University of Alberta

# The Effects of Production Practices on the Behaviour of Ruminant Animals (*Bos taurus, Bison bison* and *Cervus elaphus*)

by

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# ABSTRACT

Farming new livestock species like bison and wapiti provides much needed diversification for agricultural communities. A comparative ethological investigation was initiated to determine how three different ruminants (cattle, bison and wapiti) respond to modern commercial husbandry practices. The adaptive behaviour of the three ruminants in two different components of modern commercial husbandry: reproductive management and handling and transport was explored. Reproductive management included behaviour associated with calving and weaning. Calving was observed in 202 wapiti hinds. Approximately 90% of hinds calved. On average, parturition lasted 101 min from the appearance of the amniotic sac to delivery of the calf. In addition, interval weaning was compared with abrupt weaning in both wapiti and beef cattle. Behavioural responses to the two weaning treatments, productivity and neutrophil/lymphocyte (N/L) ratios were investigated. Interval weaning reduced stress. The clearest evidence was the gross behavioural difference in vocalizations and fenceline pacing, as well as N/L ratios. Bison and cattle were the focal species in the studies investigating handling and transportation. Mixing bison bulls upon entry into a feedlot reduced the bulls total daily grain consumption and was attributed to a slow commencement of grain consumption by alien animals entering the pen and a decrease in consumption by established animals. The importantance of maintaining bison in stable groups to prevent the impact on grain consumption was demonstrated. In a like manner, the negative effects during handling and transport of cattle moved off pasture to a sales yard simulation were shown to be ameliorated by electrolyte therapy. Control cattle displayed higher ($P<0.01$) post transport N/L ratios and lost significantly more ($P<0.01$) live weight than treated cattle. Ultimately, wapiti and bison both demonstrated some behavioural differences from cattle, but with proper management that accommodates the welfare needs of the animals, wapiti and bison adapt well to life as domestic animals.

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# Introduction

# CHAPTER 1: **Introduction and Background**

Relatively few ungulate species have been domesticated (Kilgour and Dalton 1984, Fletcher 1992). Tennessen and Hudson (1981) estimated that from a total of 204 large herbivores in three orders, no more than 36 have been domesticated and of those only about 12 have played a major role in food production worldwide. Throughout recorded history, man has utilized a great variety of animal species for several purposes. However, the number of ruminants that man has attempted to domesticate far exceeds the number of any other animal group. von den Driesch (1995) compiled a list of 19 ruminants that are currently being utilized by humans (Table 1.1). It is important to point out that camelids are foregut digesters, not true ruminants, and probably should have been omitted from this list. In addition, several commercially and historically important ruminants such as sika deer (*Cervus nippon*) and muskoxen (*Ovibovis moschatus*) were not included.

The ruminants can be divided into two groups. The first group comprises those animals which have undergone full domestication and display four principal characteristics of domestication: 1. their breeding is under human control, 2. they provide products or services useful to man, 3. they are tame, 4. they have been selected away from the wild type (Mason 1984). As man has only fully domesticated about a dozen large herbivores, it cannot be concluded that all worthwhile domestication has been completed. Some feel that the ultimate distinguishing feature of a fully domesticated animal is the presence of a range of genotypes produced by selection that is commonly observed in animals such as cattle, sheep and goats (von den Driesch 1995). However, not all ruminants shown in Table 1 exhibit the four criteria mentioned previously. About half of the ruminants in Table 1 are bred and exploited in enclosures or farms in order to supply a product, primarily meat, but they are not yet considered true domestic animals. While rearing in captivity is the logical first step leading towards domestication, these animals do not posses hereditary characteristics that distinguish them as domestic animals sensu stricto from their wild progenitors (von den Driesch 1995).

**Table 1.1** Domesticated or systematically exploited ruminants of the world

| domestic name | scientific name of the wild ancestor | fully domesticated | farm–like exploitation |
|---|---|---|---|
| Cattle | *Bos primigenius* | + | |
| Water buffalo | *Bubalus arnee* | + | |
| Banteng | *Bos javanicus* | + | |
| Gayal | *Bos gaurus* | + | |
| Yak | *Bos mutus* | + | |
| Bison | *Bison bison* | | + |
| Sheep | *Ovis orientalis* | + | |
| Goat | *Capra aegagrus* | + | |
| Dromedary | *Camelus dromedarius* | + | |
| Two humped camel | *Camelus bactrianus* | + | |
| Llama and alpaca | *Lama guanacoe* | + | |
| Red deer | *Cervus elaphus* | | + |
| Moose | *Alces alces* | | + |
| Reindeer | *Rangifer tarandus* | + | |
| Fallow deer | *Cervus (Dama) dama* | | + |
| Musk deer | *Moschus moschiferus* | | + |
| Springbok | *Antidorcas marsupialis* | | + |
| Impala | *Aepyceros melampus* | | + |
| Eland | *Taurotragus oryx* | | + |

from von den Driesch (1995)

An analysis of the physical, social and ecological traits of the world's ungulates was conducted in an attempt to identify those traits relevant to domestication (Tennessen and Hudson 1981). Major traits considered included: body size, conformation, male mating system, social unit composition, typical group size, feeding style and habitat type. Discriminant function analysis revealed significant multivariate differences among ungulates that were classified as domestic, semi-domestic or wild. Domestic species tended to be large (> 50 kg), non-selective feeders preferring open and montane habitats. Most were socially–advanced, non–territorial species typically occurring in groups of 15–100. It was further determined that traits that were useful for distinguishing domestic and wild species were of little value for identifying semi-domestic species. It was concluded that few ungulate species have been ignored or abandoned by man because of inherent, species specific characteristics irreconcilable with domestication.

No true agricultural animals with the exception of the turkey (*Meleagris gallopavo*) have been domesticated in North America (Figure 1.1) (Crawford 1984). However in the last 25 years the agricultural potential of several indigenous species has been evaluated. Recently, two animals among the second group of exploited ruminants in Table 1.1 have appeared on farms throughout North America, *Bison bison* and *Cervus elaphus* (wapiti, red deer, and wapiti–red deer hybrids). Farming alternative livestock like bison and wapiti provides much needed diversification for agriculture and rural communities. Alternative livestock supply new niche markets and offer an opportunity to develop efficient and sustainable production systems that utilize the adaptations of indigenous wild ruminants (Telfer and Scotter 1975; Renecker and Kozak 1987, Renecker 1989, Renecker and Hudson 1993).

Although domestication is a continuing process and consideration of behaviour is fundamental in any attempts to extend domestication to new species (Hale 1969, Ratner and Boyce 1975, Kilgour and Dalton 1984), it is also important to include fully domesticated animals in any investigation into how animals adapt to being raised commercially. The ability of cattle, a fully domesticated animal, to adapt to life on farms

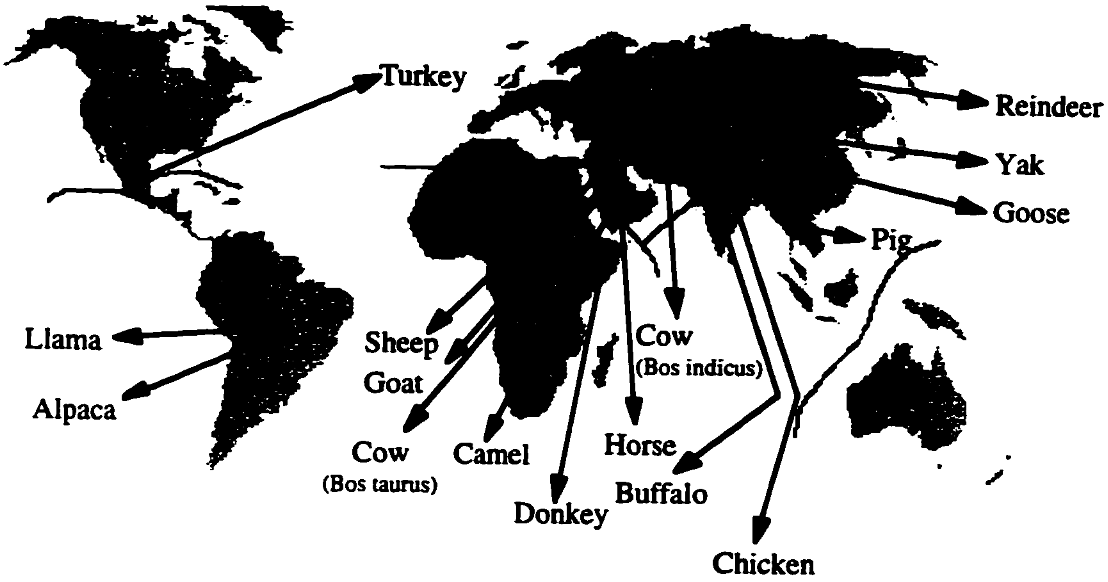


**Figure 1.1** Geographical centers of origin of some common domesticated agricultural species. No true agricultural animals with the exception of the turkey (*Meleagris gallopavo*) have been domesticated in North America.

still needs to be studied and understood because of the changes that have taken place in agriculture and the move towards more intensive production that has occured since World War II. In traditional husbandry, the number of animals managed by farmers was low and farmers spent a lot of time with each individual animal. As modern cattle husbandry moved away from traditional methods, with the implementation of intensive rearing and feeding procedures and extensive husbandry in which input is reduced and large grazing areas are utilized (i.e. mountain pastures), management techniques have not necessarily evolved along with the changes. In both systems, the number of animals per individual caretaker has increased dramatically, and consequently the implementation of current management practices on the behaviour and stress physiology of cattle needs to be continually reevaluated.

This dissertation is presented in research paper format. The underlying question guiding thesis research involves the adaptation of commercially raised ruminants to life as domestic animals. The adaptation of two of Alberta's new livestock species, wapiti and bison, and one of Alberta's oldest and most commercially important domesticated animals, beef cattle, to various different management situation and procedures was investigated. The overall guiding hypothesis for this thesis is:

Are cattle, wapiti and bison capable of being domesticated as evidenced by four unnatural or atypical events in their life: confinement calving, weaning, grouping and transportation.

The effects of modern commercial management/husbandry practices on bison, cattle and wapiti were investigated and where appropriate comparisons were made among the three species both directly and indirectly. Bison and wapiti were chosen for the comparison with cattle because they are indigenous, biologically efficient, and from a morphological standpoint are close to cattle.

More specifically, the experiments presented in this thesis attempt to address these three general concerns:

1) What is the effect of new and existing husbandry practices on the ability of ruminants to adapt behaviourally and physiologically to domestic life, and how does this influence their productivity?

2) Are there specific aspects of the behaviour and physiology of cattle and the two alternative livestock species (bison and wapiti) that either facilitate or hinder adaptation to life as domestic animals?

3) Do the new alternative livestock species posses production traits that will enable them to be utilized as domestic animals, or do they posses specific characteristics that preclude them from the process of domestication?

Where applicable, attention was paid to welfare implications. In the development of any new industry or management practice, ensuring that the animals are free from suffering is of importance. In addition, interpreting the state of the individual animal with respect to animal welfare can be used as a benchmark or guide to the sucess with which an animal adapts to life as a domestic animal.

The research strategy included five research studies designed to answer specific questions about domestication. First, the effect of domestication on some production traits was investigated through a descriptive study on calving behaviour in farmed wapiti and in a feedlot study on mixing and grain consumption in bison. The effects of mixing of bison when entering a feedlot was studied to determine the ability of bison to adapt behaviourally to feedlot practices. Bison should be able to cope with some degree of forced change which is typically found during routine husbandry practices, otherwise their long–term success as domesticated animals may be called into question. In a like manner, the calving behaviour of farmed wapiti was investigated to determine if confinement had a limiting effect on reproductive performance. These studies were designed to determine if the two alternative livestock species maintain levels of production that are comparable to cattle and enable a viable commercial industry. If these animals are to be utilized commercially by man, we would expect them to maintain reasonable production levels. Secondly, the benefits of new techniques, one physiological in nature, the other behavioural, in minimizing the effects of stressors encountered by ruminants during routine animal husbandry practices were investigated. The effect of transport and handling stress in beef cattle was investigated by offering them access to an electolyte solution prior to transport and handling. In addition, an attempt was made to ameliorate the stress imposed at weaning in juvenile wapiti and beef cattle by employing a new method of interval weaning. In both instances, we would expect some benefit from the ameliorative treatments.

The next chapter reviews the process of domestication and summarizes the evolution, taxonomy and history of *Bos taurus*, *Bison bison* and *Cervus elaphus* in Alberta. The dissertation is then divided into two sections: *Reproductive Management*, and *Handling and Transportation*.

*Reproductive Management* examines calving behaviour and investigates new weaning procedures. Only the calving behaviour of wapiti was observed as a substantive body of literature for cattle already exists (Kilgour and Dalton 1984, Fraser and Broom 1990, Houpt 1991), and a reasonable amount of work has already been done in bison (Lott and Galland 1985a, Lott and Galland 1985b, Green 1986, Green 1987, Green et al. 1989). Comparisons between species are summarized at the end of the thesis. The effects of interval weaning in both wapiti and cattle are then presented. Bison are omitted from this section as early weaning is not yet an entrenched industry practice.

*Handling and Transporation* explores the behaviour of bison in feedlots and investigates the effect of handling and transport on the intake and stress physiology of cattle. Bison were the focal species of the feedlot study as a substantive body of literature regarding the behaviour of cattle in feedlots exists (Stricklin and Kautz-Scanavy 1984), and wapiti are currently finished on pasture.Wapiti were omitted from the transport studies as wapiti transport to slaughter is currently under investigation by Dr. L. A. Renecker and associates (Animal Scientist, Renecker and Associates, RR#5 Stratford, Ontario NSA 6S6).

The final chapter summarizes the results and speculates on the future of commercial bison, wapiti and cattle production.

## 1.1 REFERENCES

**Crawford, R.D., 1984.** Turkey. In. I. L. Mason. editor. Evolution of Domesticated Animals. Longman, London. pp. 325-333.

**Fletcher, J.T., 1992.** Why Farm Deer ? – A Historical Perspective. in: W. van Hoven, H. Ebedes and A. Conrowy. editors., Wildlife Ranching: A Celebration of Diversity, Proceedings of the 3rd International Wildlife Ranching Symposium, October 1992, Pretoria, South Africa.

**Fraser, A. F. and Broom, D. M., 1990.** Farm animal behaviour and welfare. Bailliere Tindall, London.

**Green, W. C. H., 1986.** Age-related differences in nursing behavior among American bison cows (Bison bison). J. Mammal., **67:** 739-741.

**Green, W. C. H., 1987.** Mother-daughter interactions in American bison (Bison bison): Factors associated with individual variation. Ph.D. dissertation, City Univ. N.Y., pp. 1-212.

**Green, W. C. H., Griswold, J. G. and Rothstein, A., 1989.** Post-weaning associations among bison mothers and daughters. Anim. Behav., **38:** 847-858.

**Hale, E. B., 1969.** Domestication and the evolution of behaviour. In: E. S. E. Hafez, editor. The Behaviour of Domestic Animals, ed 2., London, Bailliere, Tindal and Cassel, pp. 22-42.

**Houpt, K. A., 1991.** Domestic Animal Behavior for Veterinarians and Animal Scientists. 2nd ed. Iowa State University Press, Ames, Iowa.

**Kilgour, R. and Dalton, C., 1984.** Livestock Behaviour. Methuen, Aukland.

**Lott, D. F. and Galland, J. C., 1985a.** Parturition in American bison: Precocity and systematic variation in cow isolation. Z. Tierpsychol., **69:** 66-71.

**Lott, D. F. and Galland, J. C., 1985b.** Individual variation and fecundity in American bison population. Mamm., **49:** 300-302.

**Mason, I. L., 1984.** Evolution of Domesticated Animals. Longman Group Limited, New York.

**Ratner, S.C. and Boyce, R., 1975.** Effects of domestication on behaviour. In: E.S.E. Hafez, editor. The Behavior of Domestic Animals, ed 3. Williams & Baillaire, Baltimore.

**Renecker, L.A., 1989.** Overview of Game Farming in Canada. In: R. Valdez, editor, Proceeding: 1st International Wildlife Ranchng Symposium, Cooperative Extension Service – Wildlife, New Mexico State Universtiy, Las Cruces, NM. pp. 47-62.

**Renecker, L.A. and Kozak, H.A., 1987.** Game ranching in western Canada. Rangelands **9:** 215-218.

**Renecker, L. A. and Hudson, R. J., 1993.** Advantages of game farming. In: J. B. Stelfox, editor. Hoofed Mammals of Alberta. Lone Pine, Edmonton. pp.132-134.

**Stricklin, W. R. and Kautz-Scanavy, C. C., 1984.** The role of behavior in cattle production: a review of research. Appl. Anim. Ethol., **11:** 359-390.

**Telfer, E. S. and Scotter, G. W., 1975.** Potential for game ranching in boreal aspen forests of western Canada. J. Range Manage., **28:** 172-180.

**Tennessen T. and Hudson, R. J., 1981.** Traits relevant to domestication of herbivores. Appl. Anim. Ethol., **7:** 87-102.

**von den Driesch, A., 1995.** Domestic ruminants: their incorporation and role in early rural societies. In: Ruminant Physiology: Digestion, Metabolism, Growth and Reproduction. Proceedings of the Eighth International Symposium on Ruminant Physiology, ed. by W. V. Engelhardt, Ferdinand Enke Verlag Stuttgart, Berlin.

# CHAPTER 2: **Evolution, Taxonomy and History of Domestication of *Bos taurus*, *Bos bison*, and *Cervus elaphus***

## 2.1 DOMESTICATION AS A BIOLOGICAL PROCESS

### *2.1.1 Definitions*

*Domestication* can be defined as "that process by which a population of animals becomes adapted to (humans) and to the captive environment by some combination of genetic changes occuring over generations and environmentally induced developmental events reoccurring during each generation" (Price 1984). This definition accentuates (1) long term evolutionary adaptation and (2) environmental influences attributable to a close relationship with humans over generations. Breeding in captivity is an essential component. The animal has been removed from the forces of natural selection and subjected instead to artificial selective pressures. Domestication is dealt with fully in numerous texts (Lorenz 1953, Spruway 1955, Zeuner 1963, Fox 1968, Hale 1969, Jewell 1969, Ratner and Boice 1975, Clutton-Brock 1981, Mason 1984, Price 1984, Grier and Burk 1992).

Confusion often ensues over definitions of terms such as wild, feral, tame and domestic. A *wild* animal is maintained in its habitat and not theoretically exposed, harassed or hunted by man (Kilgour and Dalton 1984). Not many animals suitably fit this definition, so it is more practical to define *wild* animals as having been left in peace with minimal disturbance from outside by humans. A *feral* animal is one that was formerly domesticated but has been released or has escaped and returned to a semi-wild state (Kilgour and Dalton 1984). There are numerous examples around the globe of *feral* cats, dogs, sheep, cattle, pigs, horses, goats, donkeys and camels. These *feral* populations are useful in providing valuable ethological information to compare and contrast with their domestic counterparts.

*Taming* is not domestication but describes the process of reducing the flight distance of the animal when approached through environmental means (Kilgour and Dalton 1984). *Tame* animals may be approached and even touched without restraint. Most mammals if obtained as juveniles may be tamed to some extent, allowing close interactions with humans.

A crucial event occurred thousands of years ago in the relationship and evolution between both ruminants and man. That crucial event was domestication. Domestication is a phenomenon that has occurred independently around the globe with different species. For example, the domestication of South American camelids is quite disconnected from any Old World domestication. An important determining characteristic commonly found amongst domesticated ungulates is a tendency to occur in close-membership herds, and for males to be non-territorial. These characterisitics lend themselves to herding and tending by humans.

In the Old World, sheep and goats were domesticated by 7500 BP (perhaps much earlier), from mouflon and wild goat. The pig was domesticated from wild boar by 7000 BP in the Middle East, but was probably domesticated independently at other centers in its wide range in Asia at other dates. Cattle are believed to have been domesticated in Asia and Europe by 6,500 BP from wild cattle or aurochs in Europe and the Near East, although other centers of domestication from rather different stock may have led to the cattle of India and East Asia during the New Stone Age. The humped cattle (Bos indicus) were developed in tropical countries; the Bos taurus cattle were developed in more temperate zones. These major domestications occurred at about the same time as domestication of wheat and barley, and preceded by 2,000-4,000 years the domestication of donkeys, horses, elephants and camels.

**2.2 CATTLE (*Bos taurus*)**

Cattle belong to the order Artiodactyla or even-toed hoofed mammals (ungulates), the family Bovidae, and the genus *Bos* (Mason 1984). They have been historically separated from *Poephagus* (yak), *Bibos* (gaur and gayal, banteng and balinese, and kouprey), and *Bison*. -Cattle will interbreed with all these to produce hybrids which, in general, are fertile in the female and sterile in the male.

The origin and taxonomic status of domesticated cattle is controversial (Loftus et al. 1994). Zebu and taurine breeds are differentiated primarily by the presence or absence of a hump and have historically been accepted as separate species (*Bos indicus* and *Bos taurus*). However, the contemporary view is that both types of cattle derive from a single domestication event that occurred 8,000-10,000 years ago. Loftus et al. recently examined the mtDNA sequences from representatives of six European (taurine) breeds, three Indian (zebu) breeds, and four African (three zebu, one taurine) breeds. Comparable levels of average sequence divergence was observed among cattle within each of the major continental groups: 0.41% (European), 0.38% (African), and 0.42% (Indian). However, the sequences fell into two distinct geographical lineages that do not correspond with the taurine-zebu dichotomy. All European and African breeds are in one lineage, wheras all Indian breeds are in the other. There is little indication of breed clustering within either lineage. Application of a molecular clock suggests that the two major mtDNA clades diverged at least 200,000 and possibly as much as 1 million years ago. This relatively large divergence is interpreted as confirmation of two separate domestication events, presumably of different subspecies of the aurochs, *Bos primigenius*. The clustering of all African zebu mtDNA sequences within the taurine lineage is credited to ancestral crossbreeding with the earlier *Bos taurus* inhabitants of the continent.

As with goats and sheep, the remains of domestic cattle have been found in archaeological sites in western Asia and south eastern Europe. It is probable, however, that cattle were not fully domesticated until a millennium after the domestication of goat and sheep. There is no evidence, from decrease in size of the bones from the Pre-pottery Neolithic levels of Jericho for domestication or even of taming of the *Bos primigenius* that was presumably quite prevalent in the region (Hale 1969, Jewell 1969). The earliest confirmed evidence for domestication of cattle was found at Çatal Hüyük in Turkey, dated to *c.* 6400 BC, although further west the earlier site of Haçilar has also provided bovine remains that are smaller than the usual *Bos primigenius*. In southern parts of the old world, in Egypt and Mesopotamia, where agriculture advances had preceeded the north, distinctive breeds of cattle are differentiated by the Bronze Age, the lyre-horned cattle of Ancient Egypt being the most observable example. As with other livestock, the Romans attempted to improve cattle breeds and were responsible for importing new stock into Nothern Europe. Columella (65 AD) described how the intermingling of artificial and natural selection produced different breeds of cattle that were adapted for particular environments and for the ploughing of different soil types (Clutton-Brock 1981). It also attests to the ancient origins of the present day remnants of local breeds.

Humped or zebu cattle (*Bos indicus*) form a distinct group from the European breeds. They are morphologically distinct: with a longer narrower skull, a heavy dewlap, long legs, long pendulous ears, and a muscular or musculo-fatty hump on the back of the neck, or withers. Zebu cattle are often lighter in colour and are physiologically better adapted to tropical environments. While it is convenient to group all humped cattle under the one name "zebu" there are as many breeds with humps as there are without humps, and it is probable that they are as ancient as the European breeds.There is no general agreement on whether zebu cattle were first developed in south western Asia or on the peninsula of India but there is little doubt that the many breeds of humped cattle in Africa at the present day are of secondary origin and were first introduced from India or the Middle East.

Zebu cattle are depicted on cylinder seals from the ancient civilizations of Mohenjo-Daro and Garappa in the Indus Valley which are dated 2500-1500 BC, whilst in southern Iraq on Sumerian and Babylonian sites they are also depicted from about the same period (Mason 1984). The neural spines of the posterior thoracic vertebrae of the zebu (lying behind the region of the hump) are bifurcated. If present in a collection of animal remains from an archaeological site, bifurcation generally confirms the presence of the zebu cattle type, although the bifurcated spine is occasionally found in European breeds of cattle. Fragments of bifurcated spines, the oldest of which dates to 1400 BC have been described from the Tell of Deir' Alla in Jordan and it can be presumed that these came from zebu cattle (Clason 1978).

### 2.2.1 History of cattle in Canada

Jacques Cartier introduced the first cattle (*Bos taurus*) from Europe to the St. Lawrence River of Canada on his third voyage in 1541 (MacEwan 1941). Cattle first arrived in Western Canada between 1700 and 1710. A bull and a heifer named Adam and Eve were transported by canoe to the settlement at Red River, Manitoba (MacEwan 1962) and were kept at the fur-trading post. In 1822 the first herd of cattle ever driven into Canada arrived in Manitoba from Mississippi and in the 1840s cattle were brought to Vancouver Island from United States by the Hudson Bay Company (Rouse 1973). There were cattle at Dunvegan in Alberta's Peace River country in 1823 and at Edmonton by the 1840s (Johnston 1974). In 1864, John M$^c$Dougall, a pioneer missionary, brought two cows and a bull, two oxen, a horse and three dogs to Fort Edmonton from Fort Gary, Manitoba (MacEwan 1962). These cattle were not the first at Fort Edmonton, but they were important in establishing cattle ranching. Decendants of these animals were relocated to the Bow River Valley, west of Calgary by John M$^c$Dougall in 1873 on the founding of his mission among the Stoney Indians at Morley. The cattle found good grazing even in the winter months. The following year, the M$^c$Dougalls travelled to Fort Benton in Montana and returned with eight more cattle of the Texas longhorn type (MacEwan 1962). In 1875, 25 cattle and calves were trailed to Fort MacLeod in southern Alberta to supply meat and milk to the police barracks. These animals were left to winter on their own and in the spring of 1876, the 14 cows delivered 14 new calves.

Bison were virtually eliminated in the Canadian plains by the 1870s, and by 1880, the Canadian prairie was virtually devoid of grazing animals. Encouraged by early experiments that cattle were quite capable of thriving on the Canadian prairies, others began to bring in more cattle. In 1879, after the disappearance of bison, which had up till that time furnished the Indians of the plains with their principal sustenance, the Canadian government contracted Tom Lynch and George Emerson to move cattle up from Montana for the pupose of creating a future source of meat supply for these aboriginal wards of the nation (Rutherford 1984). Lynch and Emerson drove a large herd, 1000 head, from Montana into Alberta in 1879 (McEwan 1962, Johnston 1974).

This herd, the introduction of which was largely considered an experiment at that time, was placed in the foothill country west and southwest of Fort Macleod and though badly handled and depleted by cattle thieves and wild animals, soon proved, beyond a doubt, that raising cattle in the Canadian west was a profitable proposition. The government responded by granting grazing leases and contracting beef supplies to encourage cattle production in the region. This precipitated the first of many major cattle drives from the United States into Alberta (Rouse 1973). The establishment of many big ranching operations quickly followed in Alberta, Saskatchewan and British Columbia in the early 1880s. Arrangements were made for the leasing of low rates of large areas of government land. Capitalists became interested, and money from Europe, from eastern Canada and from the United States flowed into the country (Rutherford 1984). From lack of experience of climatic and other local conditions some of this money was lost, but with the advent of the railway by 1883, conditions improved and a large and profitable industry was speedily built up. Most of the founding stock for these ranches were Texas Longhorns. Texas Longhorns which were driven north as far as Western Canada were wild feral cattle which had been abandoned during the American Civil War. They were re-domesticated by crossing them with British breeds. The wild and excitable nature of the early cattle was clearly evident in the early 1900s when they were shipped by rail and boat from the ranches of western Canada to England. It has been documented that after a journey of 5000 miles, the 4 and 5 year old steers arrived in England gaunt and shrunken and generally in poor condition (Rutherford 1984).

The first purebred Shorthorns in Canada were imported into New Brunswick in 1825 or 1826 (MacEwan 1941). Herefords arrived in Ontario in 1860 and Angus were also imported into Quebec in that year (MacEwan 1941). While there was considerable Longhorn breeding in the cows that arrived from the United States, Hereford, Angus and

Shorthorn became the predominant beef breeds in Canada by the early 1900s. As time went on, the country became more heavily stocked, and many men without adequate capital or experience began to keep cattle. Cross-bred bulls became common on the range, and carelessness in breeding methods served to lower natural increase (Rutherford 1984). The purchase of stocker cattle first from Manitoba and later from eastern provinces introduced many inferior animals, and a general deterioration both in quality and value soon became apparent. The climax of this deterioration was reached about the year 1902 when, tempted by the low prices of Mexican cattle, some of the larger ranchers began to make importations from Chihuahua and Coahuila. These descendants of the ancient spanish breed, hardy and long horned, proved to be very difficult to manage among typical western cattle, and , after a few years of trial, the trade practically died out by 1905 (Rutherford 1984). About this time, the Department of Agriculture began establishing annual provincial auction sales of pure bred bulls. These sales, although to some extent hampered by the jealousies of local breeders, as well as by the indifference of many of the less progressive ranchers, served to raise the standard of western cattle with regards to size and conformation. Charolais cattle first were imported into Canada in 1953 (Rouse 1973). In 1965 a quarantine station was opened on Gross Ile in the St. Lawrence River, which opened the door for the importation of live cattle from the European continent (Mathison 1993). Today, most Canadian commercial cattle are crossbreds, with many breeds represented in the industry (e.g. Angus, Charolais, Hereford, Limousin, Maine Anjou, Salers, Shorthorn, Simmental, Tarentaise, etc.) (Mathison 1993) with the vast majority of the Taurine type.

### 2.2.2 Present situation in Canada

Canada ranked 20th in the world for number of cattle in 1989 (United Nations 1992), with about 1% of the world population of cattle. Canada was a net exporter of cattle/beef in 1995. Large shipments of live cattle are currently being exported (Statistics Canada 1995), with most of these cattle originating in western Canada with a United States destination. United States, Australia and New Zealand are the major sources of beef imports with 52.8, 23.6 and 15.7%, respectively, of beef imports originating form these countries (Mathison 1993).

In Alberta in 1993, there were 22,143 farms classified as cattle farms, with an additional 1775 farms categorized as a mixed-livestock combination (Alberta Agriculture, Food and Rural Development 1993). In 1995, there were 15 million head of cattle and calves in Canada, with close to 6 million head in Alberta (Statistics Canada 1995, Table 2.1).

Most of the cattle were located in the four western provinces in 1995. The four western provinces are the only provinces in which over half the cows are kept for beef production; most of the cows in the easterm provinces are dairy cows. Over 50% of the cattle slaughtered in Canada in 1995 were killed in the three western provinces with the vast majority slaughtered in Alberta. The west, with Alberta at the fore frount, is the primary beef producing region of Canada.

## 2.3 BISON (*Bison bison*)

Cattle and bison both belong to the family Bovidae and are relatively closely related (McDonald 1981, Meagher and Meyer 1994). Bison have the same chromosome number as Bos, $2n = 60$ (Peters 1984). However, the Y chromosome differs, being a small metacentric in cattle and an acrocentric (Basrur and Moon 1967) or telocentric (Bhambhani and Kuspira 1969) in bison. Bison and cattle apparently diverged from a common ancestor in Asia in the late Pliocene Age (McDonald 1981), some 2 million years ago. Bison evolution has remained controversial (Meagher 1986). *B. priscus*, the so-called steppe bison, possibly reached North America shortly after the middle Pleistocene Age and could be ancestral to the modern North American bison. Alternatively, Wilson (1988) proposed that a second post-glacial influx about 10,000 years ago may have led to the current form.

**Table 2.1** Statistics Canada July 1 Livestock Inventory Report

| **Cattle** | **Canada** | | **Alberta** | | **West** | | **East** | |
|---|---|---|---|---|---|---|---|---|
| | **1995 '000 Head** | **95/94 %** | **1995 '000 Head** | **95/94 %** | **1995 '000 Head** | **95/94 %** | **1995 '000 Head** | **95/94 %** |
| Beef Cows | 4,717.2 | 104.9 | 2,075 | 105.5 | 3,978.0 | 105.2 | 739.8 | 103.1 |
| Beef hfrs. for breed. | 1,109.9 | 107.6 | 510 | 113.3 | 949.0 | 107.2 | 180.9 | 108.6 |
| Milk cows | 1,265.0 | 100.5 | 101 | 1.0 | 277.5 | 101.6 | 987.5 | 100.1 |
| Milk hfrs. | 554.9 | 100.4 | 43 | 100.0 | 115.0 | 100.9 | 439.9 | 100.2 |
| Slaughter hfrs. | 825.9 | 114.0 | 440 | 113.4 | 642.5 | 115.3 | 183.4 | 109.6 |
| Steers | 1,544.4 | 117.2 | 756 | 119.1 | 1,186.0 | 121.6 | 358.4 | 104.5 |
| Bulls | 267.6 | 98.8 | 100 | 95.2 | 212.0 | 99.5 | 55.6 | 96.2 |
| Calves under 1 year | 4,829.5 | 105.5 | 1,840 | 104.9 | 3,702.0 | 104.8 | 1,127.5 | 105.7 |
| Total cattle & calves | 15,114.4 | 106.1 | 5,865 | 107.8 | 11,062.0 | 107.3 | 4,052.4 | 102.8 |

**Statistics Canada 1995.**

A concensus does not exist for contemporary bison subspeciation. In view of graduation in both size and form, modern bison were dated arbitrarily by McDonald (1981) to 5000 years ago. Two subspecies frequently were recognized as plains bison (*B. bison bison*) and wood bison (*B. bison athabascae*) (Reynolds et al. 1982; Meagher 1986). Genetically there appeared to be a relationship between the two subspecies. However, Ying and Peden (1977) could not identify chromosomal differences. Peden and Kraay (1979) stated that the subspecific distinction perhaps was not valid; they did find, however, that blood types and carbonic anhydrase polymorphisms were similar. Geist and Karsten (1977) characterized phenotypic differences, and Van Zyll de Jong (1986) affirmed the subspecific designations using morphometric analyses. More recently, Geist (1991) determined that phenotypic differences were widely distributed historically and appeared to reflect a major environmental component, and that subspecific designations were no longer warranted. Recent mtDNA analyses at the University of Alberta suggested geographic isolation only (Bork et al. 1990). Strobeck (1991, 1993) has since resolved that genetically distinct subspecies can not be supported.

Bison raising on farms in Canada has demonstrated exceptional growth, expanding at a rate of 26% annually since 1986. Bison production offers the potential to develop more extensive and sustainable production systems and to further stabilize western agriculture by tapping into new niche markets. Compared with cattle, bison are equally fecund when well managed, hardy, have a long reproductive life, and yield meat which attracts premium prices.

The plains bison had been farmed or ranched since before the turn of the century (Roe 1970; Dary 1974). From 1690 until 1870, the western interior of Canada was administered by the Hudson Bay Company. Game raising was widely practiced although not on a commercial scale (Moodie and Kaye 1976). Because of their similarity to cattle, bison were among the first native species in Canada to be evaluated as livestock. Bison were frequently held at major forts as a military contingency in case of sieges by local natives or rival companies. Agriculture settlement at Red River in southern Manitoba subsequent to 1820 resulted in several experiments with both bison domestication and cross-breeding. But bison and their hybrids were difficult to manage and, with the importation of cattle from the United States, the experiment was dropped (Hudson and Burton 1993). Bison were still numerous on the Canadian prairies in the mid 1870s. However, the wild herds had disappeared almost completely by the early 1880s (MacEwan 1962). It is undeniable that game farming was instrumental in saving bison from near-extinction. The Canadian population originated from several dozen wild-caught calves. An important foundation herd was the Bedson herd developed from calves caught near Battleford, Saskatchewan in 1873 and raised near Stony Mountain, Manitoba until 1887 when a portion of the herd was sold to Buffalo Jones in Kansas and the rest donated to the City of Winnipeg and Banff National Park in 1898. A second major herd was the Pablo-Allard herd which can be traced back to several wild calves captured by Samuel Walking Coyote in the Milk River Drainage in southern Alberta in 1870. This herd was later used to stock Yellowstone National Park and herds in Oklahoma. Most of this herd was eventually sold to the Canadian government and moved to Elk Island National Park in 1907. Two years later, 325 bison were recaptured and relocated to Wainwright which received an additional 218 bison from Montana and 77 bison from Banff National Park. By 1912, Pablo had exported 716 Plains Bison from the United States to Canada. Presently, there over 30, 000 bison on farms and ranches in Canada (Hussey 1994), and only approximately 1000 live in public herds. Only 500 individuals of the Plains ecotype are protected in National Parks and of these 75% are in a rather small fenced park at Elk Island with access to only 130 $km^2$ (Hudson and Burton 1993). The rest are in small display herds. Recent conservation efforts to repatriate the Wood bison have enhanced wild and captive herds throughout Northern Canada. One of the most important wild herds is maintained in the Mackenzie Bison Sanctuary and contains several thousand individuals.

Substantial interest was shown in bison as a species to hybridize with cattle and the Dominion of Canada Department of Agriculture conducted research from 1917 to 1965 (Peters 1958, 1984) in what was then dubbed the "Cattalo Experiment". The objective of these experiments was to blend the meat-producing qualities of beef cattle with the hardiness of bison (Peters 1984). However, these experiments were hampered by the problem of hybrid infertility (especially male sterility) and by death of a large number of the breeding stock caused by embryonic mortality of hybrid fetuses at late stages of pregnancy, as well as by the large size and difficult birth of the hybrid calves (Steklenev 1990). In general, hybridization resulted in compromise rather than improvement of the desirable characteristics of both parent stocks (Hudson and Burton 1993). The problem of poor reproductive performance was never completely solved in Canadian Cattalo, although success has been claimed by American breeders of the Beefalo, a hybrid of disputed genetic background. Currently, the unique market niche and alternative production opportunities offered by pure bison seem to outweigh advantages expected for hybrids. The similarities between bison and domestic cattle, and the now lucrative market for bison, have encouraged interest in conventional bovine reproductive technology in this wildlife species (Dorn 1995). To date, there have been some successes in this area, but numbers have been limited and results have been somewhat less than that expected in cattle (Dorn 1995).

The current interest in farming wild ruminants in Canada can be attributed to work and ideas established in the early 1970s. The University of Alberta established a Wildlife Productivity & Management Program in 1974 and joined an interagency task force, the Alberta Wildlife Production Research Committee, to explore its biotechnical and economic characteristics and environmental implications (Haigh and Hudson 1993). Before it was disbanded, the committee established the Ministik Wildlife Research Station and passed responsibility for its operation to the University of Alberta. Resurgence in interest to farm bison occurred coincidentally with: 1) bioenergetics, metabolism and digestion studies (Richmond et al 1977; Christopherson et al. 1977&1978; Schaefer et al 1978; Christopherson et al. 1979 a,b), 2) demand for lean red meat and 3) a search for more suitable forms of sustainable agriculture. This renewed interest resulted in considerable growth within the Canadian bison industry. In Alberta, there are currently two bison farming organizations, the Peace Country Bison Association and the Southern Alberta Bison Association with 34 and 82 bison member farms in Alberta respectively. The Canadian bison herd includes approximately 33 834 animals, of which 50% reside in

Alberta (Hussey 1994). It has been estimated (Hussey 1991) that if nothing limits industry expansion that the national herd will be 120,161 by the year 2000.

Under present market conditions, bison production offers higher profit margins than beef cattle production. The main limitation is the supply of breeding stock. The future of the industry hinges on developing and maintaining markets for the product, consumer acceptance and the maintenance of high standards of animal care from the standpoint of both credibility of the industry and productivity of the animals.

Industry development has occurred in absence of applied scientific research. Bison research within the park herds has been ecological and zoological in scope (McHugh 1958; Roe 1970; Meagher 1978; Telfer and Cairns 1979; Reynolds et al. 1982; Hawley 1987; Reynolds and Hawley 1987; Hawley 1989; Meagher 1989) and provides little suitable data for current specific industry development questions relating to commercial bison production. The techniques that have enabled the bison industry's expansion were developed on an ad hoc basis and are described in publications of the American Bison Association (Anonymous 1993) and the National Buffalo Association ( Dowling 1990). Market values for bison breeding stock have remained relatively stable compared to the more volatile situation with wapiti. As wood bison become available for commercial farming, as they have recently in Manitoba, exceptionally high prices will be expected until supplies increase and demand stabilizes (Hudson and Burton 1993). Bison meat is said to be lean and palatable so it is expected to maintain its premium value, currently twice the prevailing beef price. Bison meat has typically come from comparatively mature animals. This degree of maturity seems necessary to develop fat cover desired by consumers following 60-90 days of grain finishing (Hudson and Burton 1993).

### 2.4 WAPITI (*Cervus elaphus*)

Wapiti, like bison, are native to western North America. While bison have been raised on farms for well over a century, deer are relatively new agricultural animals in Canada with the first farms established in the late 1970s (Hudson and Burton 1993). Deer, like cattle and bison, are ruminants: cloven hoofed animals with four-chambered stomachs. The family *Cervidae* (deer) shares these traits with three other families: *Bovidae* (cattle, sheep, antelopes), *Giraffidae* (giraffes), and *Antilocapridae* (pronghorn) (Haigh and Hudson 1993).

Deer are characterized by bony antlers rather than keratinous horns and by the absence of a gallbladder. The deer family Cervidae consists of 7 subfamilies, 17 genera and approximately 50 species with more than 200 subspecies. The genera fall into two groups (*telenmetacarpi* and *plesiometacarpi*) on the basis of leg bone structure, specifically the pattern and degree of reduction of the second and fifth digits (Haigh and Hudson 1993).

The subfamily Cervinae has a wide geographical distribution and contains the most popular species on farms including: fallow deer (*C. dama*), rusa deer (*C. timorensis*). sika deer (*C. nippon*) and red deer/wapiti (*C. elaphus*). The most prevalent member is *Cervus elaphus* (Geist 1987). Despite their wide geographical distribution and range of body size and appearance, red deer and wapiti are considered a single species (Geist 1987, Haigh and Hudson 1993). Although striking phenotypic differences exist between Scottish red deer and Canadian wapiti, the reasoning behind the taxonomic decision is that there is no precise point at which one type clearly ends and another begins. The subspecies and races form a continuous circumglobal cline of variation. Visible phenotypic characters used to identify both subspecies and races of *Cervus elaphus* include size, antler form, rump patch, tail length and bugle. In North America, there are four subspecies that are currently recognized. Two more, the eastern wapiti (*C. e. canadensis*) and Merriam's wapiti (*C. e. merriami*) are known only from museum specimens (Haigh and Hudson 1993). Minute genetic differentiation has occured since the Sagamonian interglacial (120,00 to 70,000 years ago) when wapiti were dispersed from Beringia south of the glaciers. The Wisconsin Glaciation (40,000 to 12,000 years ago) may have further isolated the Olympic and Tule wapiti from the other presumptive races (Geist 1987, Haigh and Hudson 1993). Some of the differences detectable today relate to nutritional ecology.

Roosevelt wapiti (*C. e. roosevelti*) are the largest surviving race (hinds more than 300 kg, stags up to 500 kg) and are distributed accross the coastal forest biome from northern California to Vancouver Island (Haigh and Hudson 1993). The antlers are short and heavy, and the terminal tines are often crowned.

Rocky Mountain wapiti (*C. e. nelsoni*) have the widest dispersal and are the most plentiful. Since 1900, Yellowstone National Park has provided stock for repatriation in the United States and western Canada (Haigh and Hudson 1993). Rocky Mountain wapiti are large (hinds up to 300 kg, stags 450 kg), but tend to be both light-framed and long-antlered.

Manitoba or prairie wapiti (*C. e. manitobensis*) once ranged from the Red River in Manitoba westward into Alberta, where it occupied suitable habitat in both the prairies and aspen parkland. Today, remnant herds have been preserved at the fringes of their natural range in several parks and reserves including Riding Mountain, Duck Mountain, Spruce Woods and Prince Albert.

And finally, the Tule wapiti (*C. e. nannodes*) is a small (hinds 185 kg, stags 250 kg), light-colored, small-antlered race found only in an arid sagebrush biome in California. Some authorities consider the differences of this race sufficient to warrant separate species designation. However, many feel that most of the distinguishing characteristics are not genetic.

The taxonomic status of wapiti in Elk Island National Park, a foundation stock for many game farms in Alberta, is often contested. Many authorities consider them to be Manitoba wapiti, while others consider them to be from Rocky Mountain subspecies. Some people diplomatically suggest that the wapiti in Elk Island National Park are the result of a midpoint of a geographic cline. Skull measurements have been inconclusive as to whether they should be awarded distinct toxonomic status because differences in measurements are considered to be the result of nutritional differences (Hutton 1972).

Many current populations are now intergrades because of frequent transplantation. For example, populations of wapiti in the eastern slopes of the Rockies in Alberta were reestablished with stock from Yellowstone (*C. e. nelsoni*), Riding Mountain (*C. e. manitobensis*) and Elk Island (intermediate status)(Haigh and Hudson 1993). As with the bison populations, genetic studies have failed so far to disclose definitive differences at the subspecies level. In the scientific literature, the trend is to merge them all under the taxonomic designation *Cervus elaphus canadensis*.

The utilization and domestication of deer is not a new concept. There are no living species of deer that have not at one time or another contributed to human economics (Clutton-Brock 1981). The reindeer (*Rangifer tarandus*) has long been established as a domestic animal (Skjenneberg 1984) while other Eurasian species have some history of being hunted or kept in parks under farm–like conditions (Haigh and Hudson 1993).

Red deer, in different times and in different locations have had a closer relationship with man than other wild animals (Forni 1989). It is well known through the careful excavation of faunal remains during archaeological investigations that the red deer at one time was the most important species in neolithic communities in Europe. Neolithic man at that time is thought to have husbanded herds of red deer in a manner that is similar to how red deer are presently reared in Europe in parks, or in the way in which neolithic man presumably raised sheep (Jarman 1972). The systems of red deer exploitation during prehistoric times were intermediate between hunting and herding and involved manipulation of the seasonal and social behaviour of deer (von den Driesch 1995). During the medieval age there were approximately 2000 deer enclosures in England and Wales and a substantial industry evolved (Shirley 1867, Whitaker 1892, Whitehead 1950, Gilbert 1979, Fletcher 1992). Female red deer were tamed and used as decoys for the hunting of stags (von den Driesch 1995). Pauli (1983) describes the skeleton of a male red deer that was bridled and found in a Celtic grave in Villeneuve–Renneville, France. There are authenticated accounts of the restocking of deer parks by herding deer for many miles from one park to another (Fletcher 1992). Gilbert (1979) describes wild deer being trapped in Scotland in the 13$^{th}$

century by an Englishman. He accounts the use of a fence which provided an opaque barrier for the deer. Similar systems are still employed (i.e. game fence and game netting). Following capture, the deer were transported for up to 2 days in a horse-drawn wagon either to stock a new park or replenish a park where numbers had been depleted. In the same account Gilbert described the purchase of a milk cow for the rearing of orphaned fawns. Furthermore, there are several authenticated accounts of deer being transported by ship across the North Sea between countries (Fletcher 1992, von den Driesch 1995).

It is unlikely that the deer parks of the 13$^{th}$ century were intended only as sources of meat. In Britain, hunting for pleasure within deer parks had become fashionable in the 16$^{th}$ century. Presumably, prior to that time there were sufficient wild deer for hunting purposes, and it was only when the numbers began to decline that it was necessary to hunt deer in the parks.

In his introduction to the first edition of the Hollinshead Chronicles in the early 16$^{th}$ century, Harrison mentioned that there were as many as 100 deer parks in the counties of Kent and Essex alone and he describes "the 20th part of the realm employed upon deer" (Fletcher 1992). In his Survey of Cornwall in 1602, Carew illustrates how a great number of parks "within the memory of man been disparked, the owners making their deer leap over the pale to give the bullocks place". There was a small nostalgic revival during the period of the picturesque movement in the 18$^{th}$ and 19$^{th}$ centuries, when no English county house was considered complete without a herd of fallow deer nearby (Fletcher 1992). Deer pulling a coach are seen in a picture of the 18$^{th}$ century in the museum of Kranichstein castle, Darmstadt (Siebert 1969). An old tradition, still practiced in 1700, was that German sovereigns had their ceremonial coach drawn by deer. That tradition is evidence of the behavioural plasticity and the inclination of deer to paradomestication (Forni 1989, Vigne 1993). But by 1950, when Whitehead (1950) described Britain's parks in his comprehensive account, the numbers stood at only 177 and were declining.

By the late 17th and early 18th centuries British deer parks became almost non-existent. One reason for this decline includes a shortage of labor needed to maintain brick or stone enclosures, and more importantly the shortage of large tracts of land. However, the main explanation is that over the centuries cattle and sheep farming had become far more viable and productive than keeping deer. The fat from cattle and sheep had been a crucial product since the first domestications, and on the basis of fat production, production from cattle and sheep was more economical. Fat-tailed sheep, for example, have been valued from the time of Heroditus to this day (Zeuner, 1963).

By the late 1960s there was less demand for fat and lean meat became in vogue. It was with this in mind that renewed interest in deer farming started. Modern deer farming was established in Scotland and New Zealand around 1970 in response to low mutton prices and high venison prices (Bannerman and Blaxter 1969, Blaxter et al. 1974). The fact that wild deer were increasing in large numbers in hostile environments and with little care, led Scottish biologists to devise sophisticated management systems. With improved deer management on farms in Scotland and New Zealand came the realisation that lean deer meat was desirable. Analogous to what occurred 10,000 years earlier when sheep were initially cultivated for their meat and were found to be equally valuable for their fleeces and milk, New Zealand venison was found to be almost as important as velvet antler. By 1979 the by-products of a farmed stag in New Zealand excluding the antlers, where at least as valuable as an entire fat lamb. The lean qualities of vension were fully appreciated around the globe.

The technical problems associated with domesticating deer were quickly overcome, and techniques for handling red deer were perfected (Kilgour and Dalton 1985, Mathews 1993). In Scotland wild red deer fawns were bottle-fed to ensure docility, but it soon became apparent that it was more economical to capture adult wild deer. In New Zealand, where the sheep industry was no longer subsidized by Government funding, the demand for red deer breeding stock increased significantly with up to 10 000 wild hinds per annum being captured by helicopters and net guns and a search throughout Europe for superior breeding stock (Fletcher 1992).

In 1992 New Zealand had more than one million domesticated red deer and the export of venison from New Zealand's 5000 farms exceeds NZ$40 million (Haigh and Hudson 1993). In Britain, by 1992 the numbers of domestic deer diminished to approximately 50,000 resulting from government restrictions disallowing competition between deer farming and sheep and cattle on an equal basis. Deer farming industries in other European countries have been slow to develop, but have experienced explosive growth in recent years. In the mean time venison imports from New Zealand to the United Kingdom has doubled annually over the past four years. Projections to 1995 place New Zealand's farm venison exports at about 30,000 metric tons.

In North America, wildlife management has historically been generally reactive to the 18$^{th}$ and 19$^{th}$ century aristocratic traditions that colonists sought to escape (Hudson and Burton 1993, Teer 1993). Hunting and overexploitation of wildlife led to profound depletion. In response to uncontrolled misuse, a system eventually was formed that banned the direct commercialization of wildlife and abdicated the control of wildlife to the state.

While the evolution of wildlife policy was resulting from the struggle between sportsmen and market hunters, the agricultural potential of wildlife was receiving considerable deliberation in early America, especially in western Canada (Moodie and Kay 1976). Because of their similarity to cattle, bison received the majority of the attention (Deakin et al. 1935) but wapiti and deer also began appearing on farms during the end of the 19$^{th}$ century (Haigh and Hudson 1993). One early agricultural evaluation published in 1877 by Judge J.D. Canton of Pennsylvania, considered wapiti to be superior to other species (Canton 1877). In his words, wapiti manifest "a disposition neither altogether lovely nor desperately wicked." An international committee to explore the domestication of new species was conducted by the American Breeders Association (Lantz 1908). These early efforts were basically overlooked and forgotten until deer were reestablished on farms in the 1970s, with the beginning the modern deer industry in North America. Despite official recognition of the prospects for ranching bison, deer, reindeer, musk-oxen, and exotic ungulates (Lantz 1908), game farming and ranching in North America failed to gain momentum until 1970s. This was part of a global wave of interest led by Zimbabwe, South Africa, New Zealand, Scotland, China, and the Soviet Union (Hudson et al. 1989, Haigh and Hudson 1993). The industry has since developed on many fronts, but the agricultural management of deer and especially wapiti has been particularly attractive in Alberta.

Because of their wider availability, most wapiti on farms are of the Rocky Mountain ecotype (*C. e. nelsoni*). Manitoba (*C. e. manitobensis*) and Roosevelt (*C. e. roosevelti*) ecotypes are also found on some farms. Despite an initial flurry of interest and price differential, the tendency has been to minimize their distinctiveness because many of the diagnostic traits seem to be more environmental than genetic and questions have been raised about the purity of wild stocks (Hudson and Burton 1993, Haigh and Hudson 1993). In Alberta, wapiti were historically considered the property of the Crown. Under the Provincial Wildlife Act preceeding 1984, it was illegal to keep wapiti for purposes other than viewing. A big game farm permit was necessary, and was only issued to zoos, wildlife parks, and comparable facilities. In 1984 the passage of a new Wildlife Act, which came into effect in 1987, allowed many formerly prohibited native species (elk, moose, white-tailed deer, mule deer) to be kept for game farm, display or zoo purposes. The new act contained provisions for the sale of antlers from animals held on game farms. Trapping of free ranging wapiti was no longer permitted and therefore all stock for domestic purposes had to be imported from domestic stocks from outside the province. As recently as 1986 there were only four major domestic wapiti herds in Alberta. These consisted of two private herds, the University of Alberta's research herd, and the National Park herd at Elk Island (Haigh and Hudson 1993).

Rapid growth typifyed the wapiti industry in Alberta in the late 1980's. Numerous entrepeneurs became captivated by the economic prospects of this new domesticate, and between 1986 and the fall of 1989 wapiti were imported into Alberta from game farms in the United States. Rapidly escalating prices for wapiti started in 1986 and resulted in considerable trading between herds. Despite the fact that wapiti thrived in captivity, the increasing number of display farms dramatically increased demand, resulting in insufficient breeding stock available locally, and in the fall of 1986 importers turned to the United States as a source. Major importation of wapiti into Alberta from the United States and particularly Montana commenced and continued through to 1989. This had two far reaching consequences. First, as Canadian farmers reached further into the southeastern States, they began to import animals with varying degrees of red deer ancestry. Secondly and more seriously, it indirectly lead to the introduction of a small number of animals infected with bovine tuberculosis. In response, the Alberta government imposed both mandatory genetic testing and vasectomy of hybrid stags. With recognition of shortcomings of diagnostic tests for tuberculosis and the meningeal worm (*Paraelaphostrongylus tenuis)* a moratorium on imports was declared in September 1988 to prevent possible introduction of disease and the meninigeal parasite (Nation et al. 1996). International and interprovincial borders have remained closed with few exceptions, until both federal and provincial government officials are satisfied that the borders can be opened without posing a risk to indigenous populations.

As domestic wapiti herds expanded rapidly between 1988-89, it became obvious that the Fish and Wildlife Division of Forestry, Lands and Wildlife did not have sufficient manpower to supervise game farming in Alberta. Hence negotiations were entered with Alberta Agriculture to transfer responsibility for game farming from Forestry, Lands and Wildlife to Agriculture. In addition, it seemed more appropriate to merge both administration and extension functions within one branch of government. Consequently, in August 1990 the Livestock Diversification Act was drafted. This legislation granted Alberta Agriculture the authority to licence and administer farms for the purposes of raising captive ungulates. The act was proclaimed on August 1991 and the transition to Agriculture was completed in October 1991. Regulations under the Livestock Diversification Act sanctioned the slaughter and sale of meat from domestic elk for public consumption.

In the wake of the tuberculosis control program in which 2600 animals were destroyed, prices of wapiti hinds are now $15,000, yearling hinds are $12,000 and hind calves are

$9,000. Prices of stags range widely from $3,500-$20,000 depending on perceived potential for breeding or velvet production. Due to the lucrative prices currently being paid for antler velvet, very few wapiti are currently slaughtered for meat. Of the wapiti that are slaughtered, they are generally older animals with declining velvet production. It is unlikely that wapiti would be grain finished like bison or cattle because that would only contribute to the deposition of fat and lead to downgrading of the carcass (Haigh and Hudson 1993). Slaughter in the future will be dictated by seasonal growth patterns (Hudson and Burton 1993). Currently most of the international market is served by 15 or 27 month-old red deer stags at carcass weights of 50-70 kg (Haigh and Hudson 1993). The larger bodied wapiti can easily achieve this weight and be suitably finished by 6 months of age, but they have considerable capacity for growth on pasture the following summer (Wairimu et al. 1992,Wairimu and Hudson 1993). Regardless, Canadian raised wapiti should be very competive against other deer species in the already well established venison market as the numbers of surplus animals dictate that slaughter is desirable. Currently in Alberta in 1995, there were 7587 wapiti on 331 licensed farms. As of October 11, 1995, 3008 stags, 4106 hinds, and 472 calves had been reported to Alberta Agriculture's official department inventory record. At the end of the 1996 calving season it has been estimated that there will be over 9500 wapiti residing on farms in Alberta (Chuck Heudepol, personal communication).

Prior to the legalization of the sale of venison, wapiti farmers relied soley on revenue from velvet antlers. Premium prices are currently being paid for antlers from wapiti ($220/kg or approximately $2000 per stag). This product serves an established export market for traditional oriental medicines in Korea, Hong Kong and Taiwan. Current international trade volumes of green velvet has been estimated at about 4000 tonnes (Haigh and Hudson 1993), supplied largely by New Zealand. Substantial quantities of processed products are re-exported to western countries for sale in health food stores. Trade statistics are imprecise due to the fact that different countries use different classifications and large numbers of products are lumped into one category. Canada currently supplies only about 35 tonnes of wapiti velvet annually.

## 2.5 REFERENCES

**Alberta Agriculture, Food and Rural Development, 1993.** Agricultural Statistics Factsheet, Market Analysis and Statistics Branch, Agdex 853.

**Anonymous, 1993.** Bison Breeders Handbook. 3rd Edition. American Bison Association.

**Bannerman, M. M. and Blaxter, K. L., 1969.** The Husbandry of Red Deer. Proceedings of a Conference held at the Rowett Research Institute, Aberdeen (January 1969). Aberdeen University.

**Basrur, P. K. and Moon, Y. S., 1967.** Chromosomes of cattle, bison, and their hybrid, the cattalo. Am. J. Vet. Res., **28:** 1319–1325.

**Bhambhani, R. and Kuspira, J., 1969.** The somatic karyotpes of American bison and domestic cattle. Can. J. Genet., Cytol., **11:** 243-249.

**Blaxter, K. L., Kay, R. N. B., Sharman, G. A. M., Cunningham, J. M. M. and Hamilton, W. J., 1974.** Farming the Red Deer – First Report of an investigation by the Rowett Research Institute and the Hill Farming Research Organization. Her Majesty's Stationery Office, Edinburgh.

**Bork, A. M., Strobeck, C. M., Yeh, F. C., Hudson, R. J. and Salmon, R. K., 1990.** Genetic relationship of wood and plains bison based on restriction fragment length polymorphisms. Can. J. Zool., **69:** 43–48.

**Canton, J. D., 1877.** Antelope and deer of America: A comprehensive scientific treatise upon the natural history, including the characterisitics, habitats, affinities, and capacity for domestication of the antilocapra and cervidae of North America, Hurd & Houghton, Chicago.

**Christopherson, R.J., Gonyou H.W. and Thompson, J.R., 1979a.** Effects of temperature and feed intake on plasma concentration of thyroid hormones in beef cattle. Can. J. Anim. Sci., **59:** 655-661.

**Christopherson, R.J., Hudson, R.J. and Christophersen, M.K., 1979b.** 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., 1977.** Feed intake, metabolism and thermal insulation of Bison, Yak, Scottish Highland and Hereford calves during winter. 55th Annual Feeders Day Report, University of Alberta, Dept of Anim. Sci., **55:** 51-52.

**Christopherson, R.J., Hudson, R.J. and Richmond, R.J., 1978.** Comparative Winter Bioenergetics of American Bison, Yak, Scottish Highland and Hereford Calves. Acta. Theriol., Vol 23, **2:** 49-54.

**Clason, A. T., 1978.** Late Bronze Age–Iron Age Zebu Cattle in Jordan? J. Arch. Sci., **5:** 91-94.

**Clutton-Brock, J., 1981.** Domesticated Animals from Early Times. Heinemann, British Museum (Natural History).

**Dary, D., 1974.** The Buffalo Book: The Final Saga of the American Animal. Sage Books, New York.

**Deakin A., Muir, G. W. and Smith, A. G., 1935.** Hybridization of domestic cattle, bison, and yak: Report of the Wainwright Experiment, Can. Dept. Agric. Pulbl., **479:** 30.

**Dorn, C. G., 1995.** Applications of reproductive technologies in North American bison (Bison bison), Theriogenology, **43:** 13-20.

**Dowling, K., 1990.** Buffalo Producer's Guide to Management and Marketing. National Buffalo Association. R.R. Donnelley & Sons Company, Chicago.

**Fletcher, J.T., 1992.** Why Farm Deer ? – A Historical Perspective. in: W. van Hoven, H. Ebedes and A. Conrowy. editors., Wildlife Ranching: A Celebration of Diversity, Proceedings of the 3rd International Wildlife Ranching Symposium, October 1992, Pretoria, South Africa.

**Forni, G., 1989.** Evidence for a "protobreeding" of Red Deer. Red Deer as a "domesticoid" animal. Archaeozoologia 3/1, **2:** 179-190.

**Fox, M.W., 1968.** Abnormal Behavior in Animals. W.B. Saunders, Philadelphia.

**Geist, V., 1987.** On speciation in ice age mammals with special reference to cervids and caprids, Can. J. Zool., **65:** 1067-1084.

**Geist, V., 1991.** Phantom subspecies: The wood bison *Bison bison "athabascae"* Rhoads 1897 is not a valid taxon, but an ecotype. Arctic, **44:** 283-300.

**Geist, V. and Karsten, P., 1977.** The wood bison (*Bison bison athabascae* Rhoads) in relation to hypothesis on the origin of the American bison (*Bison bison bison* Linneaus). Zeitshrift Saugetierkude, **42:** 119-127.

**Gilbert, J. M., 1979.** Hunting and Hunting Reserves in Mediaeval Scotland. John Donald, Edinburgh.

**Grier, J.W. and Burk, T., 1992.** Biology of Animal Behavior. Mosby–Year Book, Inc., New York.

**Haigh, J.C. and Hudson, R. J., 1993.** Farming Wapiti and Red Deer. Mosby, St. Louis.

**Hale, E. B., 1969.** Domestication and the evolution of behaviour. In: E. S. E. Hafez, editor. The Behaviour of Domestic Animals, ed 2., London, Bailliere, Tindal and Cassel, pp. 22-42.

**Hawley, A.W.L., 1987.** Bison and cattle use of forages. In: H.W. Reynolds and A.W.L. Hawley editors. Bison Ecology in Relation to Agricultural Development in the Slave River Lowlands, N.W.T. Occasional Paper, No. 63 Ca. Wildl. Ser. pp 49-52.

**Hawley, A.W.L., 1989.** Bison Farming in North America. In: R.J., Hudson, K.R. Drew and L.M. Baskin, editors, Wildlife Production Systems: Economic Utilization of Wild Ungulates. Cambridge University Press, Cambridge, UK. pp 346-361.

**Hudson, R. J. and Burton, B. A., 1993.** The wildlife industry. In: J. Martin, R. J. Hudson, and B. A. Young, editors, Animal Production in Canada. University of Alberta, Edmonton, pp. 151–172.

**Hudson, R. J., Drew, K. R. and Baskin, L. M., 1989.** Wildlife Production Systems: Economic Utilization of Wild Ungulates. Cambridge, Cambridge University Press.

**Hussey, G., 1991.** Marketing Strategy for the Peace Country Bison Association. Unpublished Report for the Peace Country Bison Association.

**Hussey, G. W., 1994.** What's the Score in '94?. Smoke Signals, November, 5: 16–17.

**Hutton, D. A., 1972.** Variation in the Skulls and Antlers of Wapiti; MSc thesis, University of Calgary, Calgary, Alberta.

**Jarman, M. R., 1972.** European deer economies and the advent of the Neolithic. In: E. S. Higgs, editor, Papers in Economic Prehistory. Cambridge, pp. 125–147.

**Jewell, P. A., 1969.** Wild Mammals and their Potential for New Domestication, Duckworth, London.

**Johnston, A., 1974.** Land use history related to beef cattle production. Cattlemen's Short Course, December 2–6, Banff, Alberta.

**Kilgour, R. and Dalton, C., 1984.** Livestock Behaviour. Methuen, Aukland.

**Lantz, D. E., 1908.** Deer farming in the United States. USDA Farm Bull.

**Loftus, R. T., MacHugh, D. E., Bradley, D. G., Sharp, P. M. and Cunningham, P., 1994.** Evidence for two independent domestications of cattle. Proc. Natl. Acad. Sci. USA. Washington, D.C., Mar. 29, **91:** 2757–2761.

**Lorenz, K., 1953.** Man Meets Dog. Penguin, Harmondsworth.

**MacEwan, J. W. G., 1941.** The Breeds of Farm Livestock in Canada. Thomas Nelson & Sons Ltd., Toronto.

**MacEwan, J.WG., 1962.** Blazing the Old Cattle Trail. Modern Press. Saskatoon.

**Mason, I. L., 1984.** Evolution of domesticated animals. Longman Group Limited, New York.

**Mathews, L. R., 1993.** Deer Handling and Transport. In: T. Grandin, editor, Livestock Handling and Transport, CAB International, Wallingford, pp. 253-272.

**Mathison, G. W., 1993.** The beef industry. In: J. Martin, R. J. Hudson, and B. A. Young, editors, Animal Production in Canada. University of Alberta, Edmonton, pp. 35-74.

**McDonald, J. N., 1981.** North American Bison: their classification and evolution. University of California Press, Berkeley, California.

**McHugh, T., 1958.** Social behaviour of the American buffalo (Bison bison). Zoologica **43:** 1-40.

**Meagher, M., 1978.** Bison. In: J.L. Schmidt and D.L. Gilbert,editors, Big Game of North America: Ecology and Management. Stackpole Books, Harrisburg PA., pp 123-133.

**Meagher, M., 1989.** Range expansion by bison of Yellowstone National Park. J. Mammal., **70(3):**670-675.

**Meagher, M., 1986.** Bison bison. Mammalian Species, **266:** 1-8.

**Meagher, M. and Meyer, M. E., 1994.** On the origin of brucellosis in bison of Yellowstone National Park: a review. Conserv. Biol., **8:** 645-653.

**Moodie, D. W. and Kaye, B., 1976.** Taming and domesticating the native animals of Rupert's Land. Beaver, **307:** 10-19.

**Nation, P. N., Fanning, E. A., Hopf, H. C. and Church, T. L., 1996.** Observations on the outbreak of *Mycobacterium bovis* in game farm wapiti in Alberta, Canada. personal communication.

**Pauli, L., 1983.** Eine frühkeltische Prunktrense aus der Donau. Germania **61:** 459-486.

**Peden, D. G. and Kraay, G. S., 1979.** Comparison of blood characterisitcs in plains bison, wood bison, and their hybrids. Can. J. Zool., **57:** 1778–1784.

**Peters, H. F., 1984.** American Bison and Bison–Cattle Hybrids. In. I. L. Mason. editor. Evolution of Domesticated Animals. Longman, London. pp. 325-333.

**Peters, H.F., 1958.** A feedlot study of Bison, Cattalo and Hereford calves. Can. J. Anim. Sci., **38:** 87-90.

**Price, E. O., 1984.** Behavioral aspects of animal domestication. Quarterly Review of Biology, **59:** 1-32.

**Ratner, S.C. and Boyce, R., 1975.** Effects of domestication on behaviour. In: E.S.E. Hafez, editor. The Behavior of Domestic Animals, ed 3. Williams & Baillaire, Baltimore.

**Reynolds, H. W., Glaholt, R. D. and Hawley, A. W. L., 1982.** Bison. In: J. A. Chapman and G. A. Feldhammer, editors, Wild Mammals of North America: Biology, Management, and Economics. Johns Hopkins University Press, Baltimore, Maryland. pp. 972–1007

**Reynolds, H.W. and Hawley, A. W.L., 1987.** Bison Ecology in Relation to Agricultural Development in the Slave River Lowlands, N.W.T. Canadian Wildlife Service Occasional Paper No. 63.

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

**Roe, F.G., 1970.** The North American Buffalo: A Critical Study of the Species in its Wild State. 2nd ed. Univ. Toronto Press, Toronto, Ontario.

**Rouse, J. E., 1973.** World Cattle: Cattle of North America. Vol. III. University of Oklahoma Press, Norman, Oklahoma.

**Rutherford, J. G., 1984.** The cattle trade of western Canada. Can. Vet. J., **25:** 429-432.

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

**Shirley, E. P., 1867.** Some Account of English Deer Parks. John Murray, London.

**Siebert, G., 1969.** Kranichstein, Jagdaschloß der Landgrafern von Hessen–Darmstadt. Emig, Amorbach.

**Skjenneberg, S., 1984.** Reindeer. In: I. L. Mason. editor. Evolution of Domesticated Animals. Longman, London. pp. 128-137.

**Spurway, H., 1955.** The causes of domestication: an attempt to integrate some ideas of Konrad Lorenz with evolution theory. J. Genet., **53:** 325-362.

**Statistics Canada, 1995.** Livestock Inventory Report, In: Alberta Agriculture, Food and Rural Development, Monthly Commentary and Outlook, October, 1995.

**Steklenev, E. P., 1990.** Characteristics of direct and reciprocal crosses of bison (*Bison bison bison* L.) with domestic cattle (*Bos[Bos] taurus typicus*) and characteristics of hybrid progeny. Tsitol Genet., **24:** 50-56.

**Strobeck, C., 1991.** Molecular variation and genetic differentiation of populations of bison and elk. Final report SSC068SS,K3129–0–007. University of Alberta, Edmonton, Alberta.

**Strobeck, C., 1993.** Molecular genetic research and DNA repository. Final report. University of Alberta, Edmonton, Alberta.

**Teer, J. G., Renecker, L. A. and Hudson, R. J., 1993.** Overview of wildlife farming and ranching in North America. Trans. 58th N. A. Wild. & Natur. Resour. Conf. pp. 448–459.

**Telfer, E. S. and Cairns, A., 1979.** Bison-wapiti interrelationships in Elk Island National Park, Alberta. pp 114-121. In. M.S. Boyce and L.D. Hayden-Wing, editors, North American Elk: Ecology, Behaviour, and Management, University of Wyoming Press, Larame.

**United Nations, 1992.** Statistical yearbook. 37th Issue. Department of Economic and Social development. Statistical Office, New York.

**Van Zyll de Jong, C. G., 1986.** A systematic study of recent bison, with particular consideration of the wood bison. Publications in Natural Science No. 6. National Museums of Canada, Ottawa, Ontario.

**Vigne, J. D., 1993.** Domestication ou appropriation pour la chasse: histoire d'un choix socio–culturel depuis le Néolithique. L'exemple du cerf (Cervus). XIIIe Rencontres Internationales d'Archéologie d'Histoire d'Antibes. Société de Recherche Interdisciplinaire, 201–220, Edition APDCA, Juan–les–Pins.

**von den Driesch, A., 1995.** Domestic ruminants: their incorporation and role in early rural societies. In: Ruminant Physiology: Digestion, Metabolism, Growth and Reproduction. Proceedings of the Eighth International Symposium on Ruminant Physiology, ed. by W. v. Engelhardt, Ferdinand Enke Verlag Stuttgart, Berlin.

**Wairimu, S. and Hudson, R. J., 1993.** Foraging dynamics of wapiti stags (Cervus elaphus) during compensatory growth, Appl. Anim. Behav. Sci., **36:** 65–79.

**Wairimu, S., Hudson R.J. and Price, M. A., 1992.** Catch-up growth of yearling wapiti stags. Can. J. Anim. Sci., **72(3):** 619-631.

**Whitaker, J., 1892**. A Descriptive List of the Deer Parks and Paddocks of England. Ballantyne, Hanson and Co., London.

**Whitehead, G. K., 1950.** Deer and their Management. Country Life. London.

**Wilson, M. C., 1988.** Postglacial vertebrate faunas of the Canadian plains. Proceedings of the annual meeting of the Prarie Canadian Association of Geographers. Sask. Geog., **2:** 92–109.

**Ying, K. L. and D. G. Peden., 1977.** Chromosomal homology of wood bison and plains bison. Can. J. Zool., **55:** 1759–1762.

**Zeuner, F.E. 1963.,** A History of Domesticated Animals, Harper and Row, New York.

# Section 1: Reproductive Management

# CHAPTER 3: **Calving behaviour of farmed wapiti *(Cervus elaphus)***[1]

## 3.1 INTRODUCTION

Wapiti farmers often report perinatal losses which may be related to calving difficulties, mismothering, lactation failure or disease (Gill 1985, Kozak 1988, Friedel and Hudson 1994). Of these, losses related to behavioural stress have received least attention, despite the obvious significance for a new species adapting to its role as a domestic animal. An understanding of calving behaviour would be valuable for determining when assistance is required, and what management practices would curtail unnecessary losses of new born calves.

In the wild, hinds due to calve usually leave the herd and seek an isolated site away from their normal home range (Geist 1982). When wapiti are raised intensively on farms their normal behaviour is modified by paddock confinement. To what extent this exacerbates calf losses in farmed wapiti is difficult to determine, partly because there is little good information on calving in wild populations with which to draw comparisons. Farming is associated with several inherent problems including:human interference with repeated handling and inspections, restricted space relating to paddock size, and high stocking densities.

This study was undertaken to provide basic information on calving behaviour of this new farm animal. We investigated a variety of behavioural indicators of the imminence of calving to explore whether behavioural observation could be used to provide early warning of calving difficulty and mismothering. We also tested the hypothesis that losses were related to the excitability of the dam (assessed by both flight distance and heart rate). Because we preferred not to impose treatments which may have increased perinatal losses, we explored natural variation in emotionality within the research herd.

[1] A version of this chapter has been published. Church, J. S. and Hudson, R. J., 1996. Calving behaviour of farmed wapiti (*Cervus elaphus*). Appl. Anim. Behav. Sci., 46: 263-270.

## 3.2 MATERIALS AND METHODS

### *3.2.1 Animals*

This study was based on 202 calving records from 65 hinds collected from 1988-1993 by a succession of summer students. The research herd comprised Rocky Mountain wapiti maintained at the Ministik Wildlife Research Station, 50 km southeast of Edmonton, Alberta. The initial stock originated from Sybille, Wyoming (1976 cohort) and YaHa Tinda, Alberta (1977 cohort). Since 1985, stags from nearby Elk Island National Park have been used in the breeding program.

Each calving season, breeding hinds were assembled in two pastures to keep densities low and hinds often received supplemental food to augment shortfalls in pasture supply. Approximately half of the herd had been hand reared (bottle fed), providing an additional behavioural dimension to the study.

A database was compiled which included data from an existing database (collected since 1988) of perinatal behaviour which included detailed records on the stages of parturition and delivery such as contractions, appearance of the amniotic sac, appearance of amniotic fluid, when the hooves appeared, when the calf was delivered, when it stood, and when it first suckled.

### *3.2.2 Live weights*

Body weights of study animals were measured with an electronic platform scale (Western model no. DF-1000 Accurate Scale Industries, Edmonton, Alberta Canada) bi-weekly. Feed (including pasture) and water was not withheld before weighing so body weights included fullness of the rumen. Adult animals were weighed approximately 1 month prior to calving and calves were weighed 24 hours after birth, 2 weeks following birth, and at two-week intervals until weaning at approximately three months of age in early September.

### *3.2.3 Birth parameters*

The time of birth and the different stages of labor were recorded. The time from the beginning of pacing or the appearance of the amniotic sac to the initiation of delivery was defined as the first stage of parturition. Pacing consisted of stereotyped walking along fencelines. The initiation of delivery was defined as the period when the calf's hooves were first visible and the completion of delivery was defined as the time when the entire calf was free of the hind (Kelly and Whately 1975).

Each hind and her calf was fitted with matching color-coded collars to facilitate identification of maternal-filial pairs. All hinds were collared one month prior to the onset of observations, and calves were collared within 24 hours after delivery.

A daylight watch was maintained by two alternating observers from late May to mid July of each calving season from 1988-1993. Only an intermittent watch was in place in the 1992 calving season. Observers began observing the hinds 2 weeks prior to the birth of the first calf to allow the hinds sufficient time to habituate. Observations were made at distances of 10-50 meters with binoculars and did not appear to disturb the hinds.

Calf vitality was assessed as the time period from delivery to when the calf was standing, and until the calf nursed. Approximately 24 h after birth, the calves were weighed with a hanging scale and gender was determined. Calf mortality data was compiled from post-mortem reports supplied by Animal Health Laboratories, Alberta Agriculture, Food and Rural Development, Edmonton.

### *3.2.4 Emotionality*

In early May 1993, approximately 2 weeks before the hinds were due to calve, the flight distance from an approaching human was recorded with a range meter (80/2 Pro Rangefinder™, Ranging Inc. East Bloomfield, N. Y. 14443, U.S.A). Flight distances were recorded for each individual over a five–day period to obtain an average, which was used as an indicator of the emotionality of the dam. As a second measure of emotionality, we measured heart rates of hinds while restrained in a squeeze or chute 3 weeks prior to the expected birth of the first calf and three weeks after the birth of all calves.

### *3.2.5 Statistical analysis*

Liveweights of both hinds and calves were analyzed by analysis of variance, fitting sex and age of calf, via the SuperANOVA© repeated measures procedure (Abacus Concepts, Inc. 1991). Distributions were analysed using Skewness and Kurtosis tests (Snedecor and Cochran, 1967).

## 3.3 RESULTS AND DISCUSSION

### *3.3.1 General observations*

Calving spanned approximately 3 to 4 weeks beginning in the third week of May. The details of the observations are similar to those described for red deer (Arman 1974, Arman et al., 1978, Haigh and Hudson 1993).

During late pregnancy, the hinds spent much time resting. However, 5 to 7 days before calving most became restless and separated from the rest of the herd. The distance from the herd was between 25 and 50 m. Signs of impending calving were sometimes subtle. Behaviour of the preparturient hind often differed from the behaviour shown by the herd. Some preparturient hinds became aggressive to other hinds.

The udder became noticeably more turgid and the teats became prominent approximately one week before calving. Twenty four hours prior to calving, an obvious change took place in the shape of the abdomen. The pregnant hind lost the sagging appearance of the abdomen and it became increasingly difficult to differentiate between a hind that had recently calved from a hind that was about to calve.

### *3.3.2 Calving sequence*

Observations of the calving sequence are summarized in Table 3.1. The first stage of parturition occurred 91–902 minutes before delivery. Hinds paced the fence line with an increased intensity that was distinct from previous behaviour. This second bout of pacing was much more stereotyped. Instead of the normal relaxed walking along the fence line, hinds engaged in a high stepping gait, with an extended neck. The hinds frequently turned on the fence line, but not necessarily at the corners and always away from the fence, and most hinds vocalized frequently.

During the second stage of parturition, the hind first stopped grazing and often settled away from the herd. Abdominal contractions were visible 2 h before birth. Strong contractions had a marked effect on the behaviour of the hinds. The hind would appear restless and would alternate between standing and lying. During a contraction, hinds often flattened their ears, looked to their flanks, raised their tails, and extended their legs while rolling laterally. The appearance of the amniotic sac, on average 97 minutes before birth, often coincided with the onset of increased, more intense abdominal contractions.

Often hinds licked the vulva, teats, the amniotic sac and hooves of the emerging calf. Grazing also occurred at times when the amniotic sac was visible. When the amniotic sac burst and fluids were expelled, the hinds licked the voided contents and ate the grass which had been in contact with the fluids.

**Table 3.1** Calving sequence and calf vitality in farmed wapiti observed at the Ministik Wildlife Research Station from 1988-1993.

| Observations | n | Range | Mean ± s.e.m. |
|---|---|---|---|
| **Stages of Parturition** | **Time before delivery (min)** | | |
| First Stage | | | |
| Pacing | 27 | 91-902 | 365 ± 38 |
| Second Stage | | | |
| Contractions first seen | 31 | 15-720 | 122 ± 24 |
| Appearance of amniotic sac | 12 | 27-238 | 97 ± 22 |
| Bursting of amniotic sac | 30 | <1-355 | 79 ± 17 |
| Appearance of calf | 55 | <1-193 | 45 ± 5 |
| **Calf development** | **Time after birth (min)** | | |
| Third Stage | | | |
| First stand | 58 | 13-271 | 49 ± 5 |
| First suckle | 58 | 28-223 | 76 ± 5 |

The time from the rupture of the sac until the calf was born ranged from 0 to 6 h. However, calving seldom took longer than an hour once the calf's hooves were visible. Calving difficulty was anticipated when abnormal or posterior presentations were observed, and when appearance of the amniotic sac and feet of the calf was accompanied by prolonged straining by the hind. At this point, hinds experiencing difficulty were assisted in most cases and subsequent data was excluded from this study.

After delivery during the final stage of parturition, the hinds continued to alternately stand and lie down, while their calves would struggle to stand and nurse. The movement of the calf and the presence of amniotic fluid appeared to attract the hind. The hind consumed the afterbirth, including the placenta, which was expelled approximately 90 minutes after the calf. If the calf was slow to rise, the hind often nudged it with her nose. If the calf was stillborn, the hind eventually pawed the dead calf with her forefeet.

### *3.3.3 Calf vitality*

Within half and hour after birth the calves attempted to stand and standing was achieved at 49 (± 5.1) minutes; 27 (± 5.2) minutes later the calf successfully nursed (Table 3.1). Wapiti calves rarely nursed while lying down. The calves often searched the brisket of the hind before they found the udder.

### *3.3.4 Calving rates and birth weights*

Wapiti generally first bred as yearlings and produced their first calf at 2 years of age. Similar to the results of a previous study based on data collected from 1977-1988 by Hudson et al. (1991) on the same herd, the calving rate was 52% in 2-year-old hinds and 91% for the herd. Only one set of twins was born. Male calves were slightly heavier than female calves ((mean ± SE) 19.4 ± 0.3 vs 18.3 ± 0.3 kg)(Figure 3.1). Heavier calves were born to older hinds. Birth weight was not affected by a hind's rut weight, weight loss over the winter, or emotionality as assessed by flight distance or restrained heart rate.

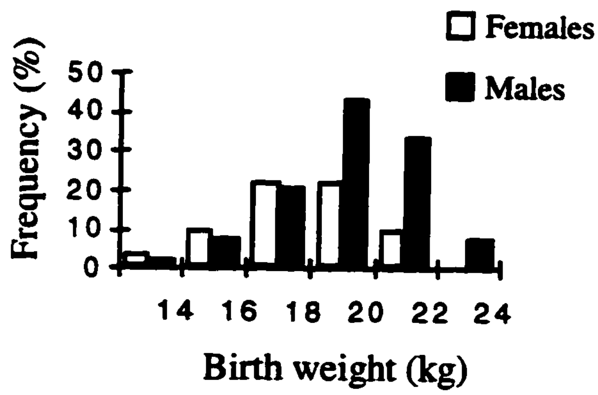


**Figure 3.1** Distribution of birth weights (kg) of male and female wapiti calves born at the Ministik Wildlife Research Station from 1988-1993

### *3.3.5 Calving difficulty (Dystocia)*

Twenty hinds or 10 % of the herd experienced calving difficulty between 1988 and 1993. Of those hinds having difficulty, 60% (12) were yearlings. Four calves were stillborn, all of which were born to primiparous hinds bred as yearlings. One calf born to a primiparous hind died of aspiration pneumonia which may be related to poor cleaning of the birth membranes by the inexperienced mother. Two calves died from mismothering; one calf was rejected by a four year old hind and one calf was trampled by her 6 year old dam. The hind that trampled her calf had raised four calves previously and has successfully raised a calf since. Lack of maternal experience seemed unrelated to desertion. Even among primiparous hinds that were offered assistance, mismothering seldom occurred after the intervention.

Intervention was deemed necessary 13 times over 6 years, and only one calf death resulted. The longest calving recorded without intervention was 3 hours and 13 minutes, the period from the first appearance of the calf until birth. Of the births assisted, five were posterior presentations and two were breach presentations. One half of the difficult calvings involved improper presentation or posture.

### *3.3.6 Correlations of calving difficulty with emotionality*

There were no significant correlations found between calving parameters and the emotionality of the hind as assessed by flight distance and heart rate. However, calves born to hinds with a large flight distance stood sooner than calves whose mothers had a small flight distance ($y=1.004-0.029\ x$; $r^2=0.22$). This probably reflects the behaviour of the dam at birth rather than the viability of the calf.

No differences in calving parameters were found between hinds that were or were not hand-reared. However, hinds that were hand reared had considerably shorter flight distances ($P<.05$), although, the difference narrowed with age. The relationship between flight distance and age in hand-reared animals was described by $y=-0.995+0.639\ x$

($r^2$=0.41) whereas the relationship for maternal reared hinds was y=23.762-1.435 x ($r^2$=0.40) By 10 years of age flight distances were similar, regardless of rearing experience.

### *3.3.7 Implications for management*

Withdrawal from the herd may reduce agonistic behaviour among hinds (Clutton-Brock and Guiness 1975). On intensively managed farms the calving period is condensed. A lack of isolation at calving time, many individuals calving at the same time, and a strong drive to separate from the herd may intensify agonistic interactions. The results suggest that only a few hinds were responsible for calf deaths, and presumably these hinds should be culled from the herd. Intervention did not result in an increase in calf mortality, therefore, assistance should be offered to the hind when necessary. Observations from this study indicate that hinds should be offered assistance after 3 hours, primiparous hinds probably should be helped somewhat earlier (e.g. 2 hours).

## 3.4 REFERENCES

**Abacus Concepts, 1989.** SuperANOVA, Abacus Concepts, Inc., Berkeley, CA.

**Arman, P., 1974.** A note on parturition and maternal behavior in captive red deer. J. Reprod. Fertil., **37:** 87-90.

**Arman, P., Hamilton W. J. and Sharman, G. A. M., 1978.** Observation on the calving of free-ranging tame red deer. J. Reprod. Fertil., **54:** 279-283.

**Clutton-Brock, T. H. and Guiness, F. E., 1975.** Behavior of red deer at calving time. Behav., **55:** 287-300.

**Friedel, B. A. and Hudson, R.J., 1994.** Production of farmed wapiti in Alberta. Can. J. Anim. Sci., **74:** 297-303.

**Gill, J.M., 1985.** Perinatal calf loss in farmed deer at Invermay. In: Proceedings of a deer course for veterinarians, Deer Branch of the New Zealand Berterinary Association, Ashburton **2:** 186-192.

**Geist, V., 1982.** Adaptive behavioral strategies. In: Elk of North America: Ecology and Management. Stackpole Books, Harrisburg, Pa. pp 219-277.

**Haigh, J.C. and Hudson, R. J., 1993.** Farming Wapiti and Red Deer. Mosby, St. Louis.

**Hudson, R. J., Kozak, H. M., Adamczewski, J. Z. and Olsen., C. D., 1991.** Reproductive performance of farmed wapiti *(Cervus elaphus nelsoni)*. Small Ruminant Res., **4:** 19-28.

**Kelly, R. W. and Whately, J. A., 1975.** Observations on the calving of red deer run in confined areas. Appl. Anim. Ethol., **1:** 293-300.

**Kozak, H.M., 1988.** Effect of winter feeding programs on weight changes, calving, and lactation of wapiti (Cervus elaphus nelsoni) on game farms, M.S.c. thesis, Department of Animal Science, Edmonton, University of Alberta.

**Snedecor, G. W. and Cochran, W. G., 1967.** Statistical Methods. Iowa State University Press, Ames, IA.

# CHAPTER 4: **Stress of two weaning procedures on farmed wapiti calves *(Cervus elaphus)***

## 4.1 INTRODUCTION

Farmed wapiti calves are often weaned at 3-4 months of age, whereas wild calves may continue to suckle for 7-8 months and maintain an association with the hind until the next calf is born (Haigh and Hudson 1993). Weaning is often considered stressful as calves show sharp reductions in lymphocyte counts during the weeks following separation from the dam, appear more susceptible to disease, and often intensely pace fencelines (Griffin et al. 1988, Pollard et al. 1992). Several approaches for minimizing the stress of weaning include indoor confinement at separation, adding unrelated barren hinds to groups of calves, or gradually removing hinds into an adjacent paddock. To avoid stress, many farmers simply wean after the rut, or choose to allow the dam to gradually wean the calf on her own. Friedel and Hudson's (1994) survey of the Alberta wapiti industry has given some insight into the possible consequences of both pre-rut and post-rut weaning, and generally found that pre-rut weaning was advantageous from a production standpoint. However, an assessment of welfare of the calves was not made.

When calves face environmental stressors (e.g. nutritional stressors, weather, or handling), activation of hypothalamic-pituitary-adrenocortical response (HPA) causes an increase in levels of circulating glucocorticoids that subsequently influence leukocyte dynamics (Griffin et al. 1988). Specifically; leukocytopaenia, involving a significant reduction in lymphocytes, has been observed in red deer calves. Leukocyte changes (neutrophil/lymphocyte ratios N/L) in response to environmental stress are less variable and more enduring than the glucocorticoid response, and may be a more reliable indicator of stress. White blood cell counts rise as a result of muscular excercise, excitement, apprehension, or emotional disturbance (Goetzl 1985; Guillemin et al. 1985; Plotnikoff et al. 1986) and constitutes physiologic leukocytosis. Therefore, the N/L ratio has been proposed as a sensitive index of chronic stress because the number of lymphocytes in blood samples decrease and the number of neutrophils increase in response to various environmental stressors which increase cortisol and corticosterone in the blood (Gross and Siegel 1983).

Previous bovine research has demonstrated the effectiveness of lymphocyte blastogenesis and neutrophil function as a secondary measure of stress (Murata 1989, Murata and Hirose 1991). For example, differential leucocyte counts obtained from Holstein calves transported by road for 4h showed a leucocytosis with neutrophilia, a decrease of T-lymphocyte population, a suppression of lymphocyte blastogenesis and an enhancement of reduction activity of neutrophils after the transportation (Murata et al. 1987). These alterations all corresponded with cortisol elevation. Therefore, N/L ratios were utilized in this study as an indicator of the stress associated with each of the respective weaning treatments.

This study compared two different approaches to pre-rut weaning, *abrupt* and *interval* replicated over two years. The *abrupt* group were quickly weaned in the first week of September with the calves subsequently being moved first to a large pen and then to a new pasture remote from their dams (an industry standard in Alberta). The *interval group* were weaned gradually at the same age over a 10-day period by shifting a few hinds each day to a new pasture remote from their calves. The responses of the calves to the two procedures in terms of average daily gain, behavior, and neutrophil/lymphocyte ratio were compared.

## 4.2 MATERIALS AND METHODS

### *4.2.1 Animals*

Thirty four wapiti calves (19 male and 15 female) in 1993 and twenty three wapiti calves in 1994 (14 male and 9 female), between the ages of 3 and 4 months were weighed and allocated randomly to the two treatments groups which were approximately balanced by gender, weight and age. The interval group in 1993 consisted of 8 females and 7 males, whereas the abrupt group consisted of 7 females and 12 males. In 1994 there were 7 males in both the abrut and interval weaned group and 4 females in the interval group and

5 females in the abrupt weaned group. Calves were weighed, sorted and assembled into their respective treatments along with their hinds 2 weeks prior to weaning to allow time for them to establish and maintain social relationships. Each hind and her calf was fitted with color-coded collars to facilitate identification of maternal-filial pairs.

### *4.2.2 Weaning Treatments*

*Abrupt weaned* calves were separated from their dams and placed in a large pen for 1 week, they were then subsequently released into a novel paddock. The hinds were separated from the calves as far as possible within the facility (1 kilometer).

*Interval weaned* calves were released into a paddock along with their dams. Every day, two or three hinds were shifted to an adjacent paddock and then quickly to another paddock approximately 1 km away. All hinds were shifted to the adjacent paddock within 10 days and then as far away as possible within the facility (1 kilometer).

### *4.2.3 Measurements*

Calves were weighed on days 0, 14 and 21 from the date weaning began. Body weights were measured with an electronic platform scale (Western model no. DF-1000 Accurate Scale Industries, Edmonton, Alberta Canada). The groups were observed from a blind for 24 min, during morning (08:30-10:00 h), afternoon (12:00-13:30 h) and evening (16:00-17:30 h) sessions. Observations were made on all groups simultaneously by employing two observers, who alternated randomly the group observed between sessions . The activities of each group were recorded following Pollard et al. (1992). Activities of both groups were observed at 4-min intervals during the 24-min period. The group was scan sampled from left to right and the number of animals engaged in each of the following activities was recorded: standing, walking, pacing (walking parallel to, and within 0.5 m of the perimeter of the paddock or pen), lying, eating (which included both eating from a feeder and grazing), drinking or 'other' (any other activity). Audio recordings in year one were taken from a centralized and standardized location within the paddock and analyzed for the number of vocalizations by the group as well as the decibel level during the 24-min observation period. Audio recordings were not taken in 1994. All procedures were approved by the Faculty Animal Policy and Welfare Committee (FAPWC).

The calves were restrained in a squeeze and heart rate measurements and blood samples were obtained 5 days before the weaning experiment began to provide a comparative baseline. Two more samples were obtained on day 7 and day 14 after the weaning date, which varied in the interval weaned group. Immediately following the heart rate measurement while the animal was restrained, 2 drops of blood were collected in a heparinized capillary tube from a vein in the rear leg just above the hoof, from which blood smears were made on 2 glass slides. These slides were stained within 4 h of preparation, using May-Grunwald-Giemsa stain. One hundred leukocytes (lymphocyte, neutrophils, monocytes, basophils and eosinophils) were counted on each slide and the neutrophil/lymphocyte (N/L) ratios were calculated and averaged for each individual.

### *4.2.4 Analysis*

Average daily gain of calves (from 0-7 days, 7-14 days and 14-21 days), N/L ratios and heart rate data were analyzed by analysis of variance, fitting year, sex and treatment group, via the SuperANOVA© repeated measures procedure (Abacus Concepts, Inc. 1991). Initial body weight was entered as a covariate. The percentage of time each activity was recorded during each observation session was calculated for both groups. Average daily gain and behavioural data were pooled between years due to the low number of individual animals in this study. For analysis of the behavioural data, one group per year was the experimental unit.

## 4.3 RESULTS

### *4.3.1 Average Daily Gain*

There was no significant difference in average daily gain between the *interval weaned group* and the *abrupt weaned group* during week 1 (day 0-7), week 2 (day 7-14) or week 3 (day 14-21) (Table 4.1). Animals gained more in 1993 than 1994 (1993 Average daily gain (ADG)= 0.90 kg $d^{-1}$ ± .39 SE, 1994 ADG= 0.64 kg $d^{-1}$ ± .40 SE; P< .0001). Calves gained the most weight in the first week, less in the third week, and the least amount of weight during week 2 (Week 1 ADG= 0.98 kg $d^{-1}$ ± .04 SE, Week 2 ADG= 0.60 kg $d^{-1}$ ± .04 SE,and Week 3 ADG= 0.81 kg $d^{-1}$ ± .04 SE; P< .0001). In addition, animals gained more during the first week in 1993 than in 1994 (P< .0001, Figure 4.1), and male calves gained more than female calves (male ADG= 0.83 kg $d^{-1}$ ± .04 SE; Female ADG= 0.71 kg $d^{-1}$ ± .04 SE; P= 0.065).

### *4.3.2 Behaviour*

The activities of the two different treatment groups (abrupt and interval) over the 14 days of observation during both 1993 and 1994 are shown in Table 4.2. The major activity was lying, occupying approximately 70% of the time of both groups. The hard wean group spent considerably more time pacing than the soft wean group. In fact, pacing was less than 1% of the observed activity in the interval weaned group.

Vocalizations were recorded in 1993 and only for the abrupt weaned group . For the interval weaned group, vocalization was absent during all observation periods in 1993. The abrupt weaned calves were recorded for two weeks, but the calves were not heard vocalizing after 7 days. The abrupt wean calves in the initial days after weaning spent long periods pacing fences and loudly vocalizing (Figure 4.2, Figure 4.3).

**Table 4.1** Average daily gain (kg $d^{-1}$) of wapiti calves following weaning during week 1 (day 0-7), week 2 (day 7-14) and week 3 (day 14-21) in 1993 and 1994.

| | Treatment | n | Mean | Std. Error |
|---|---|---|---|---|
| Week 1 | Interval Weaned | 26 | 0.93 | 0.11 |
| | Abrupt Weaned | 31 | 1.02 | 0.09 |
| Week 2 | Interval Weaned | 26 | 0.65 | 0.06 |
| | Abrupt Weaned | 31 | 0.56 | 0.07 |
| Week 3 | Interval Weaned | 26 | 0.83 | 0.05 |
| | Abrupt Weaned | 31 | 0.79 | 0.05 |

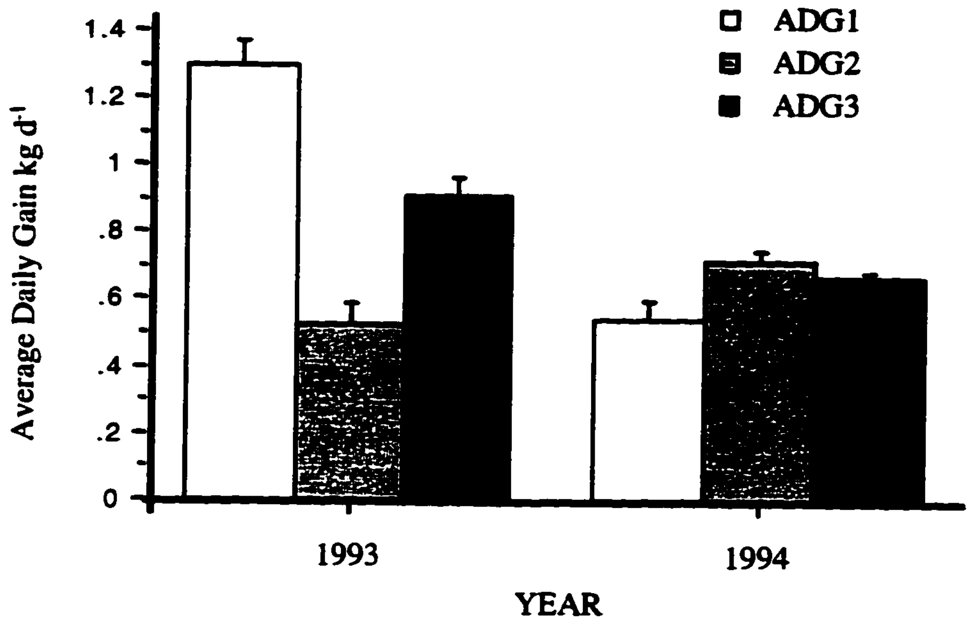


**Figure 4.1** Average daily gain (kg $d^{-1}$) of wapiti calves by year x week during the first (ADG1), second (ADG2) and third (ADG 3) week following weaning during 1993 and 1994 .

**Table 4.2** Activities of abrupt and interval weaned wapiti calves during weaning treatments over 14 days during 1994.

| Treatment | Activity (% observations) | | | | | | |
|---|---|---|---|---|---|---|---|
| | lying | standing | walking | pacing | eating | drinking | other |
| Abrupt Wean | 69.6 ± 3.0 | 9.4 ± 1.5 | 2.6 ± 0.5 | $5.7^{a}$ ± 1.4 | 12.1 ± 1.5 | 0.5 ± 0.1 | 0.2 ± 0.1 |
| Interval Wean | 73.2 ± 3.6 | 9.3 ± 1.5 | 4.2 ± 0.7 | $0.2^{b}$ ± 0.1 | 12.9 ± 2.1 | 0.2 ± 0.1 | 0.4 ± 0.1 |

Different superscript letters denotes significant differences ($P<.05$)

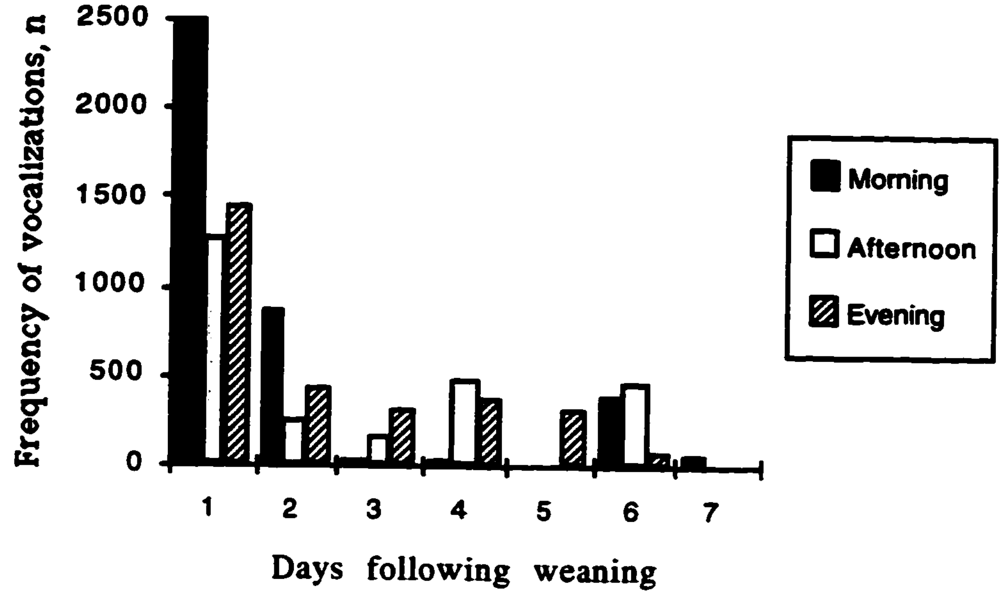


**Figure 4.2** Frequency of vocalizations (n) of the abrupt weaned wapiti calves in the days following weaning.

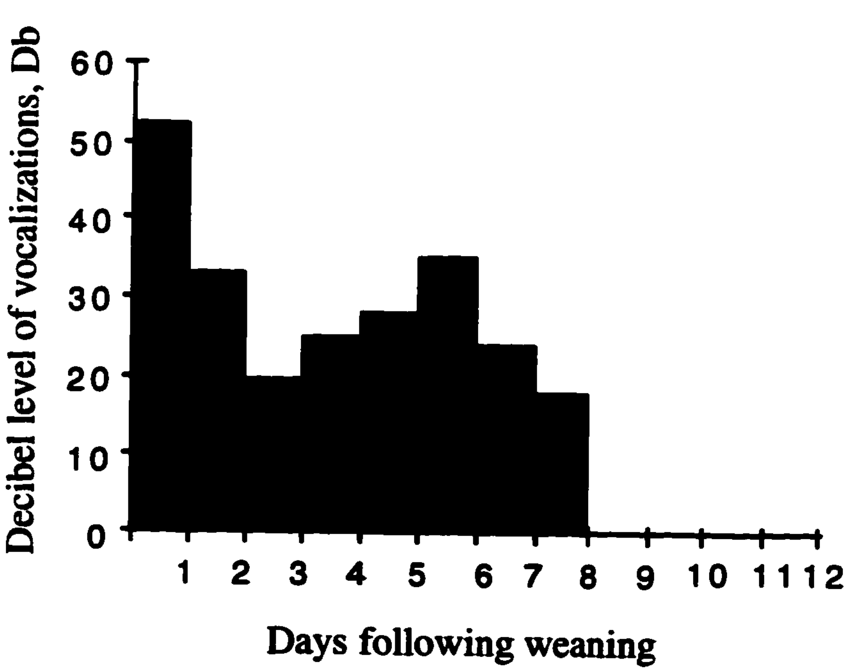


**Figure 4.3** Loudness (db) of the vocalizations of the abrupt weaned wapiti calves in the days following weaning.

### *4.3.3 Heart Rate*

There was a significant difference in the heart rate relative to the baseline measurement taken 5 days prior to weaning (Table 4.3) in 1993. The change in heart rate was higher in the abrupt weaned group than in the interval weaned group at both day 7 and 14.

### *4.3.4 Neutrophil/LymphocyteRatios*

Neutrophil/lymphocyte ratios in 1993 showed a consistent rise in animals from the abrupt weaned group (sample 1, day 7 and sample 2, day 14) whereas little or no change occured in the ratio of the interval weaned group (Figure 4.4). Also, there was an increase in individual variation as reflected in the standard error in the abrupt weaned group in the last sampling period.

## 4.4 DISCUSSION

Interval weaned calves spent less time pacing but their average daily gain was not significantly different from the average daily gain of the abrupt weaned group. The calves were sold soon after weaning so it was not possible to follow differences. Compensatory gain is well-developed in young wapiti stags (Wairimu et al. 1992) and subsequent catch-up growth would likely narrow any differences in body weight by the following spring.

Although average daily gain may not be affected, the higher N/L ratios and restrained heart rates suggest that hard weaning was more stressful. The clearest evidence was the gross behavioral difference in vocalizations and fenceline pacing. In 1993, vocalization was not observed in the *interval weaned group* but vocalization occurred in the *abrupt weaned group*. Interval weaning is therefore recommended on welfare grounds as evidenced by the neutrophil/lymphocyte ratios, but not productivity.

**Table 4.3** Heart rate deviations (beats $min^{-1}$) from the baseline measure taken prior to weaning of abrupt and interval weaned wapiti calves at day 7 and 14 after weaning.

| | Treatment | n | Mean | Std. Dev. | Std. Error |
|---|---|---|---|---|---|
| Day 7 | Interval Weaned | 26 | 8.2 | 7.3 | 1.9 |
| | Abrupt Weaned | 31 | 15.6 | 13.5 | 3.0 |
| Day 14 | Interval Weaned | 26 | 5.3 | 5.7 | 1.5 |
| | Abrupt Weaned | 31 | 10.7 | 12.7 | 2.8 |

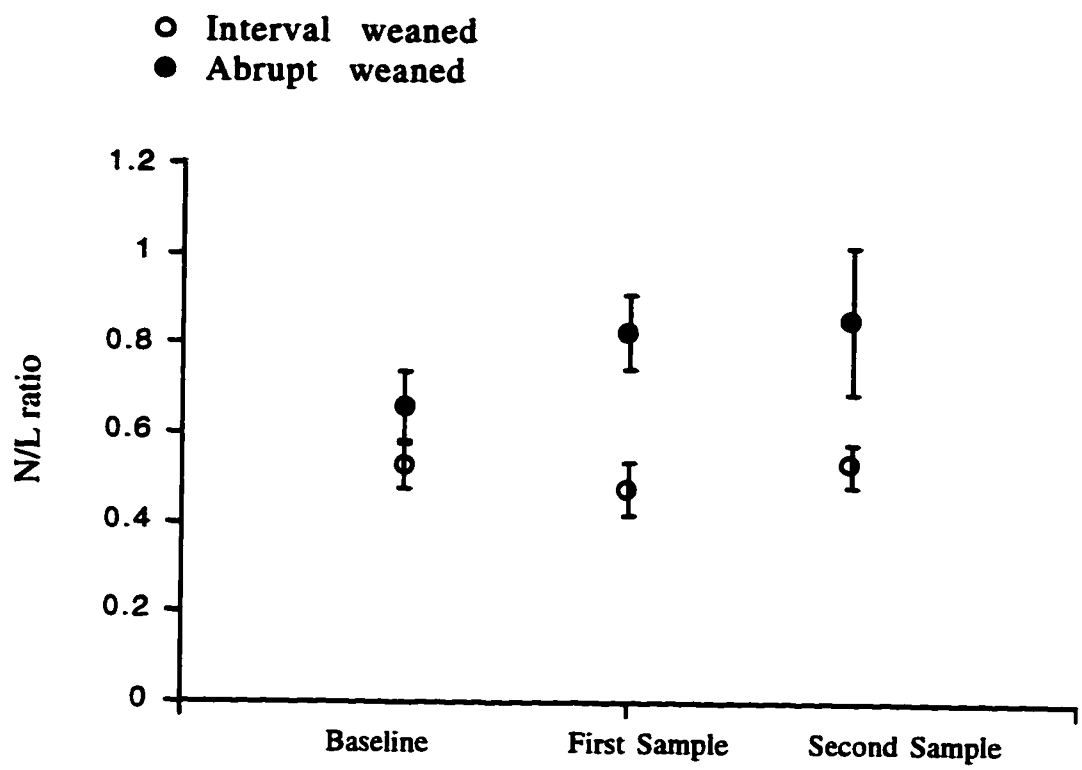


**Figure 4.4** Neutrophil/lymphocyte ratios in interval and abrupt weaned wapiti calves during a baseline measure prior to weaning and at day 7 (First Sample) and day 14 (Second Sample) following weaning. Neutrophil/lymphocyte ratios in 1993 showed a consistent rise in animals from the abrupt weaned group (Baseline, First Sample and Second Sample) whereas little or no change occured in the ratio of the interval weaned group. In addition, there was an increase in individual variation as reflected in the standard error in the abrupt weaned group in the last sampling period.

Two forces governing behavior at weaning are the filial/maternal bond and social facilitation with other members of the group. When a calf is abruptly weaned, the maternal/filial bond is quickly broken and the separation is distressing to the hind and her calf. Although individuals in the interval weaned group may have been stressed by removal of their dam, the presence of conspecifics may have dampened the impact. The behaviour of the conspecifics appears to have modified the behaviour of the individual. Abrupt weaned calves experience stress simultaneously and the stress of being separated by the dam is exacerbated empathically. In addition, remaining in a familiar environment may have served to further minimize the stress of separation from the dam as experienced by the interval weaned group.

It is important to point out, however, that due to limited numbers of animals, it was impossible to replicate this experiment within years. Larger trials with commercial cooperators are needed. Nevertheless, the results point to a promising strategy for weaning management.

### *4.4.1 Implications for producers based on this study*

Although there was not an obvious effect on liveweight gain, *interval* versus *abrupt* weaning was less stressful to wapiti calves and therefore recommended on welfare grounds. Reducing stress among calves during weaning may decrease susceptibility to stress-related diseases such as pneumonia and digestive upsets (Griffin et al. 1988, Pollard et al. 1992) through increased immunocompetence, minimize escape attempts which may increase injuries and damage to gates and fences, reduce labor and increase owner/operator satisfaction (decreased vocalizations), as well as enhance the animal care image of the industry.

**4.5 REFERENCES**

**Abacus Concepts, 1989.** SuperANOVA, Abacus Concepts, Inc., Berkeley, CA.

**Friedel, B. A. and Hudson, R.J., 1994.** Production of farmed wapiti in Alberta. Can. J. Anim. Sci., **74:** 297-303.

**Goetzl, E. J., 1985.** Neuromodulation of immunity and hypersensitivity. J. Immunol., **134:** 739-863.

**Griffin, J. F. T., Bisset, L. R. and Fisher, M. L., 1988.** Influence of management stress on immunity in farmed deer. Proc. Deer Course for Veterinarians, Deer Branch, N.Z. Vet. Assoc. **5:** 145-163.

**Gross, W. B. and Seigal, H. S., 1983.** Evaluation of the heterophil/lymphocyte ratio as a measure of stress in chickens. Avian Dis., **27:** 972-979.

**Guillemin, R., Cohn, M. and Melnechuk, T., 1985.** Neural Modulation of Immunity. Raven Press, New York.

**Haigh, J. C. and Hudson. R. J., 1993.** Farming Wapiti and Red Deer. Mosby, St. Louis.

**Murata, H., Takahashi, H. and Matsumoto H., 1987.** The effects of road transportation on peripheral blood lymphocyte subpopulations, lymphocyte blastogenesis and neutrophil function in calves. Br. Vet. J., **143:** 166-174.

**Murata, H., 1989.** Suppression of lymphocyte blastogenesis by sera from calves transported by road. Br. Vet. J., **145:** 257-262.

**Murata, H. and Hirose, H., 1991.** Suppression of bovine neutrophil function by sera from cortisol-treated calves. Br. Vet. J., **147:** 63-70.

**Plotnikoff, N. P., Faith, R. E., Murgo, A. J. and Good, R. A., 1986.** Enkephalins and endorphins: stress and the immune system. Plenum Publ. Corp., New York.

**Pollard, J. C., Littlejohn, R. R. and Suttie, J. M., 1992.** Behavior and weight change of red deer calves during different weaning procedures. Appl. Anim. Behav. Sci., **35:** 23-33.

**Wairimu, S., Hudson R.J. and Price, M., 1992.** Catch-up growth of yearling wapiti stags. Can. J. Anim. Sci., **72(3):** 619-631.

# CHAPTER 5: **Effect of abrupt vs. interval weaning on behaviour, weight gain and neutrophil/lymphocyte ratios of beef calves (*Bos taurus*)**

## 5.1 INTRODUCTION

Weaning, the forced discontinuation of nursing, is a distressing experience for most domestic animals, especially if performed before weaning would occur naturally (Houpt 1991). In modern livestock husbandry systems, animals are generally weaned earlier than they would freely choose, in order to provide separate feeding programs or to improve conception rates and/or advance breeding dates (Fraser and Broom 1990). Abrupt separation of beef calves from their dams at 8 months of age alters the circadian behaviour of calves for several days after weaning (Vessier et al. 1989). Secondly, compared to beef heifers left with their dams, weaned heifers congregate more, their activity is more sychronized and agonistic encounters are more frequent (Veissier and Le Neindre 1989). In addition, the stress imposed at weaning increases both baseline and adrenocorticotropic hormone (ACTH) - stimulated cortisol responses in beef calves of different genotypes (Zavy et al. 1992), and decreases antibody production (Gwazdauskas et al. 1978). Increased cortisol concentration has been implicated as a predisposing factor in the pathogenesis of infectious disease in cattle (Zavy et al. 1992). Increased plasma cortisol via exogenous administration of ACTH decreases antibody response to nonreplicating antigens, decreases lymphogenic response to mitogens, and depresses certain aspects of neutrophil function (Roth 1985).

When calves are faced with stress by restraint, weaning, or transport, activation of the hypothalamic-pituitary-adrenocortical (HPA) response causes an increase in circulating glucocorticoids that subsequently influences leukocyte dynamics (Griffin et al. 1988). Previous bovine research has demonstrated the effectiveness of lymphocyte blastogenesis and neutrophil function as a secondary measure of stress (Murata 1989, Murata and Hirose 1991). For example, differential leucocyte counts obtained from Holstein calves transported by road for 4h showed a leucocytosis with neutrophilia, a decrease of T-lymphocyte population, and a suppression of lymphocyte blastogenesis which are considered indicative of stress (Murata et al. 1987). In addition, these alterations all corresponded with cortisol elevation. Therefore, N/L ratios were utilized in the present study as an indicator of the stress associated with each of the respective weaning treatments.

Past attempts at trying to reduce the stress of weaning in livestock include: creep feeding (cattle: Wilson 1966, Daugherty et al. 1980, horses: McCall 1985), early handling by humans (cattle: Boissy and Bouissou 1988, Boivin et al. 1992a), housing animals indoors (red deer: Pollard et al. 1992, cattle: Boivin et al. 1994, Veissier et al. 1989), artificial rearing by humans (cattle: Boivin et al. 1992b, horses: Houpt and Hintz 1983), adding unrelated adults to a group of calves (red deer: Moore et al. 1985, Pollard et al. 1992), allowing fence line contact (horses: McCall et al. 1985), and interval weaning, in which one or a few dams are removed from the pasture over a period of time while their offspring remain with the other offspring and their dams (horses; Houpt 1991). In interval weaning, the other dams are subsequently removed, often in order of their offspring's age or weight. In this study, we investigated the effects of interval weaning on the behaviour, productivity and neutrophil/lymphocyte ratios of beef calves.

## 5.2 ANIMALS, MATERIALS AND METHODS

### *5.2.1. Animals*

The experimental cattle were crossbreds born and raised at the University of Alberta Ranch, Kinsella Alberta. A total of 55 female calves and 45 males calves and their dams were grazed in two adjacent pastures prior to weaning. They were from a synthetic (composite) breed group, with the breed composition of the herd composed of 30% Angus, 25% Charolais, 30% Galloway, and the remaining percentage provided by Hereford and other breeds. The calves in one pasture were interval–weaned, while the calves in the second pasture were abrupt–weaned. Immediately following weaning of all the calves in the interval group, all of the calves were relocated to one of six feedlot pens.

While in the feedlot, all animals were fed ad libitum twice daily after the morning and noon behavioural observation periods.

### *5.2.2. Treatments*

*Abrupt–weaned* calves (50 in total) were separated from their dams all at a single time and allocated at random but balanced by sex in one of three nearby feedlot pens. The cows were transported to a pasture away from the research station (5 km) so that there was no visual or audible contact.

*Interval–weaned* calves (50 in total) were separated from their dams (weaned) in the pasture 5 days prior to the weaning day 0 date (Oct. 28, 1994). Every day, 10 cows were quietly separated out of the paddock during morning supplemental feeding, placed on a trailer, and transported approximately 5 km away. All cows were eventually shifted out of the pasture over 5 days. When all cows had been removed from the pasture, the calves were moved into the facility feedlot and allocated randomly but balanced by sex and day of weaning into one of three pens.

Abrupt and interval–weaned calves were maintained in similar pens, except that pens with abrupt weaned calves were isolated by distance (200 meters) from pens with interval weaned calves to minimize disturbance by animals in adjacent pens.

### *5.2.3. Measurements*

Calves were weighed on day 0 (Oct. 28, 1994), the date weaning formally began, day 7 (Nov. 4, 1994) and day 14 (Nov. 11, 1994) with an electronic platform scale. The groups were observed from a blind for 24 min, during morning (08:30-10:00 h), noon (12:00-13:30 h) and evening (16:00-17:30 h) sessions over 2 weeks following weaning. The groups were scan sampled from left to right and the number of animals engaged in each of the following activities was recorded: standing, walking, pacing (walking parallel to, and within 0.5 m of the inside perimeter of the paddock or pen), lying down, eating (which included both eating from a feeder and grazing), or drinking. Animals in the interval–weaned group were also observed during the 5 days prior to weaning. Observations were made on all groups simultaneously by one of two observers. The observers alternated at random which of the weaned groups each individual observer monitored between observation sessions . The activities of each group were recorded following methods described by Pollard et al. (1992). Activities of both groups were observed at 4-min intervals during the 24-min period.

Four male calves and four female calves were randomly sampled from each of the six pens, were head restrained in a squeeze and blood samples were obtained via the caudal vein on the day the weaning experiment began. Two more samples were obtained from the same animals on day 7 and day 14. Blood samples consisted of two drops of blood collected in a heparinized capillary tube, from which blood smears were made on two glass slides. These slides were stained within 4 hours of preparation, using May-Grunwald-Giemsa stain. One hundred leukocytes (lymphocyte, neutrophils, monocytes, basophils and eosinophils) were counted on each slide and the N/L ratios were calculated and averaged for each individual.

### *5.2.4. Statistical Analysis*

Individual calf bodyweight, weight gain (from d 0-7 and d 7-14), and N/L ratios were analysed by the General Linear Models Procedure of Statistical Analysis System Institue, Inc. (1990) according to the following split-plot model:

$$Y_{ijklm} = \mu + T_i + S_j + P_{k(i)} + ST_{ij} + SP_{(i)} + W_k + TW_{jk} + SW_{ik} + STW_{ijk} + PW_{l(ij)} + e_{ijkl}$$

Where, $Y_{ijklm}$ = each dependent effect

$\mu$ = overall mean

$T_i$ = Treatment (abrupt and interval)

$S_j$ = Sex (male and female)

$P_{k(i)}$ = Pen

$ST_{ij}$ = interaction between sex and treatment

$SP_{(i)}$ = interaction between sex and pen

$W_k$ = week

$TW_{jk}$ = interaction between treatment and week

$SW_{ik}$ = interaction between sex and week

$STW_{ijk}$ = interaction between sex, treatment and week

$PW_{l(ij)}$ = interaction between pen and week

and $e_{ijkl}$ = residual error

For analysis of behavioural observations, a reduced model was used as pen rather than individual animal became the experimental unit.

$$Y_{ijkl} = \mu + T_i + S_j + ST_{ij} + W_k + TW_{jk} + SW_{ik} + STW_{ijk} + e_{ijkl}$$

Means were separated by a Student Newman Keuls test (SAS 1990).

## 5.3 RESULTS

Table 5.1 shows the body weights for the abrupt and interval–weaned calves, the gender difference, and the weight at the start of the of the trial and the subsequent weights. There was no significant difference in body weight between the abrupt and interval weaned calves. While interval–weaned calves gained more weight than abrupt–weaned calves during the first week, the reverse was true during the second week (Figure 5.1). Male calves were heavier than female calves (Table 5.1). No significant interactions were observed.

The activities of the two treatment groups over the 14 days of observation are shown in Table 5.2. Calves in both groups spent more time eating than any other activity. The interval–weaned calves spent less time standing and pacing and more time eating compared to abrupt–weaned calves. There was an interaction between treatment and time of day on time spent pacing (Figure 5.2). Abrupt–weaned calves spent considerably more time pacing in the morning and evening than the interval–weaned calves, but there

**Table 5.1** Least Squares Means of body weight (kg) of weaned beef calves

| Effect | Level | Body Weight (kg) | SEM | P |
|---|---|---|---|---|
| Treatment | Abrupt | 219.62 | 3.82 | ns |
| | Interval | 217.64 | 3.84 | |
| Sex | Female | 207.54$^{a}$ | 4.24 | 0.0001 |
| | Male | 229.73$^{b}$ | 4.69 | |
| Week | Week 1 | 213.03$^{a}$ | 0.96 | 0.0001 |
| | Week 2 | 216.93$^{b}$ | 0.96 | |

different superscript letters denote significant differences

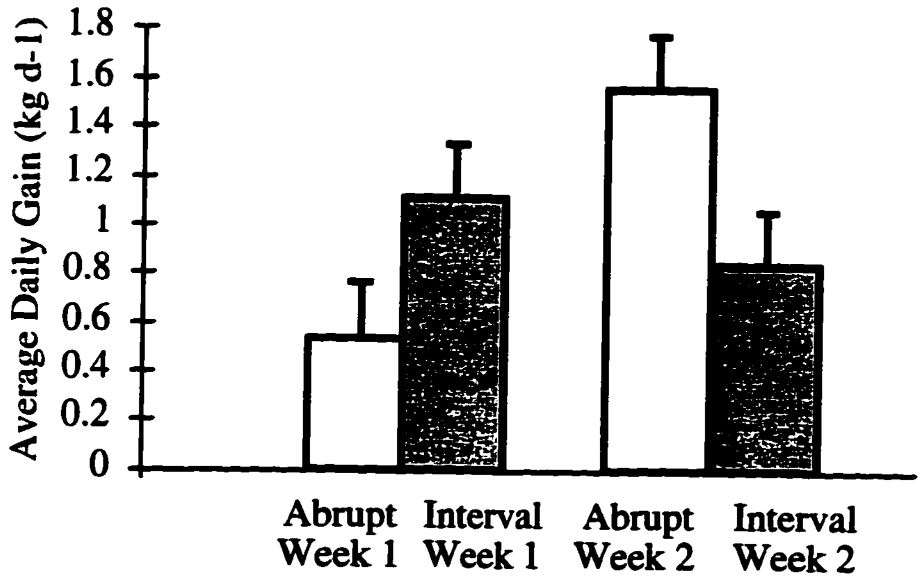


**Figure 5.1** Average daily gain (kg $d^{-1}$) of abrupt and interval weaned beef calves during the first (day 0 to day 7) and second (day 7 to day 14) week. Average daily gain was greater in interval weaned beef calves than abrupt weaned beef calves during the first week (1.11 kg $d^{-1}$ ± 0.27 SE vs. 0.53 kg $d^{-1}$ ± 0.22 SE; $P<0.05$) ; however, abrupt weaned calves had a better average daily gain compared to interval weaned calves during the second week (1.56 kg $d^{-1}$ ± 0.22 SE vs. 0.85 kg $d^{-1}$ ± 0.27 SE; $P<0.05$).

**Table 5.2** Time in minutes of observed behaviour of abrupt and interval weaned beef calves

| Effect | Level | Stand | Walk | Pace | Lying | Eating | Drinking | P |
|---|---|---|---|---|---|---|---|---|
| Weaning | Abrupt | 4.46[a] | 0.37 | 1.89[a] | 1.44 | 8.15[a] | 0.34 | 0.05 |
| | Interval | 3.12[b] | 0.27 | 0.43[b] | 2.48 | 10.00[b] | 0.31 | |
| Time | Evening | 3.48[b] | 0.23 | 1.31[b] | 3.21[b] | 8.15[b] | 0.26[a] | 0.0001 |
| | Morning | 6.48[c] | 0.44 | 1.61[c] | 0.99[a] | 6.87[a] | 0.24[a] | |
| | Noon | 1.4[a] | 0.29 | 0.53[a] | 1.68[ab] | 12.22[c] | 0.47[b] | |
| SEM | | | | | | | | |
| Weaning | | 0.29 | 0.09 | 0.36 | 0.37 | 0.45 | 0.07 | |
| Time | | 0.43 | 0.08 | 0.13 | 0.57 | 0.44 | 0.08 | |

different letters denote significant differences

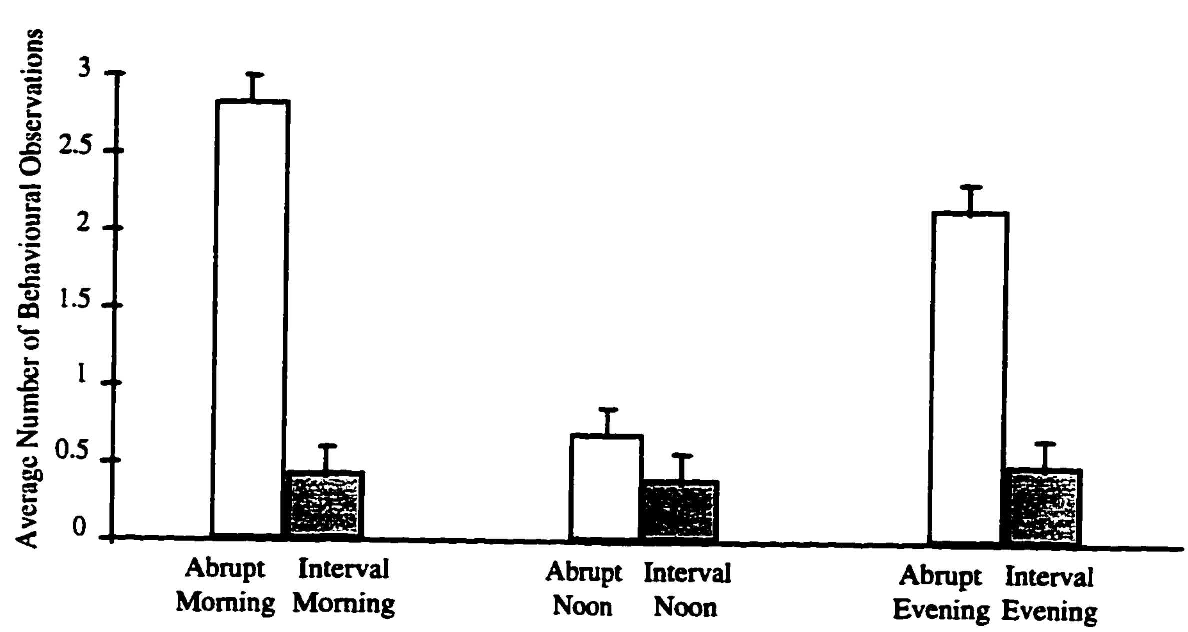


**Figure 5.2** Second order interaction between time of day and treatment with regards to pacing in weaned beef calves. Abrupt weaned beef calves paced more in the morning and evening than the interval weaned beef calves, but there was no significant difference between abrupt and interval weaned beef calves during noon behavioural observation sessions. Abrupt weaned beef calves paced most during the morning behavioural observation session.

was no significant difference between abrupt and interval weaned calves during noon behavioural observation sessions. Abrupt–weaned calves paced most during the morning. The time of day had no effect on the observation of pacing in interval weaned calves. In fact, pacing was rarely observed in the interval–weaned calves during any of the observation sessions. Prior to day 0, interval–weaned calves that were separated from their dams were monitored in the pasture, but no behavioural differences could be determined from the other calves with their dams in the five days prior to the movement into the feedlot pens.

Neutrophil/lymphocyte ratios were higher in the abrupt–weaned calves compared to the interval–weaned calves (0.81 ± .05 SE vs. 0.51 ± .05 SE; $P< 0.05$). In addition, the neutrophil/lymphocyte ratio was considerably greater in male calves than in female calves (Figure 5.3).

## 5.4 DISCUSSION

Interval weaned calves spent less time pacing and more time eating than abrupt weaned calves, but this difference did not affect body weight. While interval–weaned calves gained more than abrupt–weaned calves during the first week, abrupt–weaned calves gained considerably more than interval–weaned calves during the second week, which might be attributable to compensatory gain (Taylor 1991). Compensatory gain may have served to narrow any difference in body weight between the two treatments.

Less pacing in interval–weaned calves suggests that they were less upset during weaning than the abrupt–weaned calves. The abrupt–weaned calves often vocalized while walking the perimeter of the feedlot pen and then turned quickly and walked in the opposite direction while vocalizing. Vocalizing was rare among interval–weaned calves, but was common in the abrupt–weaned calves. Weaning treatment did not significantly affect the time calves spent lying, walking or drinking. Abrupt–weaned calves were observed standing more than interval–weaned calves. Calves often stood by the fence, looking out, presumably to re–establish contact with the dam. This was especially true in the abrupt–

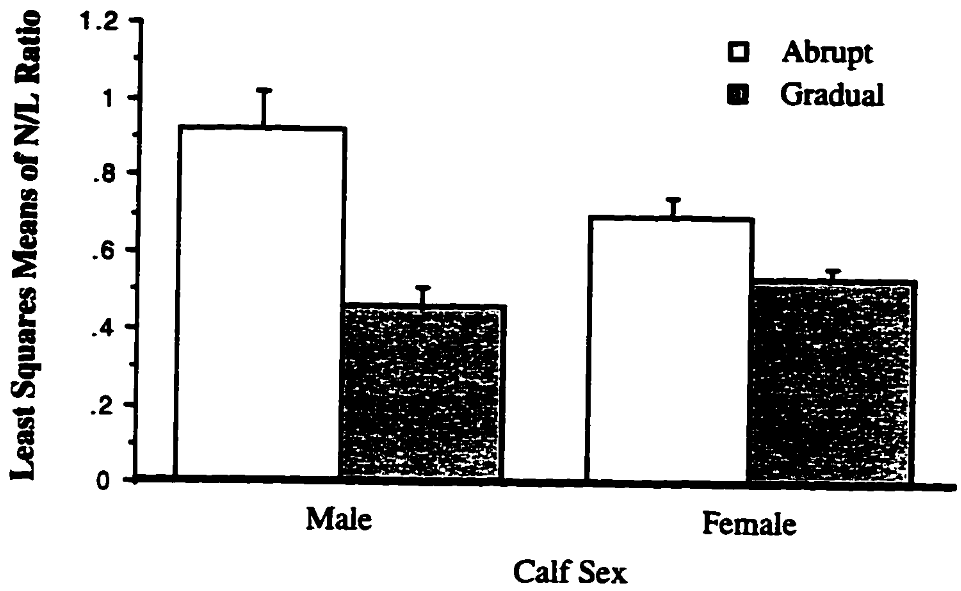


**Figure 5.3** Second order interaction for neutrophil/lymphocyte ratio between treatment and sex in beef calves. Male beef calves had higher neutrophil/lymphocyte ratios in the abrupt–weaned group compared to the interval–weaned (gradual) group (0.92 ± 0.06 SE vs. 0.47 ± 0.07 SE; $P< 0.05$), suggesting that male calves of the abrupt–weaned group were more adversly affected than female beef calves. Neutrophil/lymphocyte ratios were not significantly different between female beef calves (0.69 ± 0.06 SE vs 0.53 ± 0.06 SE; $P< 0.05$).

weaned calves. No behavioural differences were observed among the interval–weaned calves that were separated from their dam with calves that were still in contact with their dam in the five days prior to entry into the feedlot pens.

These data on the behavioural observations of abrupt and interval–weaned calves indicate that different weaning management regimes can cause behavioural differences. When subjected to abrupt weaning, calves exhibited more behavioural signs of stress than calves that were interval weaned. Two psychological forces governing behaviour at weaning include the filial/maternal bond and social facilitation with other members of the herd (Houpt 1991). Usually "Social facilitation" is a term applied to the phenomenon in which the mere presence or behaviour of another organism produces an increase in the probability, rate, or frequency of a behavioural pattern in another organism (Dewsbury 1978). However, Zajonc (1965) found that the presence of another organism can result in an interference with performance of a behaviour rather than a facilitation of it. Therefore, the presence of conspecifics may be utilized as a management tool to prevent an undesirable behaviour. When a calf's dam is removed, the filial/maternal bond is broken and the separation is distressing to both the cow and the calf. But while individual interval–weaned calves may have suffered anxiety by removal of their dam, the presence of conspecifics appears to have dampened the effect. Conversely, abrupt–weaned calves experienced the distressing separation of their dams simultaneously, and hence the stress of removal of the dam appears to be exacerbated by social facilitation. Interval–weaning is recommended on welfare grounds if not productivity.

In addition, the higher N/L ratios in the abrupt–weaned calves confirm that the abrupt–weaning of calves is more stressful than interval weaning. A reduction in lymphocytes was observed, which suggests reduced immunocompetence, and may increase suceptibility to stress-related diseases that are associated with moving calves from cow-calf operations into feedlots such as pneumonia or digestive upsets (Karren et al. 1987). Futher study is warranted to determine both the degree and duration of the of reduction in immunocompetance, and its significance in the pathogenesis of feedlot diseases such as pneumonia. Better weaning management techniques may reduce morbidity and mortality (Schipper et al. 1989).

In conclusion, the behavioural responses of calves immediately following weaning are significantly different between abrupt versus interval weaning. The inference that the behaviour observed suggests increased stress on the abrupt–weaned calves is supported by higher N/L ratios for the abrupt–weaned calves. In addition, the reduction in weight gain in the abrupt–weaned calves suggests that there may have been increased difficulty adjusting to the forced separation at weaning.

## 5.5 REFERENCES

**Boissy, A. and Bouissou, M. F., 1988.** Effects of early handling on heifers' subsequent reactivity to humans and to unfamiliar situations. Appl. Anim. Behav. Sci., **20:** 259-273.

**Boivin, X., Le Neindre, P. and Chupin, J. M., 1992a.** Establishment of cattle-human relationships. Appl. Anim. Behav. Sci., **32:** 325-335.

**Boivin, X., Le Neindre, P., Chupin, J. M., Garel, J. P. and Trillat, G., 1992b.** Influence of breed and early management on ease of handling and open-field behaviour of cattle. Appl. Anim. Behav. Sci., **32:** 313-323.

**Boivin, X., Le Neindre, P., Garel, J. P. and Chupin J. M., 1994.** Influence of breed and rearing management on cattle reactions during human handling. Appl. Anim. Behav. Sci., **39:** 115-122.

**Dewsbury, D. A., 1978.** Comparative Animal Behavior. McGraw-Hill, New York.

**Fraser, A. F. and Broom, D. M., 1990.** Farm Animal Behaviour and Welfare. 3rd Edition. Baillière Tindall, Toronoto, Ontario.

**Griffin, J. F. T., Bisset, L. R. and Fisher, M. L., 1988.** Influence of management stress on immunity in farmed deer. Proc. Deer Course for Veterinarians (Deer Branch), N.Z. Vet. Assoc., **5:** 145-163.

**Gwazdauskas, F. C., Gross, W. B., Bibb, T. L. and McGilliard, M. L., 1978.** Antibody titers and plasma glucocorticoid concentrations near weaning in steer and heifer calves. Can. Vet. J., **19:** 150-154.

**Houpt, K. A. and Hintz, H. F., 1983.** Some effects of maternal deprivation on maintenance behavior, spatial relationships and responses to environmental novelty in foals. Appl. Anim. Ethol., **9:** 221-230.

**Houpt, K. A., 1991.** Domestic Animal Behavior for Veterinarians and Animal Scientists. 2nd Edition. Iowa State University Press, Ames, Iowa.

**Karren, D. B., Basarab, J. A. and Church, T. L., 1987.** The growth and economic performance of preconditioned calves and their dams on the farm and of calves in the feedlot. Can. J. Anim. Sci., **67:** 327-336.

**McCall, C. A., Potter, G. D. and Kreider, J. L., 1985.** Locomotor, vocal and other behavioral responses to varying methods of weaning foals. Appl Anim. Behav. Sci., **14:** 27-35.

**Moore, G. H., Cowie, G. M. and Bray, A. R., 1985.** Herd management of farmed red deer. In: P. F. Fennessy and K. R. Drew, editors, Biology of Deer Production. Royal Society of New Zealand Bulletin 22, pp. 343-356.

**Murata, H. and Hirose, H., 1991.** Suppression of bovine neutrophil function by sera from cortisol-treated calves. Br. Vet. J., **147:** 63-70.

**Murata, H., 1989.** Suppression of lymphocyte blastogenesis by sera from calves transported by road. Br. Vet. J., **145:** 257-262.

**Murata, H., Takahashi, H. and Matusmoto H., 1987.** The effects of road transportation on peripheral blood lymphocyte subpopulations, lymphocyte blastogenesis and neutrophil function in calves. Br. Vet. J., **143:** 166-174.

**Pollard, J. C., Littlejohn, R. R. and Suttie, J. M., 1992.** Behavior and weight change of red deer calves during different weaning procedures. Appl. Anim. Behav. Sci., **35:** 23-33.

**Roth, J. A., 1985.** Cortisol as mediator of stress-associated immunosuppression in cattle. In: Moberg, G. P., editor, Animal Stress. Waverly Press, Baltimore. pp. 225-243.

**Statistical Analysis System Institute, Inc., 1990.** SAS user's guide: Basics and statisitics.Version 5 Edition. SAS Institue Inc., Cary, N.C.

**Schipper, C., Church, T. L. and Harris, B., 1989.** A review of the Alberta certified preconditioned feeder program - 1980-1987. Can. Vet. J., **30:** 736-741.

**Taylor, R. E., 1991.** Scientific Farm Animal Production: An Introduction to Animal Science.– 4th edition. Macmillian Publishing Company, New York, NY.

**Veissier, I. and Le Neindre, P., 1989.** Weaning in calves: its effects on social organization. Appl. Anim. Behav. Sci., **24:** 43-54.

**Wilson, L., 1966.** Comparison of early weaning, creep feeding and non-creep feeding for fall calves at the Southern Indiana Forage Farm. Purdue University, Agricultural Experiment Station, Lafayette, Indiana.

**Zay, M. T., Juniewcz, P. E., Phillips, W. A. and VonTungeln, D. L., 1992.** Effect of initial restraint, weaning, and transport stress on baseline and ACTH-stimulated cortisol responses in beef calves of different genotypes. Am. J. Vet. Res., **53:** 551-557.

**Zajonc, R. B., 1965.** Social facilitation. Science, **149:** 269-274.

# Section 2: Handling and Transportation

# CHAPTER 6: **Observations on grain consumption by bison (*Bison bison*) during animal mixing and removal**

## 6.1 INTRODUCTION

There has been a resurgence of interest in bison farming and ranching in North America (Teer et al. 1993). The bison industry is represented by a growing number of producer organizations at both the national and regional level, and producer cooperatives and organizations are involved in orderly marketing systems in response to a demand for lean red meat and a search for more sustainable forms of agriculture. As demand for bison meat multiplies, more animals will be shipped to slaughter, and the likelihood that mixing of animals will occur in lairage or in feedlots will increase.

Mixing groups is detrimental in a variety of livestock species irrespective of age or gender, and can result in economic losses (Warris et al. 1984, Moberg 1987, Mench et al. 1990), either as a direct result of injuries sustained during agonistic encounters, or as an indirect result of the endocrinological response to social stress (Kelley 1980, Moberg 1987, Mench et al. 1990) or disruption of feeding. Pollard et al. (1993) established that mixing social groups of red deer stags by confining unfamiliar stags increased heart rate, increased aggressive interactions and decreased grooming ($P<.05$). Tennessen and Price (1981) reported that mixing groups of young beef bulls dramatically increased the incidence of dark-cutting, and was indicative of increased fighting and social stress. Grandin (1980) confirmed that mixing show steers increased both fighting and incidence of dark-cutting. Mench et al. (1990) concluded that when small numbers of beef cows from different sources are mixed the alien cattle are at a social disadvantage. Mench et al. (1990) speculated that social stress on subordinate or alien cattle may be cumulative.

As one of North America's newest domesticates, the effect of mixing on bison has yet to be determined. However, observations on the behaviour and injuries incurred by bison during capture and handling in Wood Buffalo National Park (Hudson and Tennessen 1978) suggests that there is potential for profound deleterious effects. However, commercial producers have significantly improved handling systems and techniques and are working with habituated animals (Dowling 1990, Anonymous 1993).

This study was designed to evaluate the impact of mixing groups of bison bulls in feedlots on grain intake. Significant research has been directed toward effects on feed intake of varying frequency, density and form of feed, competition, and other environmental stresses in cattle (Hoffman and Self 1973, Arvae and Albright 1981, Dado and Allen 1993, Krysl and Hess, 1993, Livshin et al. 1993, Dado and Allen 1995). Research on feeding behavior of ruminants is found in a review by Baile (1981) and Stricklin and Kautz-Scanavy (1984). No similar studies have been conducted on bison. Tractability (capable of being easily handled or managed) is one of the major advantages claimed in managing domestic animals over wild animals such as bison (Stricklin and Kautz-Scanavy 1984). However, bison may have behavioural advantages over cattle in some feedlot situations. Unlike cattle, bison seldom fight when mixed when entering the feedlot (Bruce Rutley, personal communication). While no overt agonistic interactions have been observed among bison bulls during mixing, the purpose of this research was to investigate effects of mixing on grain intake.

## 6.2 METHODS

### *6.2.1 Animals*

Twenty bison bulls between 24 and 28 months of age and over 350 kg entered and exited the Bison Evaluation Unit at the Center for Agricultural Diversification, Dawson Creek, British Columbia on different dates between February 12, 1993 and May 28, 1993 (Table 6.1) and were moved into the feed-weigh station (FWS) pen. The number of animals the day after animals were moved, and the number of animals moved in or out of the pen is summarized in Table 6.2. There was no pre-set condition for which animals entered or exited, because the pen was utilized; 1) to test the use of the feed station by bison, and 2) as a holding pen to accommodate animals during a "warm-up" period prior to entering a finishing program. An additional group of 13 bulls that were not mixed arrived together on October 28, 1993 and were moved into the FWS pen and held for the same length of time to allow comparison with the mixed group of bulls.

Bulls were kept in a large pen with packed sandstone shale for footing. Dividers between the pens were page wire fence 2.15 m high with plywood hung as a visual barrier. No additional shelter was provided. They were fed a standard ration of rolled and blended oats and barley (1:1), good quality forage (fescue straw), cattle mineral and water. Grain was dispensed via the computerized FWS, forage was available from a round bale feeder, mineral was available from a standard wooden cattle mineral feeder, and city water was available from waterers.

Before entering the FWS pen, bulls were weighed and restrained in a squeeze to fit a collar carrying the transponder. Handling facilities consisted of a half-circle tub complete with three boxes, palpation cage and bison squeeze (Hi-Hog Farm and Ranch Equipment Ltd., Box 4, Site 18, R.R. 6, Calgary, AB T2M 4L5).

Upon entry into the FWS, bulls stepped onto the scales. As they approached within 16 inches of the feed bin, a sensor read the transponder attached to the collar around the bull's neck. A signal was then sent via cable to the RationMaster© Computer Control Unit (Alfa-Laval Dairy Supplies McPherson and Thom (Alberta) Ltd., 428 Moraine Road NE, Calgary AB T2W 4B5). The bull identification number, the amount of grain dispensed (set at 0.5 kg per minute), and the time of entry was automatically recorded. At midnight, the unit downloaded the data.

Daily grain consumption (24h period from midnight) was measured per individual basis. Animals that moved into an occupied pen were referred to as "aliens", whereas animals that were in the pen prior to and following the animal movement were referred to as "residents".

**Table 6.1** Entry and exit dates by 20 bison bulls into or out of the feed-weigh station (FWS) pen from February 12, 1993 to May 28, 1993.

| Entry Date | Exit Date | Animal ID |
|---|---|---|
| 12-Feb | 13-Apr | 24 |
| 12-Feb | 16-Feb | 25 |
| 12-Feb | 4-May | 27 |
| 12-Feb | 4-May | 94 |
| 12-Feb | 3-May | 103 |
| 12-Feb | 3-May | 113 |
| 12-Feb | 3-May | 149 |
| 12-Feb | 3-May | 154 |
| 17-Feb | 28-May | 54 |
| 17-Feb | 28-May | 60 |
| 17-Feb | 28-May | 95 |
| 17-Feb | 16-Mar | 168 |
| 17-Feb | 18-May | 169 |
| 17-Feb | 18-May | 170 |
| 17-Feb | 21-Apr | 171 |
| 25-Feb | 1-Mar | 90 |
| 8-Apr | 6-May | 19 |
| 8-Apr | 28-May | 23 |
| 8-Apr | 4-May | 27 |
| 8-Apr | 28-May | 240 |

**Table 6.2** Number of bison left remaining in the feed-weigh station (FWS) pen after animal movement and the number of bulls moved on days in which there was animal movement, from February 12, 1993 to May 28, 1993.

| Date | # of Animals | # Moved |
|---|---|---|
| 12-Feb | 8 | +8 |
| 16-Feb | 7 | -1 |
| 17-Feb | 14 | +7 |
| 25-Feb | 15 | +1 |
| 1-Mar | 14 | -1 |
| 16-Mar | 13 | -1 |
| 8-Apr | 17 | +4 |
| 13-Apr | 16 | -1 |
| 21-Apr | 15 | -1 |
| 3-May | 11 | -4 |
| 4-May | 7 | -4 |
| 18-May | 5 | -5 |

### *6.2.2 Statistical Analyses*

To calculate the average daily grain consumption by aliens, data for residents were not included in this analysis, and vice versa. Data were calculated and plotted using SuperANOVA (Abacus Concepts, Inc., Berkeley, CA, 1989). In all cases, we had more repeated measures on each experimental unit (individual grain consumption per day) than there were observations in the data set; therefore, the multivariate approach to repeated measures was not appropriate (correlation among observations cannot be reliably estimated) (Abacus Concepts 1989). To analyze daily grain consumption of alien and resident bison bulls as a repeated measure, the univariate repeated measures option of SuperANOVA (Abacus Concepts, Inc., Berkeley, CA, 1989) was used.

## 6.3 RESULTS AND DISCUSSION

The average daily grain consumption for the 20 animals that entered and exited the FWS pen at different dates between February 12, 1993 and May 28, 1993 is shown in Figure 6.1. Average daily grain consumption per individual declined with animal movement both in and out of the pen. Two factors may have caused this response:

1) Reduction in average daily grain consumed might be caused by a slow commencement of grain consumption by the new animals entering the pen. Potential contributing factors that may serve to reduce grain intake in new animals include: the stress of being recently handled, feeding space may be restrictive, habituating to new surroundings, the stress of establishing a new social hierarchy, and not knowing where the feed is located (learning).

2) Reduction in average daily grain consumed might be caused by a change in consumption by resident animals. If new animals enter the pen, it may serve to increase the number of agonistic interactions between animals as bulls establish a new social hierarchy. If animals are removed, the social hierarchy has to be reestablished, and animals incur the additional stress of repeated handling.

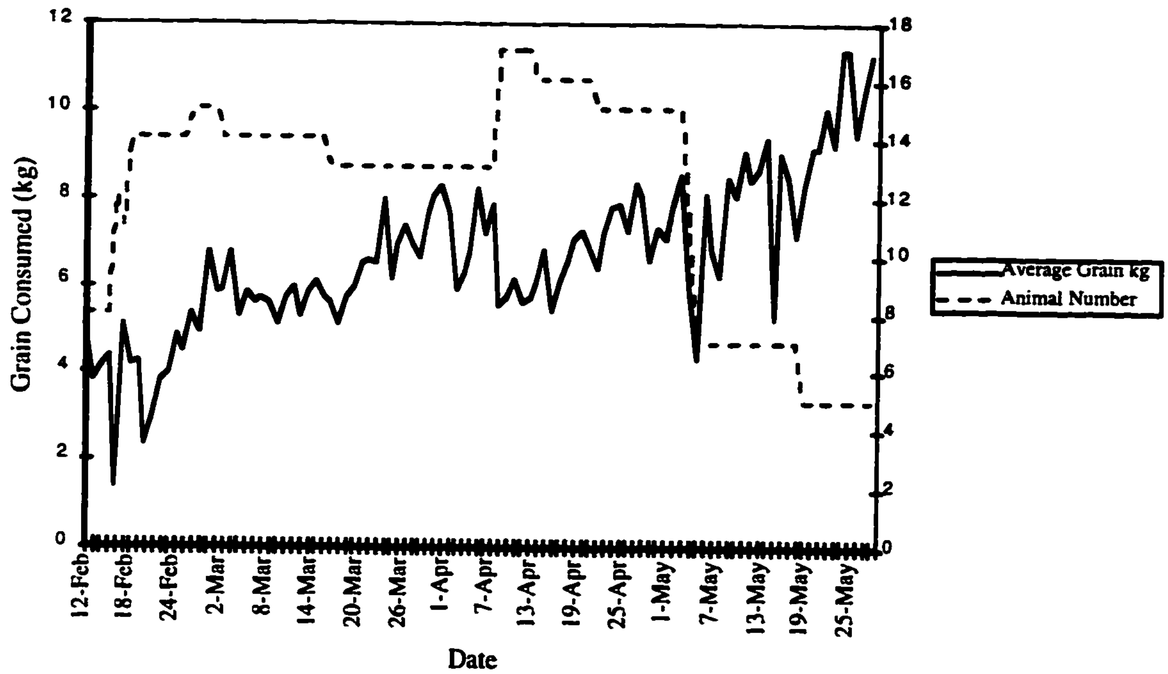


**Figure 6.1** Average daily grain consumed (kg) by the 20 bison that entered and exited the feed-weigh station (FWS) pen at different dates between February 12, 1993 and May 28 1993.

Average daily grain consumption of animals that were not mixed was more stable than animals that were mixed (Figure 6.2). A sharp drop occured on December 25 when the FWS ran out of grain, and grain consumption declines occur after January 20 as animals were removed individually for marketing.

By ignoring data from animals that were removed from the pen in the group that was mixed, and restricting analysis to the remaining animals, the effects of animal movement on resident animals can be better described. Removing one animal on February 16$^{th}$ and adding 7 aliens on February 17$^{th}$ significantly ($P< .05$) reduced average daily grain consumption of 7 residents on the day that the animals were removed (Figure 6.3). Removing one animal on March 17$^{th}$ did not significantly affect consumption on the day the animal was removed (Figure 6.4).

Adding four aliens to the pen on April 8$^{th}$ significantly affected consumption of the residents for one day (Figure 6.5). Although consumption of April 9$^{th}$ and 10$^{th}$ is reduced, it was not significantly different ($P<.05$) from the consumption on the days prior to the movement.

Removal of 4 bulls on May 3$^{rd}$ had a significant ($P<.05$) negative impact on grain consumption by residents (Figure 6.6). Movement of four additional bulls on May 4$^{th}$ provided a further insult by reducing grain consumption a second day. The double movement continued to negatively affect consumption, as consumption was significantly lower on May 6$^{th}$ and May 7$^{th}$ than May 1$^{st}$ and May 2$^{nd}$; and the removal of one animal on May 17$^{th}$ significantly ($P<.05$) reduced consumption of resident animals on the day of animal movement.

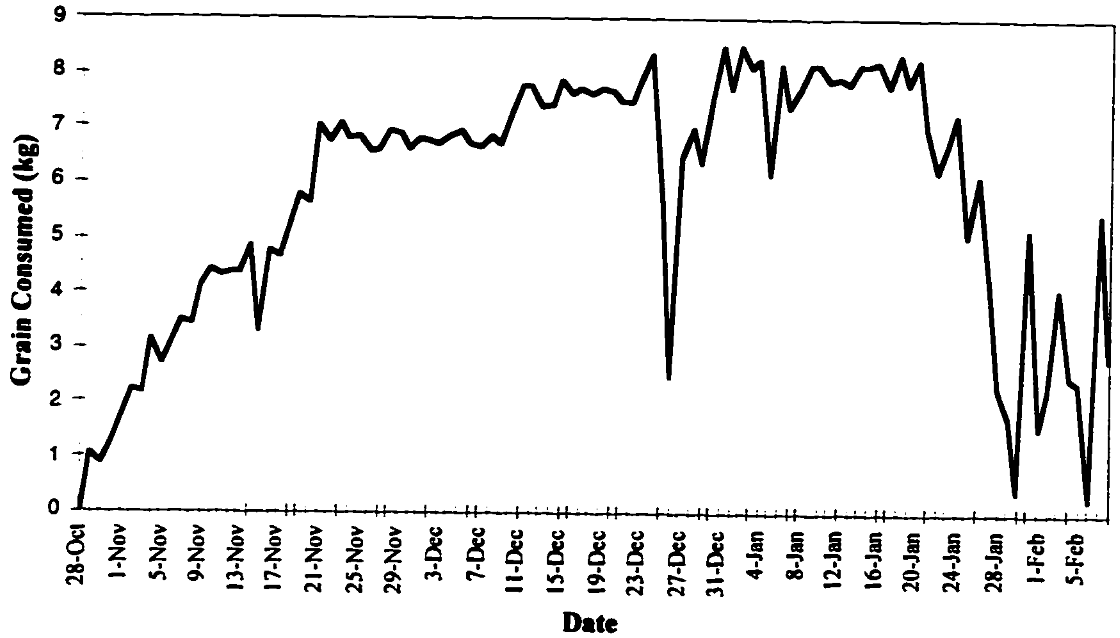


**Figure 6.2** Average daily grain consumed (kg) by bison bulls that were not mixed upon entry into the feed-weigh station (FWS) pen. A sharp decline occurs on December 25 when the feed-weigh station malfunctions.

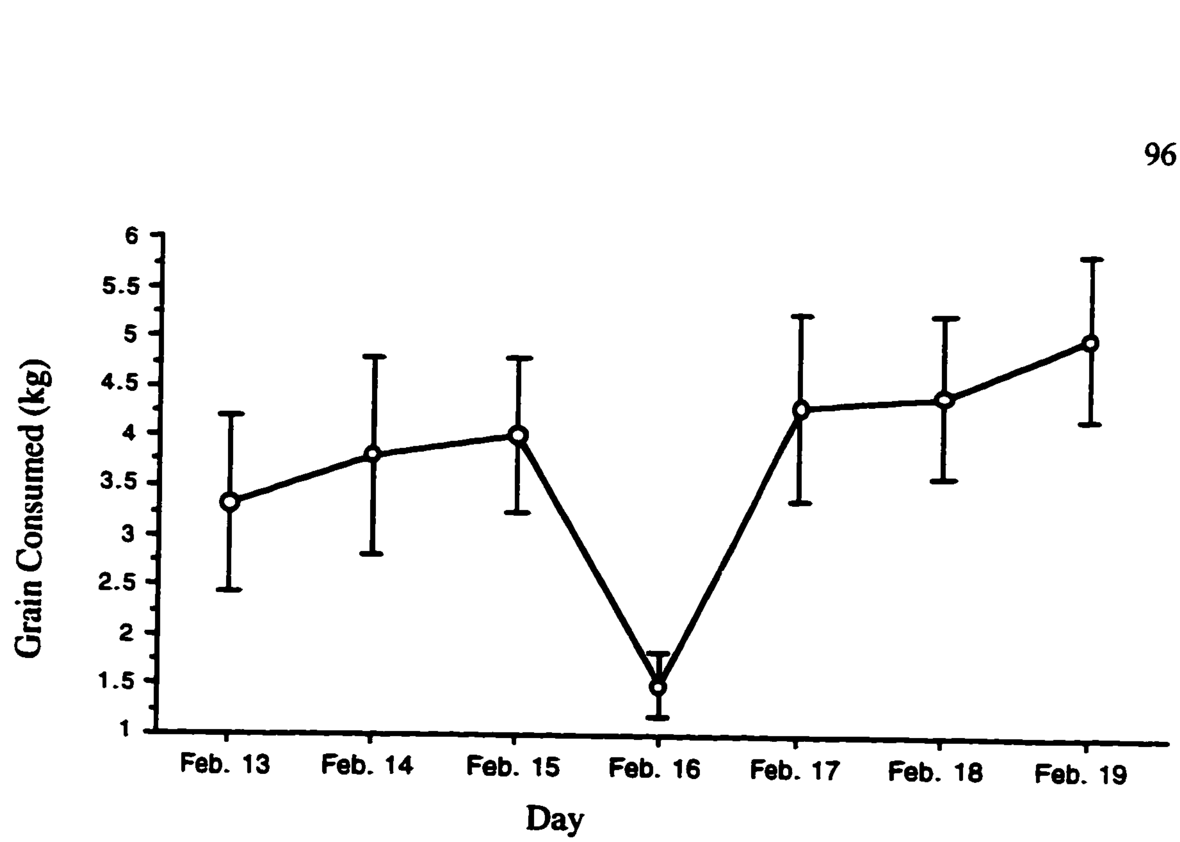


**Figure 6.3** Effects of removing one bison on February 16th and adding 7 bison on February 17th on the average daily grain consumption (kg) of seven bison within the pen both before February 16th and after February 17th.

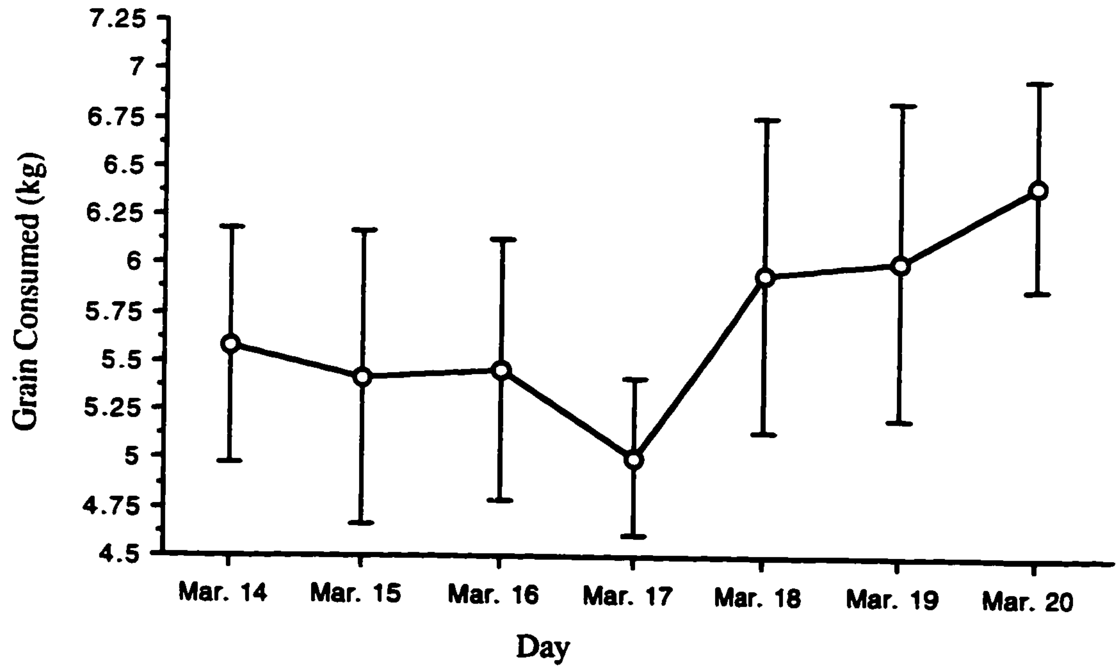


**Figure 6.4** Effects of removing one bison on March 17th on average daily grain consumption (kg) of 12 bison within the pen both before and after March 17th.

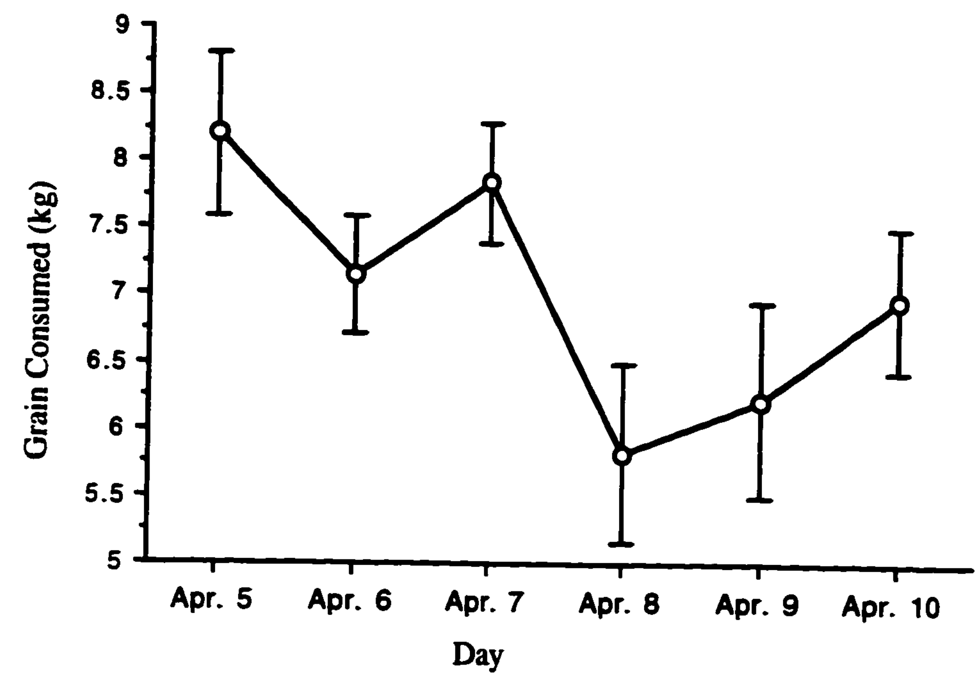


**Figure 6.5** Effects of adding four bison on April 8th on average daily grain consumption (kg) of 17 bison within the pen both before and after April 8th.

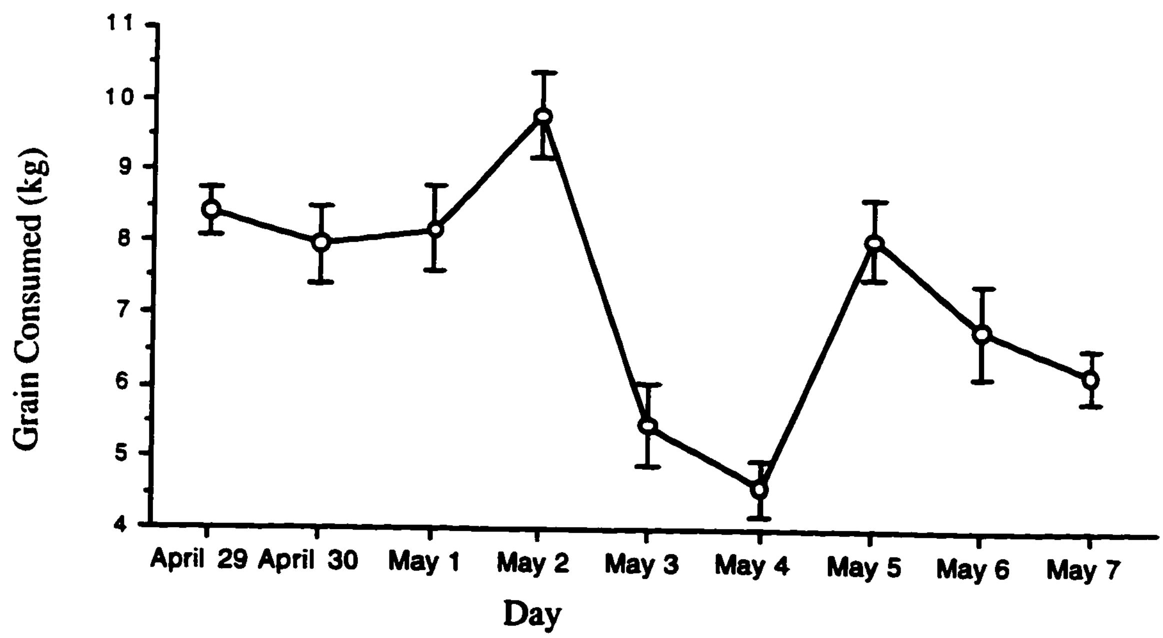


**Figure 6.6** Effects of removing four bison on May 3rd and four bison on May 4th on average daily grain consumption (kg) of seven bison within the pen both before May 3rd and after May 4th.

Together, these results suggest that removal of one animal does not always affect consumption of the remaining animals and when consumption is reduced, it tends to be restricted to the actual day of movement. However, the movement of animals on consecutive days was very detrimental to grain consumption of resident animals (Figure 6.6).

A sufficient number of animals entered the FWS pen on February 12$^{th}$ (8), February 17$^{th}$ (7) and April 8$^{th}$ (4) to facilitate comparison of the startup of animals 1) entering an empty pen and 2) when animals are already in the pen. When eight bulls first entered the pen on February 12$^{th}$, they started consuming grain sooner and consumed more grain than the seven alien animals that entered a pen of seven residents on February 17$^{th}$ and the 4 alien bulls that entered a pen of 13 residents on April 8$^{th}$ (Figure 6.7).

The number of animals that did not consume any grain during the first days of startup was higher when there were residents already in the pen (Table 6.3). On February 12$^{th}$ when bulls first entered the empty FWS pen, all animals consumed grain on Day 1, On the contrary, days in which aliens entered the pen with residents, most aliens did not consume grain.

It is concluded that introducing alien bison bulls into a pen when residents are already present results in 1) considerably longer grain startup for aliens, and 2) reduction in grain consumption for residents. Removing animals from the FWS pen resulted in further reduced grain consumption in resident animals in both the mixed and non-mixed group. We attributed this further reduction to 1) handling required to remove the animals, and/or 2) reestablishment of the dominance hierarchy. However, when animals first entered an empty pen grain consumption was considerable. These findings indicate that bison should be maintained in groups, and adding bulls to a pen of established resident bulls will reduce grain consumption and may impact subsequent productivity. Additionally, handling bison to remove individuals separately from a pen also reduces grain consumption. As feed intake is reduced, there is a strong likelihood that overall

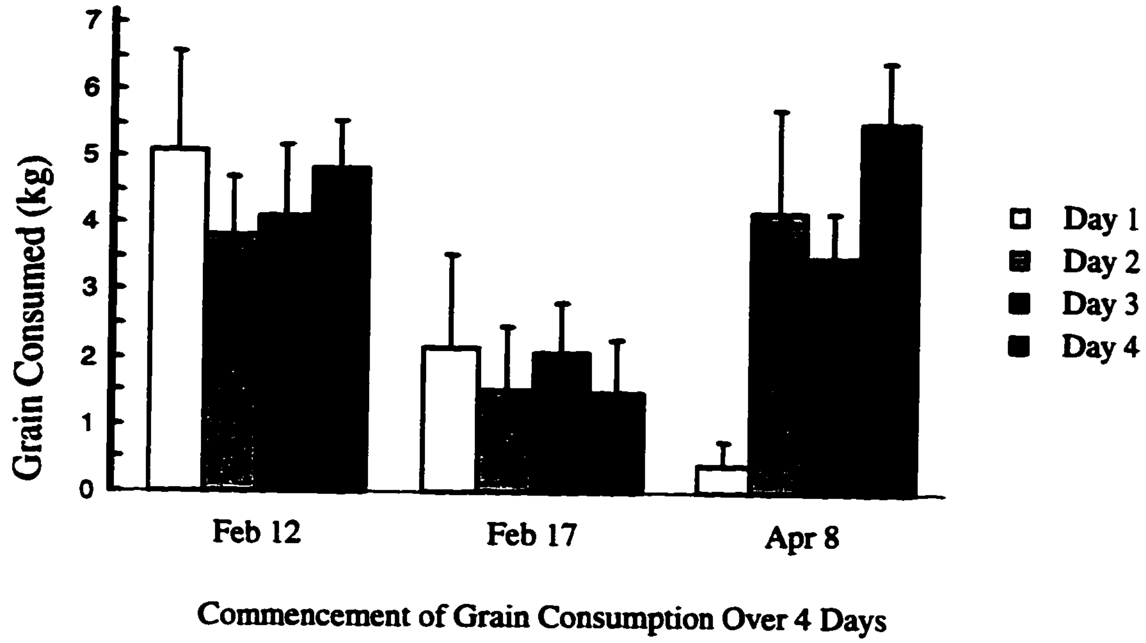


**Figure 6.7** Average grain consumption kg $d^{-1}$ during the commencement of grain consumption over four days by eight bison on February 12th, seven bison on February 17th, and four bison on April 8th.

**Table 6.3** Number of alien bison that did not consume any grain during the four days immediately following startup.

| Startup Date | # Animals moved | # Animals already in pen | Day 1 | Day 2 | Day 3 | Day 4 |
|---|---|---|---|---|---|---|
| February 12 | 8 | 0 | 0 | 0 | 0 | 0 |
| February 17 | 7 | 7 | 4 | 4 | 2 | 1 |
| February 25 | 1 | 14 | 1 | 0 | 0 | 0 |
| April 8 | 4 | 17 | 3 | 1 | 0 | 0 |

productivity will be impacted. Therefore the practice of removing bison individually as they reach a desired carcass weight for slaughter, a common industry practice, cannot be recommended. It should be emphasized, however, that these findings relate only to the social dynamics as they pertain to small groups of bison. This investigation needs to be repeated with larger pens and greater numbers of bison.

## 6.4 REFERENCES

**Abacus Concepts, 1989.** SuperANOVA, Abacus Concepts, Inc., Berkeley, CA.

**Anonymous, 1993.** Bison Breeders Handbook. 3rd Edition. American Bison Association.

**Arave, C. W. and Albright, J. L., 1981.** Cattle behavior. J. Dairy Sci., **64**: 1318-1329.

**Baile, C. A., 1981.** Nature of hunger and satiety control systems in ruminants. J. Dairy Sci., **64**: 1140-1158.

**Dado, R. G. and Allen, M. S., 1993.** Continuous computer acquisition of feed and water intakes, chewing, reticular motility and ruminal pH of cattle. J. Dairy Sci., **76**: 1589-1600.

**Dado, R. G. and Allen, M. S., 1995.** Intake limitations, feeding behavior, and rumen function of cows challenged with rumen fill from dietary fiber or inert bulk. J. Dairy Sci., **78**: 118-133.

**Dowling, K., 1990.** Buffalo Producer's Guide to Management and Marketing. National Buffalo Association. R.R. Donnelley & Sons Company, Chicago.

**Grandin, T., 1980.** Bruises and carcass damage. Int. J. Study Anim. Probl., **1**: 121-137.

**Hoffman, M. P. and Self, H. L., 1973.** Behavioral traits of feedlot steers in Iowa. J. Animal Sci., **37**: 1438-1445.

**Hudson, R. J. and Tennessen, T., 1978.** Observations on the behaviour and injuries incurred by bison during capture and handling. Anim. Regul. Stud., **1**: 345-353.

**Kelley, K. W., 1980.** Stress and immune function: a bibliographic review. Ann. Rech. Vet., **11**: 445-478.

**Krysl, L. J. and Hess, B. W., 1993.** Influence of supplementation on behavior of grazing cattle. J. Animal Sci., **71**: 2546-2555.

**Livshin, N., Maltz, E. and Edan, Y., 1995.** Regularity of dairy cow feeding behavior with computer-controlled feeders. J. Dairy Sci., **78**: 296-304.

**McHugh, T., 1958.** Social behavior of the American buffalo (Bison bison bison). Zoologica **43(1)**: 1-40.

**Mench, J. A., Swanson, J. C. and Stricklin, W. R., 1990.** Social stress and dominance among group members after mixing beef cows., Can. J. Anim. Sci., **70**: 345-354.

**Moberg, G. P., 1987.** A model for assessing the impact of behavioral stress on domestic animals. J. Animal Sci., **65**: 1228-1235.

**Pollard, J. C., Littlejohn, R.P. and Sutie, J. M., 1993.** Effects of isolation and mixing of social groups on heart rate and behaviour of red deer stags. Appl. Anim. Behav. Sci., **38**: 311-322.

**Stricklin, W. R. and Kautz-Scanavy, C. C., 1984.** The role of behavior in cattle production: a review of research. Appl. Anim. Ethol., **11**: 359-390.

**Teer, J. G., Renecker, L. A. and Hudson, R. J., 1993.** Overview of wildlife farming and ranching in North America. Trans. $58^{th}$ N. A. Wildl. & Natur. Resour. Conf., **58**: 448-459.

**Tennessen, T. and Price, M. A., 1981.** Preslaughter management and dark cutting in the carcasses of young bulls. Can. J. Animal Sci., **61**: 205-208.

**Warris, P. D., Kestin, S. C., Brown, S. N. and Wilkins, L. J., 1984.** The time required for recovery from mixing stress in young bulls and the prevention of dark cutting beef. Meat Sci., **10**: 53-68.

# CHAPTER 7: **Effect of transportation and handling stress and electrolyte therapy on neutrophil/lymphocyte ratios in cattle raised on pasture**

## 7.1 INTRODUCTION

In Canada and many other countries, cattle are raised for at least part of their lives on grassland. However, the subsequent movement of cattle from pastures, either into feedlots or slaughter facilities constitutes a substantial stressor for these animals. The result is that animal welfare may be compromised and the cattle experience substantial live and carcass weight loss. The liveweight loss experienced by cattle being moved off pasture has been reported to be approximately 5% of their body weight (Baron *et al.* 1991). Prior research has been reported to evaluate (Jones et al. 1990; Schaefer *et al.*, 1990b) and treat (Schaefer *et al.* 1990a; Gortel *et al.*, 1992) transport and handling stress in cattle primarily utilizing an electrolyte therapy program.

Increased outputs of anterior pituitary ACTH results in increased adrenal cortical steroid secretion. Continued stimulation leads to chronically high levels of corticosteroid hormones which contribute to many of the symptoms associated with long-term stress, such as cardiovascular and gastrointestinal diseases, hypercholesteraemia, metabolic derangements and modifications of immunological funcition (Seigel 1985; Khansari et al. 1990). The direct effects of corticosteroids, or the indirect effects of ACTH associated with stress on lymphoid tissues have been well documented (Doughery and White 1944; Glick 1967; Harvey et al. 1984; Seigel 1985; Khansari et al. 1990). Effects include reductions in lymphocytic tissue mass (i.e., thymus, spleen and bursa of Fabricus), depression in the number of circulating lymphocytes, and an increase in neutrophilic or heterophilic granulocytes. Wide variations are seen in the extent of leukocytosis and changes in differential numbers, perhaps reflecting the intensity of stress. Exogenous administration or endogenous release of corticosteroids is associated with predictable changes in total and differential leukocyte counts. Depending on the species, different responses are produced by the action of corticosteroid hormones on blood leukocyte dynamics. Animals with relatively high lymphocyte numbers (i.e. mice, rabbits and chickens) respond with lymphopaenia and neutrophilia, but produce a total net decrease in leukocytes, whereas animals with relatively low levels of lymphocytes (i.e. dogs, cats, horses, cattle, pigs and humans) respond with a leukocytosis attributable to neutrophilia (Blecha *et al.* 1982; Gwazdauskas *et al.* 1980). A typical response consists of neutrophilia, lymphopenia and eosinopenia (Jain 1986). WBC counts rise as a result of muscular excercise, excitement, apprehension, or emotional disturbance (Goetzl 1985; Guillemin et al. 1985) and constitutes physiologic leukocytosis. Therefore, the neutrophil/lymphocyte ratio (N/L) has been proposed as a sensitive index of chronic stress because the number of lymphocytes in blood samples decrease and the number of neutrophils increase in response to various environmental stressors which increase cortisol and corticosterone in the blood (Gross and Siegel 1983, Murata et al. 1987, Murata 1989, Murata and Hirose, 1991). The objective of the current study was to evaluate the ameliorative effect of such electrolyte therapy on the response of pasture raised cattle to transport and handling stress. Differential white blood cell (WBC) counts were used for this purpose.

## 7.2 MATERIALS AND METHODS

### *7.2.1 Animals and Management*

Sixty-two yearling crossbred steers and heifers were divided into two treatment groups and raised on barley or barley/tritcale pastures for a minimum of six weeks. The animals were divided into two treatments of 31 animals each, balanced by treatment within pasture, and received either water or electrolyte drinks free choice for 24h prior to transport. The electrolyte drinks were designed as replacement therapy for elements observed to be depleted in transported cattle (Schaefer et al. 1990a), and were manufactured and marketed by STS Agriventures (Red Deer, AB). The electrolyte solution contained (weight vol.$^{-1}$) 0.02% sodium chloride, 0.02% potassium bicarbonate, 0.01% magnesium sulfate and 0.005% each of alanine, isoleucine, leucine and valine. These metabolites were mixed in a 5% glucose solution (Feed Grade Chemicals, Hoffman LaRoche Comp., High River, Alta.), and the final solution was adjusted to pH 7 using phosphoric acid and was dispensed from 100 l plastic drums mounted above a gravity feed water bowl. Following 24h of treatment, the cattle were moved approximately 1 km into sorting yards, weighed and given a 1 hr transport in a cattle liner before being off loaded into their treatment pens. While in their pens (simulation of a sales yard), the cattle had access to their respective water or electrolyte treatments overnight (18h). The final animal liveweight was then taken the following morning.

### *7.2.2 Blood Collection and Analysis*

Blood samples were collected from animals by puncture of the jugular vein before transport, and 24 hours after transport. Whole blood was collected into 10-ml vacutainers. Blood was then collected in a heperanized capillary tube from which blood smears were made on 2 glass slides. Glass slides were stained within 4 hours of preparation, using Camco Quick Stain II (Cambridge Chemical Products Inc., FL.). White blood cell differential counts (neutrophil, lymphocyte, monocytes, basophils and eosinophils) were counted on each slide and the neutrophil/lymphocyte (N/L) ratios were calculated by dividing the number of neutrophils by the number of lymphocytes. Data were analyzed by a general linear model which included main plot effects of treatment and transportation interval. All analyses were carried out using General Linear Models Procedure of Statistical Analysis System Institute, Inc. (1985).

## 7.3 RESULTS

The cattle displayed an average daily gain of 0.43 ± 0.29 kg $d^{-1}$ and no animals were removed from the study for reasons of poor health. The liveweight loss observed in the control (water) treatment cattle post–transport was 6.7 ± 0.3% (Table 8.1) while the electrolyte treatment group experienced a 4.9 ± 0.3% weight loss or a difference of 7.2 kg ($p \leq 0.0001$).

Neutrophil/lymphocyte ratios increased when animals were transported, ratios increased ($P<0.01$) from 0.256 ± 0.02 in pre-transport values (n=59) to 0.361 ± 0.023 in post-

**Table 7.1** The effect of transport and handling on liveweight changes in yearling, pasture raised beef cattle and the influence of electrolyte therapy, least square means ± S. E.

| Animal weight loss (%) | Treatment | | |
|---|---|---|---|
| | Water (n=31) | Electrolyte (n= 31) | P |
| Transport Loss<br>(Pre-transport - Post transport (%)) | 4.53 ± 0.21 | 4.41 ± 0.21 | 0.68 |
| Lairage Loss<br>(immediate post-transport - 24 hr post-transport (%)) | 2.21 ± 0.27 | 0.48 ± 0.27 | 0.0001 |
| Total Treatment Loss<br>(pre-transport - post-lairage (%)) | 6.65 ± 0.28 | 4.87 ± 0.28 | 0.0001 |

transport samples (n=40) for all animals. However, control cattle displayed higher ($P<0.01$) pre-transport N/L ratios (0.329 ± 0.03) compared to electrolyte treated cattle (0.180 ± 0.02) (Table 7.2). The control cattle also lost significantly ($P<0.01$) more live weight (28 kg) compared to electrolyte treated animals (20.5 kg) (Table 7.1). Electrolyte therapy was effective in reducing immunological stress as evidenced by N/L ratios. However, in the current study, the majority of the ameliorative benefits were restricted to the pre-transport phase (Table 7.2).

## 7.4 DISCUSSION

Previous research conducted with bulls illustrated that handling and transportion during marketing alter fundamental acid-base and electrolyte physiology (Schaefer et al. 1990a), which results in degraded meat quality and a lower weight of carcass. The provision of electrolyte solution for consumption prior to handling and transport to slaughter modified these effects and contributed to reducing carcass shrinkage. More importantly, prior findings suggest that this weight represents not simply gut fill or hydration, but actual retention in muscle tissue (Schaefer et al. 1990a). Data from the current study suggest that the electrolyte therapy program using NutriCharge®™ was effective in reducing the weight loss in cattle moved off pasture. Economically, at an estimated $1.75/kg liveweight, the weight retained by the treated animals (7.2kg) would represent approximately $13.00 in savings over control animals and at a treatment cost of about $2.00 per animal. This research further suggests that electrolyte therapy may be useful in reducing stress in transport and handled cattle as measure by N/L ratios. In previous studies with beef cattle, white blood cell numbers and patterns have been altered as a result of weaning, transporting and adapting to a new environment (Ruppaner et al. 1978; Blecha et al. 1984; Phillips et al. 1989). Mitogen-induced blastogenesis of bovine lymphocytes has been investigated (Murata 1989). Sera collected from calves transported for four hours (Murata 1989) and in cortisol-treated calves (Murata and Hirose 1991) showed a significant suppression on blastogenesis.The decrease in the number of circulating lymphocytes and increases in polymorphonuclear white blood cells appear to be a salient indicator or measure of environmental stressors as perceived by the animal.

**Table 7.2** Neutrophil/lymphocyte ratios in electolyte therapy treated cattle and control both before and after transport, least square means ± S.E.

| N/L ratios | Treatment | | |
|---|---|---|---|
| | Water (n=31) | Electrolyte (n= 31) | P |
| Pre Transport | 0.329 ± 0.028 | 0.180 ± 0.019 | 0.0001 |
| Post Transport | 0.351 ± 0.029 | 0.368 ± 0.037 | n.s. |

## 7.5 REFERENCES

**Baron, V.S., Schaefer, A.L., Berjian, L., Morgan Jones, S.D, Young, D. G., Turnbull, I.K.S. and Dick, A.C., 1991.** Improving pasture efficiency using farm scale trials. Agriculture Canada, Lacombe Research Station, AB, Research Highlights pp. 24-25.

**Blecha, F., Barry, R.A. and Kelley, K.W., 1982.** Stress induced alterations in delayed-type hypersensitivity to SRBC and contact sensitivity to DNTB in mice. Proc. Soc. Exp. Biol. Med., **169**: 239-246.

**Blecha, F., Boyles, S.L. and Riley, J.G., 1984.** Shipping suppress lymphocyte blastogenic responses in Angus and Brahman x Angus feeder calves. J. Animal Sci., **59**: 576-583.

**Dougherty, T.F. and White, A., 1944.** Influence of hormones on lymphoid tissue structure and function. The role of pituitary adrenotrophic hormone in the regulation of lymphocytes and other cellular elements in the blood. Endocrinol., **35**: 1-26.

**Glick, B., 1967.** Antibody and gland studies in cortisone and ACTH-injected birds. J. Immunol., **98**: 1076-1089.

**Goetzl, E.J., 1985.** Neuromodulation of immunity and hypersensitivity. J. Immunol., **134**: 739-863.

**Gortel, K., Schaefer, A.L., Young, B.A. and Kawamoto, S.C., 1992.** Effects of transport stress and electrolyte supplementation on body fluids and weight of bulls. Can. J. Anim. Sci., **72**: 547-553.

**Gross, W.B. and Seigal, H.S., 1983.** Evaluation of the heterophil/lymphocyte ratio as a measure of stress in chickens. Avian Dis., **27**: 972-979.

**Guillemin, R., Cohn, M. and Melnechuk, T., 1985.** Neural modulation of immunity. Raven Press, New York.

**Gwazdauskas, F.C., Paape, M.J., Peery, D.A. and McGillard, M.L., 1980.** Plasma glucocorticoid and circulating blood leukocyte responses in cattle after sequential intramuscular injections of ACTH. Am. J. Vet. Res., **41**: 1052-1056.

**Harvey, S., Phillips, J.G., Rees, A. and Hall, T.R., 1984.** Stress and adrenal function. Exp. Zool., **232**: 633-645.

**Jain, N.C., 1986.** Schalm's Veterinary Haematology. Fourth Edition. Lea and Febiger, Philadelphia.

**Jones, S.D.M., Schaefer, A.L., Robertson, W.M. and Vincent, B.C., 1990.** Effects of withholding feed and water on carcass shrinkage and meat quality in beef cattle. Meat Sci., **28**: 131-139.

**Khansari, D.K., Murgo, A.J. and Faith, R.E., 1990.** Effects of stress on the immune system. Immunol. Today **11**: 170-175.

**Murata, H. and Hirose, H., 1991.** Suppression of bovine neutrophil function by sera from cortisol-treated calves. Br. Vet. J., **147**: 63-70.

**Murata, H., 1989.** Suppression of lymphocyte blastogenesis by sera from calves transported by road. Br. Vet. J., **145**: 257-262.

**Murata, H., Takahashi, H. and Matsumoto H., 1987.** The effects of road transportation on peripheral blood lymphocyte subpopulations, lymphocyte blastogenesis and neutrophil function in calves. Br. Vet. J., **143**: 166-174.

**Philips, W.A., Juniewicz, P.E., Zavy, M.T. and Von Tungeln, D.L., 1989.** The effect of stress of weaning and transport on white blood cell patterns and fibrinogen concentration of beef calves of different genotypes. Can. J. Anim. Sci., **69**: 333-340.

**Ruppanner, R., Norman, B.B., Adams, C.J., Lofgreen, G.P., Clark, J.G. and Dunbar, J.R., 1978.** Metabolic and cellular profile testing in calves under feedlot conditions: Minerals, electrolytes and biochemical components changes over time in feedlot. Am. J. Vet. Res., **39**: 845-849.

**Schaefer, A.L., Jones, S.D.M., Tong, A.K.W. and Young, B.A., 1990a.** Effects of transport and electrolyte supplement on ion concentrations, carcass yield and quality in bulls. Can. J. Anim. Sci., **70**: 107-119.

**Schaefer, A.L., Jones, S.D.M., Tong, A.K.W., Lepage, P. and Murray, N.L., 1990b.** The effects of withholding feed and water on selective blood metabolites in market weight beef steers. Can. J. Anim. Sci., **70**: 1155-1158.

**Seigel, H. S., 1985.** Immunological responses as indicators of stress. World Poultry Sci. J., **41**: 36-45.

**Statistical Analysis System Institue, Inc., 1985.** SAS User's Guide: Basics and Statistics. Version 5 Edition. SAS Institute Inc., Cary, N.C.

# Discussion and Synthesis

# CHAPTER 8: **Synthesis**

This thesis has evaluated through a series of five studies, the effects of production practices on the behaviour of ruminant animals (*Bos taurus*, *Bison bison* and *Cervus elaphus*) to various management techniques and procedures associated with domestication. The culmination of these studies suggests that the three ruminant species all have characteristics and abilities which allow adaptation to life as domestic animals. An adaptation is any structure, physiological process, or behavioural pattern that increases genetic fitness (Dewsbury 1978).

The calving behaviour of farmed wapiti observed and reported in Chapter 3 demonstrated that reproductive performance is not necessarily impeded by confinement, and wapiti will undoubtedly continue to maintain high fecundity rates on farms. The study did point out, however, that agonistic interactions between hinds may increase as a result of confinement. The behaviour of wapiti, specifically the drive of the parturient hind to separate from the herd, must be recognized and managed. However, the problem does not appear to preclude them from domestication

The behaviour observed when a calf's dam is removed and the filial/maternal bond is broken demonstrated that the separation is equally distressing to both wapiti calves (Chapter 4) and beef calves (Chapter 5). But in both instances while individual interval weaned calves may have suffered anxiety by removal of their dam, social influences of conspecifics appears to have dampened the effect. Conversely, abrupt weaned calves experienced the distressing separation of their dams simultaneously, and hence the stress of removal of the dam appears to be exacerbated by social facilitation. Interval weaning was recommended on welfare grounds. Both wapiti and cattle seem to have the ability to benefit from the implementation of this new husbandry practice.

The feedlot study with bison demonstrated that bison should be maintained in groups, and adding or removing bison bulls into or from a pen of established bulls will reduce grain consumption and may impact subsequent productivity (Chapter 6). Based on these results, it is recommended that bison be handled as infrequently as possible. It may prove more effective to finish bison on pasture in the future.

And finally, data collected from cattle (Chapter 7) suggest that an electrolyte therapy program was effective in reducing the weight loss in animals moved off pasture. The research further suggests that electrolyte therapy may be useful in reducing stress in transport and handled cattle as measured by N/L ratios. Even after years of close association with man, this research demonstrated that it is still possible to make substantial gains in enhancing the welfare of cattle during transportation.

The validity of the original hypothesis "Are cattle, wapiti and bison capable of being domesticated as evidenced by four unnatural or atypical events in their life: confinement calving, weaning, grouping and transportation" presented in Chapter 1 was demonstrated. All three species (cattle, wapiti and bison) are capable of being domesticated as evidenced by four unnatural or atypical events in their life: confinement during calving, weaning, grouping and transportation.

The five studies presented in this thesis successfully addressed the three general objectives that were outlined in Chapter 1:

1) All three ruminants demonstrated that they were capable of adapting both behaviourally and physiologically to life as domestic animals.

2) It was demonstrated that wapiti exhibited behaviour that is different from cattle during calving, and bison behaved quite differently from cattle in the feedlot in response to mixing, which may hinder but not rule out adaptation to life as domestic animals.

3) Neither wapiti or bison demonstrated any behavioural characteristics that would exclude them from domestication.

## 8.1 EVALUATION OF STRESS

Several different measures were used throughout this thesis to assess animal welfare. Three classes of measures were used: 1) productivity measures which included measures of reproductive performance, average daily gain, and body weight/carcass weight; 2) physiological measures which included measures of heart rate and neutrophil/lymphocyte ratios; and 3) behavioural measures which included flight distances, vocalizations, etc. Past attempts at quantifying welfare have indicated that using a variety of measures in tandem is the best approach. Reductionist science has failed to provide a single measure of animal welfare that is effective and appropriate under all situations and conditions.

Neutrophil/lymphocyte ratios appear to be a useful measure of immunological stress in adults as well as juveniles. The decrease in the number of circulating lymphocytes and increases in polymorphonuclear white blood cells appear to be a salient indicator of environmental stress in weaned calves. In addition, neutrophil/lymphocyte ratios appear to be effective in detecting reduced physiological stress in beef cattle provided electrolyte solution prior to handling and transport to slaughter, as evidenced by reduced carcass shrinkage.

Behavioural measures also were effective in detecting differences between treatments in both adults and in juveniles. Pacing can be used to determine if an animal is stressed. Pacing occurred approximately 6 hours before the onset of parturition, an obvious stressor for the dam, and may represent an attempt to seek isolation. Abrupt weaned calves also paced the fenceline in a manner which was very similar to the observed pacing of adult animals during calving. However, in this instance this behaviour is most likely indicative of a strong drive to reestablish contact with the dam. In addition, when animals were weaned there tended to be a reduction in eating immediately following weaning. A comparable absence in eating occurred in adult bison when mixed in the feedlot. Emotional disturbance as a result of changing group dynamics resulted in reduced food consumption in both adults and juveniles. Both reduced food consumption and pacing may indicate reduced or compromised welfare.

## 8.2 ACADEMIC CONSIDERATIONS

Social facilitation was thought to play an important role in many of the experiments and was illustrated in both adult and juvenile animals and between the three different species. Social facilitation occurs when the behaviour of an animal has a stimulatory influence on the desire and ability of its social partners to perform such behaviour. Usually "Social facilitation" is a term applied to the phenomenon in which the mere presence or behaviour of another organism produces an increase in the probability, rate, or frequency of a behavioural pattern in another organism (Dewsbury 1978). However, Zajonc (1965) found that the presence of another organism can result in an interference with performance of a behaviour rather than a facilitation of it. Therefore, the presence of conspecifics may be utilized as a management tool to prevent an undesirable behaviour. The effects of social facilitation were amply elucidated during the weaning experiments. When calves (beef and wapiti) were interval weaned, the maternal/filial bond was abruptly broken, and the separation was undoubtedly distressing to the calf, but social influences appear to have reduced the impact of the separation. When a calf's dam is removed, the filial/maternal bond is broken and the separation is distressing to both the cow and the calf. But while individual interval–weaned calves may have suffered anxiety by removal of their dam, the presence of conspecifics appears to have dampened the effect, as evidenced by an absence of pacing and favorable neutrophil/lymphocyte ratios. Conversely, abrupt–weaned calves experienced the distressing separation of their dams simultaneously, and hence the stress of removal of the dam appears to be exacerbated by social facilitation. In addition,the observations of the bison under feedlot conditions suggest that bison feeding behaviour might be highly coordinated or affected by social facilitation. Bison are commonly recognized as being highly gregarious (McHugh 1958).

Hand rearing is an effective way to tame wapiti, as demonstrated in Chapter 3. Hand–reared hinds had shorter flight distances to approaching humans, making them more easy to manage. However, by ten years of age, the flight distance of the animals was similar regardless of their rearing experience, which suggests that the animals habituate or adapt to humans and confinement over time. A wide variation in ease of handling exists in both wapiti and bison, and there is no doubt that genetic selection for quiet animals will result in animals that are more easy to manage. Furthermore, calves born to wapiti hinds with a large flight distance stood sooner than calves whose mothers had a small flight distance. This probably reflects the behaviour of the dam at birth rather than the viability of the calf. The rearing experience of the calf, be it through hand–rearing by humans or through modification of the calf's behaviour by the dam, and the calf's experience at weaning probably will have an impact on the manageability of the animals in the future.

Mixing bison in feedlots and transporting beef cattle to slaughter resulted in reductions in grain consumption and reduced carcass quality respectively. The handling of both bison and cattle for the purpose of marketing alters the fundamental acid–base and electrolyte physiology which may result in both degraded meat quality and a lower weight of carcass. Often this body weight represents not simply gut fill or hydration but reduction in muscle tissue. However, the provision of electrolyte solution for consumption prior to handling and transport to slaughter in beef cattle ameliorated many of these effects and reduced carcass shrinkage. Reducing the mixing of bison upon entry into a feedlot and the provision of electrolyte therapy to cattle prior to transport are just two preventative management techniques which should prove beneficial and pay dividends when sending animals to slaughter.

## 8.3 SPECIES SPECIFIC DIFFERENCES AND SIMILARITIES

Many different elements were determined to have a positive influence on the management of cattle, bison and wapiti. These included: interval weaning (cattle, wapiti), electrolyte therapy (cattle), maintaining stable groupings (bison), and bottle–rearing (wapiti). The effectiveness of these techniques is indicative of the ability of the three different ruminants to adapt to the different husbandry. All three livestock species were shown to posses production traits that enable them to be utilized as domestic animals, and no specific characteristics were found that precluded any animals from the process of domestication.

There were similarities and differences between cattle and the two alternative livestock species. When a new management technique during weaning was employed with both cattle and wapiti several similarities emerged. First, in both cattle and wapiti there was no significant difference in average daily gain. Secondly, in both species the abrupt or "hard" weaned group spent considerably more time pacing and less time eating than the interval or "soft" weaned group and vocalization was rare among interval-weaned calves, but was common in abrupt weaned calves. And finally, neutrophil/lymphocyte ratios confirmed that abrupt weaning is stressful and may reduce the immunocompetence in both species.

For all of their similarity, substantial behavioural differences were observed between cattle and the two alternative livestock species. Upon impending calving, cattle avoid conflicts with conspecifics, even with animals that are lower on the social hierarchy. Wapiti were completely different with regards to increased agonistic interactions during parturition. Aggression towards conspecifics definitely increased, and may have been heightened by confinement. Another substantial difference was that bison seldom if ever fight when mixed in the feedlot, a frequent occurrence when cattle are mixed. There are also some basic biological differences between cattle and the two new domesticates which should be considered. Both bison and wapiti undergo a rutting season, which should be taken into careful consideration during reproductive management of the two species and during the finishing of the animals to slaughter. However, none of these differences would preclude either of these two alternative livestock species to domestication.

Both wapiti and bison, not unlike cattle, are productive in terms of both reproductive performance and in average daily gain under commercial settings. Reproduction of alternative livestock did not appear impeded by intensive rearing. Wapiti generally first bred as yearlings and produced their first calf at two years of age. The calving rate in adult animals was very high (91%), however the calving rate in heifers was considerably lower (52%). The lower calving rate in heifers may be related to the fact that very few heifers are afforded the opportunity to give birth in the wild as most don't seem to reach the necessary body weight (200 kg). Selection for better reproductive performance in heifers may one day be desirable, but the effects on long term reproductive performance may offset any short term gains. Bison are productive and economically viable in a commercial setting, however their rate of average daily gain falls short of that of most commercial cattle. That result is to be expected, as no selection for rapid growth has occurred in bison prior to attempts at domestication. There is little to be gained in the wild by growing at exceptionally fast rates. The ability of bison to quickly adapt to a computerized feed–weigh station compared to the more conventional and industry standard self–feeder; suggests that bison have the ability to quickly adapt to new opportunities during different husbandry practices. And finally, the rates of average daily gain of the wapiti calves compared to beef calves in the weaning experiments were very similar. Whether the similar rates of average daily gain hold true for the rest of the year remains to be seen.

Wapiti are often referred to as "the adaptable ungulate" because they are found in extremely diverse habitats throughout North America. This ability of wapiti to adapt to a variety of different environments should prove beneficial in attempts at commercialization and domestication.

Neither bison nor wapiti were judged to posses inherent species–specific characteristics that preclude these animals from the process of domestication. The implication from this research is that contemporary experiments with domestication should not be approached with pessimism that because they are wild ruminants they are unsuited to husbandry. If an attempt is warranted economically and ecologically, then success probably depends more on the flexibility and suitability of the management systems employed. Any behavioural abnormalities that do arise are more likely to be a result of unsatisfactory husbandry techniques than any failure in the ability of the animals to adapt to life as domestic animals.

## 8.4 FINAL CONCLUSION

The popularity of alternative livestock (bison and wapiti) products, the number of animals being raised on farms and the number of new farms all continue to increase rapidly. This is perhaps the best evidence that these two ruminants are very adaptable to life as domestic animals. Presently, few studies have examined the performance of alternative livestock in North America under either intensive farm or more extensive ranch conditions. The research presented in this thesis has provided some basic industry benchmarks in terms of reproductive performance and average daily gain which will prove valuable in the future.

In addition, researchers have undertaken very few behavioural studies of development in cattle and other ruminants. Despite the detailed knowledge about growth rates in these food-producing animals, very little is known about the daily activity of young ruminants or how their relationships to their environment and their peers change with maturity. Young ruminants are born in an advanced state of development; they are true precocial animals. They can stand and walk within a few hours of birth and can apparently see and hear. The drastic changes that take place in management of young ruminants such as weaning often result in much higher incidences of infectious disease. The research conducted in this thesis has demonstrated that different weaning management regimes can cause behavioural differences with positive welfare implications. The role of stress in the etiology of neonatal pneumonias and diarrheas remains unknown. The economic value of alternative livestock dictates that more information is needed on their behavior in both naturalistic and highly artificial environments in order to best advise those who undertake commercial operations.

Historically, certain animal traits have favoured domestication (Tennessen and Hudson 1981). Domestic animals tend to be large (>50 kg), non-selective feeders occupying open and montane habitats. They are socially advanced non-territorial species, typically occuring in groups of 15–100 animals. Wapiti and bison both meet all of these criteria. In addition they fulfill all of Mason's (1984) criteria with one exception, they have not yet been selected away from the wild type. It has become clear that domestic animals, including beef cattle, were developed to fulfill needs such as the production of animal fat as a source of energy, and they have also reflected the ecological biases of our agricultural system. Throughout history as man's economic needs have changed, so have the animals upon which man has relied. Bison and wapiti meat are currently viewed as popular low–fat alternatives, that demand premium prices. History dictates that species are selected or abandonded on the basis of whether their food/habitat requirements provide an efficient mode of exploitation under the prevailing economic system (Jarman 1972, Tennessen and Hudson 1981). Both wapiti and bison should do well in a system that is no longer prepared to pay a premium for animal fat, rewards sustainable agriculture, and is increasingly environmentally conscious. In addition, selection is already occuring among wapiti and bison for economically important traits such as increased antler and body size. It is likely that over time both species will be selected away from the wild type, and one day become true domestic animals. Currently, wapiti and bison both demonstrate some behavioural differences from domesticated cattle, but with proper management that accommodates the welfare needs of the animals, alternative livestock like wapiti and bison can adapt well to life as domestic animals.

## 8.5 REFERENCES

**Dewsbury, D. A., 1978.** Comparative Animal Behavior. McGraw-Hill, New York.

**Jarman, M. R., 1972.** European deer economies and the advent of the Neolithic. In: E. S. Higgs, editor, Papers in Economic Prehistory. Cambridge, pp. 125–147.

**Mason, I. L., 1984.** Evolution of Domesticated Animals. Longman Group Limited, New York.

**McHugh, T., 1958.** Social behaviour of the American Buffalo (Bison bison). Zoologica **43:** 1-40.

**Tennessen T. and Hudson, R. J., 1981.** Traits relevant to domestication of herbivores. Appl. Anim. Ethol., **7:** 87-102.

**Zajonc, R. B., 1965.** Social facilitation. Science, **149:** 269-274.