulting in inhibited growth of calves, lactation failure by cows, low birth and weaning weights and an inconsistent calving period. Free choice access to good, clean water is essential to allow maximal feed intake, particularly during periods of high metabolic demands. This is especially important for young and growing calves up to 18 months of age and gestating/lactating cows.

When considering water availability, consider the source and it's quality. Availability of water for mature bison is more important during the hot summer months than during the colder winter months when snow can be consumed.

Dugouts

Dugouts may be used during the summer, but free access to dugouts can soon pollute the water and reduce water quality. This reduction in water quality will occur if the bison wade and wallow in the dugout, stirring up silt and body wastes. Ideally, dugouts should be fenced off and the water pumped into water troughs. Large troughs should be used to allow all animals easy access. Aeration with windmills or other methods may be necessary to prevent any problems associated with stale and stagnant water.


Snow can supplement the water source.

However, with free access to creeks and springs, there may soon be water pollution and a reduction in water quality. Also, damage to the surrounding ecosystem of creeks and springs should be considered prior to use. Sloughs should not be relied on as the sole source of water as they may not hold any water during years with low precipitation.

Snow

During the winter, bison will consume snow as a water source. Snow can be used so long as it is edible. Snow that has been trampled, defecated on or is icy is not a good water source for bison, and alternative water sources should be considered. The growth of calves may be inhibited if snow is the only water source available. For calves, it is recommended that alternative water sources be considered.

Dugouts may also become contaminated with blue-green algae which is toxic to ruminant livestock. Blue-green algae can be treated by applying copper sulfate (bluestone) at a rate of 1 lb. per 250,000 gallons of water. If copper sulfate is applied, wait 10 to 14 days before any animals have access to the water. The bison can still be poisoned at this time because when the copper sulfate kills the algae, toxins are released into the water.

Dugouts are not recommended as a water source in the winter months when the ice coverage is thin. Bison may walk onto the ice, fall through and drown. Free access to dugouts for bison should be avoided completely.


Watering bowls must be solid to withstand bison rubbing on them. Photo: R. Nixdorf

Sloughs, Creeks and Springs

Sloughs, creeks and springs are also good sources of water for bison.

Wells

Using wells as a water source is one of the more common methods of supplying water. Both deep and shallow wells can supply an adequate amount of clean water to bison. When using watering bowls with wells, it is important they are constructed solidly enough to withstand pressures from bison rubbing on them. It is also important to have adequate access for all bison. This may mean the establishment of several watering sites. Limiting water availability will result in bison at the top of the pecking order drinking to satisfaction and bison at the bottom of the order consuming limited amounts of water. If water restriction is used as a management tool, it is important to ensure all animals have equal access to water consumption.

Water Quality

Not all water is good quality water, be it from a dugout, snow or well. In particular, it is important to note that when using well water, quality can vary. Table 4 is a summary of water quality guidelines that can be used when interpreting a water analysis.

Table 4. Water quality guidelines for livestock use.

	Good	Satisfactory	Caution	Not Recommended	Comments
Total Dissolved Solids (µg/ml)	100 - 500	1500 - 3000	3000 - 5000	> 5000	Total Dissolved Solids, also known as conductivity. Is a measure of the water's ability to conduct electricity. Is influenced by amount and type of minerals dissolved in the water. High levels can cause water refusal and diarrhea.
Sulfates (µg/ml)	0 - 500	500 - 1000	1000 - 2000	> 2000	Sulfates can bind with molybdenum and copper, creating an insoluble complex. Greatly reduces copper availability to the animal. Can cause diarrhea. High levels of sulfates in water will increase the copper requirement.
Hardness (µg/ml)	0 - 20	200 - 500	> 500		Total of all calcium and magnesium in the water. High levels are not toxic to animals, but may cause odours and water refusal.
Calcium (µg/ml)	0 - 100	> 150			Amount of calcium in the water.
Magnesium (µg/ml)	0 - 100				Amount of magnesium in the water.
Sodium (µg/ml)	0 - 300	300 - 500	500 - 1000	> 1000	Amount of sodium in the water. May affect salt and mineral intake.
Alkalinity (µg/ml)	0 - 500	500 - 1000	> 1000		Buffering capacity of the water (neutralize acid). Associated with high level of hardness of high sodium level. Can have an unpleasant taste.
Nitrates (µg/ml)	0 - 90	> 100			Also includes nitrites. Reduces the ability of the blood to carry oxygen. Decreased oxygen levels to the tissues create an oxygen starvation (cellular suffocation).
pH, units	7 - 8.5	6.5 - 9.5	< 6.0->9.5		
Iron (µg/ml)	0 - 0.3	0.3 - 1.0			Measures iron level in the water. High levels will brown in water.

SOURCE: McLean, D. 1994.

Energy

Energy is the second limiting nutrient. It is the fuel used for body maintenance, growth and other processes. Energy requirements and energy levels in the feed can be described using several terms. The more popular terms are **Total Digestible Nutrients (TDN)** and **Digestible Energy (DE)**. Total Digestible Nutrients is expressed as a percentage, and Digestible Energy is expressed as megacalories per kilogram (Mcal/kg), megacalories per pound (Mcal/lb), kilocalories per gram (kcal/g) or kilocalories per pound (kcal/lb). The conversion from TDN to DE is that, for every unit of TDN per kilogram of feed, there is 0.04409 Mcal of DE.

Total Digestible Nutrients is closely related to the digestibility of the feed and essentially is considered one and the same. Digestible Energy is calculated by subtracting the energy left in the feces from total energy in the feed consumed. The difference is the energy absorbed by the animal, or Digestible Energy.

Energy deficient bison. Photo: R. Bergen.

Energy requirements are divided into two groups: *maintenance* and *growth or production* requirements. When feed is consumed, the feed energy is firstly directed toward maintaining the essential body processes of the animal (e.g. breathing, production of body heat). Once the energy requirements for maintenance are met, the remaining energy is used for production purposes. Energy requirements will vary according to age, sex and stage of production (e.g. growth, lactation). Table 5 shows estimated energy, protein and mineral requirements for bison.

There are energy differences in different feedstuffs fed to bison. Cereal grains have a high energy level as they contain low fiber and highly accessible/digestible starches and sugars. For example, whole oat grain has a TDN level of 76% (dry matter basis), or is 76% digestible. In comparison to grains, forages have lower energy levels due to higher fiber levels and lower levels of highly accessible/digestible starches and sugars. Grass hay may contain 50% TDN, or be 50% digestible. Because nutrient requirements of bison may exceed a maintenance level of 50% TDN (e.g. the lactation requirement for female bison is 54-58% TDN), extra energy must be provided or supplemented. This supplementation can take the form of a) forages containing higher energy levels or b) by feeding cereal grains.

Table 5. Estimated energy, crude protein, calcium and phosphorus requirements of bison.

Age	DMI (% BW)	TDN (%)	Crude Protein (%)	Calcium (%)	Phosphorus (%)
FEMALES					
6 mo - 1 yr	2.0 - 3.0	55 - 63	12 - 14	0.70	0.65
1 year	2.0 - 2.5	55 - 63	10 - 12	0.70	0.65
1.5 year	1.8 - 2.2	50 - 55	10 - 12	0.50	0.45
2 year	1.6 - 2.2	53 - 60	10 - 12	0.45	0.40
2.5 year	1.6 - 2.2	48 - 50	6 - 7	0.35	0.25
Late Gestation (April - May)	2.0 - 2.5	54 - 58	8 - 10	0.40	0.35
Lactation (May - November)	2.5 - 3.0	54 - 58	8 - 10	0.40	0.35
Maturity (Maintenance)	1.6 - 1.8	48 - 50	8	0.35	0.25
MALES					
6 mo - 1 yr	2.0 - 3.0	55 - 63	12 - 14	0.70	0.65
1 year	2.0 - 2.5	55 - 63	10 - 12	0.70	0.65
1.5 year	1.8 - 2.2	50 - 55	10 - 12	0.50	0.45
2 year	1.6 - 2.2	55 - 60	10 - 12	0.45	0.40
2.5 year	1.6 - 2.2	50 - 52	8	0.35	0.25
Maturity (Maintenance)	1.6 - 1.8	48 - 50	8	0.35	0.25

DMI = Dry Matter Intake. BW = Body Weight. TDN = Total Digestible Nutrients.

Energy Requirements of Mature Cows

The energy requirement of mature female bison is lower in the winter compared to the summer. The winter requirement is considered to be the maintenance requirement, as there essentially are no production demands for energy. However, in the last two to six weeks prior to calving, during lactation, breeding, and late fall fat deposition, extra production demands are incurred on the cow.

While daily maintenance requirements for a mature cow in the winter can be estimated, there are no accurate estimates for the production requirements. However, one can loosely estimate that the energy requirements for late gestation and lactation are 1.8 times the maintenance requirement level. For example, a 1,000 lb. cow has a winter maintenance energy requirement of 12.5 Mcal per day. This daily requirement could be met by consuming 8.6 kg (19 lb.) of grass hay containing 50% TDN (2.42 Mcal/kg, dry matter basis). The same cow will have an increased summer requirement of 22.4 Mcal per day. This requirement can be met by early spring pastures or a higher intake level of the same grass hay. Figure 3 shows daily Digestible Energy requirements of a 1,000 lb. cow in the winter and summer and how much energy a crested wheatgrass hay would provide given estimated intake levels. Note that while the winter energy requirement can be met by crested wheatgrass hay, that same hay would not meet summer energy requirements. Therefore, fresh pasture forages, a higher quality forage *or* grain supplementation would be required to meet summer energy demands.

Mature Bulls

Mature bulls have a winter maintenance requirement that can be met with average quality grass hay (8-10% crude protein, 50% TDN, dry matter basis). Spring and summer energy requirements can usually be reached by consuming pasture forages (dependant on pasture quality and quantity available). Bull energy requirements in the spring and summer are also assumed to be 1.8 times the maintenance level of production. However, during and after breeding, pastures in poor condition may not supply enough energy for bulls to regain body condition prior to the wintering period. Therefore, it may be necessary to provide extra energy in the form of a fresh pasture, hay or cereal grains to help the bulls regain condition before entering the wintering period.

Juveniles and grower/feeder calves

The energy requirements of calves from weaning at six months through to 18 months of age are higher than for mature bison. Juveniles have higher energy requirements as they are still growing through their first winter. Benefits may be realized by feeding extra cereal grains or supplements to calves when forage quality is poor. Higher quality forages should be spared for all weaned calves with less emphasis placed on cereal grain feeding.

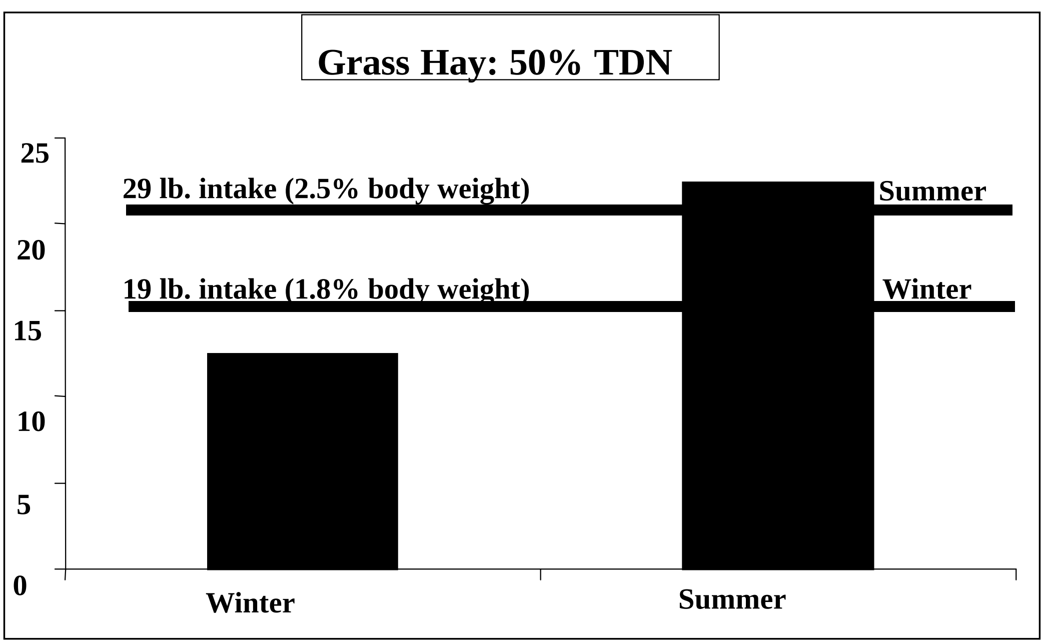


Figure 3. Daily energy requirements (bars. Mcal/day) in the winter and summer for a 1000 lb. bison cow and energy intake (lines) of a 50% TDN hay based on estimated dry matter intake as calculated from per cent body weight.

Crude Protein

The third limiting nutrient is protein. Protein is constructed from amino acids that contain nitrogen. The main function of protein is for the development of muscles, nerves and other tissues. It also is involved in several body processes including normal digestive functions, is a constituent in blood, hormones, enzymes and body secretions, lactation, growth and development. Sources of protein for ruminants can be from plants (structured) or non-protein- Nitrogen (NPN). Protein from plants is simply nitrogen or protein provided by the feed. It is structured and integrated within the plant. Non-protein-nitrogen is nitrogen that is not in a protein form but in a free form. Free nitrogen is rapidly soluble and can be utilized by rumen bacteria to produce microbial protein. Microbial protein is digested and absorbed in the small intestine. Sources of NPN include urea, ammonia and nitrate. Because of the bison's ability to recycle protein, along with relatively low protein requirements, bison most likely do not benefit from NPN supplementation.

Crude protein requirements for bison have not been adequately established. At this point, ranched bison have been successfully raised using beef cattle requirements. The reason that bison have lower crude protein requirements than beef cattle is that, when consuming forages with less than 8% crude protein, bison are able to recycle nitrogen to the rumen through saliva. Microorganisms can use this nitrogen to create new protein for absorption. This recycling ability reduces the maintenance crude protein requirement. Also, bison will excrete nitrogen in the urine when feeds contain greater than 8% crude protein. However, during periods of production such as late gestation, lactation, and body growth, protein requirements are higher to ensure that optimal production is achieved. Estimated crude protein requirements are listed in Table 5.

Minerals

Currently, all mineral (and vitamin) requirements for bison have been based on beef cattle requirements.

Table 6. Macro mineral function, deficiency and toxicity symptoms.

Mineral	Function	Deficiency Symptoms	Toxicity Symptoms
Calcium (Ca)	Bone and teeth formation, muscle contractions, milk production.	Rickets (young), milk fever, osteomalacia.	Altered calcium to phosphorus ratio affects bone development and bone structure.
Phosphorus (P)	Bone and teeth formation, energy metabolism, DNA makeup, enzyme systems.	Rickets (young), osteomalacia, depraved appetite (pica), low conception rates.	Altered calcium to phosphorus ratio affects bone development and bone structure.
Magnesium (Mg)	Normal bone development, enzyme activator (reduced blood pressure).	Hyperirritability (tetany, grass staggers), vasodilation	Upset Ca:P metabolism.
Sodium (Na)	Involved in cellular acid/base balance, muscle contractions, making bile.	Reduced growth and production levels, decreased reproduction.	Salt toxicity (blind staggers), hypertension.
Chlorine (Cl)	Involved in cellular acid/base balance, gastric juices (hydorchloric acid).	Decreased growth rate.	Other component of salt (sodium chloride). Not considered problematic.
Potasium (K)	Cellular osmotic pressure, muscle active, enzymes, carbohydrate metabolism.	Retarded growth, unsteady walk, muscle weakness, pica, diarrhea, abomasum extended.	Low Mg with high K results in excess K in urine. High K will interfere with Mg absorption.
Sulfur (S)	Required in sulfur containing amino acids (cysteine, methionine), lipid metabolism, carbyhydrate and energy metabolism.	Retarded growth (sulfur containing amino acid shortage).	Not considered problematic.

SOURCE: Ensminger, M.E., Oldfield, J. E. and Heinemann, W.W. 1990.

However, due to seasonal changes in the bison's metabolism, actual requirements may change throughout the year. Further research is necessary to determine the true mineral (and vitamin) requirements for bison.

Macro Minerals

Macro minerals required by bison include calcium (Ca), phosphorus (P), magnesium (Mg), sodium (Na), chlorine (Cl), potassium (K) and sulfur (S). These minerals are measured as a percentage of the diet. Table 6 shows a list of each macro mineral and its functions.

Micro Minerals

Micro minerals required by bison include cobalt (Co), copper (Cu), iodine (I), iron (Fe), manganese (Mn), molybdenum (Mo), selenium (Se) and zinc (Zn). These minerals are measured by parts per million (ppm) or milligrams per kilogram (mg/kg) of feed. Table 7 shows a list of each micro mineral and its functions.

Table 7. Micro mineral function, deficiency and toxicity symptoms.

Mineral	Function	Deficiency Symptoms	Toxicity Symptoms
Cobalt (Co)	Used with Vitamin B_{12}, growth of rumen bacteria.	Same as Vitamin B deficiency, reduced growth, loss of appetite.	Unlikely to be toxic.
Copper (Cu)	Hemoglobin formation enzyme systems, hair development, bone development.	Curly pale hair coat, straight hair, swollen joints, bone fragility, lameness. Can be brought on by high Molybdenum and Sulfur levels.	Accumulates in the liver, causing death.
Iodine (I)	Required by thyroid to produce thyroxin (a hormone which controls metabolism).	Goiter (swollen neck), stillbirths.	Chronic: may result in reduced Iodine absorption by thyroid gland.
Iron (Fe)	Part of hemoglobin - transports oxygen.	Lethargy, fewer red cells in blood samples, lower hemoglobin levels.	May interfere with phosphorus absorption in bone, may increase copper requirement.
Manganese (Mn)	Normal bone formation, growth and reproduction, involved in enzyme systems (amino acid metabolism, energy metabolism).	Poor growth, lameness, enlarged/swollen joints, knuckling over in calves, reduced reproductive levels.	Not known to be toxic.
Molybdenum (Mo)	Stimulates rumen microorganims, enzyme processes.	Not usually a concern	Excess Molybdenum can interfere with copper metabolism, increasing copper requirements.
Selenium (Se)	Prevents degeneration of liver in cattle. Part of glutathion peroxidase (anti-stress effects).	Muscle dystrophy (white muscle disease), stiffness, lethargy.	Related to Vitamin E, "Blind Staggers (alkalai disease)" - emaciation, hair loss, sloughing of hooves, lameness, blindness, anemia, paralysis
Zinc (Zn)	Involved in enzyme systems for protein synthesis, metabolism and insulin development.	Reduced appetite, stunted growth, poor reproductive performance. Rough skin (parakeratosis) and poor hair.	Reduced Calcium absorption, interferes with copper metabolism, may increase copper requirement.

SOURCE: Ensminger, M.E., Oldfield, J. E. and Heinemann, W.W. 1990.

Vitamins

Vitamins can be grouped into two categories: *water soluble* and *fat soluble*. Water soluble vitamins are usually not deficient in ruminant animals as most water soluble vitamins are created by the rumen microorganisms. However, Vitamin B_{12} production may not be adequate when dietary cobalt is deficient. Vitamin requirements are listed in Table 8.

Vitamin supplementation is mostly focused on the fat soluble vitamins. There are three fat soluble vitamins that should be supplemented: Vitamin A, Vitamin D and Vitamin E. Special storage considerations must be given to fat soluble vitamins as they rapidly lose efficacy when stored in areas exposed to sunlight and air.

Vitamin A can be found in some feeds in the form of ß-Carotene and is stored in the liver. A Vitamin A deficiency can occur in rapidly growing young animals if not supplied at appropriate levels. The main functions of Vitamin A include healthy skin and tissue lining development, normal vision, body and bone growth. Deficiencies include night blindness, slower bone growth and poor tooth development, rough skin and reproduction problems. Vitamin A toxicity starts with feed refusal, poor vision, loss of hair, skin flaking, nausea and diarrhea.

Vitamin D can be formed in the skin in the presence of ultraviolet light from the sun. Animals may become Vitamin D deficient when housed in barns or during the winter months. The main function of Vitamin D is to assist with calcification and mineralization of bones. This also affects tooth development and soundness. Deficiencies include rickets in younger animals, enlarged joints, bowed legs, knocked knees, osteomalacia (bone softening) and possible tetany. Vitamin D toxicity may cause excessive calcium to be absorbed, followed by loss of appetite, vomiting, weakness, diarrhea, thirst and weight loss.

The main function of Vitamin E is to act as an antioxidant. Vitamin E and selenium work together in preventing toxic wastes produced by cellular metabolism from damaging cell membranes. Vitamin E is essential to red blood cells, muscle tissues and is involved with the synthesis of Vitamin C and DNA. A primary sign of Vitamin E deficiency is muscle stiffness or white muscle disease. Vitamin E is considered non-toxic as excess levels are excreted in the urine. (Source: Ensminger, M.E., Oldfield, J. E. and Heinemann, W.W. 1990).

Effects of Stress

Stress can be a result of management and handling of the animals, or through production stress during lactation, gestation, breeding, etc. Stress affects animals by increasing the metabolic rate and the production of stress hormones. Improper nutrition leading up to periods of stress may lower production performance and in extreme cases, cause death. Nutrients such as energy and protein can sufficiently be provided by common feeds during stress periods. However, minerals and vitamins may not be present in common feeds at sufficient levels. Therefore, proper mineral and vitamin supplementation is necessary to ensure healthy animals. Table 8 shows a listing of all macro and micro mineral and vitamin requirements for stressed and non-stressed beef cattle.

Table 8. Mineral and vitamin requirements for stressed beef calves and unstressed beef cattle.

Nutrient	Unit	Stressed	Unstressed
Dry matter	%	80 – 85	-
Crude protein	%	12.5 - 14.5	-
Calcium	%	0.6 - 0.8	0.21 - 0.73
Phosphorus	%	0.4 - 0.5	0.13 - 0.34
Potassium	%	1.2 - 1.4	0.60 - 0.70
Magnesium	%	0.2 - 0.3	0.10 - 0.20
Sodium	%	0.2 - 0.3	0.06 - 0.10
Copper	mg/kg	10 – 15	10
Iron	mg/kg	100 – 200	50
Manganese	mg/kg	40 – 70	20 - 40
Zinc	mg/kg	75 – 100	30
Cobalt	mg/kg	0.1 - 0.2	0.10
Selenium	mg/kg	0.1 - 0.2	0.10
Iodine	mg/kg	0.3 - 0.6	0.50
Vitamin A	IU/kg	4000 – 6000	2200 – 3900
Vitamin D	IU/kg	500 - 1000	500 - 1000
Vitamin E	IU/kg	50 - 100	25 - 50

SOURCE: Nutrient Requirements of Beef Cattle, 1996.

PRACTICAL FEEDING FOR BISON

When feeding bison, there are two main periods to consider: a summer grazing period from May through October and a winter feeding period from November through April. During the summer, attention must be paid to lactating females and breeding bulls as energy demands are higher. During the fall, attention must be paid to the feeding program prior to metabolic slowdown and weight loss in the winter. When raising bison, it is in a producer's best interest to utilize a pasture management program that allows for grazing as long as possible while still maintaining forage quality and quantity. The optimization of pasture use also helps to reduce yearly feed costs. Finally, there are several variations of feeding and management programs that producers can utilize. The following are some suggestions that producers should consider.

Adults

During the winter, a mature bison will experience a slower metabolic rate, decreased feed intake and weight loss. Dry matter intake at this time will range from 1.4 to 1.8% of body weight. Bison will lose 10-15% of body weight from December to late March. Therefore, it is necessary to develop a feed management program prior to the winter. Mature bison that are in optimal body condition prior to the winter will thrive on average quality hay or a hay/straw diet and do not require cereal grain supplementation. However, if the forages being fed contain less than 50% TDN, grain supplementation at a level of two - four pounds/head/day can be beneficial. Finally, even though requirements are at a maintenance level during the winter, minerals are still required as part of the diet.

Summer grazing usually meets most bison nutrient requirements so long as carrying capacity is not exceeded and minerals are supplemented. If pasture quality and quantity is low, supplementation with hay or grains may be necessary.

Replacement Heifers

Most replacement heifers in the bison industry are bred when they are two years old so that they calve when three. For most ruminants, 50% conception occurs when the juvenile females achieve a weight of 66% of the mature weight. This would indicate that if the mature weight of a female bison is 1000 pounds, replacement heifers would have to weigh 660 pounds to achieve a 50% conception rate. Once heifer weights exceed 660 pounds, the conception rate should dramatically increase. Acceptable conception rates have been reported for heifer calves that weigh an average of 75% of mature body weight.

A sample feeding program that should enable bison heifers to reach 660 pounds or heavier when two years old would involve pasture grazing during the summers. During the winters, weaned heifer calves and yearlings can be fed grass hay with up to two to four pounds/head/day of whole oats. A weaning weight of approximately 400 pounds at seven months of age is a good indication that the feeding program for replacement heifers is adequate. Producers should note that, once bison heifers reach 18 months of age, their metabolism will slow down, resulting in weight loss from December to mid March. From April to August, replacement heifers should have access to quality pasture forages, clean water and minerals to ensure the best possible compensatory gain prior to being bred. Good quality hay should be reserved for winter feeding replacement heifers. It is recommended that good quality forage containing 10 to 12% protein and a minimum of 50% TDN (dry matter basis) be fed. Supplemental feeding of cereal grains or a complete feed at a level of 0.5 to 1.0% body weight could be utilized to provide energy to maximize the genetic potential for daily gain.

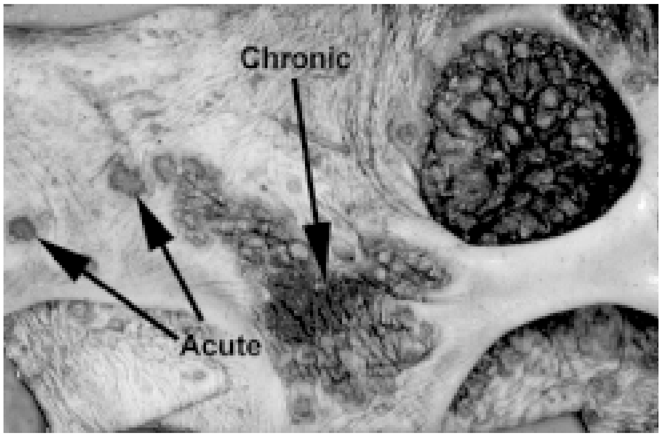
The objective when raising replacement heifers is to achieve an acceptable body weight in a period of two years. Pushing heifer calves to breed as yearlings may result in heifers that will not conceive the following year. This practice may also result in a lower mature body weight compared to heifers that are bred when two years of age.

Breeding Bulls vs. Feeder Bulls

From six to 18 months of age, it is recommended that good quality forage containing 10 to 12% protein and a minimum of 50% TDN (dry matter basis) be fed to bull calves. If forage quality is poor, supplemental feeding of cereal grains or a complete feed at a level of 0.5 to 1.0 % body weight could be utilized to provide energy to maximize the genetic potential for daily gain.

Unlike bulls destined for the feeder market, bulls selected for breeding should not be pushed with year-round energy supplementation at high levels. **Prolonged periods of high energy supplementation will result in foot problems, liver problems, a decreased**

breeding lifespan and poor breeding performance. While feeder bulls may receive rations that contain up to 90% concentrates, young bulls destined for breeding should not be fed concentrates over 50% of the ration.



Acute and chronic ulcers in a bovine rumen as a result of grain overload. Photo: J. Orr.

For feeder bulls, it is important not to suddenly introduce high levels of cereal grains. **Sudden introductions to high grain diets can potentially result in, liver abscesses, rumen ulcers, acidosis (otherwise known as feedlot bloat or rumen overload), founder and even death.** A slow introduction to cereal grains with increments of one to two pounds per head per day every three to four days should remove any possibility of rumen acidosis. If the level of grain fed goes beyond 10 pounds/head/day, twice a day feeding is recommended. If a producer's goal is to allow free choice access to grain, it is recommended that oats be the grain fed and that the bison are slowly introduced to the oats prior to feeding at free choice levels (see above).

Differences Between Cereal Grains

Currently, an industry standard when feeding cereal grains has revolved around whole oats. Whole oats have a higher fiber and a lower energy level compared to barley or wheat (Table 13). In ranking cereal grains from the highest to lowest energy level, wheat has more energy, followed by barley, then oats. Therefore, when comparing one cereal grain to the next, 10 lb. of oats is equivalent to 9 lb. of barley and 8.5 lb. of wheat. Feeding wheat or barley in substitution for the same amount of oats can result in rumen acidosis.

Mineral / Vitamin Supplementation

Mineral and vitamins can be provided through several sources. Most commonly, minerals are provided in a loose, powder/granular/crumble form mixed with grain, top dressed, or offered alone free choice. One problem when feeding loose mineral with grain is that much of the mineral filters through the grain to the bottom of the feeder. Grinding the grain may help improve mineral suspension. Bison may also pick through the mixed feed and only eat the grains/supplements while avoiding the mineral. If feeding a powder/loose/crumble form of mineral, there is the option to purchase these minerals with or without salt included. For those packages where salt is not included, salt can be mixed with the mineral package at a level of one part salt to two parts mineral. Mixing the salt with the mineral may encourage mineral consumption and should not result in inadequate or excessive intake levels.

A second method of mineral supplementation may be through liquid supplement feeders. This method has


Mixing salt with mineral supplement may encourage mineral consuption.

common use in the beef cattle industry and relies on free choice consumption. Consumption of liquid supplements (and molasses based blocks) may vary according to the type of molasses used; sugar cane versus sugar beet. Minerals can also be offered to bison using molasses based mineral blocks for free choice consumption.

Third, minerals can be offered as part of a fortified pellet or supplement. This method ensures that minerals will be consumed with the supplement. However, this method may be more expensive than a crumble, block or liquid supplement.

When selecting a mineral package, the type of feeds being used needs to be considered. For bison on a forage based diet, mineral packages containing a 1:1 calcium to phosphorus ratio is recommended. However, if bison are fed a diet where 70% or more of the diet is cereal grains, it is recommended that a mineral package containing 2:1 calcium to phosphorus be used. Cereal grains are extremely low in calcium while containing adequate levels of phosphorus, requiring higher calcium levels in the mineral package. Dietary calcium to phosphorus ratios of 1:1 to 7:1 have shown normal production performance in beef cattle, provided dietary phosphorus requirements are met.

The primary consideration is the pasture carrying capacity for bison.
Photo: J. Curran

Vitamins, while commonly present in liquid and fortified pellet supplements, may or may not be included in granular mineral supplements. It is recommended that a Vitamin ADE injections be given to calves in the autumn or whenever the calves are weaned/processed to ensure vitamin deficiencies will not occur. Supplementation of vitamins in the feed throughout the year is also recommended.

Finally, feed analysis of forages and pasture clippings will further enhance knowledge of what minerals are available and which may be deficient and need to be provided. Consultation with a professional nutritionist is recommended.

Summer Grazing

Summer grazing in Saskatchewan usually lasts from May through October. This period encompasses calving, breeding and pre-winter fattening. These are periods of heavy nutritional demand. Therefore, it is in the producer's best interest to utilize pastures and pasture management. Of primary consideration is the pasture carrying capacity for bison. This is dictated by the forage species present, soil type and age of the forage stand. Tables 9 and 10 show the number of acres required for each 1000 lb. bison for seven months of grazing on tame and native pastures.

When planning a year round feeding program for bison, all of the emphasis should be placed on forage quality and forage based diets with grain supplementation only utilized as a tool to compensate for poor pasture and forage quality.

Bison are classified as a grazing ruminant and exhibit a degree of forage selection. Forages selected by bison have been observed (Table 11). If bison are allowed to selectively graze, the nutrient intake from the forages consumed will increase. If allowed the opportunity, bison will consume feeds that will meet, if not exceed, daily protein and energy requirements. Therefore, pasture quality and quantity, forage variety and availability are extremely important for grazing bison.

There are several options available when selecting forage species for bison grazing. Native pastures can successfully be utilized if there is enough acreage to support the herd (Table 10). If utilizing tame forages, bluegrasses, brome grasses, timothy and crested wheatgrass can all be used. Alfalfa and clovers can be used for pasture as well as for stockpiled forages. Producers in Saskatchewan have reported that bison prefer grass to alfalfa when grazing.

Table 9. Acres/1000 lb. bison (or Animal Unit) based on 7 month grazing season, 30% carryover, 30% creep-rooted alfalfa and 70% meadow bromegrass pasture in good condition.

	HEAVY & MEDIUM SOIL TEXTURE			LIGHT SOIL TEXTURE		
	STAND AGE YEARS			STAND AGE YEARS		
Soil Zone	1-3	4-6	7+	1-3	4-6	7+
Dark Brown	5	7	10	6	7.5	12
Brown	8.5	10	15	10	12	20
Black & Grey	4	5	8.5	5	5.5	8.5

SOURCE: Grazing and Pasture Technology Program (GAPT), 1998.

Table 10. Acres/1000 lb. bison (or Animal Unit) based on 7 month grazing season, 50% carryover, and season long use of native range (Loam or Clay range sites).

	Range Condition			
Soil Zone	**Excellent**	**Good**	**Fair**	**Poor**
Brown (dry)	28	35	47	70
Brown (moist)	20	28	35	47
Dark Brown	16	20	28	35
Black	13	16	21	29
Grey	18	23	35	47

SOURCE: Grazing and Pasture Technology Program (GAPT), 1998.

Pasture Supplementation and Flushing

If pasture quality and quantity is lowered due to grazing, pasture supplements can be used. Pasture supplements in the past have included cereal grains or range pellets. This can be particularly important in the last two weeks of July prior to breeding in August. Pasture supplementation with cereal grains or range pellets can increase pasture stocking rate by decreasing grazing pressure. Supplementation can also increase energy intake, body condition, and flush the breeding females prior to breeding. **Flushing is best achieved by moving the breeding females into a fresh pasture, a pasture with regrowth after haying or a pasture that had been grazed earlier in the season.** Range cubes or grain supplementation should only be considered when the appropriate forage quality or quantity cannot be attained.

Forage quantity is not an indication of forage quality. While older forages produce more tonnage, they also contain higher fiber levels. Higher fiber levels reduce the energy level in the feed. Younger forage stands or forage regrowth has lower fiber levels and, therefore, higher levels of available energy.

Table 11. Nutrient levels of forages available to bison in sward sites, grazed patches, and actual feeding stations.

Sample Type	**Crude Protein (%)**	**TDN (%)**
Sward sites	8.7	50.3
Grazed patches	10.4	12.8
Feeding station	12.8	60.7

SOURCE: Rutley, B.D. 1998.
Pasture Composition: Smooth brome, timothy, quackgrass, Kentucky bluegrass, alfalfa, red clover and dandelion.

Winter Feeding

Winter feeding primarily consists of providing stored forages harvested during the summer. Grass hay is most commonly used, with greenfeeds, straws, alfalfa/grass hay and slough hays also being utilized. When feeding stored forages, crude protein and energy are of primary concern as they can vary between and within forage samples (Table 12). Also, not all forage species are considered equal. Table 13 shows the average energy, protein, calcium and phosphorus values of several feeds typically found in Saskatchewan. Alfalfa and alfalfa/grass hays exhibit better forage quality characteristics than do grass hays or greenfeeds. It is recommended that a feed analysis be conducted prior to each winter feeding season.

Table 12. Variation in forage quality for alfalfa hay and grass hay.

	CP (%)	TDN (%)	Ca (%)	P (%)
Alfalfa Hay				
Average	15.9	52	1.43	0.20
Low	6.2	45	0.52	0.10
High	26.9	62	2.60	0.30
Grass Hay				
Average	7.80	47	0.53	0.10
Low	3.60	35	0.25	0.10
High	11.8	52	0.95	0.20

SOURCE: Saskatchewan Feed Testing Laboratory, 1990.
CP = Crude Protein TDN = Total Digestible Nutrients Ca = Calcium. P = Phosphorus

Winter Swath Grazing of Annuals

Winter swath grazing is one method of extending the grazing season. Crops typically used include oats and smooth awned barley. Fall rye can also be seeded with the cereals to provide early spring grazing as well. Annuals are seeded from June 20 to 25 and swathed in September at the soft dough stage. If they are seeded too early, the plants will mature too early and, when swathed, are at risk of spoilage if rained on. If crops are seeded too late, the quality of the forage will be higher but at the cost of lower quantity. It is important that, when swathed, crops are cut immediately before or after the first killing frost to avoid problems with nitrates. The nutrient values of cereals when cut for winter swath grazing will be 8-10% crude protein and 58 to 68% TDN. Nutrient levels will decrease with crop maturity and may decrease under poor harvesting conditions such as rain.

Crops seeded for swath grazing can be sprayed for weeds in September using glyphosphate products (e.g. Roundup©). While there is no loss in forage value, swathing should be delayed for up to five days after spraying.

Bison can begin grazing the windrows in November. Beef cattle stocking rates for swath grazing range from 50 to 125 cow days per acre for annuals. If perennial forages are swathed for grazing, the forages will carry 25 to 60 cow days per acre.

For optimal use of swaths for grazing, the bison should be forced to graze small sections of swaths at a time. If allowed free access to the entire field, the bison will select the more nutritious parts of the plants, leaving behind the plant parts such as stems. If the bison are concentrated on small sections at a time, producers can maximize their utilization of the swaths.

Snow quality, snow depth, crust characteristics and size of the windrow will greatly affect grazing success. If the snow has been subjected to thawing and freezing, it will develop a hard crust, forcing the bison to dig through the snow, potentially reducing grazing capacity, grazing duration and total feed intake. This snow is not suitable as a water source, particularly for weaned calves, and fresh water should be supplied.

Moldy Forages

All feeds have molds or fungus present on them. Normally, the level of mold on feeds is quite low. Mold formation is best facilitated when a relatively high humidity is combined with heat. When forages have mold present, consumption by bison may result in several outcomes. The first effects might be mycotoxin injestion and mycotic abortion. When certain species of molds are exposed to cool, moist conditions, mycotoxins can be produced. Ingested toxins may be absorbed into the blood stream and absorbed by the fetus, causing abortion. If there is no abortion, the immune system of the newborn calf could be compromised, resulting in unseen effects such as slow growth and sickness. A second effect may be respiratory irritation and pneumonia resulting from the inhalation of spores and dust produced by molds. The spores enter the lungs, causing respiratory distress, irritation, infection and pneumonia. Finally, mold can result in feed deterioration, dust and therefore reduced palatability. Reduced palatability reduces forage intake, thereby reducing nutrient intake. Reduced nutrient intake during periods of high nutrient demand (e.g. last third of gestation, lactation, etc.) will result in reduced performance.

There are several strategies that can be implemented when feeding moldy forages to minimize potential dangers. One method is to restrict the feeding of moldy forages to bulls or grower/finisher bull calves. Forages infected with mold can be rolled out on the ground for feeding or processed in a bale processor. This practice exposes the dusts and spores to the environment, allowing the bison to be more selective of which plant parts to consume. Processing the feed also blows the mold spores and dust away leaving, “clean” forage for consumption. **As a rule of thumb, pregnant cows should not be fed moldy forages, particularly in the last trimester of gestation, to avoid any possible damage to the unborn calf.**

Nitrates in Forages

Nitrates are a common toxin in harvested cereal grain forages in Saskatchewan. Nitrate accumulation can be due to excessive nitrogen fertilization, drought, frost, dense foliages, or herbicide application. Nitrates do not occur in grain kernels and are localized to stems and leaves of plants. Oat greenfeed is notorious for nitrate accumulation. If nitrates levels in a forage exceed 0.5 % (measured as potassium nitrate, dry matter basis), there is toxic potential, particularly for younger stock, while levels greater than 1.0 % are toxic to all ages. Nitrates in feed can be detected by doing a simple qualitative nitrate test. If nitrates are present, the test will show a dark blue colour. If a dark blue colour is observed, a quantitative test can be performed by a feed testing laboratory to determine the actual amount of nitrates present. Nitrates in forages affect ruminants by reducing the ability of the blood to carry oxygen. Hemoglobin in the blood (the protein that carries oxygen) is converted into methaemoglobin, a protein that carries very little oxygen. Reduced blood oxygen flow results in tissue hypoxia. Acute symptoms include difficult breathing, diarrhea, blue colour of membranes and chocolate brown coloured blood. If acute nitrate poisoning occurs, methylene blue should be administered by a veterinarian.

Prevention of nitrate poisoning is the best management tool. Nitrates in forages are persistent and they do not deteriorate over time. If a forage is found to contain nitrates, that forage can be blended with another forage that does not contain nitrates to minimize nitrate levels consumed.

Table 13. Common nutrient values for feeds in Saskatchewan.

GRAINS	CP (%)	TDN (%)	Ca (%)	P (%)
Wheat	14.4	89	0.07	0.39
Barley	12.4	82	0.06	0.36
Oats	11.7	76	0.07	0.37
Hulless Barley	13.6	86	0.07	0.40
Rye	13.3	84	0.06	0.34
Triticale	13.9	86	0.06	0.39
Lentil Screenings	20.5	77	0.11	0.44
Pea Screenings	20.0	76	0.11	0.42
Frozen Canola Seed	21.1	101	0.39	0.69
Distillers Grains	35.2	73	0.10	0.46
Grain Screening Pellets	13.4	72	0.14	0.32
Corn Grain	9.4	89	0.06	0.31
FORAGES				
Alfalfa Hay (early)	18.0	61	1.63	0.22
Brome Alfalfa	16.0	59	1.09	0.24
Brome	12.8	57	0.36	0.34
Slough Hay	8.9	53	0.28	0.26
Oat Greenfeed	10.5	57	0.31	0.29
Crested Wheatgrass	9.6	57	0.31	0.29
Alfalfa Cubes	17.8	61	1.56	0.21
Dehy Alfalfa Pellets	19.4	67	1.56	0.22
Grass Hay (med qual)	8.3	53	0.29	0.21
Oat Hay	11.7	56	0.22	0.02
Sorghum Sudan Grass Hay	8.9	58	0.49	0.26
Lentil Straw	6.4	46	0.65	0.20
Pea Straw	6.4	46	0.60	0.19
Flax Straw	2.9	40	0.30	0.20
Wheat Straw	3.9	43	0.28	0.11
Wheat Chaff	4.4	46	0.35	0.22
Ammon. Wheat Chaff	9.5	49	0.35	0.20
Frozen Lentil Crop (late bloom)	14.5	54	1.10	0.20

SOURCE: Saskatchewan Feed Testing Laboratory, 1990.
CP = Crude Protein TDN = Total Digestible Nutrients Ca = Calcium P = Phosphorus

REFERENCES

Alberta Agriculture, Food and Rural Development, 1998. An Introduction to Swath Grazing in Western Canada. Agdex 420/56-1. Alberta Agriculture, Food and Rural Development, Edmonton, Alberta.

Christopherson, R. J. and Hudson, R. J. 1978. Effects of temperature and wind on cattle and bison. Feeder's Day Report. **57**: 40-41.

Christopherson, R. J., Hudson, R. J. and Christophersen, M. K. 1979. Seasonal energy expenditures and thermoregulatory responses of bison and cattle. Can. J. Anim. Sci. **59**: 611-617.

Christopherson, R. J., Hudson, R. J. and Richmond, R. J. 1978. Comparative winter bioenergetics of American bison, yak, Scottish highland and Hereford calves. Acta Theriologica. **23**: 49-54.

Church, D. C. 1988. The ruminant animal. Digestive physiology and nutrition. Waveland Press, Inc. Prospect Heights, Illinois.

DelGuidice, G. D., Singer, F. J., Seal, U. S. and Bowser, G. 1994. Physiological responses of Yellowstone bison to winter nutritional deprivation. J. Wildl. Manage. **58**: 24-34.

Ensminger, M.E., Oldfield, J. E. and Heinemann, W.W. 1990. Feeds and Nutrition. 2nd Edition. Ensminger Publishing Company. Clovis, California. 93612.

Feist, M.F. 1998. Evaluation and development of specialized livestock diets in Saskatchewan. Saskatoon, Saskatchewan (M.Sc. thesis). University of Saskatchewan. 154 pp.

Grazing and Pasture Technology Program (GAPT), 1998. Bison Pastures and Grazing Management.

Green, W. C. H. and Rothstein, A. 1991. Trade-offs between growth and reproduction in female bison. Oecologia. **86**: 521-527.

Hawley, A. W. L., Peden, D. G. and Stricklin, W. R. 1981a. Bison and Hereford steer digestion of sedge hay. Can. J. Anim. Sci. **61**: 165-174.

Hawley, A. W. L., Peden, D. G., Reynolds, H. W. and Keith, E. 1977. Nylon bag digestibility's of five native plants in bison and cattle. Can. J. Anim. Sci. **57**: 825.

Hawley, A. W. L., Peden, D. G., Reynolds, H. W. and Stricklin, W. R. 1981b. Bison and cattle digestion of forages from the Slave River Lowlands, Northwest Territories, Canada. J. Range Manage. **34**: 126-130.

Hofmann, R. 1988. Anatomy of the gastro-intestinal tract. Pages 14-43 *in* The ruminant animal: digestive physiology and nutrition. Church, D. C. ed. Waveland Press Inc. Prospect Heights, Illinois.

Hudson, R. J. and Frank, S. 1987. Foraging ecology of bison in aspen boreal habitats. J. Range Manage. **40**: 71-75.

Keith, E. O., Ellis, J. E., Phillips, R. W., Dyer, M. I. and Ward, G. M. 1981. Some aspects of urea metabolism in North American bison. Acta Theriologica. **26**: 257-268.

Koch, R. M., Jung, H. G., Crouse, J. D., Varel, V. H. and Cundiff, L. V. 1995. Growth, digestive capability, carcass, and meat characteristics of *Bison bison*, *Bos taurus*, and *Bos x Bison.* J. Anim. Sci. **73**: 1271-1281.

MacNeil, J. D., Patterson, J. R., Salisbury, C. D. C. and Tessaro, S. V. 1990. An investigation of the trace element status of bison in Wood Buffalo National Park and of ranch-raised bison in Saskatchewan, Canada. Intern. J. Environ. Anal. Cham. **41**: 99-104.

McLean, D. 1990. Water quality guidelines for Livestock Use. Saskatchewan Feed Testing Laboratory. Saskatoon, Saskatchewan. University of Saskatchewan.

National Research Council, 1984. Nutrient Requirements of Beef Cattle., Sixth Re. Ed. National Academy Press. Washington, D.C.

National Research Council, 1996. Nutrient Requirements of Beef Cattle., Seventh Re. Ed. National Academy Press. Washington, D.C.

Peden, D.G., Van Dyne, G. M., Rice, R. W. and Hanse, R. M. 1974. The trophic ecology of *Bison bison* L. on the shortgrass plains. J. Appl. Ecology. 489-497.

Richmond, R. J., Hudson, R. J. and Christopherson, R. J. 1977. Comparison of forage intake and digestibility by American bison, yak and cattle. Acta Theriologica. **22**: 225-230.

Robbins, C. T. 1983 Wildlife feeding and nutrition. Acad. Press, Inc., New York, N.Y. 343 pp.

Rutley, B. D. 1998 . Management, growth and performance of bison (*Bison bison*) on seasonal pastures (PhD dissertation). Edmonton, Alberta: University of Alberta. 155 p.

Rutley, B. D. and Rajamahendran, R. 1995. Circannual reproductive function of female bison (*Bison bison*). Pages 242-245 *in* Proc. West. Sect. Amer. Soc. Anim. Sci.

Saskatchewan Feed Testing Laboratory, 1996. Saskatoon, Saskatchewan. University of Saskatchewan.

Schaefer, A. L., Young, B. A. and Chimwano, A. M. 1978. Ration digestion and retention times of digest in domestic cattle (*Bos taurus*), American bison (*Bison bison*) and Tibetan yak (*Bos grunniens*). Can. J. Zool. **56**: 2355-2358.

Shaw, J. H. and Carter, T. S. 1989. Calving patterns among American bison. J. Wildl. Manage. **53**: 896-898.

Sikarskie, J. G., Schillhorn Van Veen, T., Ullrey, D. E. and Koch, M. D. 1989. Comparative serum selenium values for ranched and free-ranging American bison (*Bison bison*). J. Zoo. Wildl. Med. **20**: 34-38.

Stanton, T. L., Schutz, D., McFarlane, W., Seedig, R. and Stewart, D. 1995. Effects of concentrate level in bison finishing rations on feedyard performance. Colorado State University. Ft. Collins, Colorado.

Stelfox, J. B. and Stelfox, J. G. 1993. Hooved mammals of Alberta. Stelfox, J.B. ed. Lone Pine Publishing. Edmonton, Canada.

Young, B. A., Schaefer, A. and Chimwano, A. 1977. Digestive capacities of cattle, bison and yak. Annual Feeders Day Report. **56**: 31-34.

ACKNOWLEDGMENTS

Thank you to the following people for proof reading, suggestions and information:

Saskatchewan Bison Association

Canadian Bison Association

Dr. Marshall Patterson

Dr. Murray Woodbury, Diversified Livestock Research Coordinator, Western College of Veterinary Medicine, Saskatoon

Dr. Dave Christensen, College of Agriculture, University of Saskatchewan, Saskatoon

Vern Racz, Prairie Feed Resource Centre, University of Saskatchewan, Saskatoon

Lorne Klein, Grazing and Pastures Technology Program, Weyburn

Dr. J. Orr, Western College of Veterinary Medicine, Saskatoon.

Dr. G. Jones, College of Agriculture, University of Saskatchewan, Saskatoon.

Jana Curran, College of Agriculture, University of Saskatchewan, Saskatoon

PREPARED BY

Murray Feist, M.Sc., P.Ag.
Ruminant Nutrition Specialist
Agriculture Knowledge Centre
Phone: 1-866-457-2377 • Fax: 1-306-694-3938
Email: aginfor@agr.gov.sk.ca

For more information, contact the Agriculture Knowledge Centre at 1-866-457-2377
or by fax: 1-306-694-3938.

2M ISBN 0-88656-710-6 SUB0100