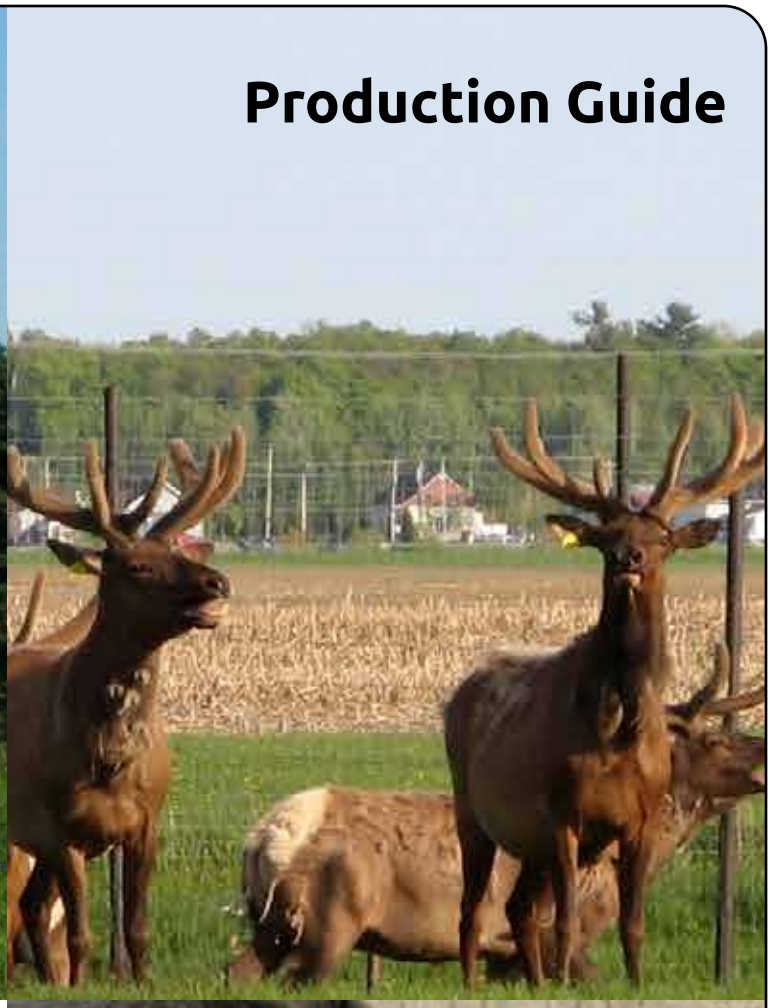

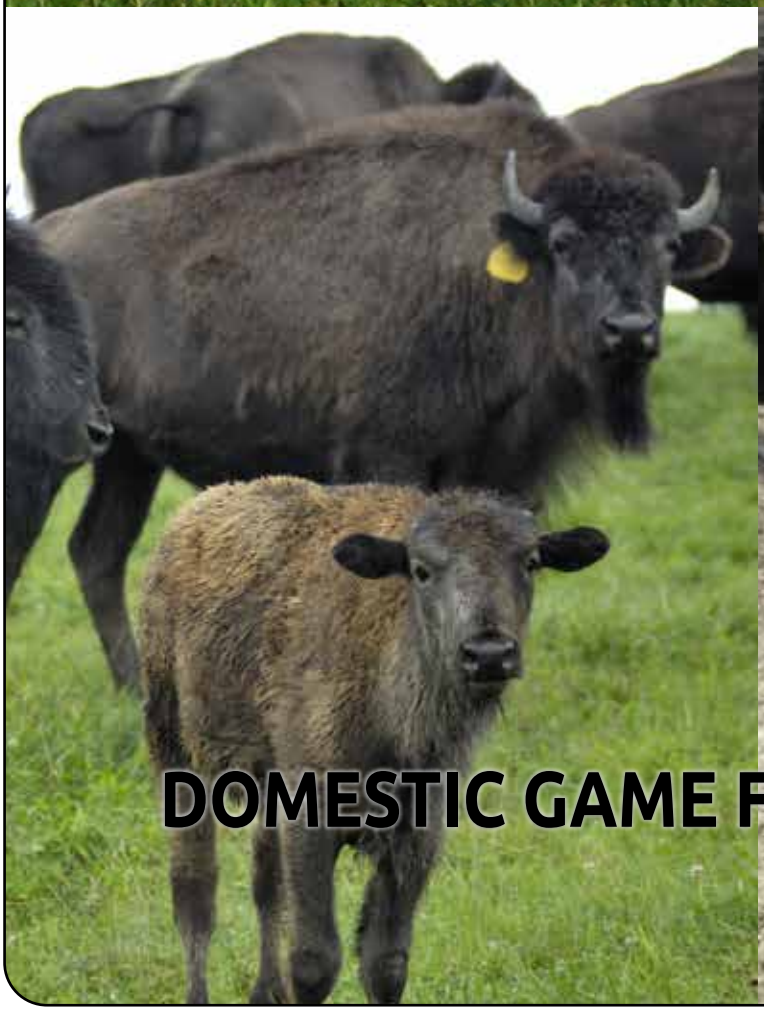

Production Guide

DOMESTIC GAME FARM ANIMALS

CRAAQ

CULTIVER L'EXPERTISE
DIFFUSER LE SAVOIR

Notice

At the time of writing, the information contained in this collection of 21 factsheets was considered representative of knowledge about the farming of large game animals. The reader bears full responsibility for any consequences that may arise from using it. Since some of the information may have evolved significantly since these factsheets were written, the reader is invited to verify its accuracy before putting it into practice.

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Production Guide

DOMESTIC GAME FARM ANIMALS

Introduction to Game Farming

CRAAQ

CULTIVER L'EXPERTISE
DIFFUSER LE SAVOIR

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Juan Pablo Soucy (red deer and wapiti)
© **Etienne Boucher**, MAPAQ (bison)
© **Michel Langlois**, MAPAQ (wild boar)

INTRODUCTION

Large game animals have been raised in Quebec since the 1980s. By 2011 there were over 208 owners of large game animals in the province (Table 1), of whom 140 had more than 10 females.

Table 1. Number of big-game owners[1] by species

	Bison	Red deer	Wapiti[2]	Wild Boar
Number of owners	50	73	45	40

1. An owner is a person who has declared at least one female of a large game species, regardless of whether other species are also present. Source: *Fichier d'enregistrement des exploitations agricoles*, MAPAQ, 2011.
2. Outside of Québec, wapiti are usually called "elk".

As in other farm sectors, the start-up process for a bison, red deer, wapiti or wild boar farm should be systematic and well structured. At several points one can either carry on or decide to stop with no harm done. One can choose between purchasing a few animals for **hobby farming** or working to develop a **commercial operation**. Commercial undertakings in particular demand thorough preparation, including a business plan, technical and economic planning, learning about animal husbandry, nutrition, genetics and reproduction, and groundwork on marketing—especially since the bills will have to be paid from business earnings.

The main generators of income are:

- sale of venison products;
- agri-tourism (farm visits, etc.);
- sale of breeding stock;
- sale of velvet antlers (deer);
- hunting (game ranches).

NINE STEPS TO SETTING UP A GAME FARM

Step 1. Self-assessment: Do you have the skills to succeed as a producer in this industry?

Game farming doesn't just mean looking after a herd. There are many other skills to develop and hone – a game farmer wears many hats!

Producer[1]

Raising livestock requires solid production knowledge, a certain know-how, and a willingness to work whenever needed. Game farmers must understand their animals' behaviour, paying attention to their needs to get the best performance possible.

Entrepreneur

An entrepreneur is well organized and resourceful, has good planning skills and is able to react quickly to the unexpected. Every farm has ups and downs, and producers must be able to deal with them. Price drops, low production volumes, problems with disease… To succeed, preparation is essential, as is the ability to adapt to new challenges – and especially, never give up.

Manager

Keeping costs in check, regularly assessing productivity, culling unproductive animals… Good management skills are essential, for without them operations will be inefficient. Every activity (purchase of inputs, product sales, etc.) must be planned, and every decision will have a direct impact on the success of the business.

Businessperson

To satisfy the target clientele, producers need to be well organized, must know how to negotiate, be able to adapt, and ensure the best service they can. A farm's success is directly tied to its earnings. **Marketing must be a top priority whenever decisions are being made.**

1. Before plunging into intensive livestock production, it's best to gain experience by starting out with a small herd. This gives the producer a chance to test his or her interest, while developing a better grasp of the synergy between processes: production, slaughter, processing and distribution.

Step 2. Exchanges and networking with other industry stakeholders

It goes without saying that big game production today requires management skills in nutrition, genetics, reproduction and marketing. This diverse expertise, acquired over many years, is intrinsically linked to a producer's professional network. To start off on the right foot:

- visit existing farms, not only to see herds, but also to take note of different types of facilities. Chat with producers who are already in business, perhaps gleaning advice on purchasing animals, to avoid possible missteps;
- present the project to family and friends and to future potential meat buyers;
- meet with local butchers, grocers, restaurant owners and consumers to better understand their needs and the different markets for specialty game meat;
- meet with a business start-up advisor at the nearest *Centre local de développement* (CLD), plus an agronomist with a production-management background, to lay the groundwork for the future business;
- meet with the livestock advisor of the nearest MAPAQ (*ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec*) office to obtain information on financial assistance programs, among other things;
- find out about local veterinary services with experience in the species you want to raise.

Step 3. Be informed: Regulations, standards and obligations affecting livestock operations

There are certain legal and administrative regulations that every producer must know and respect, including the following.

Regulation respecting animals in captivity

This Regulation falls under the *Act respecting the conservation and development of wildlife*. Red deer, wapiti, bison and wild boar may be kept in captivity without a permit, under certain conditions. If however they are kept for hunting purposes, producers must apply to the MAPAQ for a game ranch permit. Conditions and obligations related to the permit are described in Division IX of the Regulation, which can be found at: http://www.canlii.org/en/qc/laws/regu/rrq-c-c-61.1-r-5/latest/rrq-c-c-61.1-r-5.html.

Sections 3 and 4 of the Regulation outline the general obligations of any person who keeps an animal in captivity (shelter, water, food) as well as those on humane slaughter. Sections 8 to 12 set out responsibilities related to pens and perimeter fencing, with the obligation to promptly notify a wildlife protection officer on discovering that an animal has escaped.

Regulation respecting the identification and traceability of certain animals (Animal Health Protection Act)

The permanent identification of cervids with a chip tag and bar code tag, with a few exceptions specified in the Regulation (http://www.canlii.org/en/qc/laws/regu/rrq-c-p-42-r-7/latest/rrq-c-p-42-r-7.html), is

mandatory in any herd with 6 or more cervids. Set up to enable swift action in the event of a food safety or animal health problem, the traceability system is managed, in Québec, by *Agri-Traçabilité Québec*. For more information, see: http://www.atq.qc.ca.

Agricultural Operations Regulation

Falling under the *Environment Quality* Act, the *Agricultural Operations Regulation* is aimed at protecting the environment, particularly water and soil, against pollution caused by certain agricultural activities. It sets out general obligations regarding livestock waste; describes design standards for raising and storage facilities; and lists situations in which an authorization certificate must be requested from, or project notice given to, the *ministère du Développement durable, de l'Environnement, de la Faune et des Parcs* (MDDEFP). To consult the Regulation, see http://www.canlii.org/en/qc/laws/regu/rrq-c-q-2-r-26/latest/rrq-c-q-2-r-26.html.

Would-be livestock producers must also submit a project notice to municipal authorities to obtain the necessary authorizations, notably in regard to distances from wells and neighbours.

Registration of agricultural operations with the MAPAQ

Qualifying as a producer with the MAPAQ has several advantages, including access to government support programs. To qualify, an operation must generate (or be expected to generate) farm revenues of at least $5,000. For more information (in French only), see http://www.mapaq.gouv.qc.ca/fr/Productions/enregistrement/Pages/enregistrement.aspx. The regulation requiring registration may be consulted at http://www.canlii.org/en/qc/laws/regu/rrq-c-m-14-r-1/latest/rrq-c-m-14-r-1.html. First-time applicants should contact their regional service centre (see http://www.mapaq.gouv.qc.ca/fr/Regions/Pages/Carte.aspx).

Standards and obligations regarding cutting, processing and sale of food products

In Québec, the slaughter, cutting, processing and sale of food products must be carried out in compliance with strict standards, and require permits. For more information (in French): www.mapaq.gouv.qc.ca/fr/md/Permis/Pages/Permis.aspx.

Step 4. Marketing: The number one priority

Before making a single purchase, nailing a single board or buying the first piece of equipment, it is imperative that you:

- determine the primary goal or outcome of the agribusiness (hobby farm, commercial production, off-farm sales), taking into account whether it will be a part-time or full-time undertaking;
- if the goal is off-farm sales, ensure there is a slaughterhouse, processing plant or butcher, either locally or in the region, as well as points of sale (grocers and restaurants);
- define the final product (carcass, cuts, processed products) and decide what operations if any will be performed on-site (cutting and/or processing);
- obtain information on the regulations governing slaughter, cutting, processing and sales (both on and off the farm).

> Without good market planning, earnings will be meagre or slow to develop.

Step 5. Development and creation of a business plan

A business plan is the paper version of all the dreaming, planning and decisions surrounding a particular project. The business plan outlines the business as the producer sees it, identifying its orientation, defining a start-up strategy, and setting goals. The business plan is a crucial requirement in any application for financial assistance.

It is recommended that the business plan be drawn up with the assistance of a private consultant, regional economic development agency or government bureau.

Step 6. Find the necessary capital

As part of the business plan, the producer will develop an investment calendar. Whether growth is projected over the short or long term, it can take a while for earnings to compensate expenses (stock purchases, maintenance), and the business may at first seem unprofitable. However, quickly making some initial sales can bring in much-needed income, despite the low production volumes at start-up, since production will grow as sales gradually increase.

Step 7. Implementation

- Build fences to make yards and pens, and construct a sorting centre with a squeeze and loading chute, so the animals can be handled safely.
- Purchase animals (this is one of the biggest expenses). Buying quality stock (in terms of both genetics and performance) will make every aspect of the operation easier.
- Set up purchase agreements with potential meat buyers (butchers, restaurants, etc.).

Step 8. Monitoring herd performance

- Maintain detailed stock records (age, weight curve from birth to slaughter, number of births, mating, etc.) to track both individual and herd performance. This information will help in selecting the best breeding stock.

Step 9. Specialization

Strongly recommended:

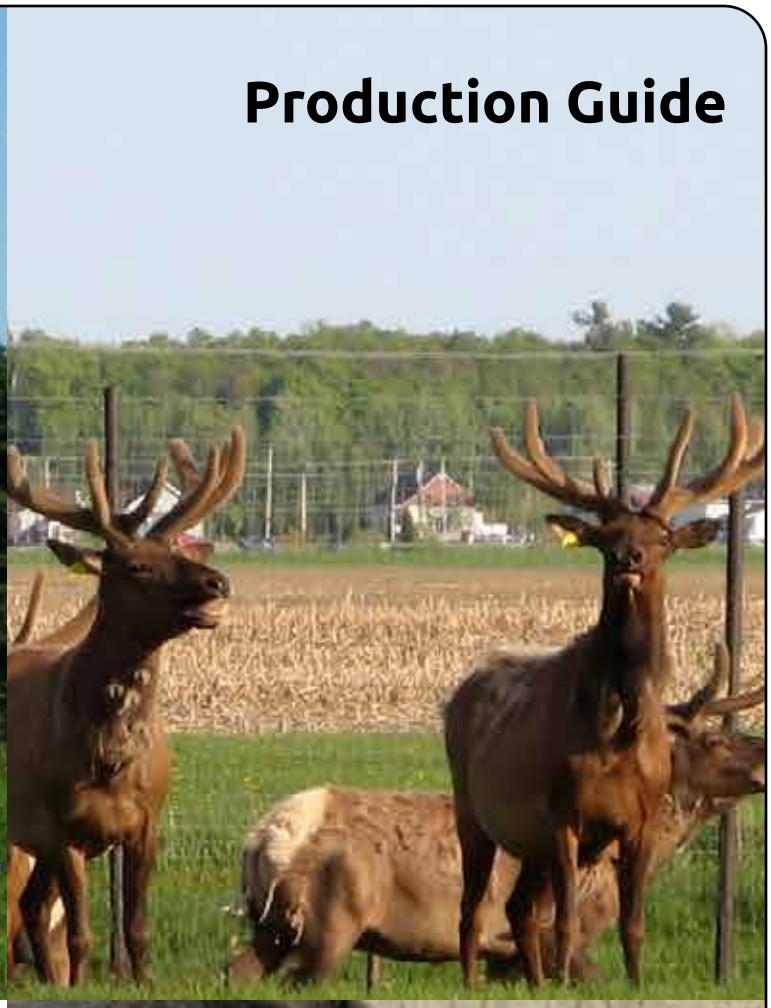
- for the first few years, take courses in production and animal husbandry, marketing, agri-tourism and so on, to expand your knowledge about aspects related to the objectives in your business plan;
- seek input from specialists in animal production, marketing and processing on any questions or challenges you encounter;
- continue learning and extending your knowledge as the business grows.

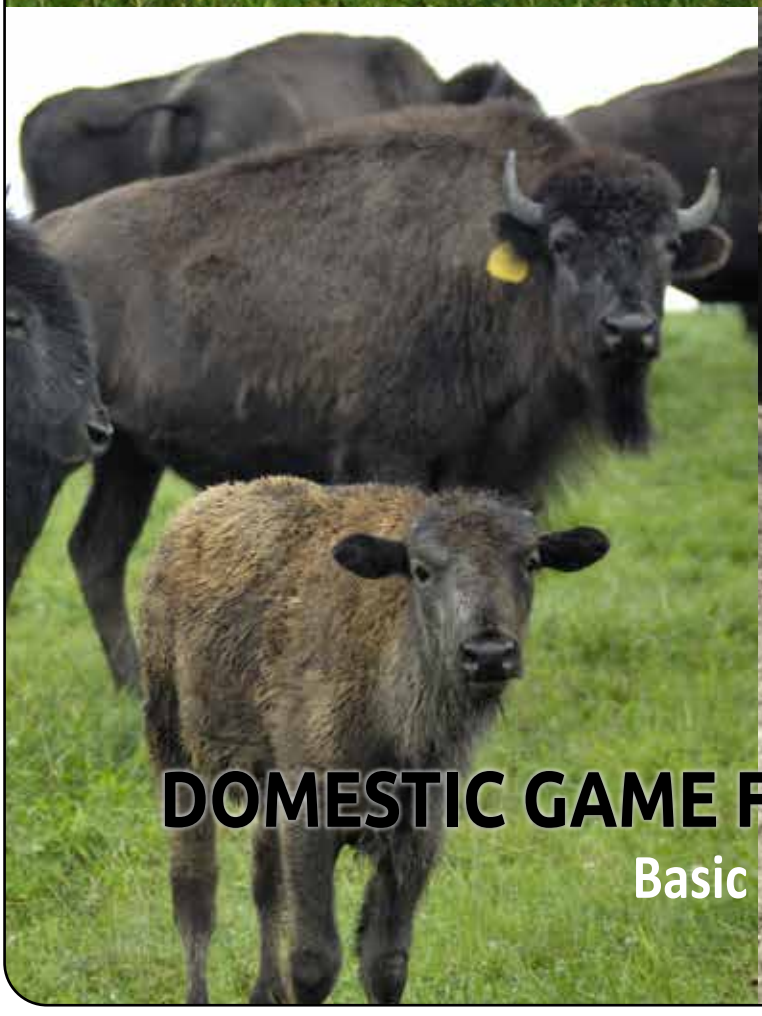
FOR MORE INFORMATION

Besides the websites mentioned above, here are some suggestions for where to obtain more information:

- the *Centre de référence en agriculture et agroalimentaire du Québec* (CRAAQ) distributes DVDs produced by the *Fédération des éleveurs de grands gibiers du Québec* on the breeding and handling of wild boar, bison, wapiti and red deer, as well as on marketing and cuts of meat. See: http://www.craaq.qc.ca/Publications-du-CRAAQ;
- the CRAAQ's "Références économiques" collection includes sample budgets for bison, red deer, wapiti and wild boar production. See: http://www.craaq.qc.ca/ReferencesEconomiques;
- other CRAAQ resources (financial assistance for young farmers, consulting services, resources for young farmers) can identify financial assistance programs, find advisors and provide certain other services. See: http://www.repertoiresducraaq.ca;
- regional agricultural training networks (*Collectifs régionaux en formation agricole*) are listed at http://www.formationagricole.com;
- the Ontario Ministry of Agriculture, Food and Rural Affairs provides good information about non-traditional livestock: http://www.omafra.gov.on.ca/english/livestock/index.html;
- the MAPAQ site offers a start-up kit for new producers on restaurant and retail sales (in French): http://www.mapaq.gouv.qc.ca/fr/restauration/nouveauxexploitants/pages/trousse.aspx

Production Guide





DOMESTIC GAME FARM ANIMALS

Basic Principles of Genetics

CRAAQ

CULTIVER L'EXPERTISE
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Juan Pablo Soucy (red deer and wapiti)
© **Etienne Boucher**, MAPAQ (bison)
© **Michel Langlois**, MAPAQ (wild boar)

INTRODUCTION

Red deer, wapiti (elk), bison and wild boar farmers need to understand the basic principles of genetic selection, so they will be able to raise, breed and market animals with the right characteristics for particular markets (meat, hunting, velvet antler, etc.). Regardless of the type of livestock, every farmer will need, at one time or another, to purchase breeding stock, choose semen for artificial insemination (red deer, wapiti, bison), or select breeding stock from within their own herd.

Understanding and using the basic principles of genetics is part of the constant evolution and improvement of livestock (conformation, productivity, growth, etc.). Quality breeding stock and optimum production conditions are key to ensuring profitability.

GENETICS AND ENVIRONMENTAL FACTORS

An animal's performance (phenotype) is linked as much to its genetic makeup (genotype) as to its environment (Figure 1): the best breeding stock in the world would never reach its full potential in a subpar environment.

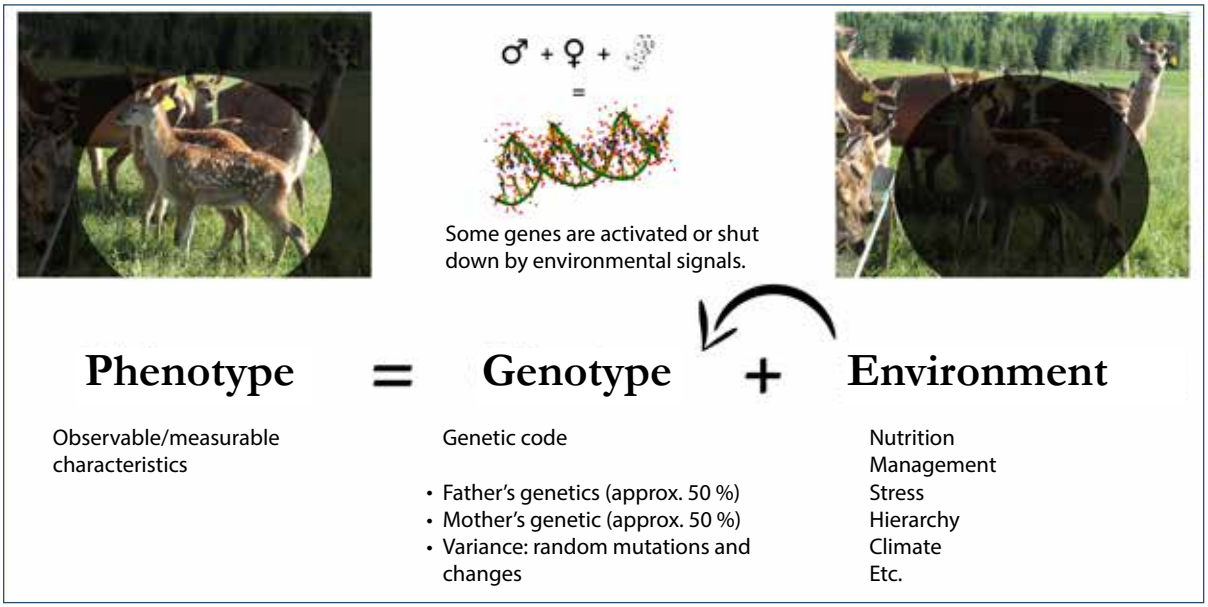

Figure 1. Factors affecting animal performance
Source: Juan Pablo Soucy

In animal production, the weakest link in the production chain determines performance. The classic illustration of this concept is a barrel in which each plank corresponds to some aspect of performance: inevitably, the shortest plank determines the maximum water level (Figure 2).

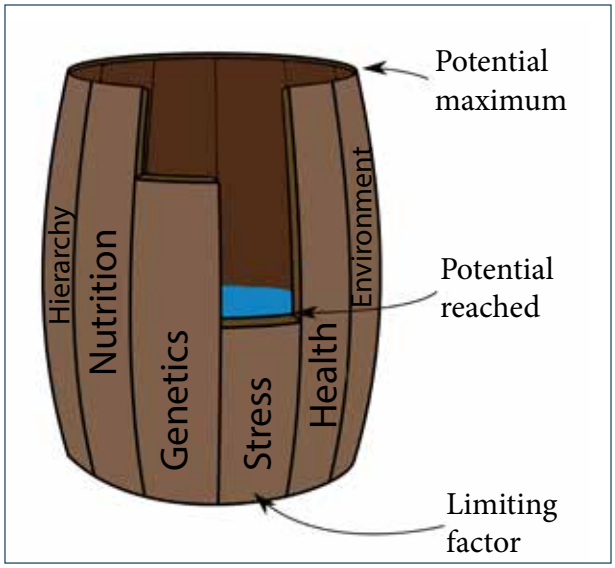

Figure 2. The weakest link in any production system limits potential animal performance
Source: Juan Pablo Soucy

DEFINITIONS

Genes and genetic makeup

A gene is a sequence in a unit of DNA that occupies a specific position on a chromosome and carries genetic information transferred from parents to offspring. With ~50% of its genes from its father, and ~50% from its mother, each individual carries a unique combination of genes (genetic makeup) that makes it different from other individuals.

Qualitative traits

Environmental conditions have little or no effect on qualitative traits, which are easily observable (e.g. eye colour, conformation, cervid antlers, hardiness, vigour, wild boars' flight instinct, etc.).

Producer organizations are working to develop conformation[1] tables for these alternative livestock, similar to those used for conventional livestock.

Quantitative traits

Quantitative traits are measurable characteristics that can be altered to a greater or lesser extent by environmental conditions (nutrition, housing, etc.). The genes involved in quantitative traits interact with environmental factors, and an animal's genetic potential may be undermined by inadequate production practices.

Most economically significant characteristics (growth rate, milk production, etc.) are quantitative traits.

1. For more information on red deer conformation see the following factsheet: *Evaluating Red Deer for Breeding*.

Heritability of qualitative traits

Heritability is a value between 0 and 100% (sometimes expressed as a decimal or fraction between 0 and 1) that indicates the importance of heredity in the expression of a particular characteristic and its transmission from parents to offspring. Environment is the other factor. Knowing the heritability of a trait facilitates the selection of breeding stock.

A desirable trait with high heritability will depend largely on heredity and should be included among selection criteria. The expression of a less heritable trait is influenced more by environmental factors than by heredity, but this does not preclude it from being a selection criterion; it simply means that genetic improvement for that trait will be slower.

Inbreeding

Inbreeding is a reproductive technique that consists of mating closely related individuals. Inbreeding was often used in the past to develop herds. It is no longer recommended because it increases the risk of accumulating unfavourable genes, reducing zootechnical performance, and creating hereditary anomalies.

If the same male is used over several years and bred with its own daughters, granddaughters, etc., inbreeding results, increasing the degree of consanguinity within the herd. Parentage should therefore be considered in planning reproductive groupings and purchasing breeding stock. Generally, the herd should be managed to ensure a maximum coefficient of consanguinity of no more than 6.26% to 10% (the equivalent of first cousins).

STEP-BY-STEP SELECTION PROCESS

The purpose of selecting breeding stock is to improve the herd by only mating animals that perform best in one or more ways. Selecting the best breeding stock ensures that their genes are transmitted and multiplied. The selection process must therefore start with clearly defining the type of animal desired to meet the target market, followed by considering which selection criteria can lead towards that animal.

The first step is to exclude animals that do not fit the desired profile, then to select for one or two criteria at a time until a satisfactory level is achieved.

Attempting to select for multiple traits at once will only slow the process of improvement. It is important to assess and account for the impact of selection on other aspects of production. For instance, selecting for higher weights at one year of age could also lead to higher birth weights, increased birthing difficulties, higher nutritional requirements, etc.

Bison

Only healthy, vigorous, productive animals with good conformation and a good temperament should be selected for breeding stock. Currently, most producers keep the majority of their females if they are good breeders. The selection of breeding bulls is more important, hinging on one or two characteristics with high heritability (carcass, growth, weight, reproductive efficiency) (Table 1). A producer who is raising bison for meat will want to develop animals with the highest feed efficiency possible. Breeding-stock operations will want to develop fertile animals that calve easily and produce offspring with good growth and conformation.

Table 1. Comparative heritability estimates for various characteristics in beef cattle[1]

Characteristics	Heritability (%)	Characteristics	Heritability (%)
Adapted from Alberta Agriculture, 1988; Hamilton and Wilton, 1987		*Adapted from Utrera and Van Vleck, 2004; Cammack and coll., 2009*	
Reproduction		Carcass mass	35 – 42%
Age at puberty (females)	20 – 40%	Area of rib-eye muscle	28 – 36%
Scrotal circumference	20 – 50%	Carcass yield	37 – 41%
Milk production	25%	Calving date	10 – 49%
Weight performance			
Birth weight	25 – 40%		
Weaning weight	25 – 30%		
Weight at 1 year	50 – 60%		
Weight at maturity	50 – 80%		
Growth			
Daily gain: birth to weaning	25 – 30%		
Daily gain: post-weaning to market weight	45 – 50%		
Carcass characteristics			
Carcass classification	35 – 45%		
Backfat thickness	25 – 40%		
Area of rib-eye muscle	25 – 40%		

1. Because bison are of the same family as cattle, similar characteristics may be assumed between the two species.

Wapiti and red deer

Females that have had repeated problems with calving in previous seasons, and males with lower reproductive performance (number of offspring, distribution of births) should not be selected as breeding stock. Breeding bulls can be selected to meet the target market (breeding stock, velvet, venison) based on weight and velvet yield (Table 2). Cows can be selected based on the birth weight of their offspring, tendency to conceive in the early autumn, temperament, growth curve, etc.

Table 2. Comparative heritability estimates for various characteristics in red deer and wapiti

Red deer and wapiti		Red deer	
Characteristics	Heritability (%)	Characteristics	Heritability (%)
Adapted from Jordan and coll., 1994; Friedel, 1994		*Adapted from McManus and Hamilton, 1991; van den Berg and Garrick, 1997; Kruuk and coll., 2002; Delgadillo Calvillo and coll., 2008; Quinn-Walsh and coll., 2010; Ramírez Valverde and coll., 2011*	
Weaning weight	25%	Velvet antler mass	26 – 36%
Weight: 1 year	35 – 40%	Body mass at maturity	54 – 62%
Weight: 3 years	40%	Body mass at birth	15 – 27%
Milk production	20 – 30%	Body mass at weaning	14 – 21%
Type	35 – 40%	Body mass at 1 year	16 – 34%
Fat accumulation	35%	Gain post-weaning	10 – 14%
Antler weight	20 – 25%		
Velvet antler growth	35%		
Behaviour	20 – 30%		

Wild boar

Male breeding stock should be selected for good conformation and solid legs. The parents' behaviour and social hierarchy are also important selection criteria.

For the hunting market (game ranches), hardy individuals with good flight instincts should be selected. Producers raising their own stock will probably have to compromise between sow selection and hunting stock. As for meat producers, they require prolific sows with good mothering abilities, high rates of offspring survival, good growth rates, good carcass yield, good muscling, etc. Sows must have enough nipples to feed 6 to 8 piglets. If data are available, producers should use male and female breeding stock from uniform litters, which will help guarantee a good lineage.

Table 3 outlines the heritability of major characteristics in domestic hogs.

Table 3. Heritability estimates of major characteristics in swine[1]

Characteristics	Heritability (%)
Reproduction	
Age at first estrus	30%
Number of nipples	30%
Gestation period	40%
Growth	
Average daily growth	30%
Appetite	35%
Leg quality	35%
Carcass	
Carcass yield	35%
Backfat thickness	45%
Area of rib-eye muscle	45%
Percentage muscle	50%
Carcass length	60%

1. Because hogs are of the same family (*Suidae*) and close cousins of wild boar, similar characteristics may be assumed between the two species.

Adapted from CPAQ, 1995

SPEED OF GENETIC IMPROVEMENTS

The speed at which selection advances genetic improvement (and thus, herd performance) depends on four main factors:

- selection differential: the difference (with regard to one or more traits) between the parents selected to produce the next generation and the average for that species. The greater this difference, the stronger the effects of selection will be;
- heritability: the more a given trait is heritable, the more precisely breeding stock can be selected for it;
- selection intensity: the degree of superiority of animals selected for breeding, compared to the average;
- generation interval: the average age of parents at the birth of their first offspring. The shorter this interval, the more swiftly genetic improvement can progress.

Example

A wapiti producer sets a selection differential of 3.2 kg for velvet antler production by 2 year bulls. By mating bulls that will be 3 years old at their offspring's birth with cows that will then be 7 years old, the producer can expect the calves to produce 0.22 kg/year more velvet than the previous generation, based on the following calculation:

$$\text{Genetic progress} = \frac{0.35 \text{ (heritability)} \times 3.2 \text{ kg}}{5 \text{ yrs (average age of parents)}} = 0.22 \text{ kg/yr}$$

ARTIFICIAL INSEMINATION

In red deer, wapiti, bison and wild boar, artificial insemination is primarily used for genetic improvement:

- to tap into the genetic makeup of semen from high-quality male breeding stock without having to invest in the purchase of elite animals;
- to improve herd quality faster than with natural mating;
- to allow the extensive use of male breeding stock with desirable genetic characteristics, by:
  - fertilizing a greater number of females;
  - using the same semen over a long period through freezing;
- to mitigate the risks of diseases transmitted through natural mating.

Despite these advantages, artificial insemination can be challenging, and is not for everyone. For most producers, natural mating with the best male breeding stock in the herd will be a better option.

Artificial insemination is more commonly used for red deer than for wapiti or bison. Some producers use artificial insemination for several years to improve herd genetics, then go back to natural mating with the resulting stock. Even if artificial insemination is used, the use of a back-up male is recommended in the cycle following insemination[2].

The success rate of artificial insemination varies depending on several factors. Artificial insemination requires considerable handling of the animals, including the administration of hormones to stimulate and synchronize estrus and ovulation, and the insemination process itself. These procedures require good anatomical and physiological knowledge, and must be performed with precision. Many producers start by using the services of an experienced professional (e.g. a veterinarian), but eventually learn the technique themselves. Note that it is essential to have the proper equipment (a squeeze) for immobilizing the females during handling.

2. For more information (particularly on insemination), see the following factsheets: *Reproductive Management of Red Deer* and *Reproductive Management of Wapiti*.

Production objectives should first be identified (herd improvement, velvet production, trophy animals, etc.) in order to select the most appropriate semen to achieve those objectives. Basic selection criteria should be applied in choosing females for artificial insemination: quality animals, previous births, calm and accustomed to handling, good body condition, etc.

CROSS BREEDING

Cross breeding refers to reproduction between unrelated strains of the same species (such as red deer and wapiti) to rapidly improve specific characteristics. Cross breeding is common in New Zealand, where red deer cows are bred (either naturally or artificially) with elk: the hybrid calf (which is then called "wapiti" in that country) is bigger than red deer calves, and the hybrid animals have better growth rates. Depending on its origin, a herd of deer may include both purebred and hybrid animals. For the purebred red deer industry, such hybridization is problematic, since crosses between hybrids or with purebred animals result in the herd having persistent hybrid genes, and thus to the gradual erosion of genetic purity.

Blood tests to identify variants of hemoglobin, a blood protein, can be used to verify the status of herd members or animals being considered for purchase. Such tests exploit the fact that the hemoglobin of a purebred is different from that of a hybrid. There is also a registration system for producers of purebred red deer.

Bison

Bison/cattle crosses are possible, but not recommended. The two types of meat are distinct in terms of taste, composition (protein) and cost. Bison meat has advantages that would be undermined by interbreeding.

Cross breeding between plains bison and wood bison does seem beneficial, and producers have noted that the hybrid offspring have higher, wider and deeper haunches, and higher carcass weights, attractive features for meat producers. The animals do not appear to have greater bone mass, but do seem to have smaller heads. However, such hybrid bison cannot be registered, exported, or entered in competitions.

BIBLIOGRAPHY

Alberta Agriculture and Rural Development. 1988; rev. 1995. *Beef Herd Management* Reference Binder and Study Guide. Sect. 201, 202, 203 and 210.

Cammack, K.M., M.G. Thomas and R.M. Enns. 2009. *Review: Reproductive Traits and Their Heritabilities in Beef Cattle*. The Professional Animal Scientist 25(5): 517-528.

CPAQ. 1997. *Le cerf rouge-Guide d'élevage*. Conseil des productions animales du Québec. 131 pp.

CPAQ. 1997. *Le bison-Guide d'élevage*. Conseil des productions animales du Québec. 129 pp.

CPAQ. 1995. *Guide porc-Section Génétique*. Conseil des productions animales du Québec.

CRAAQ. 2006. *L'élevage du wapiti*. Centre de référence en agriculture et agroalimentaire du Québec. 88 pp.

CRAAQ. 2003. *Le sanglier-Guide d'élevage*. Centre de référence en agriculture et agroalimentaire du Québec. 113 pp.

Delgadillo Calvillo, A.C., R. López Ordaz, H.H. Montaldo, J.M. Berruecos Villalobos, A.A. Luna and C.G. Vásquez Peláez. 2008. *Componentes de varianza genéticos, directos y maternos para características de crecimiento en ciervo rojo (Cervus elaphus scoticus)*. Vet. Méx. 39(3): 237-245.

Friedel, B. 1994. *Selecting elk for velvet growth, body size or reproduction*. Canadian Elk and Deer Farmer, Summer: 34-35.

Hamilton, T. and J.W. Wilton. 1987. *Crossbreeding Systems for Commercial Beef Production*. Ontario Ministry of Agriculture and Food. Agdex 420/36. 4 pp.

Jordan, R.M., C. Anfang, C. Sheaffer and C. Wolf. 1994. *A Deer Production Primer*. University of Minnesota. 69 pp.

Kruuk, E.B, J. Slate, J.M. Pemberton, S. Brotherstone, F. Guinness and T. Clutton-Brock. 2002. *Antler size in red deer: Heritability and selection but no evolution*. Evolution 56(8): 1683-1695.

McManus, C.M. and W.J. Hamilton. 1991. *Estimation of genetic and phenotypic parameters for growth and reproductive traits for red deer on an upland farm*. Animal Production 53(2): 227-235.

Quinn-Walsh, E.C., D.L. Johnson, J. Chardon and R.J. Spelman. 2010. *Deer Improvement's breeding programme for venison production in red deer (Cervus elaphus)*. Proceedings of the New Zealand Society of Animal Production 70: 278-282.

Ramírez Valverde, R., A. Sánchez Cervantes, J.G. García Muñiz, R. Núñez Domínguez and V. Lemus-Ramírez. 2011. *Efectos ambientales y parámetros genéticos de variables de crecimiento para un rebaño de ciervo rojo (Cervus elaphus) en cautiverio*. Rev. Mex. Cienc. Pecu. 2(3): 319-330.

Utrera, A.R. and L.D. Van Vleck. 2004. *Heritability estimates for carcass traits of cattle: A review*. Genetics and Molecular Research 3(3): 380-394.

Van den Berg, G.H.J. and D.J. Garrick. 1997. *Inheritance of adult velvet antler weights and live weights in farmed red deer*. Livestock Production Science 49(3): 287-295.

Production Guide

DOMESTIC GAME FARM ANIMALS

Evaluating Red Deer for Breeding

CRAAQ

CULTIVER L'EXPERTISE
DIFFUSER LE SAVOIR

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INTRODUCTION

Red deer farming was for many years oriented toward spectacular hunting trophies, with meat as a by-product. Today the situation in Québec has reversed, and the strongest market is clearly for venison. While there is still a hunting market it is relatively small, and to make it profitable considerable effort and financial investments must be devoted to genetic improvement. Producing a quality deer for hunting takes 4 to 8 years, while a deer can be ready for the meat market in 5 to 19 months.

While cattle are categorized as either dairy or beef, a herd of red deer can be developed to produce either hunting trophies or carcasses of high quality meat, though rarely both at once. This leaflet outlines the evaluation criteria (performance, temperament, body condition and conformation) that pertain to breeding for the purpose of meat production. Whether purchasing new breeding stock or selecting from within the herd, the breeder must attempt to choose stags and hinds that will improve the herd's genetics and contribute to the production of better feeder animals. The goal of this document is to guide that process.

SPECIES DEFINITION AND OTHER CONSIDERATIONS

In mammals, the cervid family (*Cervidae*) is divided into two sub-families: the *Cervinae* (Eurasian and African deer) and the *Capreolinae* (New World deer). The sub-family *Cervinae* comprises 4 genera, including the genus *Cervus* which in turn consists of 10 to 12 species depending on the method of classification. The number of species varies with the reference source, since taxonomy has evolved considerably since the advent of genomic analysis. Thus, it is now possible to distinguish more precisely whether two groups of animals belong to the same species.

The European red deer or elaphe deer, from the Latin name *Cervus elaphus*, is not immune to this ambiguity. For a long time it was classified in the same species as wapiti (often called elk outside of Québec). Wapiti are more commonly identified today as *Cervus canadensis*, though it would be more appropriate to consider the red deer and wapiti as two sub-species. The genus *Cervus* has great potential for hybridization. This complicates the task of classification, since genetically the red deer is almost as close to the sika deer (*Cervus nippon*) as to wapiti. All of them can in fact be crossbred. Recent studies combine these animals into a single species divided into 23 sub-species (Geist, 1998; Kuwayama and Ozawa, 2000; Polziehn and Strobeck, 2002; Ludt and coll., 2004).

In the context of deer farming the situation is somewhat clearer. Worldwide, most farms work with a single group of cervids, though many breeders take advantage of the species' hybridization potential, primarily by using male elk in herds of red deer. Nearly half the animals produced in New Zealand have elk genes (Nicol and coll., 2003). At marketing time, the correct term must applied if hybrids are used (e.g. "deer meat" as a generic).

In Québec, red deer farming is for the most part separate from wapiti farming. Producers, particularly those who produce breeding stock for sale, use different bloodlines within a breed to bring their herd toward their objectives. (A bloodline, or breed line, is all the members of a family group over generations,

as confirmed by pedigree records and as observed through inherited traits.) Distinct geographic territories have given rise to great variation in conformation among groups of European red deer. Thus the English, Yugoslavian, Hungarian, Scandinavian and Spanish breed lines, like the Asian breed lines, all have very different characteristics. However, assembling different genes from among all the genes available to obtain animals of superb quality requires many years of judicious selection. To perform such selection, a clear understanding is needed of the breeder's objectives as compared to the herd's current performance. Accurate evaluation of each animal in the herd is essential for the optimal use of genetics.

PURCHASING ANIMALS

Certain precautions should be taken when preparing to purchase breeding stock. This means:

- asking the seller for complete documentation for each animal (documents from Agri-Traçabilité Québec (ATQ), genetic purity test, weight data, etc.);
- asking for pedigrees (documents certifying the genealogy of purebred animals); they are very useful when available (Figure 1);
- observing the herd of origin; consistent quality is a sign of constant effort for improvement, whereas an animal that is the only standout in a mediocre herd, unless purchased from a different herd, would be of questionable genetic potential;

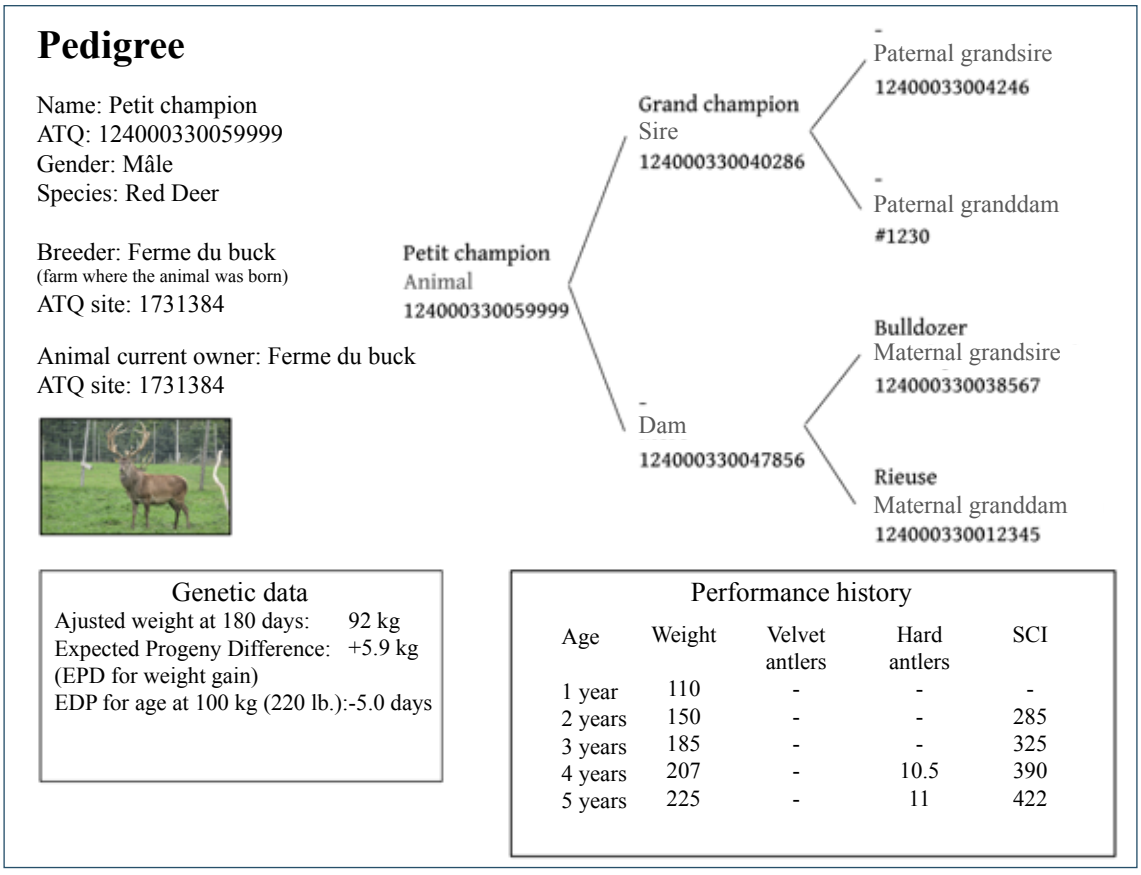

Figure 1. Example of a pedigree

- evaluating each animal's conformation and body condition, as discussed in detail below;
- ideally, for stags, knowing the results of fertility tests to be sure their semen is viable (this information is not always available);
- asking about the breeder's management practices, including feeding; an animal that does well in a herd where only forages are provided could perform differently when forages are supplemented with concentrates (and vice-versa).

GENETIC PERFORMANCE

Keeping records

It is impossible to achieve genetic improvement without having a clear starting point. Keeping good records is therefore essential, whether on computer or on paper (very practical when working with animals, if data is entered promptly). All relevant data about the animals must be recorded and saved.

Important information to record:

- identification of the stag used in each group of hinds;
- dates when the stag was introduced and removed;
- weight at specific ages (all animals);
- slaughter data (offspring);
- feed used;
- reasons for culling or mortality;
- conformation scores and other notes;
- data on the thickness of back fat and muscle (ultrasound) (Figure 2).

Figure 2. Use of an ultrasound device to measure back fat and muscle thickness
Photo: Juan Pablo Soucy

Data interpretation and other selection tools

Keeping records is great, but using them is what really pays off. The data collected can be used to produce an in-depth portrait of the herd. With a simple spreadsheet, calculations and analyses can reveal average weaning weights, heaviest animals at slaughter, growth curves, etc. Sophisticated statistical analyses can be done with other software, as well as long-term monitoring to identify hinds that year after year produce the heaviest calves; stags that consistently sire the best calves; carcass yields per breed line; detailed pedigrees, etc.

Regardless of how extensively the data is analyzed, breeders should take every opportunity to compare their herd's performance with that of other farms. No matter how certain you are that you're on the right track, finding out where you stand relative to other operations is always worthwhile. Whether with a professional or other breeders, there are several ways of measuring the performance of your herd. For example, model growth curves can be used as a basis for comparison with respect to weight gain (Figure 3). Such growth curves do not include animals in the upper or lower 5%.

Over the next few years, genetic selection tools will become available that can analyze multiple herds. This will allow a breeder to obtain information on the animals' real potential, as can already be done in more traditional livestock productions (beef, pork). The point is that an animal with exceptional characteristics (phenotype) will not always be able to transmit those characteristics to its offspring. Calculating the genetic potential index (GPI) or expected progeny difference (EPD) in descendants provides a more precise evaluation of the animals' real genetic value. For several years now a genetic selection program using just such tools has been in place for red deer in New Zealand.

Genomic selection tools called SNP chips (for single nucleotide polymorphism) are already in use for cattle, and are starting to appear in the cervid industry. A single chip (detector) can identify thousands of genes in a single animal, giving a precise portrait of its genetic traits and therefore its potential. This can be done as soon as an animal is born. The tests currently available for cattle evaluate over 800,000 different variations in a single analysis.

On the other hand, it must be remembered that poor performance can be due not only to genetics, but also feed, stress, parasites, disease and climate. In addition, if hinds that are performing poorly are not systematically culled, their productivity will decline dramatically from about 9 years on (Hill and coll., 2003; Vásquez and coll., 2003; Nussey and coll., 2006).

TEMPERAMENT

Temperament is an important but often neglected aspect when choosing animals for reproductive purposes. This applies to both stags and hinds. Since temperament is moderately heritable, it has an influence on both the herd's productivity and its overall health (Boivin and coll., 2010; Hoppe and coll., 2010; Schutz and Pajor, 2010). Choosing calm animals increases the probability of obtaining higher productivity, better quality meat and good general health. In addition, calm animals are easier to handle and to transport, reducing the risk of accident.

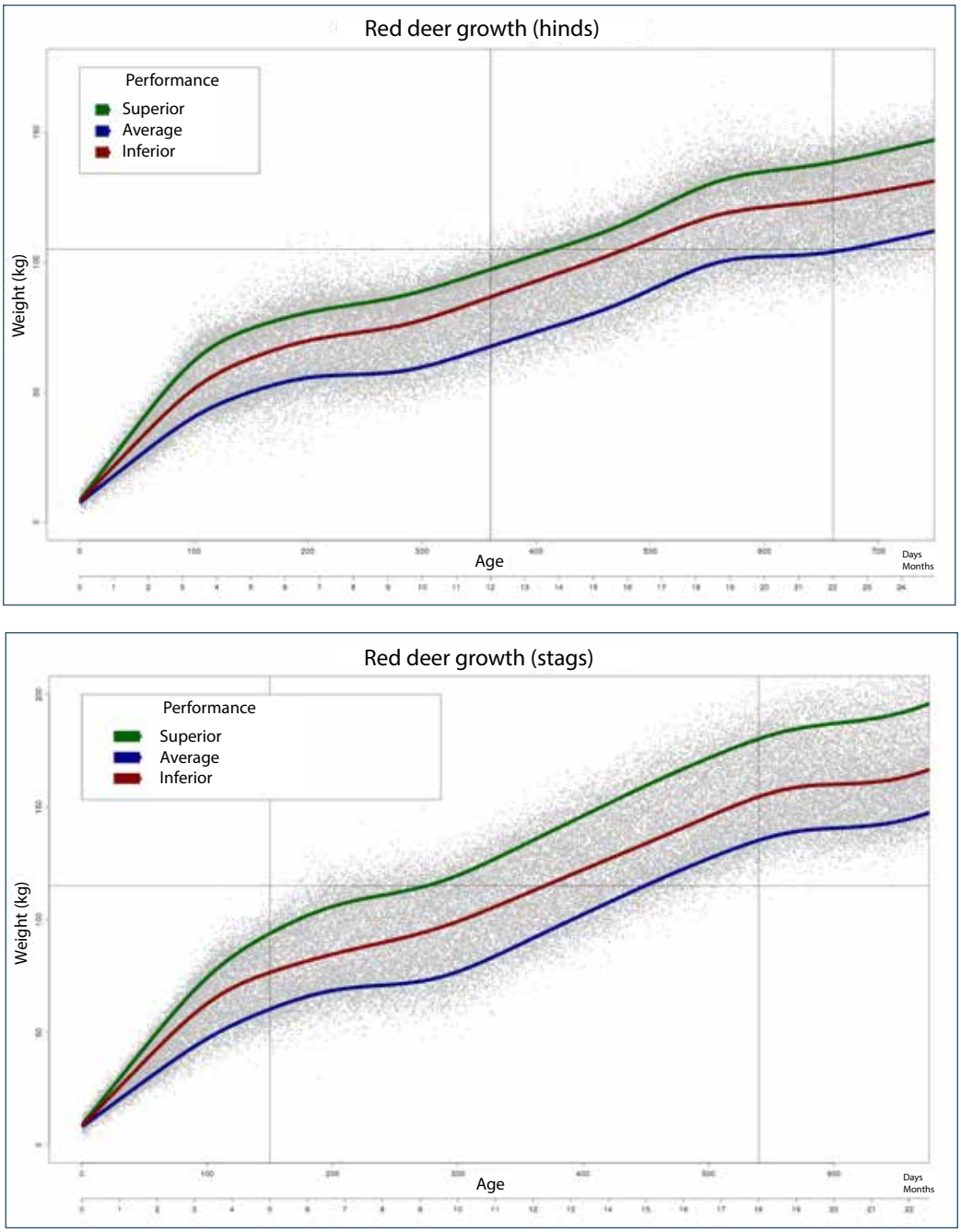

Figure 3. Model growth curves for red deer raised in Québec

In the hinds, behaviour related to calving and calves should be observed closely. Maternal traits play an important role in the calf's growth and survival. Hinds that allow other calves to nurse are preferable, since they contribute to uniform weight gain throughout the herd. Staying away from the rest of the herd a

few days before calving is also a sign of good maternal instinct. Hinds that are too nervous in the presence of humans should be culled quickly, since they will tend to stress the rest of the herd (Hill and coll., 2003; Pollard, 2003; Vásquez and coll., 2003; Delgadillo-Calvillo, 2008).

In stags, when not in rutting season a mild temperament is desirable; but not too mild, since a stag should not be constantly dominated by other stags or the hinds. Good libido and good reproductive performance are also signs of quality stags for breeding.

BODY CONDITION

Body condition corresponds to the animal's degree of fat cover; it is an important parameter. An animal that is excessively fat has a body condition score (BCS) of 5 (on a scale of 1 to 5), while an animal that is extremely thin has a score of 1 (Figure 4). Too low a BCS can be a forewarning of poorer reproductive capacity. Too high a BCS on the other hand, in hinds, can lead to difficulty in calving.

The best parts of the body for measuring body condition correspond to the principal sites of fat deposits: the sides, back and rump. Body condition is independent of conformation, but the two are sometimes confused because they influence each other.

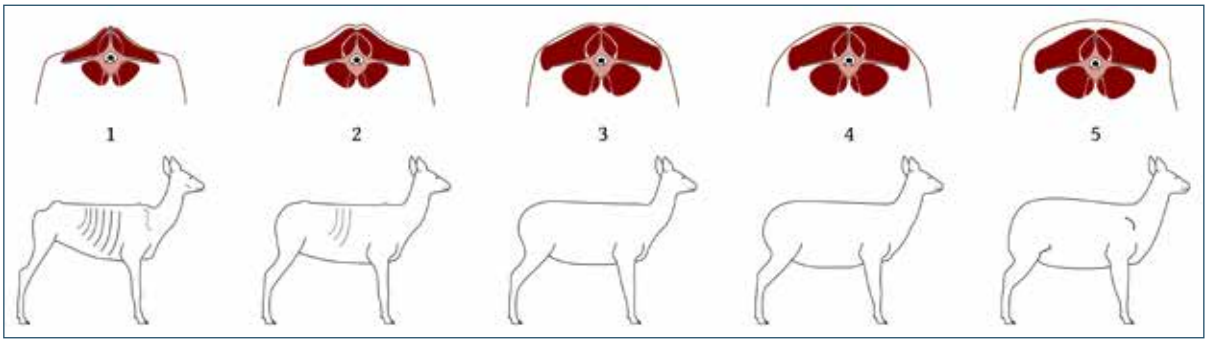

Figure 4. Illustration of body condition scores in red deer

In the red deer, body condition varies naturally with the time of year and the animals' activities in the different seasons (Figure 5).

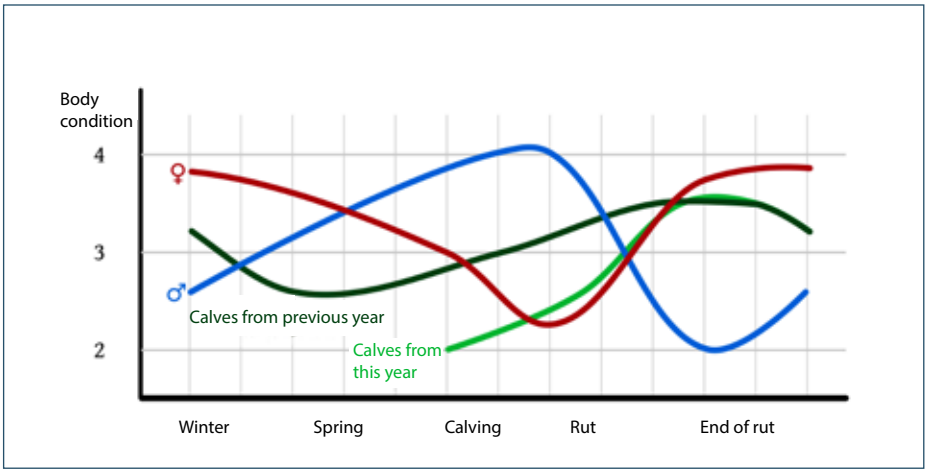

Figure 5. Variation of body condition in the red deer

CONFORMATION

While it is normal for body condition to vary throughout the life of the animal, conformation will never improve if it is not satisfactory from the beginning. It is therefore crucial to select breeding stock with good conformation. In Québec, red deer tend to be evaluated with a "hunter's eye". This section considers them in a different manner, as animals intended for meat production.

Musculature

Meat corresponds to the muscle in a living animal. Muscular animals should therefore be selected, particularly in the case of males. Broad, deep rump muscles are preferable (Figures 6, 7 and 11), as is a broad, well-muscled back. These are the most profitable parts of animals that will be processed for meat. Good musculature is equally important for reproductive hinds, but to avoid calving problems it should not be excessive. Musculature is scored on a scale of 1 to 3: 1 (excellent), 2 (normal) and 3 (poor).

Capacity

Capacity corresponds to the volume of the animal's rib cage (Figures 7 and 11) and is also scored on a scale of 1 to 3: 1 (excellent), 2 (normal) and 3 (poor). Large volume in front means more space for the rumen and lungs, improving the animal's digestive and respiratory potential. To the rear, good volume and wide hips provide a large attachment surface for muscles and a wider passage for calving in the females. Animals with a broad, deep trunk are therefore preferable.

Figure 6. Rump musculature (left to right: poor, normal, excellent)
Photo: Juan Pablo Soucy

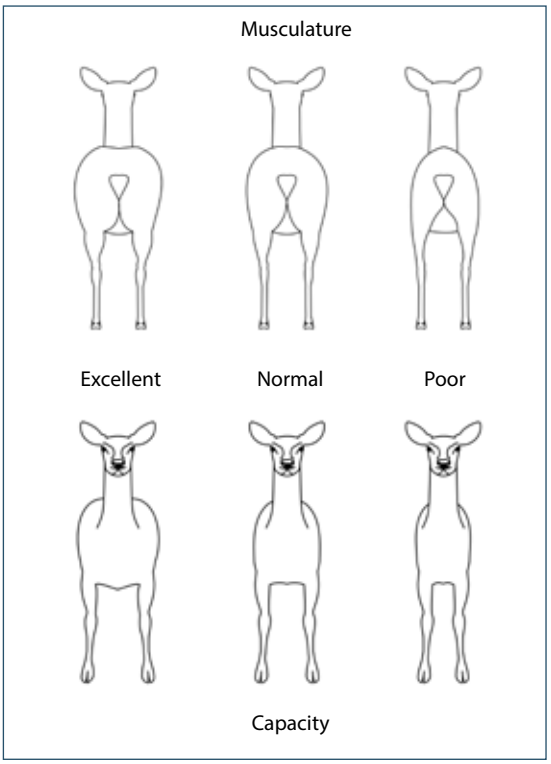

Figure 7. Musculature and capacity
Photo: Juan Pablo Soucy

Back length

Related to capacity, back length (Figures 8 and 11) is another important parameter because it determines the length of the tenderloin and strip loin, two of the most profitable meat cuts in a red deer. Back length is scored on a scale of 1 to 3: 1 (short back), 2 (normal back) and 3 (long back). Back length is easiest to evaluate by observing the proportion between the animal's back length and that of its legs. The back should also provide the animal with solid support, a trait referred to as back structure.

Figure 8. Back length in three animals of similar size (left to right: short back, normal back, long back)
Photo: Juan Pablo Soucy

Back structure

The animal's back is the central beam for every limb of the body. It should therefore be as broad and straight as possible, in part to allow a good deposit of muscle. A slight hump at the shoulders is normal, but there should be no break behind them. A hollow at the hips or the middle of the back (Figures 9 and 11) must be avoided, since it weakens the animal's support and increases the risk of injury. The score for back structure is either 1 (poor) or 2 (good).

Legs and hooves

To support the animal's weight, it is crucial that its limbs be straight and solid (Figures 10 and 11). The hooves should be equal and not overly long, a defect often combined with weak musculature that in hinds is an impediment to mating. Both front and back legs should be straight and as parallel as possible.

Close-set legs are often the main defect in this part of the body, frequently related to the animal having poor capacity. Legs that angle beneath the animal, instead of being at right angles to the trunk, are another common problem in cervids (Figure 11).

Figure 9. Left: straight back, as desired. Right: hollow back, a structural defect
Photo: Juan Pablo Soucy

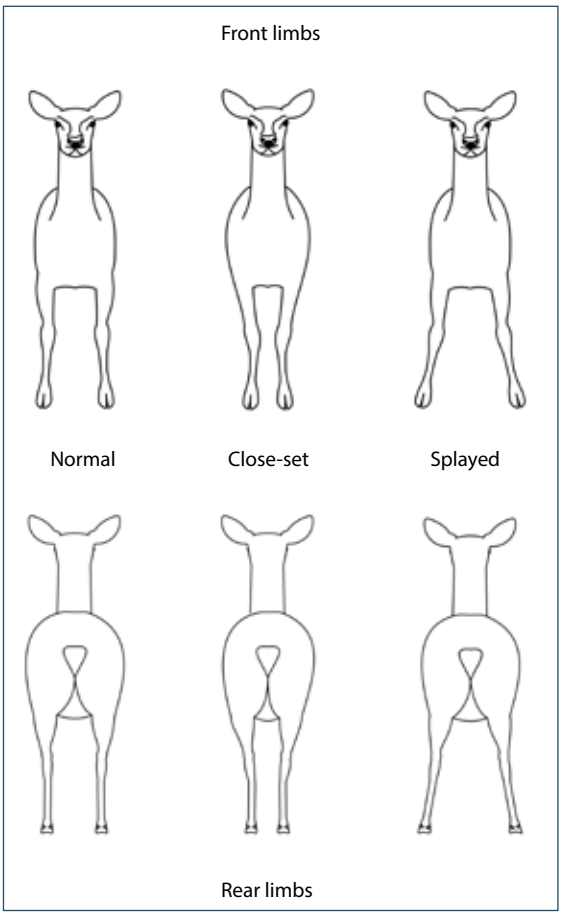

Figure 10. Legs and feet

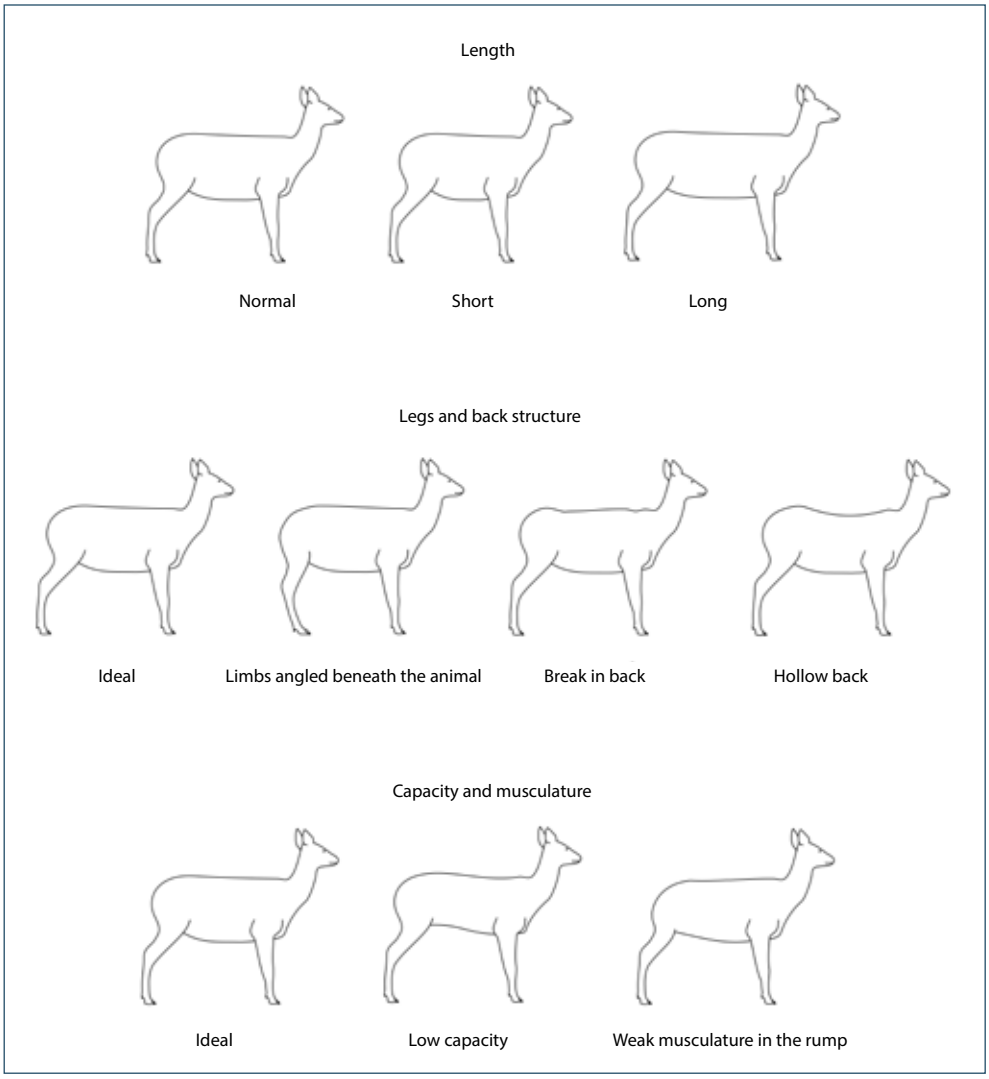

Figure 11. Relationships between certain selection traits related to conformation

Harmony

While it is imperative to select for good conformation, the harmony of the animal as a whole must also be considered. Hinds for example should have a finer head and bone structure than stags, these traits being similar to dairy traits in cows. Gait is another feature to be evaluated carefully, since a poor gait usually leads to the development of conformation problems. Finally, a breeder who is aiming for the secondary market (hunting, velvet antler production) should apply secondary selection criteria that are appropriate to that type of animal.

CONCLUSION

To improve a herd's profitability, the evaluation of prospective breeding stock must be done rigorously, both in terms of analyzing performance data and doing a visual assessment of body condition and conformation. They are complementary tools. Careful and patient selection is often what determines the price paid for breeding stock, the value of the carcasses subsequently produced, and the profitability of the business.

BIBLIOGRAPHY

Boivin, X., J. Sapa, P. Pellegrini, P. Boulesteix, P. Lajudie and F. Phocas. 2010. *Assessment of different on-farm measures of beef cattle temperament for use in genetic evaluation*. J. Anim. Sci. 88(11): 3529-3537.

Cammack, K.M., M.G. Thomas and R.M. Enns. 2009. *Review: Reproductive Traits and Their Heritabilities in Beef Cattle*. The Professional Animal Scientist 25: 517-528.

Delgadillo Calvillo, A.C., R. López Ordaz, H.H. Montaldo, J.M. Berruecos Villalobos, A.A. Luna and C.G. Vásquez Peláez. 2008. *Componentes de varianza genéticos, directos y maternos para características de crecimiento en ciervo rojo (Cervus elaphus scoticus)*. Vet. Méx. 39 (3): 237-245.

Geist, V. 1998. *Deer of the world*. Stackpole books, PA, United States. 421 pp.

Hill, S.C., T. Pearse and C. Mackintosh. 2003. *Review of calving losses in an intensively managed red deer herd*. Proc. of the Deer Branch NZVA, 19: 89-95

Hoppe, S., H.R. Brandt, S. König, G. Erhardt and M. Gauly. 2010. *Temperament traits of beef calves measured under field conditions and their relationships to performance*. J. Anim. Sci. 88(11): 1982-1989.

Kruuk, L.E.B, J. Slate, J.M. Pemberton, S. Brotherstone, F. Guiness and T. Clutton-Brock. 2002. *Antler size in red deer: Heritability and selection but no evolution*. Evolution 56(8): 1683-1695.

Kuwayama, R. and T. Ozawa. 2000. *Phylogenetic Relationships among European Red Deer, Wapiti, and Sika Deer Inferred from Mitochondrial DNA Sequences*. Molecular Phylogenetics and Evolution 15: 115-123.

Ludt, C.J., W. Schroeder, O. Rottmann and R. Kuehna. 2004. *Mitochondrial DNA phylogeography of red deer (Cervus elaphus)*. Molecular Phylogenetics and Evolution 31: 1064-1083.

Nussey, D.H., L.E.B. Kruuk, A. Donald, M. Fowlie and T.H. Clutton-Brock. 2006. *The rate of senescence in maternal performance increases with early-life fecundity in red deer*. Ecology Letters 9: 1342-1350.

Polziehn, R.O and C. Strobeck. 2002. *A Phylogenetic Comparison of Red Deer and Wapiti Using Mitochondrial DNA*. Molecular Phylogenetics and Evolution 21: 342-356

McManus, C.M. and W.J. Hamilton. 1991. *Estimation of genetic and phenotypic parameters for growth and reproductive traits for red deer on an upland farm*. Animal Production 53: 227-235.

Nicol, A.M., H.G. Judson and A.W. Taylor. 2003.*The effect of hybridisation on venison production*. Proceedings of the New Zealand Society of Animal Production 63: 222-228.

Pollard, J.C. 2003. *Research on calving environments for farmed red deer: a review*. Proceedings of the New Zealand Society of Animal Production 63: 247-250

Quinn-Walsh, E.C., D.L. Johnson, J. Chardon and R.J. Spelman. 2010. *Deer Improvement's breeding programme for venison production in red deer (Cervus elaphus)*. Proceedings of the New Zealand Society of Animal Production 70: 278-282.

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Schutz, M.M. and E.A. Pajor. 2010. *Genetic Control* of Dairy Cattle Behavior. J. Dairy Sci. 84 (E. Suppl.): E31-E38.

Utrera, A.R. and L.D. Van Vleck. 2004. *Heritability estimates for carcass traits of cattle: a review*. Genetics and Molecular Research 3(3): 380-394.

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Vásquez, C.G., L. Olvera, Y. Siqueiros, M.L. Kuri, V.A. Navarro, A.E. Rovelo and A. Shimada. 2003. *Nursing and feeding behaviour of confined red deer (Cervus elaphus scoticus) in the Mexican highlands*. New Zealand Journal of Agricultural Research 47: 1-9.

Visscher, P.M., W.G. Hill and N.R. Wray. 2008. *Heritability in the genomics era — concepts and misconceptions*. Nature ReviewslGenetics 9: 255-264.

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INTRODUCTION

Generating an economic profit from red deer farming depends heavily on the ability to produce superior quality animals year after year. To stay in front of the market, producers must constantly strive to improve their herds' genetics. Effective management of herd reproduction is a critical ingredient in any livestock operation. This means staying informed, keeping abreast of Canadian and international literature on cervids. By reading about new techniques like artificial insemination, producers can assess their potential impact on profitability and decide whether to apply them to their herds.

This leaflet describes the principal phases of the red deer's reproductive cycle, the steps involved in an artificial insemination program, and key factors for its success.

SEASONALITY OF REPRODUCTION

Like other cervids and small ruminants, the red deer is seasonally reproductive; more specifically, it is a "short-day breeder". When days shorten and the length of darkness increases, this sends a signal to the brain that unleashes a cascade of hormonal events in both stags and hinds.

Stags

In the male, shorter day length causes testosterone levels to increase by acting directly on the hypothalamic-pituitary axis (Figure 1), stimulating the secretion of various hormones in a precise sequence.

Summer is a period of sexual inactivity for the male, even though its velvet antlers are growing rapidly. Its testosterone level is very low, and the testicles and secondary sex glands are small and under-developed leading up to August. In August however, the increasing length of darkness stimulates receptors in the retina that transmit a nerve impulse through the superior cervical ganglia to the pineal gland via the post-ganglionic fibers. This causes the pineal gland to increase secretion of the hormone melatonin, which in turn causes the hypothalamus to increase production of GnRH (gonadotropin releasing hormone). GnRH stimulates the pituitary gland, which secretes luteinizing hormone (LH), and this is what directly induces secretion of testosterone by the testicles.

The rise in testosterone level makes the testicles enlarge and start producing sperm. The antlers calcify and the neck thickens. A few weeks before the rut begins, around mid-September, the stag's vocal tone changes: it bugles instead of bellowing. The level of testosterone reaches its peak in October or November (Haigh, 2007).

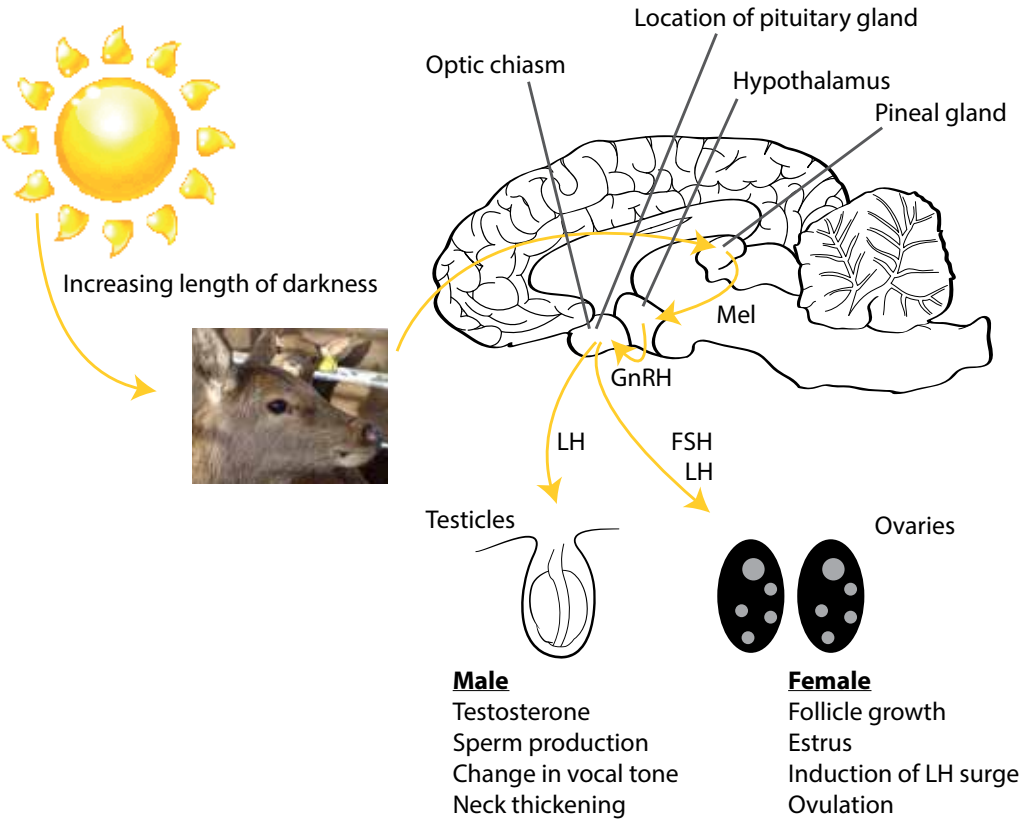


Figure 1. Effect of light on red deer (mel = melatonin, GnRH = gonadotropin releasing hormone, FSH = follicle-stimulating hormone, LH = luteinizing hormone)

Photo : Juan Pablo Soucy

Hinds

As shown in Figure 1, hinds are also affected by the increasing length of darkness, through its effect on the hypothalamic-pituitary axis. The latter regulates production of the hormones involved in the release of gonadotropins, which control the seasonal activity of the ovaries (estrus cycle) and consequently ovulation. Darkness stimulates the secretion of melatonin by the pineal gland, causing an increase in the production of GnRH by the hypothalamus. The increased levels of GnRH induce the secretion of follicle-stimulating hormone (FSH) and luteinizing hormone (LH) by the pituitary gland. This first follicular growth induces the first heat (estrus), which is often silent (with no apparent signs). Prior to the first heat, the female's ovaries and uterus were inactive.

The hind has her first heat of the season around the end of September or early October. Throughout the reproductive season, the estrus cycle repeats every 18-19 days or until the hind conceives. The cycle can continue repeating into January or February.

Each heat lasts for a full day and the hind may be bred up to twelve times by the stag. Since ovulation occurs 24 hours after the first signs of heat (Asher, 2007), the best time for mating is 18-24 hours after the

onset of heat. Determining the onset of heat is difficult however, since the animals are shy and will hide from observers.

MANAGEMENT OF NATURAL MATING

Preparation and selection of breeding stock

For breeding, it is important to choose animals with outstanding performance in terms of the traits desired for the intended market (rapid growth or majestic antlers)[1] . Though such phenotypic traits are not determined solely by genetics but also by herd management, it is essential to make these traits the focus of mate selection to ensure that their genes are transmitted to offspring. In New Zealand, the genetic selection techniques used for cattle have now been adapted for use with red deer. In future, these techniques could help identify which genes are truly superior.

Beyond superior genetics, it is important to choose male breeders with a body condition score greater than 3, the ideal being 5. A stag can lose up to 25-30% of its pre-rut weight over the course of the mating season. Young stags are fertile at around 16 months and can already be used for breeding.

Hinds should have a body condition score of 2.5 to 3.5 when mated, and should be in good health. Hinds that are too thin or too fat have lower conception rates (Table 1). Producers vaccinate and worm the hinds in mid-September, sometimes using this as an opportunity to wean the calves.

The best conception rates are obtained when the hinds are placed on a rising plane of nutrition in the mating season. Young hinds (1 ½ year old) should be put together in a paddock and mated with an experienced, very fertile stag.

Table 1. Relation between fertility and the hind's weight when bred

Weight (kg)	Fertility (%)
120	100
110	95
95	50

Source : Munyam (www.cerfsrouges.com/frameset.html)

Introduction of stags

The first step is to decide whether to rely entirely on natural mating or to use artificial insemination (AI) on hinds that have superior genetics. The latter would have been rigorously selected on the basis of traits like the weight of their calves at weaning, their own growth rate, and so on. Hinds intended for AI should be separated from the herd after weaning.

1. For more information about the choice of selection traits, the following factsheets are recommended: *Basic Principles of Genetics* and *Evaluating Red Deer for Breeding*.

In mid-September, hinds chosen for natural mating are divided into groups of at most 30 to 40 (if put with a mature stag), or groups of 10 to 15 if put with a young (1½ year old) stag. Early introduction of a stag into a group of hinds (late August to early September) advances estrus by about a week while inducing estrus synchronization in the entire group. In the first two weeks the animals establish a hierarchy within the group, which reduces stress during mating in late September to early October. The male should be kept with the hinds for at least 2 full estrus cycles, or till the end of October.

The date when the first calf of the year is born is used for determining, next year, when best to introduce the stag among the hinds. If this date (minus gestation time) coincides with when the stag was introduced, this indicates that the hinds were already in heat. The stag can therefore be introduced earlier the following year.

Ideally, 6 to 9 weeks after the stags were introduced they should be separated from the hinds. Many producers wait longer in hopes of increasing the conception rate, but this is not recommended. Calves born late in the season have a higher mortality rate. Hinds that calve late in the season are less likely to be ready for breeding the following autumn.

To ensure that an infertile stag does not have a drastic effect on the conception rate, after 3 to 4 weeks the stags can be switched to different groups of hinds. This can be a dangerous task due to the aggressiveness of rutting stags. The producer should also keep a close watch on the health and well-being of the male breeders. An estimated 10% of stags have reduced fertility due to injuries or fatigue caused by activities early in the season.

An example of reproductive management is presented in Table 2.

Table 2. Example of reproductive management in a red deer herd

Date	Steps
Early to mid-August	• Remove the stags' hard antlers
Early September	• Introduce chosen male breeders into their designated group of hinds
Mid-September	• Wean the calves • Vaccinate hinds, stags and calves against rabies, leptospirosis and clostridium (depending on veterinary recommendations for the region) • Worm all the animals after the first killing frost • Collect the breeding hinds and calves into groups: young hinds in groups of 10, the others in groups of 30 • Begin estrus synchronization in hinds chosen for insemination
Late October	• Switch the stags to different groups of hinds (if desired)
Mid to late November	• Worm all the animals
Late March	• Vermifuger tous les animaux
May-June	• Remove velvet antlers • Monitor births

Records

It is important to keep detailed records. Each calf's date of birth and subsequent weight gain, each stag's apparent fertility (number of births produced), health-related problems and interventions, are only part of the information that must be recorded.

GESTATION AND CALVING

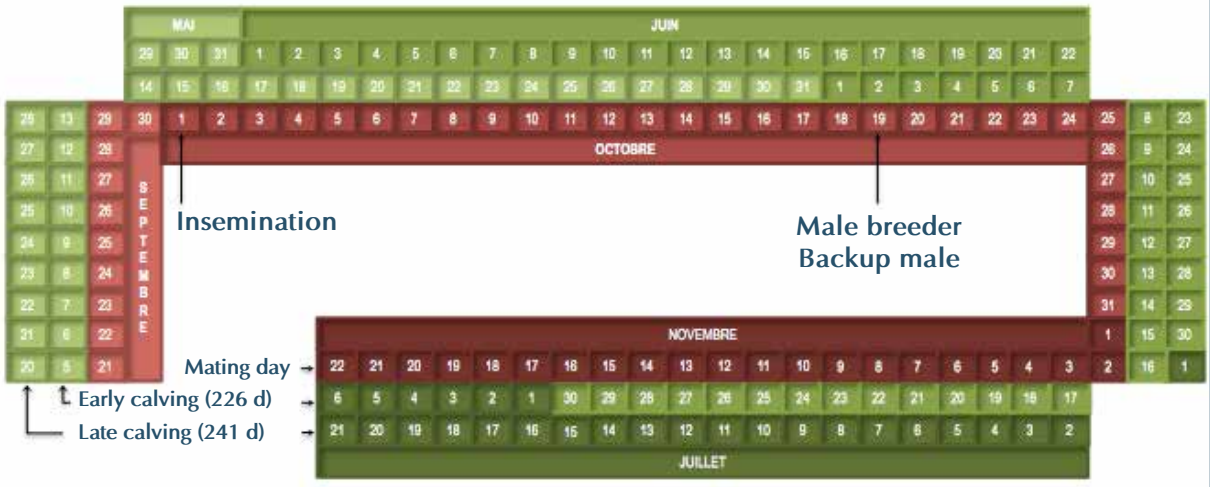
Most hinds conceive in their first estrus cycle. Pregnancy can be diagnosed by the 40th day after conception. Unfortunately, due to the stress suffered by the hinds when being diagnosed, the risk of spontaneous abortion is high, sometimes as high as 50%. Generally, only genetically superior hinds that are sold pregnant will be subjected to a pregnancy test.

One diagnostic technique to determine pregnancy requires taking a blood sample after the 40th day of pregnancy. The period of 40 to 42 days is only critical if the producer wants to know whether conception occurred after artificial insemination (a detectable pregnancy) or after subsequent mating with a «backup» male (pregnancy not detectable on the 40th day). The blood sample can be sent directly to BioTracking in the United States (www.biotracking.com) or via the IDEXX Canada Laboratory (www.idexx.com/reproduction). The test used is called BioPRYN®.

The other method of diagnosis uses ultrasound. With ultrasound, a veterinarian who is experienced with red deer can distinguish between a pregnancy caused by artificial insemination and one resulting from natural mating. The test should be performed 40 to 60 days after conception.

The average gestation period is 234 ± 7 days (Figure 2). To reduce calving problems, the hinds' body condition must be monitored diligently. From December 1 to April 1, they should be able to maintain a body condition score of 3.0 to 3.5 on good forage only. A small weight loss of 10% toward the end of winter is acceptable; in fact a slight weight loss in the months before calving reduces the risk of calving difficulties. From April 15 to May 15 (the end phase of gestation) the hinds should be removed from their winter pens and transferred into clean and spacious paddocks with plenty of pasture, if possible, to regain a little weight and get some exercise. Addition of concentrates should be done very methodically, since too much can cause calving or lactation problems.

As calving time approaches, the hind stays away from the rest of the herd and remains hidden until the calf is big enough to escape predators. Calves are born with spots that disappear by late summer. After one or two weeks the hinds rejoin the herd along with their calves. The parentage of a calf can be determined for certain by mailing hair samples from the calf and adults to the Genomnz™ laboratory in New Zealand (www.genomnz.co.nz).



Interpretation example: A hind inseminated or mated naturally on October 1 will calve between May 15 and 30. If she did not conceive during that heat, she will come into heat again around October 19; if she becomes pregnant on that date, she will calve between June 2 and 17.

Figure 2. Prediction of calving date

ARTIFICIAL INSEMINATION

In red deer, artificial insemination is a highly effective and proven technique for genetic improvement. Semen from an elite stag can rapidly improve a herd's genetic quality in terms of the traits desired, whether it be antler size or growth rate.

Critical steps

Producers should decide in the summer whether to use artificial insemination. If so, the inseminator should be contacted as soon as possible to arrange a schedule.

Usually, due to the seasonality of reproduction in red deer, artificial insemination is performed early in the mating season, the goal being to inseminate the hinds at their first heat. When a hind transitions to ovarian activity after the long period of ovarian inactivity, there is an initial silent ovulation followed by corpus luteum formation (10-12 days); the first visible heat comes a few weeks later. To ensure that insemination coincides with the first heat of the season (whether visible or silent), the producer can implement an estrus synchronization program. If desired, subsequent heats can also be induced through synchronization later in the season. From 4 to 14 days after insemination, a backup stag is put in with the inseminated hinds and kept with them for at least two estrus cycles, to maximize chances of the hinds being pregnant by the end of the rutting season.

Selection of elite hinds

Judicious selection of hinds to be inseminated is crucial for the success of an insemination program. The ideal hinds possess superior genetics, have a calm behaviour and calve without problems every year. They should have a body condition score between 2.5 and 3.5, and be allowed at least 60 days between calving and breeding. Weaning the calves isn't mandatory, but for most producers this is done when the intra-vaginal insert is inserted for heat synchronization (see below). Young, 1½ year old hinds can be included in the insemination program if they have reached at least 80% (110 kg) of their adult body weight.

Selection of semen

The best choice of stag to inseminate a given hind will depend on which phenotypic features the producer wishes to improve. Having a good understanding of the genetic background of the herd's hinds is the essential place to start. The producer must then inquire into the genetics of stags whose frozen semen is available, and the availability of the two types of semen: sexed semen, which has a 90% chance of producing offspring of the desired sex, or non-sexed semen. For frozen semen purchased in North America, purchase and delivery should be completed at least a week before the insemination date (4 weeks in the case of semen from New Zealand). Delivery details can be worked out with the help of the inseminator.

Synchronization of heats

The inseminator is responsible for providing the producer with a heat synchronization program (Table 3). One common method of heat synchronization uses an intra-vaginal CIDR® insert (CIDR® is a trademark that stands for *controlled internal drug release*). The insert releases the hormone progesterone within the hind's vagina over a period of 10-12 days. The CIDR® 330 insert contains 0.330 gram of progesterone. When the insert is removed, the progesterone level drops rapidly, causing a rise in follicle-stimulating hormone (FSH) and a surge of luteinizing hormone (LH). To maximize the likelihood of ovulation, when the insert is removed a small dose of precisely 200 IU of equine chorionic gonadotropin (eCG) is injected into muscle.

Table 3. Example of a heat synchronization program, for artificial insemination on October 1 at 9:30 a.m.

Day of treatment relative to insemination day (ID)	Procedure	Date	Time
10-12 days before ID	Insertion of CIDR®	September 17 to 19	During the day
2¼ days before ID	Removal of CIDR® + Injection of 200 IU eCG	September 29	2:00 a.m.
Insemination Day	**Artificial insemination** 54-60 hours after CIDR® removal	**October 1**	**9:30 a.m.**
4-6 days after ID	Introduction of a backup male	October 5 to 17	
40-60 days after ID	Pregnancy test (optional)	November 9 to 29	

During his or her visit, the inseminator will try to predict the success of heat synchronization. Have the hinds been walking the fence lines over the last 12 to 24 hours? When they are in heat they seek a stag and walk along the fences. The presence of vaginal mucus and ruffled or missing hair at the hind quarters are other signs of estrus.

Factors to monitor

An artificial insemination program should have a success rate of at least 70%. Unfortunately, sometimes the results are very disappointing. The following considerations may shed light on potential problems.

Male fertility and semen quality

The quality of frozen semen varies widely from one stag to the next, even between different semen straws from the same stag. Also, if the seminal plasma recovered during semen collection is not separated from the sperm it can significantly reduce the fecundity of frozen semen.

It is difficult if not impossible to judge the fertility of semen by sperm motility, since sperm can appear normal despite a loss of fecundity. Motility is a poor indicator of fertility and indeed a very subjective matter, yet it is the only criterion that can be assessed on the farm. Commercially, the general rule is that a thawed dose of semen must contain at least 20 to 30 million spermatozoa with at least 40% motility.

Damage incurred during storage, packing or shipment can drastically reduce the effectiveness of semen. Exposure to air for more than a second, or storage in a defective tank or one with insufficient liquid nitrogen, can result in the semen in a straw having very low fecundity. Here again, sperm motility after thawing does not necessarily mean anything; motility can be 40 to 50% without the semen having to the same degree of fecundity.

Synchronization and quality of heats

Keeping the intra-vaginal insert in place for 10-12 days increases the risk of infection, and the potential of infection ascending into the uterus. A major vaginal infection will reduce the success rate of insemination to 30-40%, compared to 70% in a healthy animal. Strict hygiene is therefore essential during insertion and withdrawal of the CIDR® insert. With each animal to be treated, new disposable gloves should be put on and the applicator disinfected in a solution of Virkon® or chlorhexidine (Hibitane®). Also essential is to make sure the hinds are injected with precisely 200 IU of eCG when the CIDR® is removed.

Equipment

Sometimes the best equipment is the simplest. The ideal setup allows the hinds to be led to the squeeze (whether hydraulic or manual) with little or no stress and agitation. The best squeeze is one that will prevent the hind from backing out, keeping it immobilized with its rump at the back of the squeeze. A squeeze that allows too much movement could be dangerous for both the animal and the inseminator, while reducing the chances of successful insemination.

CONCLUSION

To survive in this industry, red deer producers must strive to improve the genetics of their herds. With artificial insemination, this can be achieved quickly and effectively, sharpening the focus on the producer's specific objectives (rapid growth rate or the development of majestic antlers). The technique is now affordable for every producer and generally has a high success rate.

SUGGESTED READING

Asher, G.W. 2007. *Reproductive Cycles in Female Cervids*. In: Current Therapy in Large Animal Theriogenology, Chap. 125. pp. 921-931.

Haigh, J.C. 2007. *Reproductive Anatomy and Physiology of Male Wapiti and Red Deer*. In: Current Therapy in Large Animal Theriogenology, Chap. 126. pp. 932-936.

Munyam, L. *La reproduction* [online]. Website of the Association Cerfs rouges du Québec. http://www.cerfsrouges.com/frameset.html (accessed March 14, 2012).

Plante, C., J. Pollard and M. Bringans M. 2007. *Estrous Synchronization and Artificial Insemination in Domesticated Cervids*. In: Current Therapy in Large Animal Theriogenology, Chap. 135. pp. 987-990.

Tuckwell, C. 2003. *The Deer Farming Handbook*. Published by Rural Industries Research & Development Corporation. 299 pp.

Wilson, P.R. and J.C. Haigh. 2007. *Reproductive Management of Farmed Red Deer and Wapiti*. In: Current Therapy in Large Animal Theriogenology, Chap. 128. pp. 943-952.

Production Guide

DOMESTIC GAME FARM ANIMALS

Reproductive Management of Wapiti

CRAAQ

CULTIVER L'EXPERTISE
DIFFUSER LE SAVOIR

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INTRODUCTION

Generating an economic profit from wapiti farming depends heavily on the ability to produce superior quality animals year after year. To stay in front of the market, producers must constantly strive to improve their herds' genetics. Effective management of herd reproduction is a critical ingredient in any livestock operation. This means staying informed, keeping abreast of Canadian and international literature on cervids. By reading about new techniques like artificial insemination, producers can assess their potential impact on profitability and decide whether to apply them to their herds.

This leaflet describes the principal phases of the wapiti's reproductive cycle, the steps involved in an artificial insemination program, and key factors for success.

A little terminology

In North America, *wapiti* refers to a purebred animal whose Latin name is *Cervus elaphus canadensis*. English speakers (in N.A.) often refer to it as *elk*, but since Quebecers call it *wapiti*, and it appears as such on restaurant menus and meat counters, that is the term used here. Note that in New Zealand, *wapiti* means a hybrid of elk and red deer.

The word *wapiti* comes from the Algonquian name for the animal, *wapiti*, meaning «white rump». Use of the word *elk* derives from the first European settlers, who thought the animal resembled the European elk. However, what Europeans call *elk* is in North America a moose.

SEASONALITY OF REPRODUCTION

Like other cervids and small ruminants, the wapitiis seasonally reproductive; more specifically, it is a "short-day breeder". When days shorten and the length of darkness increases, a signal is sent to the brain that unleashes a cascade of hormonal events in both bulls and cows.

Bulls

In the male wapiti, shorter day length causes testosterone levels to increase by acting directly on the hypothalamic-pituitary axis (Figure 1), stimulating the secretion of various hormones in a precise sequence.

Summer is a period of sexual inactivity for the male, even though its velvet antlers are growing rapidly. Its testosterone level is very low, and the testicles and secondary sex glands are small and under-developed leading up to August. In August however, the increasing length of darkness stimulates receptors in the retina that transmit a nerve impulse through the superior cervical ganglia to the pineal gland via the post-ganglionic fibers. This causes the pineal gland to increase secretion of the hormone melatonin, which in turn causes the hypothalamus to increase production of GnRH (gonadotropin releasing hormone). GnRH stimulates the pituitary gland, which secretes luteinizing hormone (LH), and this is what directly induces secretion of testosterone by the testicles.

The rise in testosterone makes the testicles enlarge and start producing sperm. The antlers calcify and the neck thickens. A few weeks before the rut begins, around mid-September, the bull's vocal tone changes: it bugles instead of bellowing. The level of testosterone reaches its peak in October or November (Haigh, 2007).

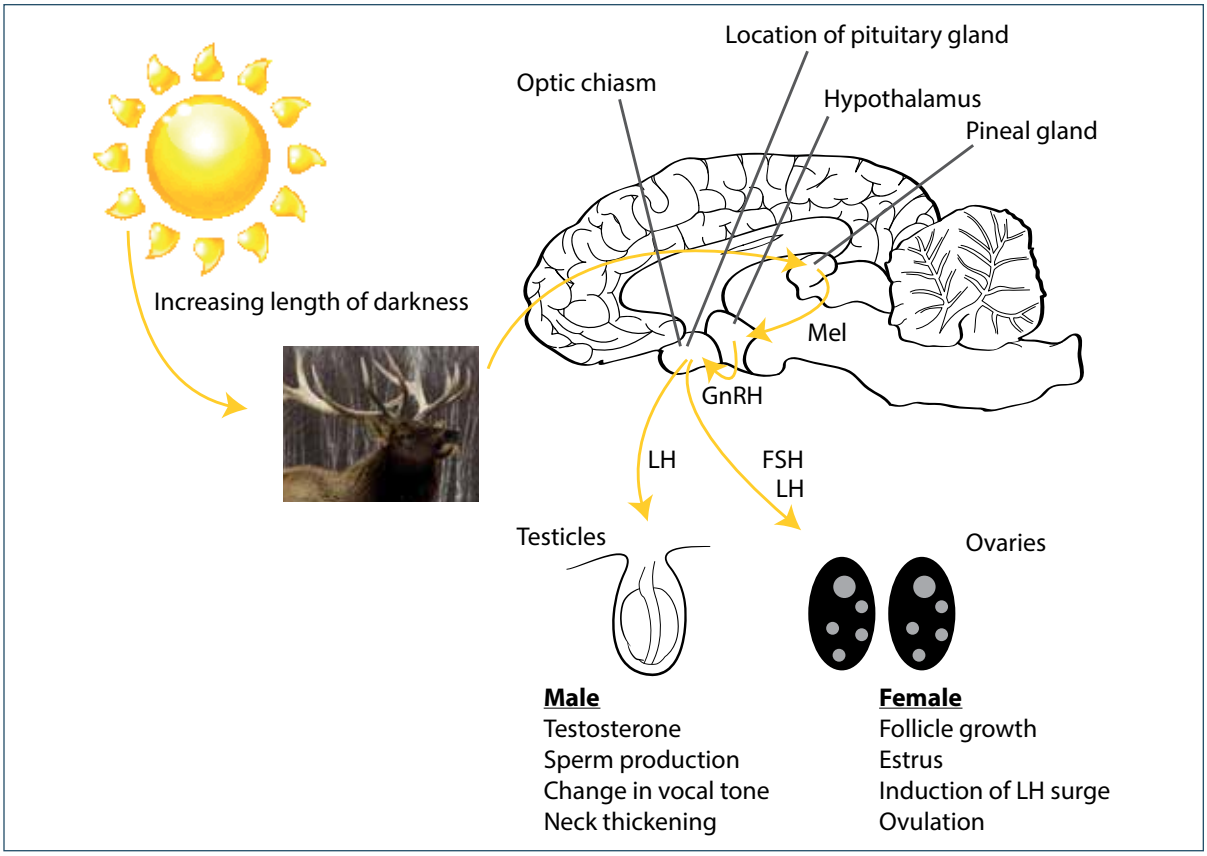


Figure 1. Effect of light on wapiti (mel = melatonin, GnRH = gonadotropin releasing hormone, FSH = follicle-stimulating hormone, LH = luteinizing hormone)

Cows

As shown in Figure 1, the female wapiti is also affected by the increasing length of darkness, through its effect on the hypothalamic-pituitary axis. The latter regulates production of the hormones involved in the release of gonadotropins, which control the seasonal activity of the ovaries (estrus cycle) and consequently ovulation. Darkness stimulates the secretion of melatonin by the pineal gland, causing an increase in the production of GnRH by the hypothalamus. The increased levels of GnRH induce the secretion of follicle-stimulating hormone (FSH) and luteinizing hormone (LH) by the pituitary gland. This first follicular growth induces the first heat (estrus), which is often silent (with no apparent signs). Prior to this first heat, the cow's ovaries and uterus were inactive.

The cow has her first heat of the season in mid-September. Throughout the reproductive season, the estrus cycle repeats every 19-21 days or until the cow conceives. The cycle can continue repeating into January-February. She remains in heat for 1 or 2 days and may be bred a dozen or more times by the bull. Since ovulation occurs 24 hours after the first signs of heat (Asher, 2007), the best time for mating is 18-36 hours after the onset of heat. Determining the onset of heat is difficult however, since the animals are shy and will hide from observers.

MANAGEMENT OF NATURAL MATING

Preparation and selection of breeding stock

For breeding, it is important to choose animals with outstanding performance in terms of the traits desired for the intended market (rapid growth or majestic antlers)[1]. Though such phenotypic traits are not determined solely by genetics, but also by herd management, it is essential to make these traits the focus of mate selection to ensure that their genes are transmitted to offspring. In New Zealand, the genetic selection techniques used for cattle have now been adapted for use with red deer, and in future, could probably be applied to wapiti. This would help considerably in identifying which genes are truly superior.

Beyond superior genetics, it is important to choose reproductive bulls with a body condition score greater than 3. A bull can lose up to 15% of its pre-rut weight over the course of the mating season. Young bulls are fertile at around 16 months and can already be used for breeding.

Cows should have a body condition score of 2.5 to 3.5 when mated, and should be in good health. Cows that are too thin or too fat have lower conception rates. Often, breeders vaccinate and worm the cows in late August to early September, and sometimes use this as an opportunity to wean the calves.

The best conception rates are obtained when the cows are placed on a rising plane of nutrition in the mating season. Young cows (1½ year old) should be put together in a paddock and mated with an experienced, very fertile bull.

Introduction of bulls

The first step is to decide whether to rely entirely on natural mating or to use artificial insemination (AI) on cows that have superior genetics. The latter would have been rigorously selected on the basis of traits like the weight of their calves at weaning, their own growth rate, and so on. Cows intended for AI should be separated from the herd after weaning.

At the end of August, cows chosen for natural mating are divided into groups of at most 30 to 40 (if put with a mature bull), or groups of 10 to 15 if put with a young, 1½ year old bull. Early introduction of a bull into a group of cows (in the first days of September) advances estrus by about a week while inducing estrus synchronization in the entire group. In the first two weeks of September, the animals establish a hierarchy within the group, which reduces stress during mating in mid-September. The bull should be kept with the cows for at least 2 full estrus cycles, or until mid-October.

The date when the first calf of the year is born is used for determining, next year, when best to introduce the bull among the cows. If this date (minus gestation time) coincides with when the bull was introduced, this indicates that the cows were already in heat. The bull can therefore be introduced earlier the following year.

1. For more information about the choice of selection traits, the following factsheet is recommended: *Basic Principles of Genetics*.

Ideally, 6 to 9 weeks after the bulls were introduced they should be separated from the cows. Many breeders wait longer in hopes of increasing the conception rate, but this is not recommended. Calves born late in the season have a higher mortality rate. Cows that calve late in the season are less likely to be ready for breeding the following autumn (see Table 1).

To ensure that an infertile bull does not have a drastic effect on the conception rate, after 3 to 4 weeks the bulls can be switched to different groups of cows. This can be a dangerous task due to the aggressiveness of rutting bulls. The producer should also keep a close watch on the health and well-being of the bulls. An estimated 10% of bulls have reduced fertility due to injuries or fatigue caused by activities early in the season.

An example of reproductive management is presented in Table 1.

Table 1. Example of reproductive management in a wapiti herd

Date	Steps
Mid-August	• Remove the bulls' hard antlers
Late August	• Wean the calves • Vaccinate cows, bulls and calves against rabies, leptospirosis and clostridium (depending on veterinary recommendations for the region) • Worm all the animals after the first killing frost • Collect the cows and calves into groups: young cows (1½ yr-olds) in groups of 10, the others in groups of 30 • Begin estrus synchronization in cows chosen for insemination
Early September	• Introduce bull breeders into their designated group of cows
Early October	• Switch the bulls to different groups of cows (if desired)
Early November	• Remove all bull breeders from the groups of cows
Late March	• Worm all the animals
May-June	• Remove velvet antlers • Monitor births

Records

It is important to keep detailed records. Each calf's date of birth and subsequent weight gain, each bull's apparent fertility (number of births produced), health-related problems and interventions, are only part of the information that must be recorded.

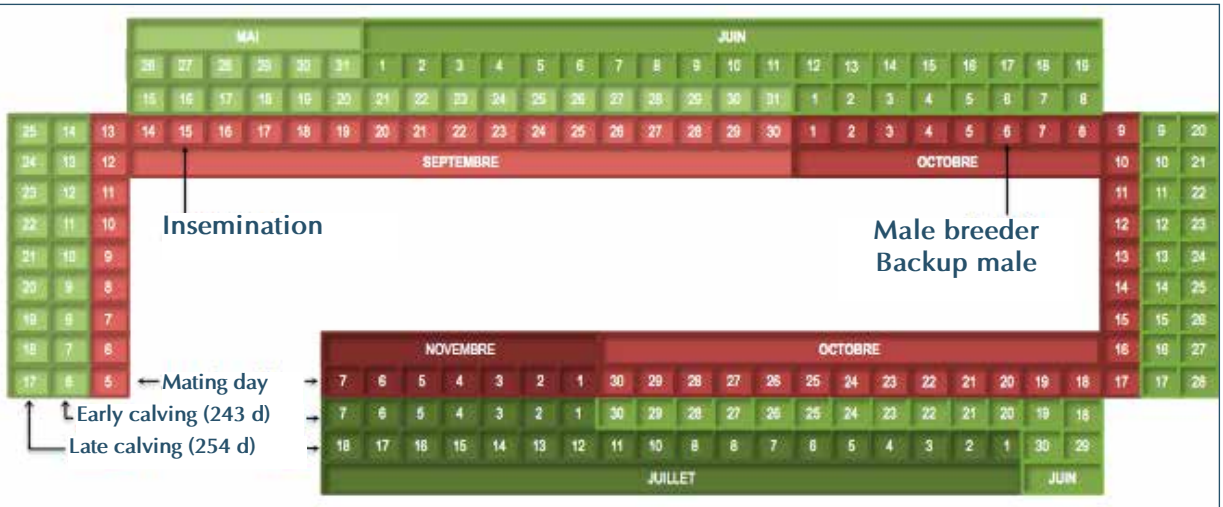
GESTATION AND CALVING

Most cows conceive in their first estrus cycle. Pregnancy can be diagnosed from the 40th to the 60th day after conception. Unfortunately, due to the stress suffered by the cows when being diagnosed, the risk of spontaneous abortion is high, sometimes as high as 50%. Generally, only genetically superior cows that are sold pregnant will be subjected to a pregnancy test.

One diagnostic technique to determine pregnancy requires taking a blood sample after the 40th day of pregnancy. The 40 day period is only critical if the breeder wants to know whether conception occurred after artificial insemination (a detectable pregnancy) or after subsequent mating with a backup bull (pregnancy not detectable on the 40th day). The blood sample can be sent directly to BioTracking in the United States (http://www.biotracking.com); forms are provided for this purpose on the website.

The other method of diagnosis uses ultrasound. With ultrasound, a veterinarian who is experienced with wapiti can distinguish between a pregnancy caused by artificial insemination and one resulting from natural mating. The test should be performed 40 to 60 days after conception.

The average gestation period for Canadian purebred wapiti is 250 ± 5 days (Figure 2). A study on the reproductive performance of wapiti kept in captivity showed a calving rate of 89.6% for adult cows and 79% for young cows (Woodbury and coll., 2006). To reduce calving problems, the cows' body condition must be monitored diligently. From November 1 to April 1, they should be able to maintain a body condition score of 3.0 to 3.5 on good forage only. A small weight loss of 10% toward the end of winter is acceptable; in fact a slight weight loss in the months before calving reduces the risk of calving difficulties. From April 1 to May 15 (the end phase of gestation) the cows should be transferred onto good pasture to regain a little weight and get some exercise. Addition of grain or concentrates should be done gradually, since too much can cause calving or lactation problems (Dupchak, Manitoba Agriculture and Rural Initiatives).



Interpretation example: A cow inseminated or mated naturally on September 15 will calve between May 16 and 27. If she did not conceive during that heat, she will come into heat again around October 6; if she becomes pregnant on that date, she will calve between June 6 and 17.

Figure 2. Prediction of calving date

As calving time approaches, the cow stays away from the rest of the herd and remains hidden until the calf is big enough to escape predators. Calves are born with spots that disappear by late summer. After one or two weeks the cows rejoin the herd along with their calves. The parentage of a calf can be determined for certain by mailing hair samples from the calf and adults to the *Genomnz*™ laboratory in New Zealand (http://www.genomnz.co.nz).

ARTIFICIAL INSEMINATION

In wapiti, artificial insemination is a highly effective and proven technique for genetic improvement. Semen from an elite bull can rapidly improve a herd's genetic quality in terms of the traits desired, whether it be antler size or growth rate.

Critical steps

The producer should decide in the summer whether to use artificial insemination. If so, the inseminator should be contacted as soon as possible to arrange a schedule.

Usually, due to the seasonality of reproduction in wapiti, artificial insemination is performed early in the reproductive season, the goal being to inseminate the cows at their first heat. When a cow transitions to ovarian activity after the long period of ovarian inactivity, there is an initial silent ovulation followed by corpus luteum formation (12-14 days); the first visible heat comes a few weeks later. To ensure that insemination coincides with the first heat of the season (whether visible or silent), the breeder can implement an estrus synchronization program. If desired, subsequent heats can also be induced through synchronization later in the season. From 4 to 14 days after insemination, a backup bull is put in with the inseminated cows and kept with them for at least two estrus cycles, to maximize chances of their being pregnant by the end of the rutting season.

Selection of elite cows

Judicious selection of cows to be inseminated is crucial for the success of an insemination program. The ideal cows possess superior genetics, have a calm behaviour and calve without problems every year. They should have a body condition score between 2.5 and 3.5, and be allowed at least 60 days between calving and breeding. Weaning the calves isn't mandatory, but for most producers this is done when the intra-vaginal device is inserted for heat synchronization (see below). Young, 1½ year old cows can be included in the insemination program if they have reached at least 80% (180 kg) of their adult body weight.

Selection of semen

The best choice of bull to inseminate a given cow will depend on which phenotypic features the producer wishes to improve. Having a good understanding of the genetic background of the herd's cows is the essential place to start. The producer must then inquire into the genetics of bulls whose frozen semen is available, and the availability of the two types of semen: sexed semen, which has a 90% chance of producing offspring of the desired sex, or non-sexed semen. For frozen semen purchased in North America, purchase and delivery should be completed at least a week before the insemination date (4 weeks in the case of semen from New Zealand). Delivery details can be worked out with the help of the inseminator.

Synchronization of heats

The inseminator is responsible for providing the producer with a heat synchronization program (Table 2). One common method of heat synchronization uses an intra-vaginal CIDR® insert (CIDR® is a trademark that stands for *controlled internal drug release*). The insert releases the hormone progesterone within the cow's vagina over a period of 10-14 days. The CIDR® 1380 insert contains 1.38 gram of progesterone. When the insert is removed, the progesterone level drops rapidly, causing a rise in follicle-stimulating hormone (FSH) and a surge of luteinizing hormone (LH). To maximize the likelihood of ovulation, when the insert is removed a small dose of precisely 200 IU of equine chorionic gonadotropin (eCG) is injected into muscle.

Table 2. Example of a heat synchronization program, for artificial insemination on September 14 at 9:30 a.m.

Day of treatment relative to insemination day (ID)	Procedure	Date	Time
12-14 days before ID	Insertion of CIDR®	August 29 to 31	During the day
2.5 days before ID	Removal of CIDR® + Injection of 200 IU eCG	September 11	9:30 p.m.
Insemination Day	**Artificial insemination** 60-66 hours after CIDR® removal	**September 14**	**9:30 a.m.**
4 to 16 days after ID	Introduction of a backup bull	September 18 to 30	
40 to 60 days after ID	Pregnancy test via ultrasound		

During his or her visit, the inseminator will try to predict the success of heat synchronization. Have the cows been walking the fence lines over the last 12 to 24 hours? When they are in heat they seek a bull and walk along the fences. The presence of vaginal mucus and ruffled or missing hair at the hind quarters are other signs of estrus.

Factors to monitor

An artificial insemination program should have a success rate of at least 70%. Unfortunately, sometimes the results are very disappointing. The following considerations may shed light on possible problems.

Bull fertility and semen quality

The quality of frozen semen varies widely from one bull to the next, even between different semen straws from the same bull. Also, if the seminal plasma recovered during semen collection is not separated from the sperm it can significantly reduce the fecundity of frozen semen.

It is difficult if not impossible to judge the fertility of semen by sperm motility, since sperm can appear normal despite a loss of fecundity. Motility is a poor indicator of fertility and indeed a very subjective matter, yet it is the only criterion that can be assessed on the farm. Commercially, the general rule is that a thawed dose of semen must contain at least 20 to 30 million spermatozoa with at least 40% motility.

Damage incurred during storage, packing or shipment can drastically reduce the effectiveness of semen. Exposure to air for more than a second, or storage in a defective tank or one with insufficient liquid nitrogen, can result in the semen in a straw having very low fecundity. Here again, sperm motility after thawing does not necessarily mean anything; motility can be 40 to 50% without the semen having to the same degree of fecundity.

Synchronization and quality of heats

Keeping the intra-vaginal insert in place for 12-14 days increases the risk of infection, with the potential for an infection ascending into the uterus. A major vaginal infection will reduce the success rate of insemination to 30-40%, compared to 70% in a healthy animal. Strict hygiene is therefore essential during insertion and withdrawal of the CIDR® insert. With each animal to be treated, new disposable gloves should be put on and the applicator disinfected in a solution of Virkon® or chlorhexidine (e.g. Hibitane®). Also essential is to make sure the cows are injected with precisely 200 IU of eCG when the CIDR® is removed.

Equipment

Sometimes the best equipment is the simplest. The ideal setup allows the cows to be led to the squeeze (whether hydraulic or manual) with little or no stress and agitation. The best squeeze is one that will prevent the cow from backing out, keeping it immobilized with its rump at the back of the squeeze. A squeeze that allows too much movement could be dangerous for both the animal and the inseminator, while reducing the chances of successful insemination.

CONCLUSION

To survive in this industry, wapiti producers must strive to improve the genetics of their herds. With artificial insemination, this can be achieved quickly and effectively, sharpening the focus on the producer's specific objectives (rapid growth rate or the development of majestic antlers). The technique is now affordable for every producer and generally has a high success rate.

SUGGESTED READING

Asher, G.W. 2007. *Reproductive Cycles in Female Cervids*. In: Current Therapy in Large Animal Theriogenology, Chap. 125. pp. 921-931.

Dupchak, K. *Feeding Elk Cows* [online]. Manitoba Agriculture, Food and Rural Initiatives. http://www.gov.mb.ca/agriculture/livestock/elk/bbb02s03.html

Favero, R. *Preparing for the Artificial Insemination Season* [online]. http://www.wapiti.net/ai.cfm

Haigh, J.C. 2007. *Reproductive Anatomy and Physiology of Male Wapiti and Red Deer*. In: Current Therapy in Large Animal Theriogenology, Chap. 126. pp. 932-936.

NAEBA. 2000. *Elk Farming Handbook*. North American Elk Breeders Association. Viking Livestock (ed.), Saint-Albert, Alberta. 300 pp.

Plante, C., J. Pollard and M. Bringans. 2007. *Estrous Synchronization and Artificial Insemination in Domesticated Cervids*. In: Current Therapy in Large Animal Theriogenology, Chap. 135. pp. 987-990.

Tuckwell, C. 2003. *The Deer Farming Handbook*. Published by Rural Industries Research & Development Corporation. 299 pp.

Wilson, P.R. and J.C. Haigh. 2007. *Reproductive Management of Farmed Red Deer and Wapiti*. In: Current Therapy in Large Animal Theriogenology, Chap. 128. pp. 943-952.

Woodbury, M.R., J. Brezowski and J. Haigh. 2006. *An estimation of reproductive performance of farmed elk* (Cervus elaphus) in North America. Can. Vet. J. 47(1): 60-64.

Production Guide

DOMESTIC GAME FARM ANIMALS

Reproductive Management of Bison

CRAAQ

CULTIVER L'EXPERTISE
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INTRODUCTION

In bison farming, the function of a cow is to produce a live calf every year. The general objective of a bison farm is to maximize the net harvest of bison calves, or rather the number of kilograms of weaned bison calf per breeding cow in the herd, at the lowest possible cost. To that end, the producer must constantly make decisions that, from generation to generation, will improve the genetic potential of his or her breeding stock.

The first task is to design a solid reproduction program based on set objectives for reproduction and breeding. These objectives will serve as reference points that can then be used, as time goes by, to assess the effectiveness of breeding decisions.

A good breeder will have the following reproduction and breeding objectives:

- 95% conception rate;
- one bison calf per cow per year;
- calving at 27 to 30 months for primiparous cows with good growth;
- calvings grouped in time, i.e. 70% of the herd's cows calve in the first 20 days of the calving period;
- average of 365 days between calvings;
- weaning rate of 90% of bison calves born;
- adult cows gestating again within 65 to 70 days after calving, i.e. 2 to 3 estrus cycles later;
- primiparous cows grouped and mated with a 3-year-old breeding bull, at least 3 weeks before the adult cows, for a mating period of 42 days (2 cycles);
- average weight of bison calves at weaning, at 6 months, equal to 50% of their mother's weight (with good management and good lactation);
- calves' pre-weaning mortality rate under 3%;
- calves' post-weaning mortality rate under 1%;
- cows' average annual mortality rate under 1%;
- breeder culling rate of 10% or less, though this depends on the age of the cows: it can be higher if the average age is over 10 years. Culling may be required for reasons other than age, such as infertility, problems with hooves and limbs, lack of maternal aptitude, accidents, etc.

To achieve these objectives, good management practices and careful selection of breeding stock are essential.

REPRODUCTIVE PERIOD

No human intervention is needed when it comes to bison reproduction; just let nature take its course. As with most wild mammals at our latitudes, bison reproduction is seasonal. In natural conditions the rut extends from late July to early December, but on Québec farms it is generally from late July to early October. Gestation takes about 9 months (275 to 290 days). Calving generally begins toward the end of April, when the calves are most likely to survive and perpetuate the species.

Though it is possible to leave bulls with the females all year long, it is wiser to put them together for a shorter breeding period to avoid late season calvings. For the same reason, some producers prefer not to breed any cows that are not pregnant by early October. They can be mated the following year or simply culled.

Bulls should be separated from the cows no later than early November, when the herd is rounded up for fall vaccinations, so that calves will be sufficiently developed to withstand the winter. Calves that are born late are at a disadvantage to those born in spring, since they cannot be weaned and put together with the others. The later born calves spend the winter with their mothers, are at greater risk of having an accident, and can only join the other calves the following year.

Calving problems are fairly rare in bison. The cows stay away from the rest of the herd and look for a safe and quiet place to calve. Newborn calves are very vigorous, with birth weights ranging from 16 to 18 kg. Calves often suckle within minutes after birth and then suckle regularly every two hours or less. For the next 6 to 8 months until it is weaned, the calf will follow its mother step by step. Calves are born from late April till mid-July and for the most part are weaned in early December.

MAIN FACTORS AFFECTING CONCEPTION RATE

The conception rate is influenced by both hereditary factors and herd management. To attain a 95% rate of conception, close attention should be paid to the following:

- fertility of bulls;
- fertility of cows and heifers (females from 6 months of age until their first calving);
- ratio of cows per breeding bull;
- nutrition;
- environment;
- health of the herd.

Looking at the number of calves born per breeding-age cow in the herd, we find many herds with conception rates under 90%. This can be improved with careful selection of cows and breeding bulls. For example, a cow that does not produce a calf each year should be culled. Though fertility is genetic, fertility can be enhanced through good husbandry and good nutrition.

Fertility of bulls

Generally, 20% to 40% of bulls do not meet the standards of a modern breeding program, due to insufficient sperm production, inferior quality sperm, physical defects that interfere with breeding or deficient libido. Therefore it is important to have a fertility test performed each year (by a veterinarian) about a month before the start of the breeding season.

Fertility of cows and heifers

The cow's body condition at calving and through to the next mating largely determines the return of estrus and consequently fertility. Ensuring proper nutrition is important throughout the postpartum period. A conception rate of 95% can be expected if proper husbandry and feeding are provided.

Aim for a body condition score of 3.0 to 3.5 at calving (see Appendix 1). A cow that scores less than 3.0 at calving will take longer to rebreed. Cows that are thin when they calve, or that lose significant weight afterwards, take longer than average to come into heat, have a lower rate of conception at first breeding and a longer calving interval.

Ratio of cows per breeding bull

As a species bison reproduce easily, since 80% to 100% of the cows will conceive each year if the ratio of cows per breeding bull is no more than 15-30 to 1. An adult bull can cover 50 to 60 cows, while a young bull of 2½ to 3 years is generally not effective with more than 20 cows.

Feeding and nutrition

In the natural environment, bisons can withstand harsh winters and survive when food is scarce. In extreme conditions the bison has the ability to slow its metabolism, drawing on reserves built up over the summer. These reserves are stored as fat around the muscles of the hump at the back of the neck above the shoulders. However, when food is scarce the first function affected is reproduction, so on a bison farm it is important to ensure an abundant and quality feed supply.

In the summer, depending on the temperature, an adult bison drinks 22 to 65 litres of water per day (average 12 litres/100 kg live weight). Sufficient good quality water is necessary at all times, even in the winter, since snow alone cannot provide bison all the water they need.

Minerals and vitamins are essential for good growth and conception rates. The breeding season and the lead-up to it are particularly critical, since cows that are not in good body condition, or that are borderline, are much less likely to reproduce. No wild animal will risk its life or weaken itself to perpetuate the species, and bison are no exception.

To avoid competition that could prevent the animals from getting enough feed, adequate feeder space must be provided. There should be no more than 10 to 12 bison per round bale feeder, even if that means buying more feeders. On pasture there is little or no competition, and every bison will find enough to eat if there is a good density of forages and the pasture is well maintained. Depending on the region there should be about 0.8 hectare of pasture per animal.

Environment

The environment needs to be comfortable, clean and dry, particularly where female bison are concerned. The animals should have access to a place where they can get out of the wind. A bison that is constantly out in bad weather will need more food to maintain its body condition.

Herd health

In the wild, bison are fairly resistant to disease. Farmed bison are more vulnerable because they live in a more restricted space. They can contract the same diseases and parasitic infections as domestic cattle. This makes it necessary to have general prophylactic measures in place, including regular treatments against internal and external parasites. Close collaboration with the veterinarian is essential: working together, you can develop an annual herd health program and apply it rigorously.

IMPORTANCE OF BODY CONDITION

Throughout the reproductive cycle, the cows' body condition has a direct influence on their productivity and subsequently on the performance of their weaned calves. Also, cows that are too thin or too fat can develop problems that will limit their longevity in the herd.

At weaning

To determine nutritional requirements, assess the body condition of breeding stock, especially cows that have nursed throughout the grazing season, and calculate the herd's average body condition. Pay special attention to young cows that have just had their first calf: since they are still growing, they need more feed. To rebuild the body condition of cows, make sure they have abundant, quality feed, whether from pasture or fodder supplemented by grain as necessary. To avoid excessive competition, some producers keep young cows (1st and 2nd calving) in separate pastures from the adult cows (3rd calving and up). A good opportunity to perform pregnancy tests and preventive treatments is when stock are being handled during weaning.

In the 90 days before calving

Unlike beef cows, a bison cow slows down her metabolism over the winter and draws on the fat reserves accumulated from September to November. Female bison that were properly fed during the accumulation phase will maintain better body condition in the period prior to calving.

Nutrition needs increase significantly over the last three months of gestation; the growth rate of the fetus increases, and its weight doubles in the last two months. Insufficient feed during this period results in calves that are weaker and lighter at birth, are more susceptible to disease and have a higher mortality rate.

30 days before the mating period

The cows should begin regaining weight. The animals are out on pasture, and even if they are already getting good inputs of protein and energy, the ration should generally be supplemented with grain (oats

or corn) to be eaten freely. This is called “flushing” (conditioning): provide 2.3 to 2.7 kg of grain per day per cow, and 3.6 to 4.5 kg per day per breeding bull. Such energy and protein supplements stimulate the return of estrus and improves conception rates.

Scoring body condition is particularly important in winter and during the 60 days after calving, when the cows start coming into heat again and before the first breeding. Keep in mind that in the same period, the cow should reach peak lactation to feed her calf sufficiently. Feed rations should eventually be adjusted to make sure she gets adequate nutrition.

PHYSIOLOGY OF REPRODUCTION IN FEMALE BISON

Estrus cycle

As with beef cows, in the absence of gestation, the bison cow comes back into heat (estrus) at regular intervals of 18-23 days (the estrus cycle), the average being 21 days. A bison cow is most fertile from the end of July till early December. Out of season the cow is much less fertile, though fertilization is not impossible.

The estrus cycle (Figure 1) has four distinct phases:

- estrus proper (ovarian activity, dominance of estrogens and luteinizing hormone (LH)). Characteristic signs: the cow lets herself be mounted and tries to mount other cows that are in heat; discharge of a clear, thin mucus hanging from the vulva. Duration: day 0 (12-18 hours);
- postestrus: period immediately after heat, corresponding to ovulation (release of one ovule per follicle, which then transforms into the corpus luteum). The corpus luteum develops gradually and secretes progesterone, which blocks ovarian activity. Duration: days 1 to 5;
- diestrus: the presence of progesterone causes the mucus lining of the uterus (endometrium) to secrete the elements essential for development of the embryo during the initial weeks of gestation. At the beginning of diestrus the embryo travels from the oviduct to the uterus. Gestation prolongs the survival of the corpus luteum, and thus of diestrus, throughout the duration of gestation. Duration: days 5 to 17-18;
- proestrus: period in which, if there is no gestation, the corpus luteum regresses, ovarian activity resumes and a new follicle grows. Characteristic signs: restlessness and discharge of a more or less whitish mucus. Duration: days 19 to 20-21.

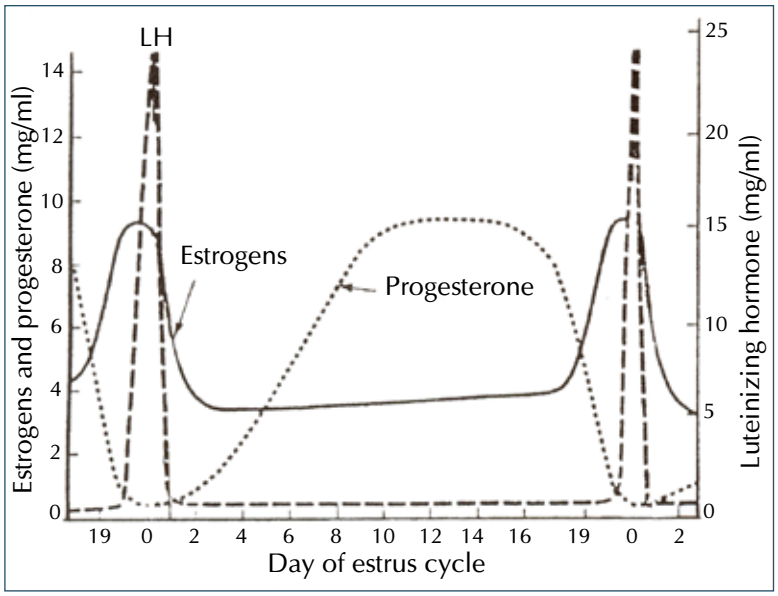


Figure 1.Hormonal variations in the estrus cycle
After Haps and Boyd

Puberty and sexual maturity

Puberty is the period when the reproductive organs become functional. In the female, estrus activity begins, with each estrus cycle producing hormonal variations and ovulation. The average age of puberty in female bison is 18 to 20 months. Typically, on Québec bison farms cows are first bred at around 27 months of age and have their first calf at 3 years of age. To maximize profitability however, the target to aim for is a first calving at 27 to 30 months (one of the objectives set out at the beginning of this facsheet). With superb feed management, some producers succeed in obtaining the first calving at 24 to 26 months.

PHYSIOLOGY OF REPRODUCTION IN MALE BISON

In male bison, reproduction is influenced by external factors like temperature, feed and sensory phenomena. All contribute to stimulating a part of the brain called the hypothalamus, which in turn stimulates the pituitary gland. The pituitary responds by secreting gonadotropins, specifically follicle stimulating hormone (FSH) and luteinizing hormone (LH). Reaching the testicles through the bloodstream, these hormones stimulate the production of testosterone and other male hormones, along with spermatogenesis (the formation of sperm cells).

In bison, spermatogenesis lasts for about 41 days. Once sperm cells are fully formed they travel to the epididymis, where they mature and take on a protective protein coating. Depending on the frequency of ejaculation they remain there for 8 to 20 days.

Puberty

Puberty is characterized by the development of libido and secondary sexual characteristics, the ability to copulate and the presence of viable sperm in semen. The secondary sexual characteristics include long, thick hair at the end of the penis sheath, pronounced development of the shoulder hump, aggressiveness and fighting among the bulls to determine the herd hierarchy. A bull reaches puberty at 14 to 19 months, the average being 16½ months. A well-fed bull is usually well developed by 26 to 27 months, but will not reach full genital potential until around 3 to 5 years. Since this trait is strongly hereditary, it is one basis for selecting lines of breeding stock to improve the herd's productivity. Puberty is conditioned by heredity, feed and environment. Sexually precocious males are highly prized, since this trait is strongly transmissible to male and female offspring.

QUALITIES OF A BREEDING BULL

The effectiveness of a breeding bull depends on the following criteria:

- optimal testicular development;
- good sperm production;
- good scrotal conformation;
- overall conformation typical of the species and compatible with mounting;
- superior libido.

Optimal testicular development

Testicular volume is an indicator of the amount of tissue that can produce sperm. In normal conditions, scrotal circumference is proportional to testicular volume, and in most cases is a reliable indicator of a bull's reproductive potential.

A bull with an above average scrotal circumference will give its female offspring the following positive traits:

- early puberty;
- regular cyclic activity;
- greater fertility.

The bull's male offspring will inherit the following traits:

- superior scrotal circumference;
- greater fertility.

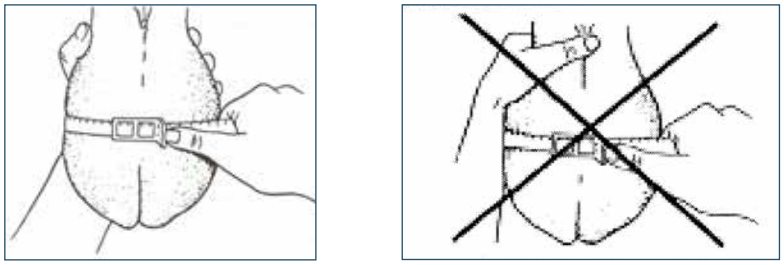
Measuring scrotal circumference

Scrotal circumference is easily measured, a task the veterinarian can perform after collecting an ejaculate of semen to test the bull's fertility. Such measurements can be recorded with other data in PATBQ (see page 13), to help build a database from which every bison producer will ultimately benefit.

- Scrotal circumference is best measured using a metal tape designed for that purpose (Coulter™, ReliaBull™) (Figure 2). The procedure to obtain a precise measurement is as follows:
- with one hand, firmly hold the testicles at the base of the scrotum;
- take care to align the testicles side by side;
- with the other hand, slip the metal tape around the scrotum;
- tighten the tape firmly around the scrotum at its largest diameter (Figure 3), then take the reading.

Poor technique can give faulty readings. Cold can distort the reading, as can fat deposits in the scrotum (in fat bulls).

Figure 2. ReliaBull™ tape



Good technique Bad technique

Figure 3. Measuring scrotal circumference with a metal tape

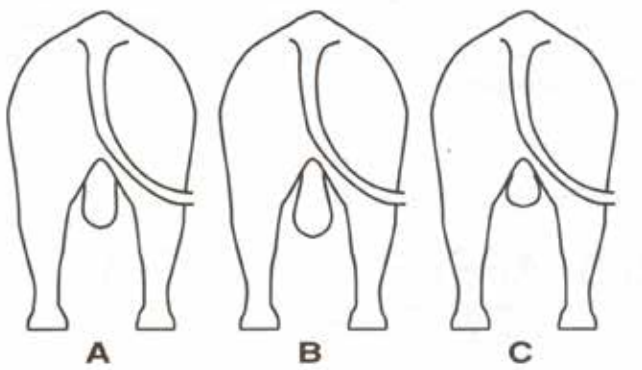
A chart of minimum scrotal circumference measurements for the various breeds of beef cattle has been prepared by the Society for Theriogenology (an American veterinary society for the study of reproduction). A similar chart could be prepared for bison once producers have contributed sufficient data to the PATBQ or a program like it (see page 13).

Good sperm production

During the mating season an adult bull produces some 13 billion sperm cells per day, depending on the number of germ cells and thus testicular volume. An ejaculate (suspension of sperm in seminal plasma) can range from 2 to 10 ml (average 6 ml) and in the fall breeding season can contain several hundred million sperm cells. Outside of the breeding season (winter and spring), production of sperm cells drops by 50%.

Good scrotal conformation

The shape of the scrotum (Figure 4) has an effect on the development and functioning of the testicles. Along with supporting and protecting the testicles, the scrotum plays an important role in regulating their temperature. Since sperm cells only form at a temperature of 4 to 5 °C below the normal body temperature, involuntary muscle in the scrotum will cause the testicles to rise or fall (thereby warming or cooling them) to compensate for changes in the ambient temperature.



A: Scrotum with straight, parallel sides. Fat deposits in the upper part of the scrotum prevent the testicles from rising adequately in cold weather. Thus exposed to the cold, the testicles develop more slowly or even degenerate, causing lesions that can be irreversible.

B: **Ideal conformation**, the upper part of the scrotum is clearly distinct from the body. This conformation facilitates thermoregulatory mechanisms.

C: Triangular scrotum with small testicles that are always close to the abdominal wall. In hot weather, this conformation impairs spermatogenesis with unacceptable results.

Figure 4. Types of scrotal conformation

Overall conformation compatible with mounting

The conformation of a breeding bull should be better than average, especially in the hooves and back legs, musculature and the length of the loin. Repeated mounting takes solid rear legs, while in a standing position the front legs support over 60% of the animal's total weight. A bull has a major impact on the herd, since it will sire a large number of calves over the years. Some producers are expert judges of conformation. Bison shows in Western Canada are held every year.

In Québec, producers do the initial male selection at weaning, singling out calves that already show the best potential. A second selection of males is done at 24 to 27 months, and those that have posted the best "average daily gain" (ADG) (kg/day) are kept for breeding while the others are marked for meat production.

When choosing a bull to produce breeding females, it is best to choose a maternal line that is not already present in the mother's genetics. However, the hooves and legs should also be considered if you want the progeny to be kept in the herd for years to come.

Superior libido

Libido is expressed as a desire to mount, so it is crucial to the bull's breeding capacity. A bull with low or no libido has little interest in females that are in heat; not much breeding happens, and by the end of the rut, few if any conceptions have been achieved. It is therefore essential to have a bull that is sexually alert, immediately notices females in heat and knows when to mount them.

Purchasing tips

In nature, the weakest individuals either die or are otherwise eliminated from breeding; only the strongest males earn the privilege of covering females and siring progeny. The challenge for the producer is to do even better than nature, combining bison bulls and cows of good quality from good genetic lines.

A serious producer looking to purchase one or more breeding bulls should consider the following tips:

- buy from a recognized producer whose herd is the result of years of selection and who can provide a certificate of fertility;
- ask the producer about the fertility of the father and mother (records, breeding registers); ask to see its parents, sisters and paternal brothers;
- buy a bull with proven post-weaning gain performance: make sure the male's ADG is higher than average for its herd mates. In Western Canada, many producers calculate their bisons' ADG, but so far it is not a widespread practice in Québec;
- buy a bull whose scrotal circumference is larger than average for its herd mates. Taking and recording this measurement regularly on bison under two years of age will contribute to the development of charts and standards for the species;
- buy a bull whose scrotum hangs well clear of the body, in a bottle shape. If the scrotum is too close to the body, the fertility of the spermatozoa will be impaired;

- choose a bull that does not have excessive fat in the scrotum, and whose body condition score is 3.5 to 4.0;
- buy a bull with a strong frame and musculature, good hooves, sturdy legs and good vision. Eyes that are clear and bright are a sign of good health;
- have the bull's fertility tested when purchased, and each year thereafter a month before mating season. Fertility tests are performed and certified by a veterinarian and include an examination of the reproductive system. This helps ensure that optimum conception rates are achieved.

PATBQ

The *Programme d'analyse des troupeaux de boucherie du Québec* (PATBQ – program for analyzing Québec beef herds) is an online database administered by the ministère de l'Agriculture, des Pêcheries et de l'Alimentation (MAPAQ). It was designed to enable Quebec's beef producers to improve the productivity and profitability of their herds by drawing on data from across the province for genetic evaluation and selection. This tool is now available for bison farmers. While producers first learned of the subject some ten years ago, finally PATBiQ ("Bi" for bison) is ready to receive the first bison registrations.

The purpose of PATBiQ is to give producers more precise information about the genetic value of breeding stock, thereby supporting them in the process of selecting the optimal male and female candidates for breeding. The program lets you register (online) a variety of data for your herd, including weight, scrotal circumference and carcass characteristics. Valuable information can then be extracted from the database, including benchmarks and rankings for each animal in a group of herd mates, and the calculation of expected progeny differences (EPD).The system also provides insights into how your herd compares to the average.

CONCLUSION

As the ultimate goal of a bison farm, effective reproduction depends on a complex of parameters involving the quality of breeding stock and the producer's husbandry practices. A critical factor for success is the body condition of bison cows throughout the production cycle, since it directly affects the herd's productivity and the weight of weaned calves. Once you understand the principal factors that determine body condition, you can learn how to manage it effectively and profitably.

BIBLIOGRAPHY

Allen, D. 1992. *Rationing Beef Cattle*. Chalcombe publications. (A Practical Manual), Beef Improvement Services for the UK Meat and Livestock Commission. 79 pp.

Altizio, B. and M. Westendorf. 2001. *Bison Husbandry*. Rutgers Coop Extension, New Jersey State University. FS 945. 4 pp.

Armstrong J. and coll.1998. *Bison Production*. Sustainable Production Branch, Saskatchewan Agriculture and Food. 72 pp.

Belzile, M. 1990. *Le Bison, généralités*. MAPAQ. 95 pp.

CPAQ. 1997. *Le Bison : guide d'élevage*. Conseil des productions animales du Québec. 123 pp.

CRAAQ. 2007. *La production vache-veau*. Centre de référence en agriculture et agroalimentaire du Québec. 231 pp.

Dobbs, S. 1993. *Economics of Bison Production in Saskatchewan*. Sustainable Production Branch, Sask. Agric. and Food. Regina, Saskatchewan. 45 pp.

Greaser, G.L. and coll. 2002. *Bison Production*. Agricultural Alternatives, Penn State University College of Agricultural Sciences Coop Extension. 7 pp.

Hebbring, J. 1987. *An Introduction to the Buffalo Industry: ''Why raise Buffalo?''* Buffalo Vol. 15 No. 5, pp. 8-11.

Keith, J.A. and H. Reynolds. 1994. *North American Bison*. Canadian Wildlife Service, Environment Canada. http://www.hww.ca/en/species/mammals/north-american-bison.html.

Murray, F. 2007. *Basic Nutrition of Bison*. Saskatchewan Agriculture and Food. 19 pp.

APPENDIX 1. EVALUATING BODY CONDITION IN BISON

To understand the terminology specific to evaluating body condition, you must be able to recognize the different parts of the animal's body.

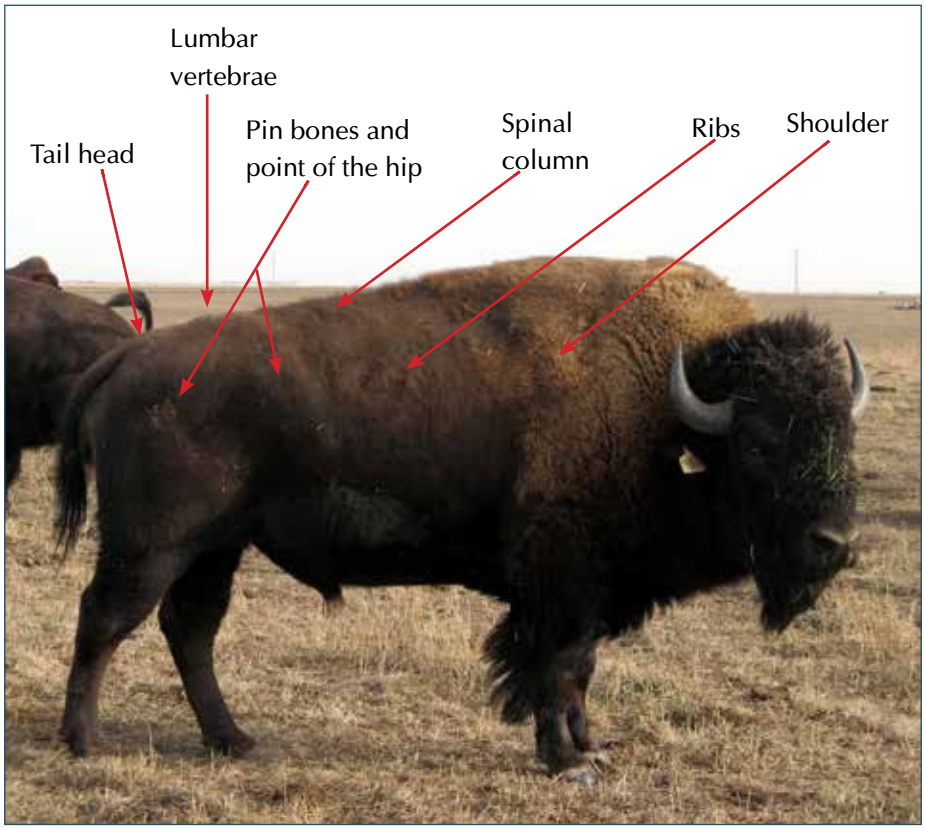


Photo: Juan Pablo Soucy

Body condition is best evaluated with the animal held in a restraint cage (squeeze), using palpation. This gives a much more precise assessment of the animal's fat cover than simple visual evaluation. The technique is quick and easy to learn, and does not require any specialized equipment.

You should start however by assessing your breeding stock visually, making an initial overall judgment about their body condition. Palpating all the bulls and cows is neither easy nor necessary, but with practice and experience you can learn how to combine the two approaches: a good visual appreciation accompanied by palpation of a certain percentage of the cows and bulls will add up to a good evaluation of the herd.

A good stockman will regularly evaluate the herd's body condition, while occasionally calling on another competent person (someone who is not regularly on the farm) to validate their technique. When seeing your herd day in and day out, you may not notice that the herd's average body condition score has changed by half a point.

Body condition is evaluated with the recognized Canadian system developed for dairy and beef cattle. Using this system, animals are classified on a scale from 1 (very thin) to 5 (very fat, even obese).

The animal should stand on a flat surface with its head up. The evaluation starts with a brief visual observation, then proceeds as follows:

- palpate the area of the short ribs, noting how the flesh follows the end of the bones to form a lacy pattern, then pass the hand along the ribs toward the spinal column. Continue along the spine toward the ligaments that attach the hip bones to the spine, noting along the way how much fat there is between the vertebrae;
- follow the ligament, away from the back, until reaching the hip bone. Slide the hand over the hip bone and follow the trochanter to the pin bone. Evaluate the amount of flesh covering the point of the hip and the pin bone, and the degree of sag between them. Finally, run the hand from the pin bone toward the tail head to palpate the fat cover.

SCORE = 1

Score = 1 – Very little fatty tissue covers the bony parts. With your thumb, you can easily feel the roughness of the bones. The lumbar vertebrae give the loin an angular shape. The hip bones, ribs and tail head are very prominent.

SCORE = 2

Score = 2 – The lumbar vertebrae can be felt quite easily. Bony parts are covered by a light layer of fat, so they feel less rough. You can easily identify the ribs by feel, but they have a roundness to them. The ribs are not visually apparent.

SCORE = 3

Score = 3 – If you press firmly you can feel the lumbar vertebrae. The angular shape of the loin is no longer apparent. By touch, you will notice the presence of a certain amount of fat at the tail head.

SCORE = 4

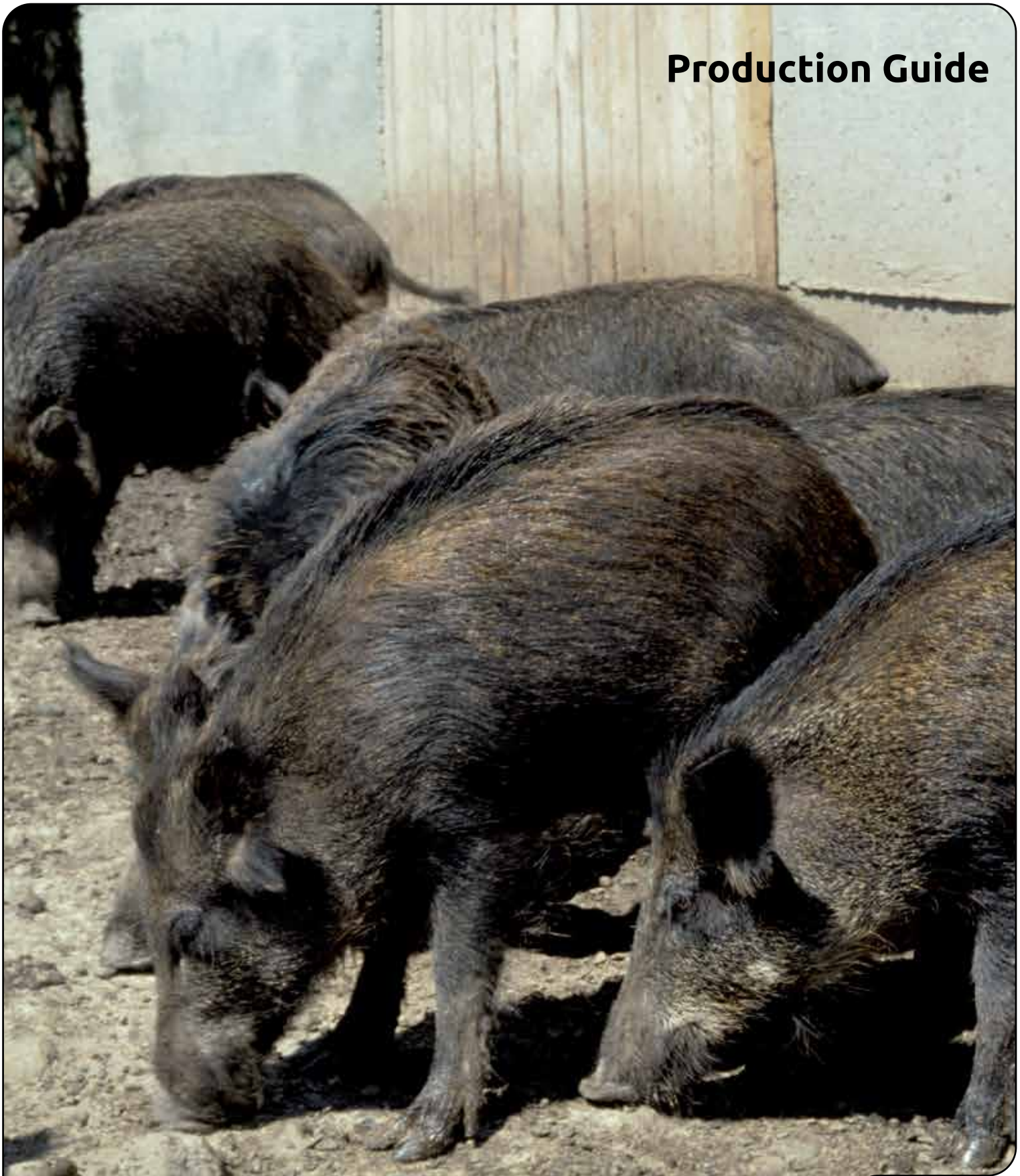
Score = 4 – Even if you press very firmly you cannot feel the lumbar vertebrae. The tail head and trochanters are soft to the touch, made round by a layer of fat. The ribs are also covered by a layer of fat.

SCORE = 5

Score = 5 – The bony structure is not apparent and the bison (whether male or female) really presents a rectangular shape. The tail head and hips are surrounded by fat. This animal is excessively fat.

Photos: Juan Pablo Soucy

Production Guide



DOMESTIC GAME FARM ANIMALS

Reproductive Management of Wild Boar

CRAAQ
CULTIVER L'EXPERTISE
DIFFUSER LE SAVOIR

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INTRODUCTION

The wild boar of western continental Europe (*Sus scrofa scrofa*) has 36 chromosomes, while the domestic pig (*Sus scrofa domesticus*) has 38. Their hybrids may have 37, 36 or 38. The presence of porcine genes in wild boar makes marketing more complex, and is prejudicial to production. With its low and heavy profile, coloration ranging from pale to dark, abundant hair and elongated groin, the wild boar's anatomy is fairly different from most of its cousins (pig, peccary and warthog).

Regardless of the purpose of production (meat sales or hunting), wild boar are generally raised extensively in pastures and bushes. One technique is to keep selected breeding stock in pens and separate them into herds of at least 20 females (sows) and 2 males (sires) that can be controlled and handled efficiently. To increase the chances of success, the wild boar farmer must be mindful of the species' habits and reproductive cycle. Reproductive success depends on various parameters, including climate, feeding and a peaceful habitat or breeding site.

As in most wild mammals at our latitudes, wild boar reproduction is seasonal, being conditioned and influenced by environmental factors:

- natural physical factors: photoperiod and temperature;
- chemical and nutritional factors: pheromones, group effect, sharing of space, all of which influence social relationships among individuals.

A wild boar farmer cannot do much about environmental factors, except to modify photoperiod slightly through changes in lighting in indoor areas. This can help to increase fertility and thus the number of farrowings per year.

PHYSIOLOGY AND BEHAVIOUR

Males

On average, male wild boars reach sexual maturity (puberty) at 10 to 12 months, while complete body development will not be reached until 5 years. To improve development and optimal reproductive performance, even though a sire can mate at 8 months it should not be used for reproduction before 2 years of age. From the onset of puberty, exocrine activity in the testicles is constant. However, there is seasonal variation consisting of significantly lower testicular weight and testosterone levels in the summer months, a period of sexual inactivity. The gap between young male and young female weights becomes increasingly pronounced after age 2, when sexual dimorphism begins.

Depending on a breeding male's age and nutrition, its live weight can reach 250 kg.

Females

In Quebec, wild boar sows reach sexual maturity at 10 to 12 months, but to avoid compromising their growth and future productiveness they should not be mated until they weigh 90 kg. Physiologically, a sow

can give birth at 15 months, but generally on the farm a sow will have its first litter at 20 months, when it is better developed, farrows more live piglets and is a better nursing mother.

The estrus cycle lasts 21 days, with ovarian function halting in early June (summer solstice). The inactive sexual period lasts at least until September and can extend into November, since stops and starts in sexual activity are closely linked to nutritional and photoperiod factors (see the section on seasonal anestrus below). In each estrus cycle, for the best conception rates, the sow should only be exposed to the males for 2-3 days of the receptivity period.

A sow's live weight varies from 90 to 150 kg, with full body development being reached by 3 years of age.

Mating

Generally speaking, in Québec a wild boar sow will come into heat from September to mid-November, and as long as she is not pregnant the 21-day estrus cycle will repeat regularly until the end of June. The breeding season can vary depending on the abundance of food and the sow's body condition.

In the wild as in captivity, it is generally the lead sow (the first to come into heat) that triggers heat in the other females in the herd. A little before that, she starts leaving saliva and lachrymal gland secretions on trees and other objects, to alert and arouse the males. In full heat, the lead sow secretes a great deal of estrogen and other pheromones in her urine and saliva. Stimulated by the various secretions and odours, the other sows in the herd will also go into heat. In the production conditions common in Quebec, where farrowing occurs in a maternity barn, not all the females are necessarily in heat at the same time. Estrus can also be triggered by weaning and will start about 7 days after the piglets are separated from their mothers.

According to Meynhardt (1991), wild boar use 10 basic sounds for all their communication needs; some are particular to the individual, while others, such as warnings, are common to all wild boar. One such sound is particular to the breeding season and mating when the male communicates at length with the female, pursues and mounts her, caresses her, butts her in the flanks with his groin and repeats this ritual until the sow is ready and consents to mating. Sometimes the sows are capricious; they enjoy being courted and don't submit easily to the male. Breeding lasts only a few minutes, and often an experienced and physically fit adult male will cover the sow a second time, after a 20 to 30 minute rest. The male ejaculates 250 to 400 ml (9 to 14 oz.) of semen at each mating. Semen quality and volume vary with the time of year (Kozdowski and Dubiel, 2004).

Sires eat less when the sows are in heat, and can even lose weight during the breeding season.

Gestation

Gestation lasts an average of 115 days (3 months, 3 weeks and 3 days), but can range from 110 to 120 days. In the wild, a sow usually has just one litter per year, or occasionally two. In production conditions in Quebec, with adequate management and good nutrition, two litters per year are possible for sows 3 years and older (Figure 1). In a well-designed nursery, all sows can average three gestations every 2 years (Figure 2). In this case there is a spike in litters farrowed in February and March, with piglets weaned by late April to early May, and with the sows rebred in May and early June (before anestrus, the drop of summer sexual activity) for another farrowing peak in August and September.

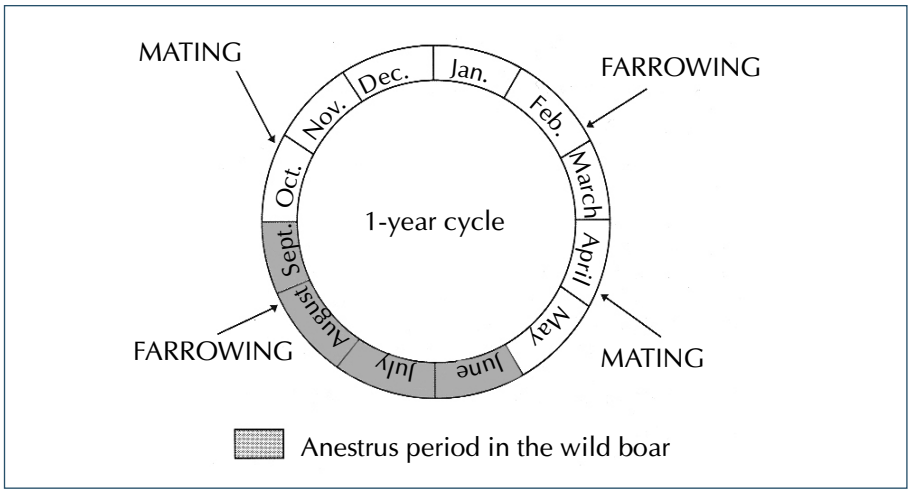


Figure 1. Managing breeding to obtain two deliveries per year in sows of 3 years and up

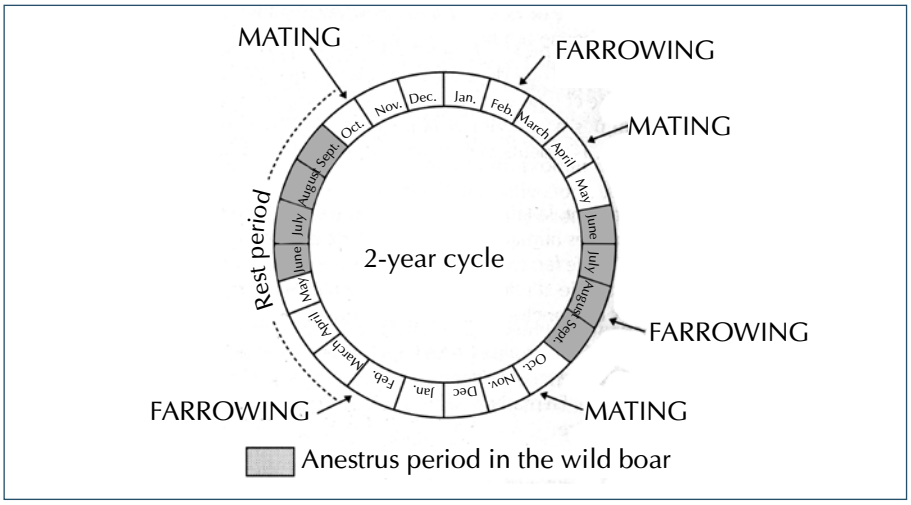


Figure 2. Managing breeding to obtain an average of three farrowings every 2 years for all sows

Farrowing

Farrowing usually takes place from January to September, with spikes in February and March, then in August and September. Depending on when first mating occurs, first farrowings usually come at the beginning of February, or occasionally as early as December. Each sow needs to be alone in her own nest prior to farrowing, and generally will not leave the nest except to eat during the first week after farrowing. The nest is built by the sow. The nest retains the mother's body heat, due to the nest's cauldron shape and good insulation properties, and stays at a temperature of 32 to 33 °C (90 to 92 °F). Farrowing usually lasts 3 to 4 hours.

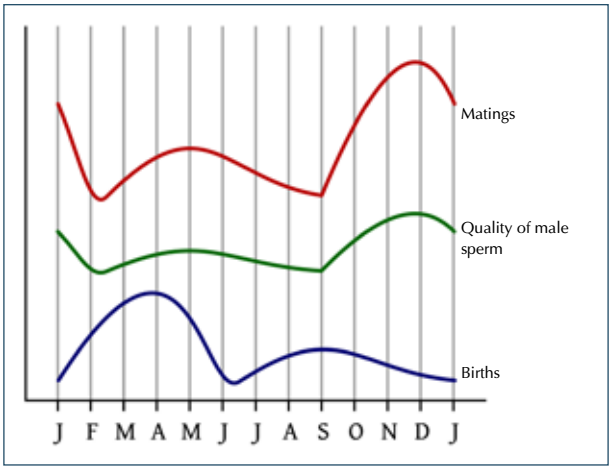


Figure 3. Seasonality of wild boar reproductive activity

A litter can range from 2 to 12 piglets (5 on average), which are born with their eyes open. A sow farrowing for the first time usually has no more than 2 to 4 piglets. The litter size will correlate to the sow's age, weight and body condition at the time of mating. A 5 or 6 year old adult sow with optimal body condition will deliver 7 or 8 vigorous, healthy piglets that benefit from better lactation and will therefore grow faster.

Piglets are born weighing about 750 g (1.7 lb.) on average, but ranging from 600 g to 1100 g (1.3 to 2.4 lb.), and measuring about 25 cm (10") in length. At birth, the sow imprints the piglets with her scent, a process lasting about 2 hours. The sow and piglets recognize each other by scent and sound, rarely by sight, which is weak in wild boars (Meynhardt, 1991).

The primary cause of mortality among piglets born outdoors is cold and humidity. To maintain body temperature the piglet needs to burn calories, but it has no fat reserves to provide the necessary energy.

From birth to 3 or 4 months, the piglet sports 11 parallel stripes, dark brown to black on a light grey background, running from head to tail. This feature gradually disappears, the hair turning from beige to reddish brown by 12 months. From uniform red at 12 to 15 months, it gradually becomes dark grey by around 20 to 24 months.

Nursing and care of piglets

The piglet's first weeks after birth are crucial since the piglets are completely dependent on the mother's milk. Nursing continues for 42 to 50 days. At first the piglets go from one teat to the next, but by the second or third day each piglet chooses a particular teat that it will suckle until weaned. The milk production from a given teat will therefore determine the piglet's growth. From birth to weaning, a piglet may gain from 4 to 6 kg (9 to 13 lb.), and will weigh 6 to 7 kg (13 to 15 lb.) when weaned.

The iron content of sow's milk is poor. To prevent anaemia, it is recommended that piglets be given iron injections starting three days after birth. Males destined for meat production must be castrated as soon as possible, and before 15 days.

For the first 5 or 6 days, the piglets live exclusively in the nest; later they start to move around, progressively discovering their environment under the sow's surveillance. As little as a week after birth the piglets tend to follow their mother. For the first few days the sow feels very vulnerable and can be highly aggressive if her tranquility is disturbed. Consequently, since there is a risk of her destroying or injuring her young if she feels insecure, it is important that she be disturbed as little as possible. Any sow that has eaten her young must be culled, since the behaviour will repeat at the next farrowing.

To complement the mother's milk, after 15 days the piglets will eat solid food given to the sow. In outdoor production systems it is important to set aside a creep feed area accessible only to the piglets so they can feed adequately.

Weaning

After weaning, piglets are separated from their mothers at around 42 to 50 days and receive a balanced ration of feed to promote healthy growth.

Seasonal anestrus

In optimal feeding conditions, there is always a summer anestrus period (a rest period due to the absence of reproductive heat) generally lasting from mid-June to mid-September (Mauget, 1980).

Photoperiod, i.e. the cycle of daylight, has a significant influence on the sow's estrus cycle. The latter is triggered when the days shorten, while higher summer temperatures and longer days have the opposite effect of provoking anestrus. Lower temperatures and shorter days influence the timing of the resumption of estrus cycles, delaying or hastening it depending on conditions. Peak breeding season often occurs during the winter solstice in mid-December.

HUSBANDRY AND PRODUCTIVITY

Gestating sows need rest, peace and quiet, so visits by strangers should be restricted. The fright provoked by unexpected/unfamiliar sounds or unusual actions can cause traumatic abortions, particularly at the approach of farrowing.

Farrowing in a maternity barn

When a maternity barn is used the producer should gradually increase each sow's meal ration every day, starting 8 to 10 days before farrowing to meet the sow's nutritional needs. This reduces competition for food and ensures that each sow receives her daily ration. For the sow's comfort, and for nest-building, a good quantity of straw should be available. Straw also has a calming effect that helps the sow get used to her new environment.

Farrowing in individual pens

Another practice is to set up individual outdoor pens consisting of a small enclosed area or shelter where only the piglets can go. This enables the producer to provide the piglets with all the necessary feed, care and treatments, and to gradually prepare them for weaning.

Production in outdoor group enclosures

Some wild boar producers use large paddocks, with treed sections to protect the animals from inclement weather and to provide shade. Such paddocks generally include a few shelters in which 15 to 20 wild boar can take cover. This production method is satisfactory for animals that are growing and of uniform weight and the same sex, to avoid undesired pregnancies (unless the males are castrated). Since large paddocks tend to give disappointing results where farrowing is concerned, they are not recommended.

Reproductive capacity

Compared to other ungulates of the same size (red deer, fallow deer, sheep, etc.), the wild boar has the greatest reproductive capacity. Its great adaptability has no doubt contributed to its domestication, as it does to its productivity. The average litter size of 5 piglets per sow depends heavily on the sow's age and body condition at breeding. Adult sows of 6 to 8 years old that are in good body condition generally have larger litters (7 to 8 piglets) and successfully wean a higher percentage of the piglets.

Surviving weaning

In the wild, piglet mortality is 30 to 50% in the first week of life. In farmed production systems, the mortality rate of piglets should not exceed 10 to 15% from birth to weaning. The main cause of pre-weaning mortality is the sows crushing or killing the piglets. To maximize profitability, wild boar producers should aim to farrow and wean as many piglets as possible, and to market as many wild boars as possible per sow.

BIBLIOGRAPHY

CPAQ. 1997. *Le Sanglier - Guide d'élevage*. Collection Grands Gibiers domestiques, Conseil des productions animales du Québec. 123 pp.

Hector, D. and J. Hector 1973. *Le sanglier et son élevage*. La Maison Rustique, Paris. 108 pp.

Kozdowski, R. and A. Dubiel. 2004, T*he effect of season on the properties of wild boar (Sus scrofa L.) semen*. Animal Reproduction Science, 80: 281–289

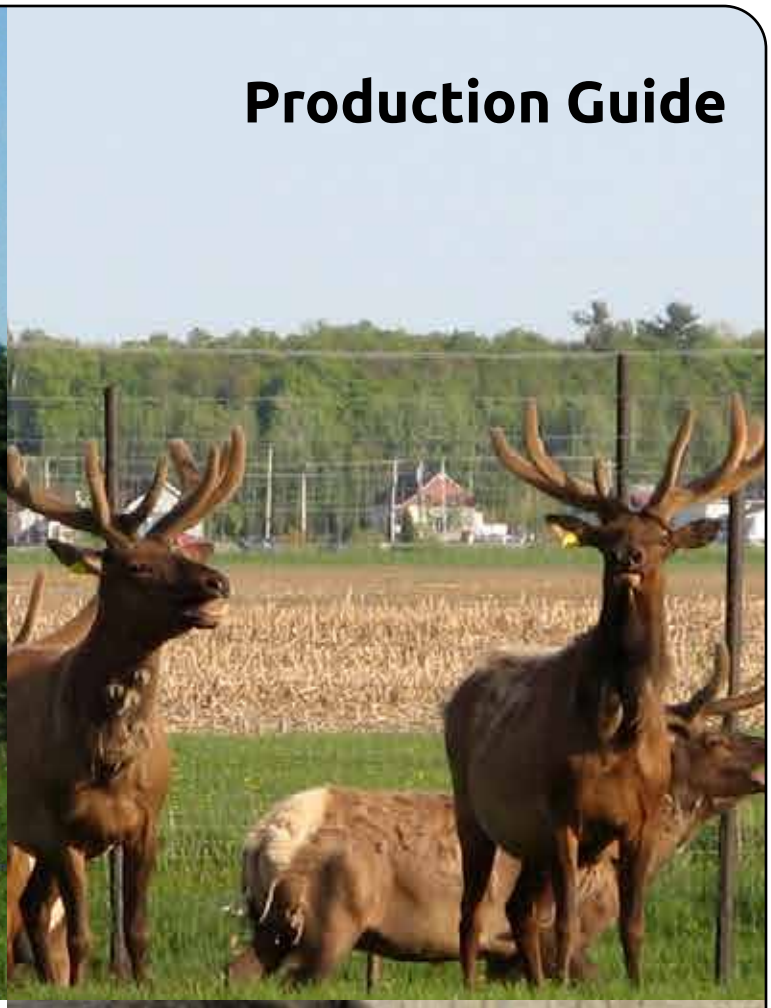
Marion, F. 1982. *Le sanglier.* Collection "Grand gibier", Gerfaut Club-Princesse, Paris. 177 pp.

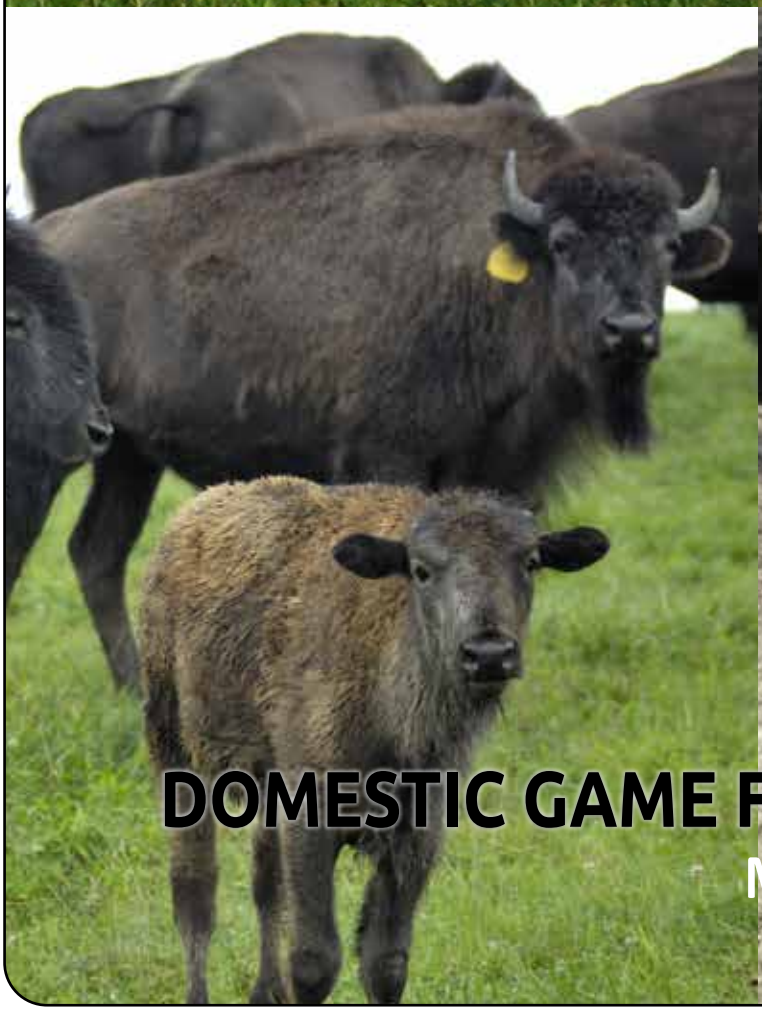
Meynhardt, H. 1991. *Ma vie chez les sangliers*. Hatier, Les Éditions du chasseur français, Paris, (translated from the German by André Dick). 165 pp.

Pinet, J.-M. 2005. *L'élevage du sanglier de race pure.* Éditions de l'ADEPRINA, Paris. 171 pp.

Sonnier, T. 1988-1989. *Le Sanglier: un élevage peu connu mais un revenu d'appoint intéressant*. Mémoire de fin d'études. BTS Productions animales. 79 pp.

Spitz, D. and D. Pepin (eds). 1984. *Symposium international sur le sanglier*. Les colloques de l'INRA, nº 22, INRA, Paris. 226 pp.





Production Guide

DOMESTIC GAME FARM ANIMALS

Marketing – Overview

CRAAQ

CULTIVER L'EXPERTISE
DIFFUSER LE SAVOIR

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Photos (cover page)

Juan Pablo Soucy (red deer and wapiti)
© **Etienne Boucher**, MAPAQ (bison)
© **Michel Langlois**, MAPAQ (wild boar)

INTRODUCTION

On a number of points, marketing meat from farmed large game, with related activities like agritourism and hunting, is different from marketing conventional livestock (beef, pork, poultry, etc.). Farmed game meat is a high-end, niche product with a special flavour and a strong identification with small, local producers. For some people the animals themselves are more appealing, in part because they are associated with free-range farming in a natural environment. These differences present some advantages, counterbalancing the challenge of constant competition with other types of meat.

The four main types of farmed game meat in Québec are red deer, wapiti (generally referred to as "elk" outside of Québec), bison and wild boar. Not all are at the same level where marketing is concerned, but the gaps are narrowing. Some of the marketing groups formed by red deer farmers have been operating for over 10 years, while there are groups of wapiti farmers whose marketing is handled by processor/distributors. For bison and wild boar producers however, no such groups have been formed so far.

Whichever animal they raise, Québec's large game farmers must stay on their toes, paying careful attention not only to the market but to social and economic factors. Above all, they should keep in mind that diversification (of products, services and marketing) can be the key to profitability.

FARMED GAME MEATS

Game meat can be sold either wholesale (as carcasses) or retail (as cuts and processed products). In either case, for the producer to be certain of being able to sell his production, sales agreements should be in place before animals are purchased and shipped to the farm. As well, early consideration must be given to how animals will be shipped to the abattoir, and to the proximity and type of slaughter services available.

Wholesale

The wholesale market involves producers selling whole carcasses to a processor/distributor, either directly or in a group with other producers. The group approach is popular with red deer farmers, and becoming more so with wapiti producers, while bison and wild boar producers are at the discussion stage. It is an approach that resembles how animals are marketed in more traditional livestock industries. It lets producers concentrate on their herds, focusing their efforts on optimizing performance and genetics. The potential drawbacks include production limits (depending on the group) and lower profitability. When processing, distribution and/or marketing are not handled by the producer, the farmer loses the opportunity to profit from the value added by these steps.

For a new producer, the group approach can be particularly attractive inasmuch as it provides some assurance of sales. However, the producer must be able to meet the standards of the group (or its distributor) in terms of quality and volume. Not all such groups have a large enough market to be able to take on a new producer.

The wholesale market is generally preferred by producers in remote locations, those who farm intensively to generate economies of scale, and those who focus on breeding stock or high-quality stags, bulls or male wild boars for hunting (as opposed to the sale of meat).

The main processor/distributors in the wholesale market are *Les Viandes de la Petite-Nation*, *Gibiers Canabec* and *La Maison du Gibier*. Over the years their marketing and promotional activities have made consumers more aware of venison products.

Retail

Farmers who process, distribute and market their own products can achieve greater levels of profitability, since there are fewer middlemen between them and the consumer. This is primarily how wild boar meat is marketed.

Retail sales include the sale of carcasses to individuals for méchouis, farm gate sales of cuts and/or processed products, and sales in farmer's markets, through websites, to retailers and local restaurants, and for country dining (see the section Agritourism). Retail sales require the most work and the highest initial investment. Since the best days for retail sales are when consumers are off work, this approach requires a producer who can work on weekends and holidays, and who enjoys interacting with the public. The added layer of regulations and obligations regarding processing and sales can be daunting for smaller processors.

In the retail market it takes quality products, attractive presentation, and sales personnel who are good at dealing with the public, to maintain repeat sales.

Méchouis

Perhaps in part thanks to the *Asterix* movies, wild boar has become popular for méchouis in Québec. Deer, wapiti and bison producers would do well to explore the potential of this market. Sale for a méchoui turns an entire carcass to profit, with added value since the producer provides the service. Providing a méchoui requires time, equipment and a permit. Considerable travel may be necessary, usually on weekends. Good presentation, attention to detail and cleanliness are essential for a successful méchoui business

On-farm sales

There are several types of on-farm sales. Whether through a sales counter, farm dining, agritourism visits or photo safaris, this type of marketing enables some producers to make a good profit. They take courses about the different cuts of meat, processing methods and sales techniques, and hygiene and food safety (this is mandatory), then set themselves up with the facilities needed and the required permits. By also offering processed products (terrines, sausages, meat sauce etc.) they can extract full value from each carcass.

Some of these businesses are so successful, they also provide an outlet for other producers or distributors.

Farmer's markets and internet sales

Where customer traffic to the farm would be insufficient, producers who are good at dealing with the public can sell directly at farmer's markets, eliminating the need for marketing infrastructure on the farm. There are however costs associated with selling at farmer's markets, including sales permits and fees charged by market administrators. Another option is to set up a website and sell over the internet. This can complement other kinds of marketing while offering consumers the ultimate in convenience.

Supplying local retailers and restaurants

A number of grocery and restaurant chains have "buy local" policies that give local producers a place on store shelves and a presence on menus. Since producers deal with them directly, they can obtain better prices than when middlemen are involved. Good cooperation is essential to ensure a regular supply and consistent quality despite the seasonality of farm production. This can mean selling fresh products during the period when animals are slaughtered, while using frozen products during periods when the animals are being finished.

Special initiatives

It is worth mentioning a few initiatives currently available for developing new markets for game meat from certified farms. These include the *Cerf de Boileau* in the Outaouais, *Sélection Nordique* deer produced by 15 red deer farmers, *Cerf des Appalaches*, and the registered certification program *Grands gibiers du Québec certifiés™* (http://www.grandsgibiers.com/certification.php).

BREEDING STOCK

Producing quality breeding stock requires a solid understanding of genetics for informed choices to be made when selecting breeders. The animals are expected to be of superior quality, so prices are higher. Often, the seller will provide advice and follow-up if requested.

Thanks to the long experience of producers in this area, the genetic quality of Quebec's breeding stock has improved considerably in the last 30 years. Buying animals is a major investment, especially for a new producer who is building a herd. It is important to purchase quality stock[1] that will help the business achieve its production and economic goals. At the same time, the price paid for the herd must be affordable, in terms of the potential profit earned by the purchaser from the sale of meat and other products.

Demand for breeding stock is closely linked to the development potential of commercial operations, and thus to demand for meat. Prices for breeding stock are therefore higher when there is stronger demand for meat, but lower when the market is slow. In recent years, difficulties in developing new markets for farmed game meat have led to lower prices for breeding stock.

1. Two other factsheets in this series discuss the principal criteria to consider when purchasing red deer or bison: *Evaluating Red Deer for Breeding* and *Reproductive Management of Bison*.

AGRITOURISM

Agritourism is defined as a tourism activity associated with agriculture that takes place on a farm and brings producers and tourists together. Examples of agritourism include farm stays and educational activities, accommodation, food services, promotional activities and the sale of farm produce and regional agrifood products.

Depending on a region's agritourism potential, farm stays, on-farm sales and country meals can help make an operation profitable. Customers may be willing to pay a little more for a visit combined with a flavourful farm-cooked meal.

What is the average age and income of the surrounding population? How much do people know about large game animals and how they are raised? Successful agritourism means satisfying the interests, needs and expectations of the pool of prospective customers. Besides having the necessary permits, the premises must be clean and be equipped with adequate toilet facilities.

One does not become an "agritourism farmer" overnight. Being available, sociable, hospitable and open to others, and having pride in your business, animals and products, are just some of the qualities needed to succeed. *Le Pense-bête de l'agrotourisme* provided at http://www.mapaq.gouv.qc.ca/fr/Productions/agritourism/Pages/pense_bete.aspx (in French only) is a great source of information for producers who are interested in developing an agritourism project. Presented as a series of topical factsheets, this checklist is a practical guide to the procedures and stages involved, from the business plan to visitor reception to customer service, along with site preparation and regulations.

On the other hand, if the farm is distant from any city, major road or tourist attraction, the producer must go to his or her customers, since they will not come out to the farm. Distance to the abattoir is another factor: the business plan must include a realistic estimate of shipping costs and potential losses during shipping. Refrigeration equipment could be needed, adding to costs, while frequent deliveries of small quantities would cut into profits significantly.

VELVET ANTLER AND HARD ANTLER

Velvet antler (antler covered with velvet, early in the growth period) can be harvested and sold to be dried, ground and packaged in capsules. Velvet antler is highly prized in Asia for its therapeutic properties. In Canada, velvet antler capsules may be available in pharmacies or directly from the farmer.

Velvet antler prices have varied enormously. In the late 1990s producers could get over $100 for a pound of frozen velvet antler, leading to high prices for breeding stock. The market dropped significantly in the early 2000s when bovine spongiform encephalopathy (BSE) was detected in a small number of cattle, while chronic wasting disease (CWD) was found in cervids in Western Canada. Countries that had been the main buyers of Canadian velvet antler closed their borders, causing velvet antler prices to plummet to less than $20 a pound in 2010. This devastating price drop forced wapiti and red deer farmers to focus on

developing the market for game meat. The ups and downs of world markets and the presence of CWD in Canada are still affecting velvet antler sales. However, prices are slowly recovering, thanks to marketing efforts to recapture overseas customers that emphasize producers' efforts to eliminate CWD.

Hard antlers, i.e. antlers that are beyond the velvet stage, are in demand for crafts and the domestic pet food market, where a few companies process and market them as dog chews. The hard antler market is a temporary alternative to velvet antler, and prices reached record highs in 2011 and 2012.

HUNTING ACTIVITIES

Some operators have developed networks of contacts who provide them with a clientele of hunting enthusiasts eager for a trophy at any price.

Game ranches buy trophy animals from a small number of large game producers with extensive experience in advanced genetics. There seems to be a steady demand, since year after year, just before hunting season, trophy animals are sold by game farms to the game ranches. The producer should insist on being paid before the animals are shipped.

Producers interested in adding a hunting component to their business should review the applicable regulations, in particular the *Regulation respecting animals in captivity*, under the *Act respecting the conservation and development of wildlife*. They must also obtain a permit from the ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec.

Hunting activities practised in Québec primarily involve cervids. Bison and wild boar are also exploited for hunting, but to a lesser extent.

MARKETING STRATEGY

A good marketing strategy takes into account the producer's geographical location, the socio-economic environment, the markets, possible types of marketing, the producer's skills, labour needs and availability, existing or needed facilities, and the possible subcontracting of one or more parts of the marketing process. When the target clientele and product offering have been determined, a marketing plan can be developed to guide the producer's overall strategy. The marketing plan proposes activities to reach the target clientele, develop sales and position the producer in the market. A budget should be drawn up, covering not only the preparation of the marketing plan but the practical steps of implementing the strategy. Too often, producers forget to budget for promotional, distribution and marketing elements. Publicity can take different forms depending on financial means: posters, media, website, etc.

There are resources available to help the producer develop a marketing plan and strategy, including:

- the nearest local development centre (see http://www.acldq.qc.ca);
- companies specializing in communication and graphics;
- marketing students in universities and colleges.

SURVEY OF LEGISLATION APPLICABLE TO MARKETING

While there is no legislation specific to farmed large game animals, there are laws and regulations applying to various sectors that could affect large game producers.

Quebec legislation governs economic activities within the borders of the province. Thus, intraprovincial trade in game meat is subject to Québec legislation, while interprovincial and international trade are governed by federal legislation.

The laws and regulations of Québec are most easily consulted through the website of the Canadian Legal Information Institute (http://www.canlii.org/en/qc/laws/index.html). Those of greatest relevance include the:

- *Act respecting the conservation and development of wildlife* (*Regulation respecting animals in captivity*). The operation of a game ranch requires a licence;
- *Animal Health Protection Act*. Sets out sanitation standards for places where animals are raised and sold;
- *Food Products Act*;
- *Act respecting tourist accommodation establishments*;
- *Act respecting reserved designations and added-value claims*.

Canada's laws and regulations are most easily consulted through the same site as above (http://www.canlii.org/en/ca/laws/index.html). Those of greatest relevance include the:

- *Meat Inspection Act*;
- *Canada Agricultural Products Act*;
- *Health of Animals Act* (particularly with regard to importing and exporting livestock);
- *Agricultural Products Marketing Act*;
- *Consumer Packaging and Labelling Act*.

Production Guide

DOMESTIC GAME FARM ANIMALS

Cervid Meat – Overview

CRAAQ

CULTIVER L'EXPERTISE
DIFFUSER LE SAVOIR

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INTRODUCTION

Noble animals that for millennia have figured in the legends of peoples around the world, today the cervids represent a real opportunity for livestock production, one that despite its challenges offers considerable potential and is growing rapidly. This leaflet provides an overview of the principal aspects to master for the profitable production of venison (cervid meat): productivity, quality criteria, processing, marketing, etc., with further reference to customer satisfaction and relations with processors. The focus is on red deer and wapiti (often referred to as elk outside of Quebec), since they are the dominant species on Québec game farms. However, much of what is said here also applies to white tailed deer, sika deer, fallow deer and other cervids.

MARKETING

For an operation to be profitable, marketing considerations must be part of the business plan from the get-go. For the producer whose market is not already assured, there are two solutions: either find a market and supply it (this is practically a business in itself), or hand over marketing to a middleman. Unlike certain other farm sectors, cervid producers do not have the benefit of guaranteed sales or a system for income security. Is there a market for venison in Québec? Yes. Is there room for new producers? Yes. Will all their meat be sold? Probably not.

The more middlemen there are between producer and consumer, the lower the producer's share of the income per kilogram sold. Yet the difference in price often represents the colossal amount of work performed between the animal leaving the farm and meat arriving on the consumer's plate.

PAST AND PRESENT

Farmed cervids are relative newcomers to Québec, compared to more traditional livestock like cattle and hogs. Yet cervid farms have been known for centuries in China, while in England red deer have long been farmed for hunting. In the United States, wapiti have been farmed since the late 19th Century, while New Zealand pioneered the large-scale farming of deer on pasture in the late 1970s (Roots, 2007). What was once reserved for the nobility is now a flourishing industry, producing high-end meat for the general public.

Cervid farming arose in Québec in the 1980s, with stags/bulls and velvet antler as the main products. Things changed early in the new millennium, as exports of velvet antler to China and Korea shrank, cross-border trade with the United States in animals for hunting became more difficult, and the genetic market became saturated. At the same time however, consumers began to seek healthier types of meat. All in all, things have become much more favourable to the farming of cervids for their meat, as to opposed to velvet antler and stags for hunting.

Potential markets

Potential markets for cervid meat include wholesale (whole carcasses for processors or distributors), restaurants, institutions (hospitals, schools) and retail (direct sale to consumers). Institutional markets are rare due to the higher cost of cervid meat.

It was once common for restaurants and families to buy whole carcasses to butcher themselves, but this is rare nowadays. Whole carcasses may be sold on game farms, but must follow additional food safety regulations.

Most restaurants prefer to purchase only the cuts they need. For producers who can ensure a regular supply, consistent quality and a uniform product, restaurants can be an attractive market.

Retail marketing offers a variety of options. By order of increasing convenience for the consumer, they include: on-farm sales, country dining, farmer's markets, and selling through a website.

There are also more marginal markets, such as exports and food for domestic pets. However, these tend to be niche opportunities that arise when an operation is already established, as opposed to being integral to the start-up plan.

Sales structures

In Québec, cervid meat is primarily marketed through three different sales structures.

Marketing groups

Some producers cooperatively market their products as a group through a given processor or retailer. This approach most closely resembles how other types of livestock are marketed. Producers can concentrate on their herds, focusing their efforts on optimizing performance and genetics. Since sales are almost guaranteed, for a new producer it can be an attractive solution, provided he can meet the standards of the group or distributor. However, not all such groups have a large enough market to accept a new producer. Depending on the group there may be other drawbacks, such as a limit on production volume, or lower profitability if not enough effort is devoted to marketing.

Producer-processor-distributors

Producer-processor-distributors market their products themselves, whether on the farm, to retailers, in public markets or to restaurants. This structure demands the greatest amount of effort and the highest initial investment. If the business is short on manpower, there are significant time constraints. Since the best times for selling are when consumers are off work, this marketing approach requires a producer who can work on weekends and holidays, and who enjoys interacting with the public. Small processors also have a harder time handling the complex regulations governing meat processing.

The producer-processor-distributor model can potentially be quite profitable, since it provides control over both the initial processing (primary products, meats and expensive cuts) and any high-end processing (smoking, pâtés, etc.). It lets the producer specialize in one or more niche products.

Partnerships

Increasingly, farm businesses are forming complementary partnerships. This approach allows each partner to perform only the tasks in which it excels. For example, one partner may produce the animals, another may handle transportation, while yet another with facilities for slaughtering, butchering, processing and marketing may handle those aspects. The producer's remaining output can be sold at a group sales booth, through a nearby market gardener, or to a local grocery.

There are many possibilities, since Québec now has an extensive network of entrepreneurs in every phase of the industry, from transportation to retail. For businesses with few employees, partnership can be a good solution, letting them concentrate on aspects over which they want to retain the greatest control, whether out of interest or for greater profit. To explore these possibilities, talk with other producers and reach out to local businesses and agrifood clusters in your region. In short, grow your own network! Local development centres, chambers of commerce and producer groups are excellent resources to help you get started.

EFFECTIVENESS OF THE VALUE CHAIN

Regardless of which market and sales structure are chosen, cervid farms must be profitable. Though venison is a high-end product, customers will always want the best possible price, and will always have a price above which they will not buy. In an environment of global competition, improving profitability means evaluating the real potential of every link of the chain, so that performance can be optimized throughout. This has to begin on the farm.

Performance on the farm

A producer's first concern is to bring the animals to the desired market weight, as quickly as possible, while achieving excellent carcass quality. The factors explored below have the greatest impact on quality, but are in turn influenced by each animal's genetics, behaviour and place in the hierarchy of the herd.

Stress

Stress experienced by the animal will have an impact on the carcass. Rough handling, extreme temperatures, lack of water or food, all are stresses that have a negative effect on growth, causing it to slow, stop or even regress.

Feed

Feed has an impact on the taste and composition of meat. In New Zealand, one study found that carcass quality was good overall regardless of whether red deer were fed on pasture or concentrates. However, in meat from pasture-fed animals the omega-3/omega-6 ratio was more beneficial to human health, while a sensory analysis panel preferred the taste of meat from animals fed on concentrates (Wiklund and coll., 2003). Similar results were obtained with other cervids in Europe and North America.

Sex and age

While there are differences between meat from males and females, they are less pronounced when the animals are slaughtered young (Purchas and coll., 2010). In older animals (18 months and older), the meat of females has a stronger taste, is more tender, and has higher fat content and better water-retention (Daszkiewicz and coll., 2009).

Males should ideally be slaughtered before 15 months of age, mainly because the first rut reduces tenderness (Wiklund and coll., 2010). For females, slaughter age varies considerably, depending on economics and how the herd is managed; since it has less impact on quality, it has not been studied extensively.

Slaughter weight

Heavier animals obviously yield the most meat, but not always in the most profitable cuts. In a study of a small number of wapiti in Alberta, it was found that most of the additional weight was in fat and meat for grinding (Robertson and coll., 2003).

In red deer, studies suggest that the sensory qualities of meat are not affected by selecting for faster weight gain (Wiklund and coll., 2008).

Transportation from farm to abattoir has an impact on weight at slaughter, causing a weight loss (shrinkage) of 2 to 5%. The number of animals shipped per load also affects costs, since the rate per head tends to be less when more animals are shipped together. Good planning can reduce shipping costs.

Dressing percentage

Normally, animals are slaughtered relatively soon after arriving at the abattoir. If they do have to wait more than a few hours, providing feed and water can reduce losses in carcass weight (Robertson and coll., 2003). The quality of cervid meat is improved by taking steps to reduce pre-slaughter stress, though not as dramatically as in other species (Pollard and coll., 2002).

Dressing percentage is the ratio between live weight and the weight of the skinned, eviscerated, headless carcass. In cervids the dressing percentage is normally around 58%, plus or minus 10%. Though an interesting indicator, the dressing percentage varies depending on the type of feed. For example, pastured cervids will have a lower dressing percentage than those fed primarily on concentrates, the ruminal mass being greater in pastured animals.

Dressing percentage should be taken with a grain of salt, since sometimes the “live weight” in the calculation is the animal’s weight when it leaves the farm, while sometimes it is the weight on arrival at the abattoir. The two can produce significantly different dressing percentages for the same animal.

Cutting yield

Cutting yield is the percentage of the total weight of butchered, saleable meat to the weight of the carcass. Not all processors provide the cutting yield, but it is useful to producers. The cutting yield percentage can range from 50 to 80% depending on how the meat is cut and the quality of the butcher’s work. The butcher alone can make the cutting yield vary by plus or minus 15% depending on his or her skill (Table 1).

Table 1. Typical cutting yields for different cuts of meat[1]

Cut	Typical yields
Tenderloin	1.1 to 1.8%
Strip loin	2.7 to 6%
Sirloin	2.1 to 2.4%
Rib eye	1.7 to 2.7%
Sirloin tip	3.6 to 5%
Round	11 to 20%
Ribs	1 to 4%
Chuck (Neck)	4 to 8%
Osso bucco	4 to 8.3%
Shoulder	4 to 10%
Stewing meat	6 to 14%
Trimmings (ground)	17 to 40%
Bones	12 to 18%
Losses	5.5 to 15%

1. Values drawn from scientific articles, various compilations from butchers, and a symposium on large game held in Drummondville in 2002 (*Colloque sur les grands gibiers 2002*).

Sale price to the consumer

Figures 1 and 2 illustrate (for red deer and wapiti respectively) the sequence of stages in the journey from live animal to butchered carcass. With each stage there is a loss of potential yield in saleable meat, the final yield being crucial in determining what price the consumer should pay. With this data, the information in Table 1, and a producer's own production costs and sales forecasts, an average retail price can be calculated for the farm to be profitable.

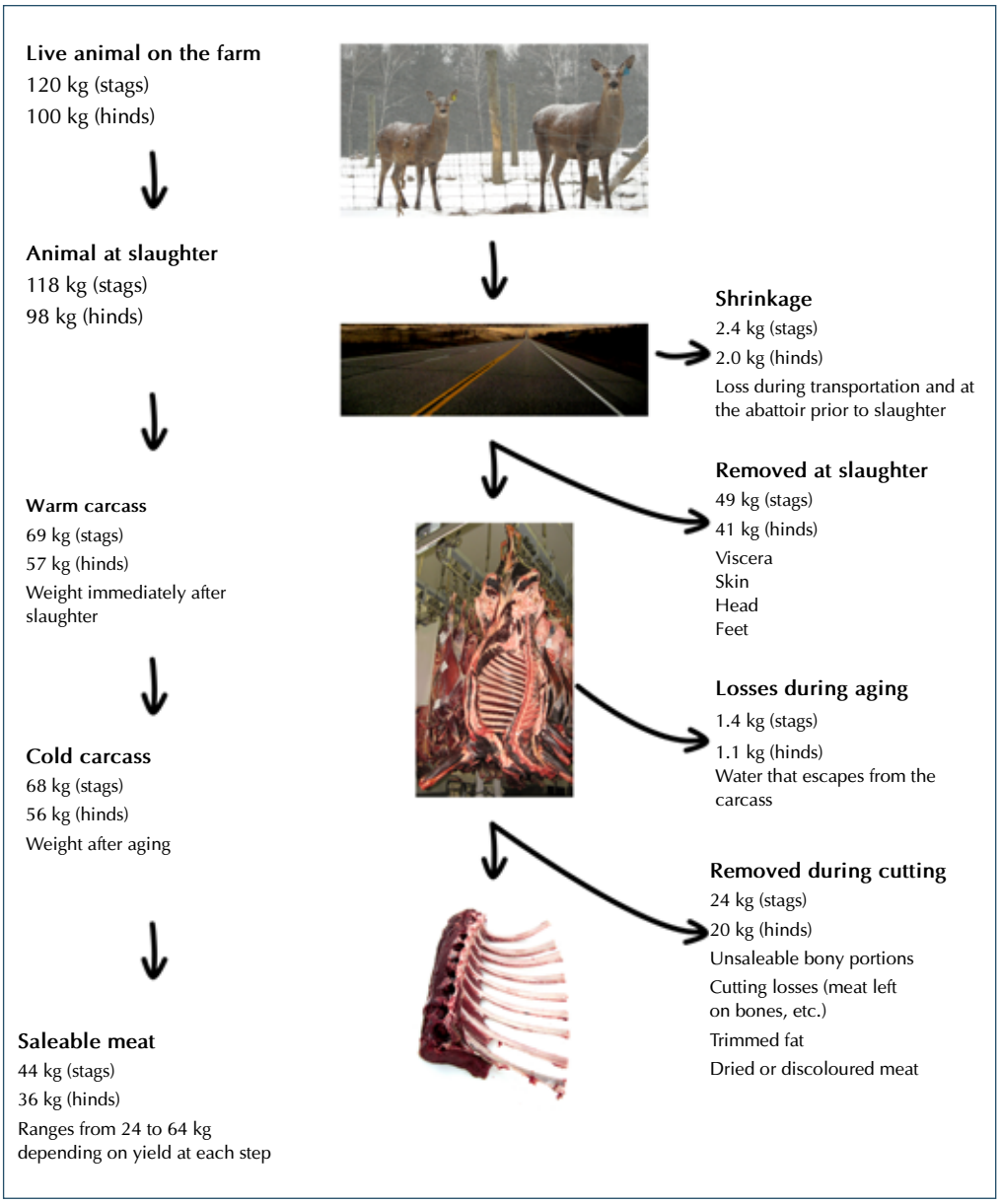

Figure 1. Stages and losses affecting the yield of saleable meat (red deer)

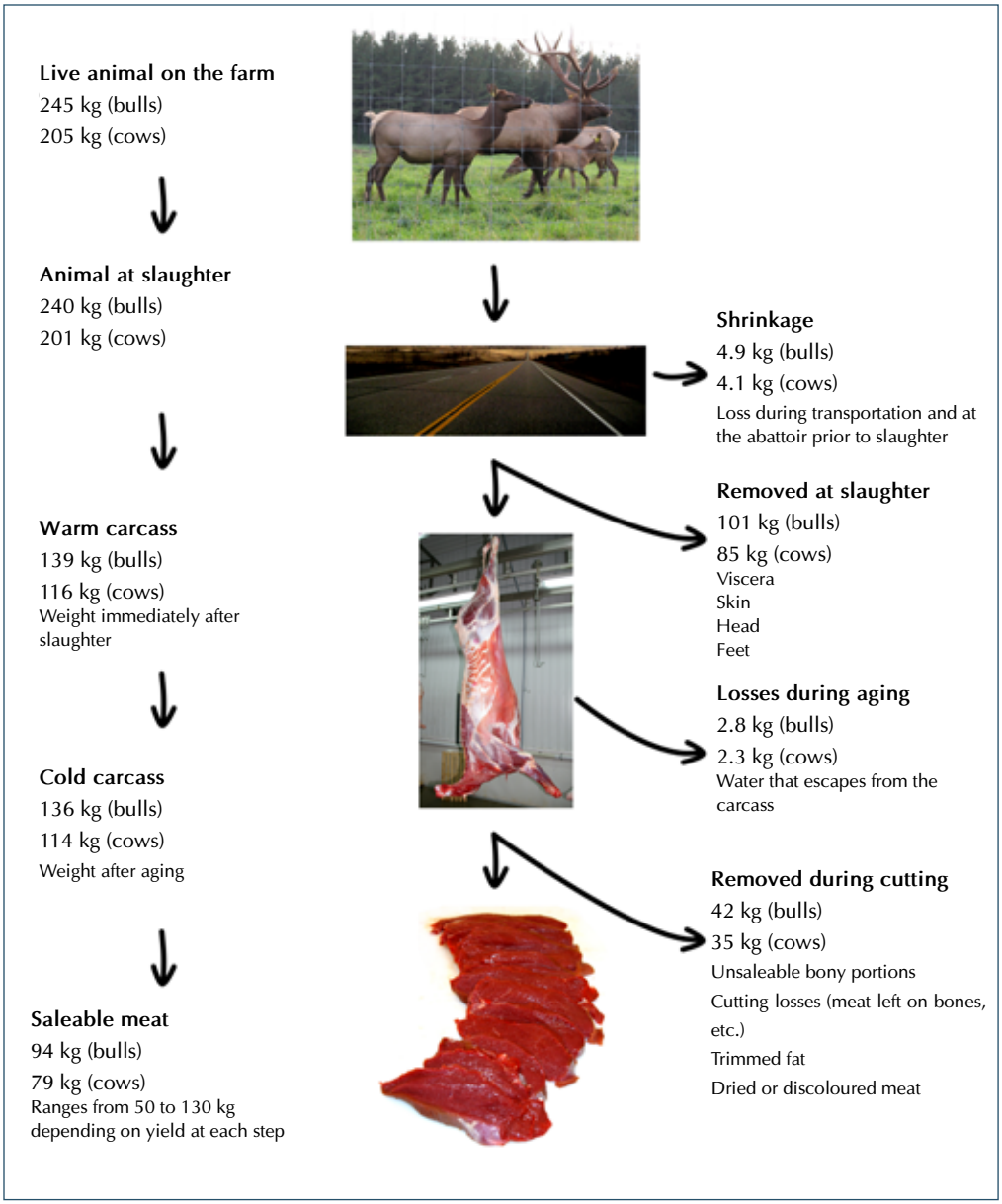

Figure 2. Stages and losses affecting the yield of saleable meat (wapiti)

VISUAL QUALITIES OF THE MEAT

Colour

The meat's colour is the first criterion judged by the consumer, who looks for meat that is bright red and does not have an excessive amount of fat. Variations in colour are primarily due to muscle myoglobin (a molecule that serves to transport oxygen). Myoglobin changes colour when it oxidizes, changing

progressively from purple to bright red, then greyish brown. These are chemical changes, as opposed to microbiological changes that could make the meat unsafe to eat. Myoglobin is denatured by cooking, thus the brown colour of cooked meat.

Raw meat that is exposed to carbon monoxide (and thereby protected from oxidation) takes on a bright red or pink colour. Protection against oxidation helps to preserve the myoglobin. This is why vacuum packing best conserves the colour of meat, and why it takes time for thawing meat to recover its colour through re-oxygenation.

Because game meat contains more myoglobin, it tends to be darker in colour than beef or lamb.

Packaging

The natural appearance of raw venison sometimes makes it more difficult to market. Various methods are used to improve its visual appeal, such as vacuum packing, butcher paper or a coloured box with a window to display the product. Good packaging is crucial to effective marketing, including every possible way of making meal preparation easier, such as frozen meals, prepared dishes, etc. Consumers buy first with their eyes.

Water loss

Water loss is perceived very negatively by consumers. No one wants to buy a package of meat swimming in juice, not to mention that such meat will shrink more during cooking and be dry and tough.

The water-retention capacity of meat is also important to the processor. Poor water retention causes problems when processing methods such as brine curing are applied. Excessive water loss represents a direct loss of saleable meat, in terms of the weight of product sold to consumers. Factors influencing water loss include stress levels before slaughter, the animal's condition when slaughtered, genetics, slaughter conditions and refrigeration.

Cervid meat has a greater water-retention capacity than beef (Farouk and coll., 2007), an advantage when it is sold fresh. On the other hand, it does not withstand prolonged freezing as well as beef. The meat of female cervids has better water-retention capacity than that of males (Daszkiewicz and coll., 2009; Purchas and coll., 2010).

SENSORY QUALITIES

Tenderness

Tenderness is the second most important criterion to the consumer after appearance. Cervid meat has a natural tenderness that is considered superior to that of beef (Farouk and coll., 2007; Wiklund and coll., 2008), perhaps due to the greater activity of enzymes during aging. However, tenderness is affected significantly by the method of cooking, so it is vital that consumers be well informed about how to properly cook venison. To maximize tenderness, cervid meat should be cooked slowly and to a lower internal temperature than that required for beef (Robertson and coll., 2003).

Meat tenderness can also be affected by the timing of slaughter (in the case of males) and by how the carcass is chilled. The meat of male cervids is a little less tender during and immediately after the rutting period (Stevenson, 1992). Also, if a cervid carcass is chilled too quickly the muscles tend to stiffen more. The chilling areas of abattoirs are generally intended for beef carcasses, which are larger and have more fat cover than cervids. The higher enzymatic activity of cervid meat is not enough to compensate for overly rapid chilling, which can cause the meat to lose a considerable degree of tenderness (Robertson and coll., 2003).

Flavour

Flavour is a combination of sensations arising from tastes, aromas and tactile sensations in the mouth. Venison has a stronger flavour than beef, and for many consumers the desire for intense flavours is greatest in the fall, perhaps through a natural association with hunting.

Succulence

Succulence refers to the liberation of juices during chewing. It is strongly related to the amount of water in the meat after cooking. In sensory analyses, venison is considered a somewhat drier meat than beef (Dhanda and coll., 2003; Wiklund and coll., 2008). However, there are significant differences between the venison from different cervid species.

pH

One factor that influences all of the characteristics mentioned above is the meat's pH (degree of alkalinity or acidity). If the pH is too high (alkaline) there is a greater risk of bacterial growth, along with problems affecting tenderness and succulence. On the other hand, if the pH is too low (acidic) the meat's colour will be less stable, and succulence and water-retention capacity will be diminished.

Factors affecting meat pH include the animal's stress levels during transportation and prior to slaughter, and the carcass temperature. If the carcass temperature is too high the pH will drop too quickly. However that is rarely a problem with cervids, since usually it is the opposite that occurs (chilling too quickly) because the refrigeration system was designed for beef, as noted above.

Though pH can vary widely in cervids due to individual differences in animals and different husbandry methods, the average pH is about 5.62 at 24 hours after slaughter (Pollard and coll., 2001; Dhanda and coll., 2003; Wiklund and coll., 2008).

HEALTH BENEFITS

Apart from the overall nutritional quality of venison, one of its principal advantages (and best selling point) is its low fat content (Table 2). The benefits of omega-3 are often touted in advertising, but since omega oils are in the fat, it is hard to demonstrate any real advantage in a product as lean as cervid meat.

Table 2. Nutritional value of cervid meat compared to other species

Element	Red deer/ Wapiti	Beef	Pork	Chicken
Water (% or g/100 g)	73 – 76	69.93	72.23	75.79
Protein (% or g/100 g)	21.6 – 23.0	21.85	21.43	21.23
Fat (% or g/100 g)	0.63 – 1.9	16.71	5.66	2.59
Iron (mg/100 g)	3.07 – 3.34	1.94	0.84	0.37
Energy (kJ/100g)	484 – 658	645	598	477

Data compiled from: Stevenson, 1992; Dhanda and coll., 2003; Farouk and coll., 2007; Wiklund and coll., 2008; Daszkiewicz and coll., 2009; Purchas and coll., 2010; Wiklund and coll., 2010.; USDA, 2011.

PRODUCT IMAGE

Cervid meat is a high-end product that consumers do not simply purchase as a matter of course, the way they do beef. The product's image is therefore very important from a marketing point of view. We should try to take advantage of how deer and wapiti are perceived in the collective imagination.

Cervid farming is relatively new in Québec, and hunting activities are still present on many cervid farms. Whether speaking of cervids in general, red deer, wapiti, or large game, most people instinctively make the connection with wildlife. Some producers are successful at capitalizing on this, focusing on a market that appreciates the "wilder" taste of game meat, a taste that can be enhanced by putting cedar branches in the paddock for the last 3 weeks before the animals are slaughtered.

Most people envision cervid being farmed on vast pastures. While it is indeed more extensive than other productions, not all producers have the land to raise their animals that way. If hard-won markets are to be gained or maintained, good husbandry practices (Canadian Cervid Alliance, 2009) and careful attention to the image of the cervid farming sector are important. Farm facilities and husbandry practices must reflect the animals' needs and the values of consumers, especially with respect to animal welfare.

There are various certifications and trademarks by which a cervid producer can gain consumer recognition and become a preferred supplier. Examples include "*Grands Gibiers du Québec*" and "*Aliments du Québec*" certification, the trademarks of various distributors, and an array of designations and certifications at the regional, provincial, national and international levels. More formal designations that would be protected by legislation are in development, but this concept is still new in Quebec. To learn more, see the website of the Conseil des appellations réservées et des termes valorisants (council on reserved designations and added-value claims), at http://www.cartv.gouv.qc.ca.

CONCLUSION

Whether raising red deer or wapiti, producing quality meat demands just as much work as with other types of livestock, as demonstrated by the wide variations in quality and yield. The beauty and the challenge of the cervid farming industry lies in its wealth of possibilities and the freedom of producers to create their own solutions for sales and marketing.

BIBLIOGRAPHY

Canadian Cervid Alliance. 2009. *On Farm Food Safety Quality Recognition: Good Production Practices*. 28 pp.

Daszkiewicz, T., P. Janiszewski and S. Wajda. 2009. *Quality characteristics of meat from wild red deer (Cervus elaphus L.) hinds and stags*. Journal of Muscle Foods 20: 428-448.

Dhanda, J.S., R.B. Pegg and P.J. Shand. 2003. *Tenderness and Chemical Composition of Elk (Cervus elaphus) Meat: Effects of Muscle Type, Marinade Composition, and Cooking Method*. Journal of Food Science 68(5): 1882-1888.

Farouk, M.M., M. Beggan, S. Hurst, A. Stuart, P.M. Dobbie and A.E.D. Bekhit. 2007. *Meat quality attributes of chilled venison and beef*. Journal of Food Quality 30: 1023-1039.

Field, R.A., F.C. Smith, W.G.H. Hepworth and W.J. Means. 2003. *The Elk Carcass*. University of Wyoming, Agricultural Experiment Station, B-594R.

Hoffman, L.C. and E. Wiklund. 2006. *Game and venison – meat for the modern consumer*. Meat Science 74: 197-208.

Nicol, A.M., H.G. Judson and A.W. Taylor. *The effect of hybridisation on venison production*. Proceedings of the New Zealand Society of Animal Production 63: 222-228.

Pollard, J.C., R.P. Littlejohn, G.W. Asher, A.J.T. Pearse, J.M. Stevenson-Barry, S.K. McGregor, T.R. Manley, S.J. Duncan, C.M. Sutton, K.L. Pollock and J. Prescott. 2001. *A comparison of biochemical and meat quality variables in red deer (Cervus elaphus) following either slaughter at pasture or killing at a deer slaughter plant*. Meat Science 60: 85-94.

Purchas, R.W., E.C. Triumf and B. Egelandsdal. 2010. *Quality characteristics and composition of the longissimus muscle in the short-loin from male and female farmed red deer in New Zealand*. Meat Science 86: 505-510.

Robertson, W.M., A. Schaefer, S.J. Landry and D. Brereton. 2000. T*he Evaluation of Meat Yield and Quality in Elk, Report Prepared for the Alberta Elk* Association, Agriculture and Agrifood Canada, Lacombe, Alberta, Canada.

Robertson, W.M., A.L. Schaefer, N.J. Cook and S.J. Landry. 2003. *Carcass and Meat Quality of Farmed Elk*, Highlights of Research Conducted at the Lacombe Research Centre, Lacombe, Alberta, Canada.

Roots, C. 2007. *Domestication*, Greenwood Publishing Group. USA. 199 pp.

Stevenson, J.M., D.L. Seman and R.P. Littlejohn. 1992. *Seasonal variation in venison quality of mature, farmed red deer stags in New Zealand*. J. Anim. Sci. 70: 1389-1396.

U.S. Department of Agriculture. 2011. USDA *National Nutrient Database for Standard Reference*. Release 24. [online]. Agricultural Research Service, Nutrient Data Laboratory Home Page, http://www.ars.usda.gov/nutrientdata (accessed January 23 and May 15, 2011).

Wiklund, E. 2009. *Venison quality, from plate to gate*. Proceedings of the Deer Branch of the NZVA. pp. 24-26.

Wiklund, E., T.R. Manley, R.P. Littlejohn and J.M. Stevenson-Barry. 2003. *Fatty acid composition and sensory quality of Musculus longissimus and carcass parameters in red deer (Cervus elaphus) grazed on natural pasture or fed a commercial feed mixture*. J. Sci. Food Agric. 83: 419-424.

Wiklund, E., G.W. Asher, J.A. Archer, J.F. Ward and R.P. Littlejohn. 2008. *Carcass and meat quality characteristics in young red deer stags of different growth rates*, Proceedings of the New Zealand Society of Animal Production 68: 174-177.

Wiklund, E., P. Dobbie, A. Stuart and R.P. Littlejohn. 2010. *Seasonal variation in red deer (Cervus elaphus) venison (M. longissimus dorsi) drip loss, calpain activity, colour and tenderness*. Meat Science 86(3): 720-727.

Wiklund, E. and F.J.M. Smulders. 2011. *Muscle biological and biochemical ramifications of farmed game husbandry with focus on deer and reindeer*. Game meat hygiene in focus, Wageningen Academic Publishers, Netherlands.

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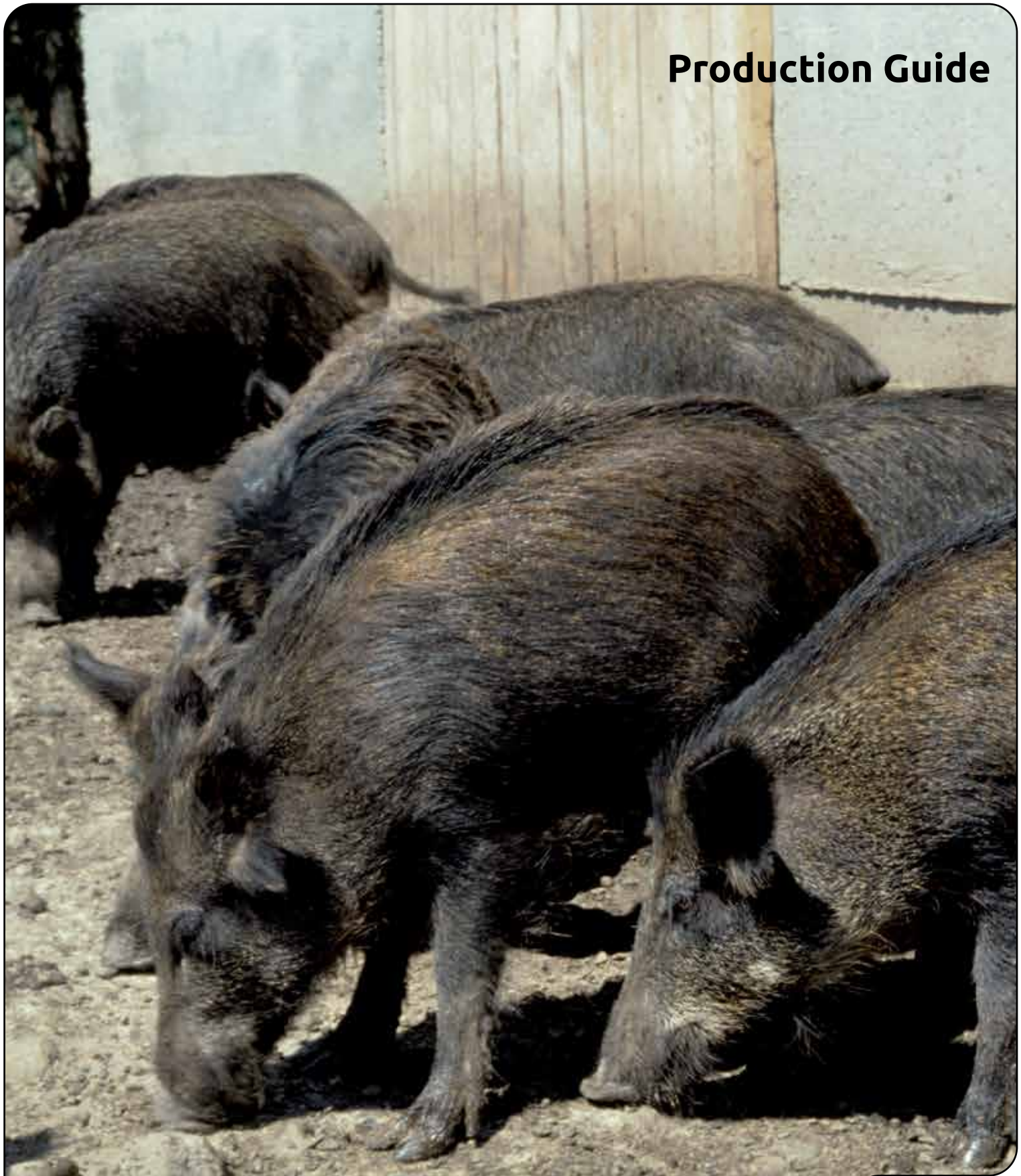

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INTRODUCTION

Québec consumers are increasingly eager for new foods and flavours, a context that suggests interesting opportunities for products like wild boar. Recognized as a high-end product, wild boar meat was initially limited to top restaurants, country dining and méchouis. Today, with the steady growth of farm sales, the ever more frequent presence of wild boar and other game meats in food markets, and the popularity of processed products like wild boar sausages, we are clearly in the midst of a revolution in Quebecer's eating habits. This makes it all the more important to offer consumers a top quality product that consistently makes for delicious eating.

GENERAL INFORMATION

In Québec, wild boar herds generally consist of purebreds, with some herds having a certain proportion of hybrids with a greater or lesser share of porcine (domestic pig) genetics. Hybrids (between wild boar and domestic pigs) are usually the result of less rigorous quality control in breeding and reproduction programs. The animal's genotype has an impact on its muscle tissue characteristics, the process by which muscle is transformed into meat, and the quality of the meat. Genetic variation therefore creates a situation where carcasses and meat are variable and hard to typify. To avoid this, breeding stock must be systematically screened for genetic purity.

How much exercise the wild boar gets, and the nature of its feed in terms of energy and protein content, have an enormous influence on the growth rate, fat stores and muscle tissue characteristics, and in turn influence carcass quality and the eating quality of the meat. As a result, meat from farm-raised wild boar is very different from that of feral wild boar. The latter generally finds food of poorer quality, highly variable and less abundant, and the animal has to be constantly on the move to find what it needs to survive.

For these reasons, what little information is available on the subject of wild boar meat should be put in context when describing and characterizing the wild boar meat produced in Québec.

YIELD

Compared to pigs and even hybrid crosses, wild boar growth is relatively slow (Alberta Agricultural Food and Rural Development, 1997; Rehfeldt and coll., 2008; Skewes and coll., 2008; Oshima and coll., 2009). A farm-raised wild boar is slaughtered when it weighs about 90 kg, at 13 to 18 months of age, whereas a domestic hog, with an average daily weight gain (ADG) of a kilogram per day, is slaughtered at 125 kg before it reaches 5 months. The slaughter age for wild boar is variable because of more diverse farming practices and less homogeneous species genetics.

On average, the dressing percentage output per skinned carcass is 58% of the live weight, or 78% with hide (unpublished data collected in Québec). The skin therefore accounts for a large percentage of the carcass, i.e. nearly 20%. Figure 1 presents the weights of the different parts of the carcass of a wild boar raised in Québec, with and without trimmings.

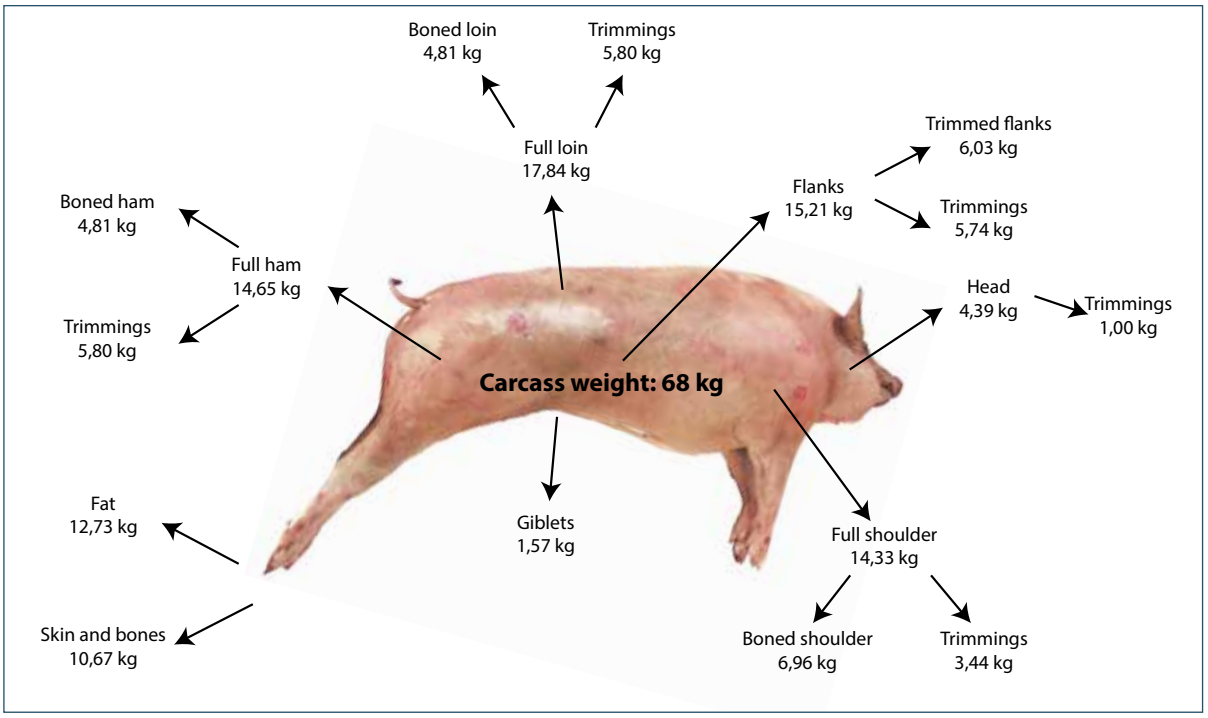


Figure 1. Yield from a typical 87 kg butchered wild boar (live weight)

PROPERTIES

Like most red meats, wild boar meat is a good source of protein. The available data indicates that it is a relatively lean meat (Zomborszky and coll., 1996; Alberta Agricultural Food and Rural Development, 1997; Oshima and coll., 2009), since there is little fat in the muscle. In most species, adipose tissue first develops under the skin (subcutaneous fat) and subsequently, throughout growth, between the muscles (intramuscular fat). Toward the end of growth, given the right genetic and nutritional conditions, fatty tissue develops inside the muscles. Known as marbling, this intramuscular fat contributes significantly to the eating quality of the meat.

Though farm-raised wild boar are fatter than feral wild boar, their growth rate, genetics and feed result in the fat being deposited under the skin instead of in the muscles. Overfeeding should be avoided, since excessive fat deposits require additional effort by the butcher to prepare a visually pleasing product (Figure 2).

Figure 2. Influence of body condition on subcutaneous fat deposits (these two slices of loin are from wild boars of comparable weight, but with different body conditions)
Photo: Juan Pablo Soucy

Though the nutritional composition of meat varies by cut, Table 1 presents the carcass average. As with most red meats, wild boar meat is a good source of iron and vitamin B complex (USDA Agricultural Research Service, 2011).

Table 1. Average nutritional composition of raw wild boar meat (100 g)

	Water (g)	Lipids (g)	Cholesterol (mg)	Protein (g)	Energy (kJ)
Wild boar	72,5	2,85	77	21,5	510

Source: Health Canada, 2010

PRODUCT QUALITY

Meat quality can be defined in different ways depending on your approach and what characteristics are desired. Organoleptic (sensory) characteristics have to do with the pleasure of consuming the product. They include four perceptible parameters of one or more senses: colour, juiciness, flavour and tenderness. These parameters are especially important because they influence consumer eating habits. It is from that perspective, eating pleasure, that the following paragraphs explain the quality of wild boar meat.

The first thing to understand is that meat quality is influenced by changes that occur in muscle after the animal dies. The organoleptic or sensory quality of a cut of meat depends on the character of the raw material (muscle), its transformation into meat, and finally the preparation and conservation of the cut in question. For optimal quality, it is important that all three stages be properly controlled.

Raw material

Muscles are composed of three types of tissue that have a decisive impact on the organoleptic quality of the meat: connective tissue, adipose tissue (fat) and muscle tissue.

Connective tissue, consisting mainly of collagen, affects the tenderness of the meat. Forming a sheath around the bundles of muscle fibres, connective tissue is responsible for transmitting the contractile force of muscle to the skeleton during movement. Thus, skeletal muscle (e.g. shoulder or calf muscle) contains more connective tissue than supporting muscle (e.g. loin or filet mignon). This is why skeletal muscle should be cooked slowly in the oven or slow-cooker, while loin or filet mignon, containing less connective tissue, can be quickly grilled. Also, since connective tissue ages with the animal, meat from older animals takes longer to break down during cooking.

From the available data it appears that connective tissue is more developed in wild boar (especially when raised in their natural environment), and in game animals in general, than in domestic pigs (Oshima and coll., 2009). To minimize the connective tissue's influence on meat tenderness, a faster growth rate is preferable so the animals can be slaughtered while relatively young. Cooking methods must also be adapted to the cut for its full gastronomic potential to be expressed.

Today's health-conscious consumers want to reduce their consumption of fat. Less subcutaneous fat and fat around muscle (partly removed during butchering) is therefore desirable. However, fat should not be completely eliminated, since it contributes to flavour, juiciness and tenderness. Marbling, the presence of veins of fat in meat, is desirable from the point of view of sensory quality.

A wild boar in its wild state is relatively lean, but farm-raised wild boar are very different. While farmed wild boar will generally have a significant amount of subcutaneous fat, genetic selection and good husbandry practices can minimize excessive subcutaneous fat. As well, this fat is easily trimmed by the butcher or the consumer.

Lastly, muscle tissue is composed of red and white muscle fibres whose respective characteristics affect all the quality parameters. The most obvious illustration is the difference between chicken breast meat (white fibres) and a chicken drumstick (red fibres).

Wild boar meat has a higher proportion of red fibres than pork (Essen-Gustavsson and Lindholm, 1984; Rehfeldt and coll., 2008; Oshima and coll., 2009; Żochowska-Kujawska and coll., 2009), which gives it a dark red colour. The wild boars' genetics are largely responsible for this trait. Over thousands of years, exercise has always been an integral part of the life of wild boar, strongly determining the characteristics of its muscle fibres. Exercise promotes the development of red fibres, which are more aerobic and resistant to fatigue. In the case of domestic pigs, selection for faster growth and muscle bulk favoured the development of white fibres. In short, domestication (less exercise, abundant food and selection for muscle bulk and faster growth) favours white fibre development and increased fibre size. In contrast, the muscle fibres of wild boar are generally smaller than those of pigs (Müller and coll., 2002; Rehfeldt and coll., 2008).

All of these muscle characteristics (connective tissue, fat, fibre size and type) combine to make wild boar meat different from other meats in terms of colour, juiciness, flavour and tenderness.

Colour

The high proportion of red muscle fibre gives wild boar meat its dark red, almost burgundy colour. An abundance of myoglobin (a pigment that stores oxygen in the muscles) is what gives red muscle fibre its colour (Livingston and Brown, 1981). Beyond genetic factors, exercise can increase the high concentration of myoglobin in wild boar, a concentration that increases with age. This is why meat from culled wild boar is darker than that of feeder wild boar, which in turn is darker than that of piglets. Some producers obtain darker meat by keeping their wild boar beyond their target market weight, but careful management is required to avoid higher production costs or reduced tenderness. Proper aging and careful control of input costs are essential.

Meat colour is also strongly influenced by pH. While no pH problems have been reported in farm-raised wild boar in Québec, it is important to keep stress to a minimum before slaughter, both for the animals' well-being and to allow a normal lowering of pH. Inadequate lowering of pH results in overly dark meat. Stress before slaughter can cause the animal to deplete its energy reserves, and if these reserves are too low, the acidity of the meat cannot develop normally and pH remains high. With a darker, sticky quality, the resulting meat is unattractive and has a shorter shelf life. On the other hand, if pH declines too quickly or too far, the meat will be paler. This phenomenon has been extensively studied in pigs, where the genetic factors responsible have been identified. The large proportion of red fibres in wild boar meat makes it much less susceptible to turning pale.

Transformation of muscle into meat

After the animal's death, muscle loses its energy reserves. A natural acidity develops, observed as a drop in pH. With the depletion of energy reserves, the muscle passes from a quivering[1] state to a firm state called rigor mortis. When this occurs, various enzymes are released that tenderize the meat and work throughout the aging process. The transformation of muscle into meat thus occurs in three stages: drop in pH, onset of rigor mortis and aging due to enzymes. Together they influence meat colour, flavour and tenderness.

Figure 3. Quality of wild boar meat in terms of colour (left to right: optimal colour, too dark, too light)

Photo: Juan Pablo Soucy

1. A soft muscle that still shows signs of palpitations.

Flavour

Flavour is a combination of sensations perceived by both the taste buds and olfactory receptors (smell). The taste buds enable us to distinguish sweet, salty, bitter and sour, while smell enables us to perceive an array of compounds that are liberated during chewing. The different aromas of meat develop in cooking, through various reactions among the molecules in the meat. The fat and protein content of the meat therefore has an important impact, with the characteristic flavour of a particular type of meat being largely related to its fat content and the molecules therein, while the muscle (proteins) is responsible for the general meat taste.

Feeding practices affect the taste of meat by influencing its composition (tissues and molecules). Wild boar meat has a "gamey" flavour that is stronger than in most other meats, intensifying as the animal ages. Quite distinct from pork, this characteristic flavour is caused by different levels of the compounds present in all meat (Lammers and coll. 2009). That is, in both pork and wild boar meat the same compounds develop during cooking, but in different proportions. The differences are due to genetics and nutrition.

Tenderness

The tenderness of meat depends essentially on three factors: the basic toughness of collagen, the state of contraction during rigor mortis and the tenderizing of the meat by aging (Koohmaraie and Geesink, 2006).

More developed in the wild boar than in pigs, connective tissue is responsible for the meat's "basic toughness", i.e. a toughness present at the moment of slaughter that is moderated by aging (Bailey, 1972). Generally speaking, as an animal ages its connective tissue becomes harder to dissolve during cooking, making it less tender.

The more a muscle contracts during rigor mortis, the less tender it will be. Normally this contraction is quite limited. However, cooling the carcass too quickly can cause a contraction phenomenon called "cold shortening" (Honkel, 2004). Generally, to avoid this problem the temperature of the carcass should not reach 10 °C until the energy reserves are sufficiently spent (pH 6.0).

In the days following slaughter, enzymes go to work that tenderize the meat. This is why meat is left to age in a cooler or refrigerator, either as a complete carcass or butchered and packaged, before being consumed. The important thing is to let the meat age long enough, which varies from species to species. In pork for example, meat can be 80% tenderized in 4 days, while for lamb or beef it takes 8 to 10 days (Dransfield and coll., 1981), and often beef is aged for 14 to 21 days. It generally takes longer to tenderize muscle composed of red fibres. In wild boar meat, the composition of the muscle fibres suggests that aging time should be somewhere between that for pork and beef. One study reports a 25% increase in tenderness after 12 days, with 17% in the first 6 days (Żmijewski and Korzeniowski, 2001). A week of aging (or 4 to 14 days) should therefore be enough to obtain adequate tenderness.

MARKETING

Every aspect of selling the product, including determining the target clientele, is vital to the producer's economic survival.

The principal markets available for wild boar meat are restaurants and retail sales. Most restaurants prefer to buy only the cuts they need. Restaurants are an attractive market for producers who can ensure a regular supply, consistent quality and a uniform product. As for retail, the solutions possible (by order of increasing convenience for the consumer) include on-farm sales (cuts or carcasses for méchoui barbecues), country dining, a stall at a farmer's market, and selling through a website.

On-farm sales are handled by the producer-processor-distributor, i.e. a producer performing all three operations. Distribution is what takes the most time and the greatest initial investment. For a business short on manpower, on-farm sales come with significant time constraints. Since the best times for selling are when people are off work, opting for this type of marketing requires a producer who can work on weekends and holidays and who enjoys interacting with the public. The producer must also comply with regulations that can be complex and costly for small producers (obtaining the right permits, health and safety training, etc.).

In Québec, most of the laws and regulations around food preparation and distribution are administered by the ministère de l'Agriculture, des Pêcheries et de l'Alimentation (MAPAQ) under the *Food Products Act*. A producer who wishes to export must consult the Canadian Food Inspection Agency, which administers additional legislation to that end.

Sales of whole carcasses to individuals account for a much smaller portion of the market, often consisting of direct sales of live animals by the producer to the consumer.

Though not yet common in Québec, marketing through a distributor lets the producer focus on the herd, devoting all his or her efforts to optimizing performance and genetics. This can be attractive for a new operation, since sales are relatively assured. However, the distributor must have access to a large enough market to be able to take on a new producer. In turn, the producer must ensure that the quality and volumes produced consistently meet expectations.

Though still marginal, mixed marketing strategies are emerging in which certain stages of production or sales are done on a contract basis. They let the producer focus on the tasks in which he or she excels, delegating the rest to others. For example, a breeder can contract out some of the finishing, while a producer who only raises a few sows but has a farm outlet can sell wild boar meat supplied by other producers.

Lastly, with the appropriate permit from MAPAQ a producer can diversify the business by adding a hunting option. The crucial regulations are set out in the *Regulation respecting animals in captivity*. Some game farms are themselves in the market for wild boar of 40 to 50 kg or more, provided they were raised in conditions that promote wild behaviour. This can be a good market for new producers.

Keep in mind that the more middlemen there are between producer and consumer, the less income the producer will receive per kilogram sold. Nonetheless, the price differential is indicative of the many steps and considerable effort involved between an animal at the farm gate and quality meat on the consumer's plate.

CONCLUSION

Wild boar meat is a high-end product that consumers seek out for a culinary experience. In that context, it is imperative that practices be put in place to ensure the supply of a quality product that will consistently satisfy consumer expectations. There are many challenges to be met (in genetics, farm management, marketing, etc.), but with such a new product the opportunities are considerable.

BIBLIOGRAPHY

Alberta Agricultural Food and Rural Development. 1997. *Agricultural Business Profiles: Commercial Wild Boar Industry*. Agdex 498/830-1. pp. 1-13.

Bailey, A.J. 1972. *The basis of meat texture*. J. Sci. Food Agric. 23: 995-1007.

Dransfield, E., R.C.D. Jones and H.J.H. MacFie. 1981. *Tenderising in M. longissimus dorsi of beef, veal, rabbit, lamb and pork*. Meat Sci. 5: 139-147.

Essen-Gustavsson, B. and A. Lindholm. 1984. *Fiber types and metabolic characteristics in muscles of wild boars, normal and halothane sensitive Swedish landrace pigs*. Comp. Biochem. Physiol. A Comp. Physiol. 78: 67-71.

Health Canada. 2010. *The Canadian Nutrient File* [online]. http://hc-sc.gc.ca/fn-an/nutrition/fiche-nutri-data/cnf_aboutus-aproposdenous_fcen-eng.php

Honikel, K.O. 2004. *Conversion of muscle to meat: Cold and heat shortening*. In: W. Jensen, C. Devine, M. Dikeman, eds. Encyclopedia of meat sciences, pp. 318-323, Elsevier Academic Press, Oxford, UK.

Koohmaraie, M. and G.H. Geesink. 2006. *Contribution of postmortem muscle biochemistry to the delivery of consistent meat quality with particular focus on the calpain system*. Meat Sci. 74: 34-43.

Lammers, M., K. Dietze and W. Ternes. 2009. *A comparison of the volatile profiles of frying European and Australian wild boar meat with industrial genotype pork by dynamic headspace-GC/MS analysis*. J. Muscle Foods 20: 255-274.

Livingston, D.J. and W.D. Brown. 1981. *The chemistry of myoglobin and its reaction*. Food Technol. 35: 244-252.

Müller, E., M. Rutten, G. Moser, G. Reiner, H. Bartenschlager and H. Geldermann. 2002. *Fibre structure and metabolites in M. longissimus dorsi of Wild Boar, Pietrain and Meishan pigs as well as their crossbred generations*. J. Anim. Breed. Genet. 119: 125-137.

Oshima, I., H. Iwamoto, Y.-N. Nakamura, K. Takayama, Y. Ono, T. Murakami, N. Shiba, S. Tabata and S. Nishimura. 2009. *Comparative study of the histochemical properties, collagen content and architecture of the skeletal muscles of wild boar crossbred pigs and commercial hybrid pigs*. Meat Sci. 81: 382-390.

Rehfeldt, C., M. Henning and I. Fiedler. 2008. *Consequences of pig domestication for skeletal muscle growth and cellularity*. Livest. Sci. 116: 30-41.

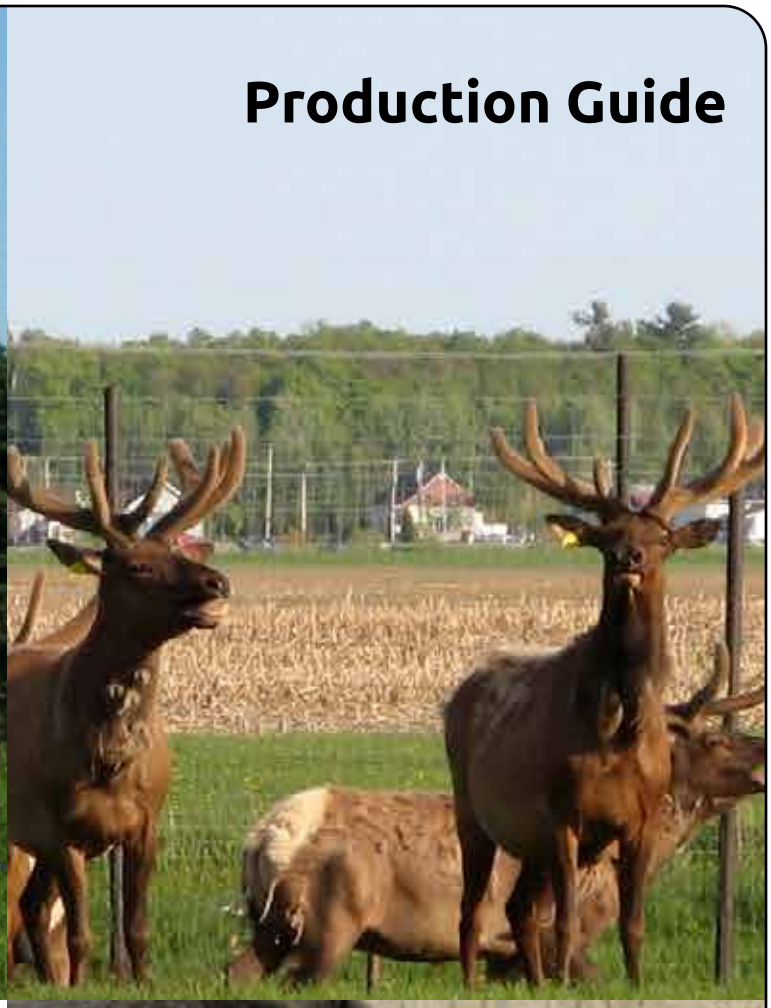
Skewes, O., R. Morales, F. González, P. Hofbauer and P. Paulsen. 2008. *Carcass and meat quality traits of wild boar (Sus scrofa s. L.) with 2n = 36 karyotype compared to those of phenotypically similar cross-breeds (2n = 37 and 2n = 38) raised under same farming conditions. 1. Carcass quantity and meat dressing*. Meat Sci. 80: 1200-1204.

USDA Agricultural Research Service. 2011. *USDA National Nutrient Database for Standard Reference, Release 24* [online]. http://www.ars.usda.gov/ba/bhnrc/ndl.

Żmijewski, T. and T. Korzeniowski. 2001. *Technological properties of wild boars meat*. EJPAU. 4.

Żochowska-Kujawska, J., M. Sobczak and K. Lachowicz. 2009. *Comparison of the texture, rheological properties and myofibre characteristics of SM (Semimembranous) muscle of selected species of game animals*. Pol. J. Food Nutr. Sci. 59: 243-246.

Zomborszky, Z., G. Szentmihalyi, I. Sarudi, P. Horn and C.S. Szabo. 1996. *Nutrient composition of muscles in deer and boar*. J. Food Sci. 61: 625-627.



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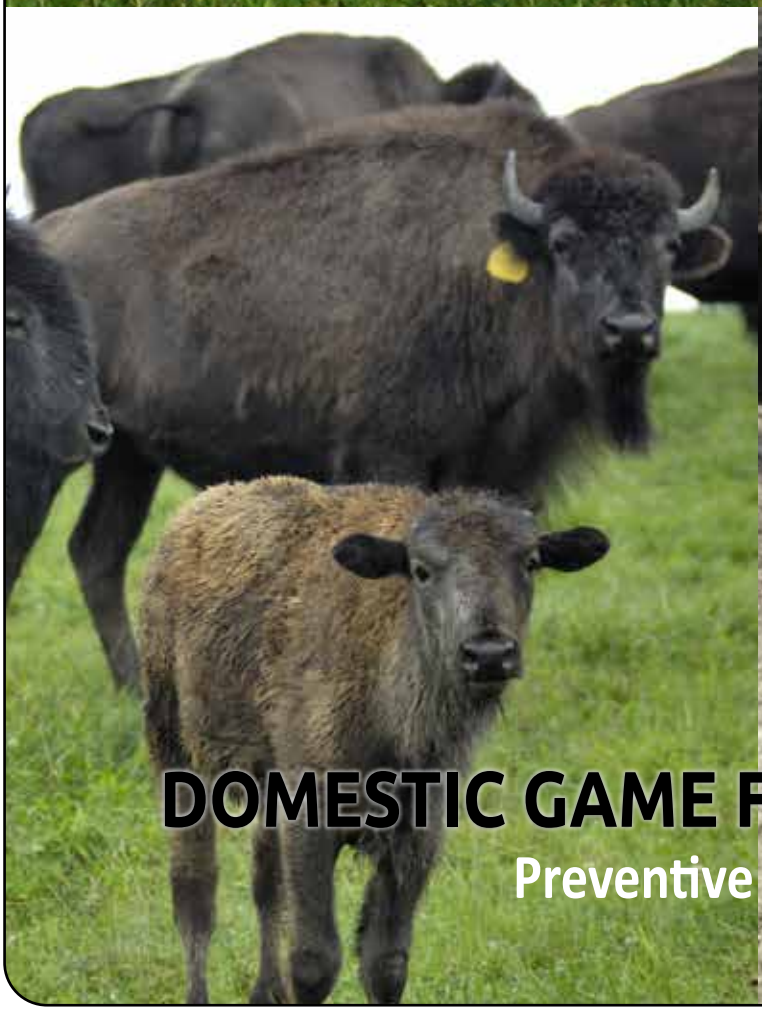

DOMESTIC GAME FARM ANIMALS

Preventive Medicine – Overview

CRAAQ

CULTIVER L'EXPERTISE
DIFFUSER LE SAVOIR

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INTRODUCTION

For anyone farming game animals like wild boar, bison, deer and wapiti (known as elk outside of Québec), disease prevention should be a priority. Healthy conditions and proper feeding will go a long way toward ensuring the health of a herd. Remember that when animals live in poor conditions they are stressed and weakened, which predisposes them to disease.

Also, since many problems are multi-factoral, the effectiveness of preventive and curative treatments can be significantly influenced by the conditions in which animals are raised.

This leaflet presents the various preventive health measures that can be used by game farmers with animals like wild boar, bison, deer and wapiti.

GENERAL RULES

Here are the fundamental rules of disease prevention in game farming:

1. For wild boar farming, keep a distance of at least 5 km from the nearest pig farm. To reduce the risk of disease transmission, keep well away from fields where pig manure is spread;
2. To reduce stress on the animals, keep a good distance from busy roads;
3. Ensure that pens and pastures are well drained, since mud and stagnant water are breeding grounds for parasites;
4. Feeders and feeding areas should be kept clean to reduce disease transmission;
5. Restrict visitor access;
6. Quarantine newly purchased animals;
7. Divide the animals into age groups;
8. Practise pasture rotation and alternative tillage to reduce the parasite load in pens and pastures;
9. Keep good records of all curative and preventive treatments performed;
10. Promptly dispose of carcasses of dead animals.

WILD BOAR

Since the wild boar is very similar to the domestic pig, it is susceptible to many of the same diseases. Unfortunately there is no documentation specific to wild boar describing their diseases and the effectiveness of vaccines and other livestock medicines.

The preventive treatments listed in Tables 1 and 2 are administered to domestic pigs. The pros and cons of applying such measures to a wild boar herd should be discussed with your veterinarian. Specifically, you must assess whether the benefits of an intervention outweigh the stress and risk of an accident associated with handling the animals.

Tableau 1. Vaccination bactérienne chez l'espèce porcine

Disease	Type of vaccine	Dose	Advantages-disadvantages
Neonatal diarrhea	Inactivated vaccine	• Sow : two doses of 2 ml (IM[1]), 3 to 6 weeks apart; then every year, 2 to 6 weeks before farrowing	• Withdrawal time[2]: 0 day • Used on sows (maternal transmission in colostrum) • Can be combined with a vaccine against clostridiums, which in some cases are associated with neonatal diarrhea and other less common conditions affecting sows
Porcine proliferative enteropathy	Attenuated vaccine	• Piglet over 3 weeks: 2 ml (IM)	• Withdrawal time: 0 day • Can be administered in water • Protection after 3 weeks; lasts 17 weeks
Glasser's disease	Inactivated vaccine	• Piglet over 5 weeks: two doses of 2 ml (IM), 2 weeks apart • Sow: two doses of 2 ml, 4 weeks apart; then every year, 2 to 4 weeks before farrowing	• Protection about 14 weeks • Important to immunize sows, since the disease mostly affects 2-week piglets • Withdrawal time: 0 day
Contagious pleuro-pneumonia	Inactivated vaccine containing APX toxins	• Two doses of 2 ml (IM), 4 weeks apart, for animals 6 weeks and over	• Withdrawal time: 0 day • Partial clinical protection
Enzootic pneumonia	Inactivated vaccine	• Piglet 5 days and up: two doses of 2 ml (IM), 3 to 4 weeks apart • Piglet 10 weeks and up: 2 ml (IM)	• Most effective at weaning, but ideally the entire herd should be vaccinated • Can be obtained in combined form with a vaccine against Glasser's diseaser
Atrophic rhinitis	Inactivated vaccine	• Piglet over 18 months: two doses of 2 ml (IM), 6 weeks apart • Sow: once a year, 2 to 6 weeks before farrowing	• Important to administer to sows (maternal transmission in colostrum) • Withdrawal time: 0 day
Swine erysipelas	Inactivated vaccine	• Piglet over 12 weeks: two doses of 2 ml (IM), 4 weeks apart • Yearly vaccination: 2 ml before each lactation	• Withdrawal time: 0 day • Protection for 6 months • Can be combined with vaccine against parvovirus (see Table 2)

1. IM : intramuscular injection.
2. Withdrawal time: minimum time required between administration of the drug and slaughter of the animal.

Table 2. Viral vaccination in porcine species

Disease	Type of vaccine	Dose	Advantages-disadvantages
Porcine circovirus	Inactivated vaccine	• Two doses of 2 ml (IM[1]), 3 to 4 weeks apart; then 2 ml each year, 2 weeks before farrowing	• Withdrawal time[2]: 0 day • Used in the sow and piglets at weaning
Influenza	Inactivated polyvalent vaccine	• Two doses of 2 ml (IM), 3 to 4 weeks apart • Repeat each year, 2 to 3 weeks before farrowing	• Especially during fattening • Withdrawal time: 0 day
Parvovirus	Inactivated vaccine	• Two doses of 2 ml (IM), 3 weeks apart, then annually	• First dose given 6 weeks before breeding • Can be combined with vaccine against swine erysipelas (see Table 1) • Withdrawal time: 0 day
Porcine reproductive and respiratory syndrome (PRRS)	Live vaccine for piglets Inactivated vaccine for sows	• Piglet 4 to 5 weeks: 2 ml (IM) • Sow: 2 ml (IM), 3 weeks before breeding	• Withdrawal time: 2 days

1. IM: intramuscular injection.
2. Withdrawal time: minimum time required between administration of the drug and slaughter of the animal.

Depending on production conditions, parasites can cause a lot of problems in wild boar. In principle, de-worming efforts should focus on the periods of highest risk. Thus, it is strongly recommended that de-worming be done at the following times: in spring before the animals are put in pens; whenever they are rotated from one pen to another; in autumn before the first frosts; and in the case of sows, before farrowing. The various treatments available are listed in Table 3.

Table 3. Antiparasitic drugs that can be used in wild boar

Product	Dose	Withdrawal time[1]	Use
Amprolium	20 mg/kg (oral)	7 days	Coccidiosis
Doramectin Injectable	300 µg/kg (IM[2])	35 days	Intestinal worms Lungworms Lice, mites
Febendazole 20%	9 mg/kg for 3 days (oral)	7 days	Intestinal worms Lungworms
Ivermectin Injectable	300 µg/kg (SC[3])	28 days	Intestinal worms Lungworms Lice, mites
Ivermectin (oral)	100 µg/kg	7 days	Intestinal worms Lungworms Lice, mites
Levamisole 10%	2 kg of ration at 0.04% per 100 kg of weight	4 days	Intestinal worms Lungworms
Levamisole Injectable	1 ml/10-20 kg (SC)	28 days	Intestinal worms Lungworms
Sulfaquinoxaline	1 g/4 litres water	14 days	Coccidiosis

1. Withdrawal time: minimum time required between administration of the drug and slaughter of the animal.
2. IM: intramuscular injection.
3. SC: subcutaneous injection.

CERVIDS AND BISON

Many of the diseases to which cervids and bison are susceptible are similar to those seen in cattle. As a result, experience gained with bovines has provided many preventive measures that are applicable to game animals. However, since very few studies have focused on the vaccination of cervids and bison, its use is largely up to the experience of the veterinarian. The main preventive measures applying to large game animals (according to the literature available) are presented in Tables 4 and 5.

Table 4. Principal vaccines used with large game animals, particularly cervids and bison

Disease	Type of vaccine	Dose	Advantages-disadvantages
Neonatal diarrhea *E.coli*-Rotavirus-Coronavirus	Bacterin and inactivated vaccine	• Two doses of 2 ml (SC[1]), 1 month apart • Repeat annually	• Withdrawal time[2]: 60 days • Rota and corona viruses have not been proven in cases of diarrhea in deer and bison, despite having been isolated
Clostridium family	Bacterin with 8 serotypes	• Two doses of 5 ml (SC or IM[3]), 21 days apart • Repeat annually	• Used for several years now on deer and bison • Withdrawal time: 21 days
IBR-BVD-PI3-BRSV[4]	Modified live vaccine Inactivated vaccine	• Live vaccine (SC or IM): two doses of 2 ml, 1 month apart, then annually • Inactivated vaccine: two doses of 5 ml (SC or IM), 3 weeks apart, then annually	• Live vaccine used for bison during fattening • Inactivated vaccine used for females • Withdrawal time: 21 days • Despite the presence of antibodies in bison and deer, these diseases have not been diagnosed with certainty
IBR-PI3	Attenuated vaccine (intra-nasal)	• 1 ml/nostril	• Withdrawal time: 21 days • Can be used on the entire herd • Handling difficulties
Pasteurellosis	Bacterin	• Two doses of 2 ml (IM), 3 weeks apart • Then annually	• Use on bison farms in Montana seems to have given some protection • Withdrawal time: 21 days

1. SC: subcutaneous injection.
2. Withdrawal time: minimum time required between administration of the drug and slaughter of the animal.
3. IM: intramuscular injection.
4. IBR: infectious bovine rhinotracheitis; BVD: bovine virus diarrhea; PI3: parainfluenza type 3; BRSV: bovine respiratory syncitial virus.

Vaccines against leptospirosis, infectious keratoconjunctivitis, anaplasmosis and babesiosis are not recommended for these species.

Cervids and bison are susceptible to parasitic infection after being confined in pens, but with good production conditions and a de-worming program parasites can be controlled. Generally, de-worming is recommended in the spring to prevent pastures from being contaminated, and in the fall after the first frosts. The principal livestock medicines used are presented in Table 5.

Table 5. Principal antiparasitic drugs used with cervids and bison

Product	Dose	Withdrawal time[1]	Use
Albendazole	• 10 mg/kg (oral)	27 days	Flukes
Amprolium	• 5 ml per 100 lb (oral), once a day for 5 days	7 days	Coccidiosis
Cyfluthrin 1%	• 2 to 12 ml (pour-on[2]) depending on weight • Repeat after 21 days	1 day	Flies, lice
Doramectin	• 200 µg/kg (SC[3] and IM[4]) • 500 µg/kg (pour-on)	40 days (SC and IM) 55 days (pour-on)	Intestinal worms Lungworms Lice, mites
Eprinomectin	• 500 µg/kg (pour-on)	0 day	Intestinal worms Lungworms Lice, mites
Febantel	• 7.5 mg/kg (oral)	21 days	Intestinal worms Lungworms
Febendazole	• 7.5 mg/kg (oral)	14 days	Intestinal worms Lungworms
Ivermectin	• 200 µg/kg (SC) • 500 µg/kg (pour-on)	49 days	Intestinal worms Lungworms Lice, mites
Levamisole	• 7.5 mg/kg (oral and SC) • 10 mg/kg (pour-on)	10 days (oral and SC) 7-28 days (pour-on)	Intestinal worms Lungworms
Moxidectin	• 500 µg/kg (pour-on)	36 days	Intestinal worms Lungworms Lice, mites
Permethrin 1%	• 15 ml/45 kg up to a maximum of 150 ml (pour-on)	1 day	Flies, lice
Permethrin 10%	• Ear tags	0 day	Horn flies Face flies

1. Withdrawal time: minimum time required between administration of the drug and slaughter of the animal.
2. Pour-on: applied locally on the animal's back, the product being absorbed through the skin.
3. SC: subcutaneous injection.
4. IM: intramuscular injection.

CONCLUSION

Farm production of large game animals is still a recent phenomenon in Québec, and little research has been done on the subject. The veterinary medicine required, both preventive and curative, has yet to be developed and registered for use in game animals. As a result, the veterinary interventions currently practised on game farms in Québec are essentially based on experience gained with cattle and hogs.

Raising game animals in pens contributes to the development of disease because they are held together in greater concentration than in their natural environments. Good production conditions and practices are therefore very important for the herd's health. At the same time, since disease cannot be controlled by livestock medicines alone, regular preventive treatments are essential.

BIBLIOGRAPHY

Berezowski, J. *A Literature Review of Disease in Bison* [online]. Saskatchewan. Specialized Livestock Health and Production. http://www.usask.ca/wcvm/herdmed/specialstock/bison/ (accessed March 15, 2011).

CBIPvet. *Vaccination contre les maladies bactériennes chez le porc* [online]. Centre belge d'information pharmacothérapeutique. http://www.cbip-vet.be/fr/texts/FSUOOOL1BL2o.php (accessed May 6, 2011).

CBIPvet. *Vaccination contre les maladies virales chez le porc* [online]. Centre belge d'information pharmacothérapeutique. http://www.cbip-vet.be/fr/texts/FSUOOOL1AL2o.php (accessed May 6, 2011).

Haigh, J.C. and R.J. Hudson. 1993. *Farming Elk and Red Deer*. Mosby Yearbook, Missouri. 369 pp.

JFO. *Les pathologies du sanglier, ses maladies* [online]. http://jfo.chez-alice.fr/les_diseases_du_boar.htm (accessed May 6, 2011).

Pathologie des maladies parasitaires 2006-2007 [online]. Deuxième doctorat en médecine vétérinaire, Université de Liège. http://www.dmipfmv.ulg.ac.be/parasitovet (accessed May 6, 2011).

Woodbury, M. 2007. *The Control of Internal Parasites in Bison* [online]. Canadian Bison Association Annual Convention, November 17-20, 2007, Regina, Saskatchewan. http://www.canadianbison.ca/producer/documents/ParasitePresentation.pdf (accessed March 15, 2011).

Wright, B. 2003. *Withdrawal Times for Medicines Used in Deer* [online]. Ministry of Agriculture, Food and Rural Affairs, Ontario. http://www.omafra.gov.on.ca/english/livestock/alternat/facts/info_withdrawal.htm (accessed May 6, 2011).

Production Guide

DOMESTIC GAME FARM ANIMALS

Principal Diseases of Red Deer and Wapiti

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INTRODUCTION

Red deer and wapiti (often referred to as "elk" outside of Québec) are rarely sick. Many of the diseases that can affect them are also observed in domestic cattle. Detection is exceedingly difficult however, because cervids do not become domesticated. This means that a sick cervid will instinctively try to conceal its abnormal condition, to avoid being noticed by predators. The result is that producers must be very attentive, observing their animals regularly to detect whether an animal is unwell. Early detection of disease will prevent propagation in the herd, limiting the economic impact on the producer. With some diseases (referred to as zoonotic) there is a risk of animal-to-human transmission, making early detection especially important.

To facilitate the veterinarian's work when conducting examinations and administering treatment, the farm must be equipped with good facilities for handling the animals. With a crowding pen to guide the animals in the desired direction, and a squeeze to immobilize them, administering preventive and curative treatments is relatively straightforward. This will ensure both the animals' safety and that of the humans working with them.

This leaflet presents most of the bacterial, parasitic and viral diseases that can affect red deer and wapiti, together with the various treatments that can be administered by a veterinarian.

BACTERIAL DISEASES

Table 1 presents the bacterial diseases that are encountered most often in red deer and wapiti herds. Various treatments can be provided by the herd veterinarian.

Table 1. The most common bacterial diseases

Name	Causal agent(s)	Symptoms	General treatment
Anthrax[1]	*Bacillus anthracis* (contamination by ingestion)	• Sudden death frequently occurs • Dehydration • Constipation • Blood loss through natural orifices	• Follow Canadian Food Inspection Agency (CFIA) guidelines
Brucellosis[1]	*Brucella abortus*	• Abortion • Lameness with joint damage	• Follow CFIA guidelines
Blackleg[2]	*Clostridium chauvoei* (contamination by ingestion)	• Rare in cervids • Mostly young animals under 2 years old • Lameness, depression, muscle swelling with joint clicking • Death within 24-48 hours • Swift post-mortem decomposition	• Primarily high-dose penicillin for 3 to 5 days • Tetracyclines

Table 1 (continued). The most common bacterial diseases

Name	Causal agent(s)	Symptoms	General treatment
Colibacillosis	*Escherichia coli*	• Mostly young animals under 3 weeks old • Abundant whitish diarrhea • Complicated by arthritis and pneumonia	• Bolus of oral antibiotics • Parenteral antibiotics (various means of administration) • Fluid therapy, either intravenous or oral
Enterotoxemia (œdema disease)[2]	*Clostridium perfringens*	• Mostly young animals • Anorexia • Diarrhea • Depression • Sudden death	• Long-acting intramuscular tetracyclines at first, followed by oral treatment in feed
Kerato-conjuncti-vitis (Pink eye)	*Moraxella bovis*	• Corneal opacity • Tearing • Conjunctival inflammation • Corneal ulcer	• Subconjunctival injection of penicillin and streptomycin • Tetracyclines orally for the entire herd • Topical ointment in the eyes
Leptospirosis	*Leptospira* (various serotypes; contamination by food, water, urine and semen)	• Young animals most susceptible • Abortion, anorexia and loss of coordination • Hematuria and jaundice	• Streptomycin: 25 mg/kg/day for 4 days
Listeriosis[2]	*Listeria monocy-togenes* (found especially in haylage/silage)	• Abortion • Septicemia • Meningoencephalitis • Unilateral facial paralysis • Circling • Abnormal head carriage • Difficulty eating feed	• Chlortetracycline: 10 mg/kg/day intravenously for 5 days • Penicillin: 44,000 UI/kg/day intramuscularly for 7 to 14 days (treatment is often unsuccessful, requiring that the animal be culled)
Malignant oedema	*Clostridium chau-voei,* *C. septicum,* *C. perfringens,* *C. novyi,* *C. sordellii* (after calving, a bad injection or an injury)	• Mostly white-tailed deer and wapiti • Fever, lameness, depression, difficulty breathing • Muscle swelling with presence of gas	• Long-acting high-dose penicillin

Table 1 (continued). The most common bacterial diseases

Name	Causal agent(s)	Symptoms	General treatment
Para-tuberculosis[2]	*Mycobacterium paratuberculosis* (contaminated water or feed)	• Many asymptomatic carriers • Deer, 1 year old • Wapiti, 18 months to 2 years old • Dramatic weight loss • Death within a few weeks or months • Diarrhea	• No satisfactory treatment • Often the best thing is to cull the animal
Pasteurellosis	*Pasteurella multocida, Mannheimia hemolytica*	• Difficulty breathing • Drooling • Anorexia and depression	• Long-acting tetracyclines: 20 mg/kg intramuscularly • Trimethoprim-sulfa: 3 to 5 ml/45 kg/day for 3 days • Penicillin: 20,000 to 30,000 UI/kg/day for 3 days • Draxxin®: 2.5 mg/kg subcutaneously • Ceftiofur: 6.6 mg/kg subcutaneously in the ear • Tetracyclines in feed
Foot rot, interdigital dermatitis[2]	*Fusobacterium necrophorum*	• Lameness, revealed especially when the animal is supported in the squeeze • Necrosis in the interdigital space	• Penicillin and tetracyclines • Copper sulfate footbath
Salmonellosis[2]	*Salmonella* (various serotypes; ingestion of contaminated feed)	• Mostly young animals under 2 weeks old • Acute diarrhea • Anorexia and depression • Septicemia	• Various antibiotics: ampicillin, gentamicin, trimethoprim-sulfa • With fluid therapy
Bovine tuberculosis[1]	*Mycobacterium bovis, M. tuberculosis* (air-borne transmission)	• Carriers often asymptomatic • Emaciation • Respiratory problems	• Follow CFIA guidelines
Pseudo-tuberculosis (yersiniosis)	*Yersinia pseusotuberculosis* (primarily) and *Y. enterocolitica* (following stress due to inadequate feeding or overpopulation)	• Mostly young animals under 1 year old • Anorexia and diarrhea	• Treatment based on tetracyclines, trimethoprim-sulfa (success varies) • With fluid therapy

1. This disease must be reported to the CFIA. For information on treatment, see the factsheet provided on the CFIA's website at http://www.inspection.gc.ca.
2. Annually notifiable disease for which Canada must present a report to the World Organization for Animal Health (OIE) indicating its presence in the country, if any.

A number of other bacterial diseases, such as actinobacillosis, actinomycosis and tetanus, are occasionally encountered in cervid herds.

PARASITIC DISEASES

Parasitic diseases are probably the most important health related problem in cervid herds. Promoted by the animals' confinement in pens, they can quickly infect the entire herd. Their various manifestations and principal recognized treatments are presented in Table 2.

Table 2. The principal parasitic diseases

Type	Causal agent(s)	Symptoms	General treatment
Cestodes	*Echinococcus* *Monezia* *Taenia* *Thysanosoma*	• Rarely causes problems • In a heavy infestation: - Stunting - Weight loss - Diarrhea	• No specific treatment known • Fenbendazole and cambendazole have been used
Coccidiosis[1]	*Eimeria isospora* (primarily)	• No clinical signs described for cervids, but in cattle, diarrhea with weight loss is noted	• Amprolium: 5 ml/45kg/day orally for 5 days • Sulfonamides
	Cryptosporidiosis Sarcocystosis Toxoplasmosis	• Occasionally found in cervids	• No specific treatment
Nematodes	*Heamonchus* *Ostertagia* *Trichostrongylus*	• Weight loss • Diarrhea • Anemia	• Ivermectin: 1 ml/10 kg transcutaneously[2] • Mebendazole: 10 mg/kg/day for 3 days
	Dictyocaulus viviparus (a lungworm)	• Weight loss • Unexplained mortality over several weeks • Respiratory signs infrequent in deer	• Ivermectin: 1 ml/10 kg transcutaneously
	Parelaphostrongylus tenuis (a brainworm)	• Loss of coordination • Loss of fear of humans • Lameness • Paralysis • Abnormal carrying of head and neck	• Ivermectin: 0.1 to 0.2 mg/kg subcutaneously in third larval stage • Albendazole: 25 mg/kg/day for 2 weeks in feed for adult forms
	Elaphostrongylus cervi (a muscle worm)	• Interstitial pneumonia in the larval stage • Nervous problems	• Ivermectin: - 0.1-0.2 mg/kg subcutaneously - 1 ml/10 kg transcutaneously

Table 2 (continued). The principal parasitic diseases

Name	Causal agent(s)	Symptoms	General treatment
Nematodes (continued)	*Elaeophora schneideri* (an arterial worm)	• Chronic dermatitis • Bilateral blindness in wapiti • Sudden death after thrombosis	• No known treatment, since the lesions are too advanced when symptoms appear
Trematodes	*Dicrocoelium dendriticum* *Fasciola hepatica* *Fasciolides magna*	• Depending on the severity of the infestation, which primarily affects the liver: - Weight loss - Stunting	• Triclabendazole 24%: 50 mg/kg orally, repeat after 7 days • Albendazole in feed for 7 days
External parasites	Mites Flies Lice Ticks	• Implicated in the transmission of diseases and other parasites: - Biting insects: arterial worms - Flies: Pink eye - Ticks: anaplasmosis	• Lice and mites: - Ivermectin: 0.2 mg/kg by injection or 1 ml/10 kg transcutaneously[2] - Delice® transcutaneously - Cylence® (cyfluthrin 1%) transcutaneously • Ticks: Flumethrin 1% • Flies: Delice® transcutaneously

1. Annually notifiable disease for which Canada must present a report to the World Organization for Animal Health (OIE) indicating its presence in the country, if any.
2. Transcutaneous: applied locally on the back of the animal, the drug is absorbed through the skin (pour-on products).

VIRAL DISEASES

There is little documentation on viral diseases in cervids. In Canada, a number of viral diseases have occasionally been detected through the presence of antibodies, without the animals displaying any clinical signs. The principal viral diseases that can affect cervids are presented in Table 3.

Table 3. The principal viral diseases

Name	Causal agent(s)	Symptoms	General treatment
Bluetongue[1] (epizootic hemorrhagic disease in deer)	Orbivirus (transmitted by midges)	• Respiratory distress • Lameness and diarrhea • Abortion and fever • 90% mortality	• Follow CFIA guidelines
Neonatal diarrhea	Coronavirus Rotavirus	• These viruses are often associated with *E.coli* in neonatal diarrhea • 50% mortality	• Supportive treatment with antibiotics and oral fluid therapy
Bovine viral diarrhea / mucosal disease (BVD-MD)	Togavirus	• No known clinical manifestation in red deer and wapiti, even though antibodies have been found	• Supportive treatment with antibiotics and fluid therapy

Table 3 (continued). The principal viral diseases

Name	Causal agent(s)	Symptoms	General treatment
Bovine malignant catarrhal fever[2]	Herpesvirus	• Infection transmitted in the first 3 months of life • Bloody diarrhea • Fever, drooling and tearing • Death within 48 hours	• Massive doses of antibiotics in the acute phase, but results often disappointing. The animals are left with the chronic forms.
Poxvirus	Parapoxvirus	• Encountered in wapiti • Scabs on the muzzle, at the junction of lips and gums, on the ears and velvet antlers	• No specific treatment • Often spontaneous recovery
Rabies[1]	Rhabdovirus	• The aggressive form is rare in deer • Primarily the progressive paralytic form is encountered in cervids	• Follow CFIA guidelines
Infectious bovine rhinotracheitis (IBR)[2]	Herpesvirus-1	• No known clinical signs in red deer and wapiti • Mule deer: anorexia, drooling, respiratory distress	• Supportive treatment with antibiotics for secondary infections

1. This disease must be reported to the CFIA. For information on treatment, see the factsheet provided on the CFIA's website at http://www.inspection.gc.ca.
2. Annually notifiable disease for which Canada must present a report to the World Organization for Animal Health (OIE) indicating its presence in the country, if any.

OTHER DISEASES

Other diseases not belonging to the categories above may also be encountered in red deer and wapiti herds. They are presented in Table 4.

Table 4. Other diseases

Name	Causal agent(s)/ Disease	Symptoms	General treatment
Prion disease	Chronic wasting disease (CWD)[1]	• Emaciation • Increased salivation and urination • Head tremors • Wide posture • Lack of coordination	• Follow CFIA guidelines
Rickettsia	*Anaplasma marginale* (anaplasmosis[1])	• Severe anemia • Weakness, listlessness	• Follow CFIA guidelines
	Coxiella burnetii (Q fever[2])	• Primarily abortions • Transmissible to humans	• No known treatment
Fungal disease	*Absidia* sp. *Aspergillus*	• Rumenitis • Abomasal ulcers • Pneumonia • Abortion • Granulomatous abscess • Renal damage	• Nystatin and Copper sulfate

1. This disease must be reported to the CFIA. For information on treatment, see the factsheet provided on the CFIA's website at http://www.inspection.gc.ca.
2. Annually notifiable disease for which Canada must present a report to the World Organization for Animal Health (OIE) indicating its presence in the country, if any.

REPORTABLE DISEASES AND IMMEDIATELY NOTIFIABLE DISEASES

A number of diseases are listed as either reportable or immediately notifiable under Canada's *Health of Animals Act*. Table 5 presents all such diseases that may affect cervids. The CFIA is the authority responsible for updating and administering the Act.

Reportable diseases present a danger to human or animal health and can have a significant economic impact on international trade. Animal owners, veterinarians and laboratories are required to immediately report the presence of an animal that is contaminated or suspected of being contaminated with one of these diseases to a CFIA district veterinarian. Control or eradication measures will be applied immediately.

In general, immediately notifiable diseases are diseases exotic to Canada for which there are no control or eradication programs. Only laboratories are required to contact the CFIA regarding the suspicion or diagnosis of one of these diseases.

Table 5. Reportable and immediately notifiable diseases that may affect cervids[1, 2]

Diseases reportable by animal owners, veterinarians and laboratories	• Anaplasmosis (15 in 2010, 6 in 2011) • Brucellosis • Bovine cysticercosis[3] (parasite) (1 in 2010) • Foot-and-mouth disease[3] (virus) • Bluetongue (virus) • Anthrax (5 in 2010) • Rift Valley fever[3] (virus) * • Chronic wasting disease of cervids (spongiform encephalopathy associated with the presence of an abnormal protein called a prion (3 in 2010, 3 in 2011) • Rinderpest[3] (virus) * • Sheep and goat pox[3] (virus) * • Contagious bovine pleuropneumonia (bacterium)[3] • Pseudorabies[3] (virus) * • Rabies (123 in 2010, 115 in 2011, but none were in cervids) • Vesicular stomatitis[3] (virus) • Bovine tuberculosis (1 in 2011)
Diseases that are immediately notifiable by laboratories	• Herpes virus of cervidae

1. Diseases with an asterisk have never been declared in Canada.
2. Figures in parentheses indicate the number of infected herds reported in 2010 and 2011 in Canada, for all farmed animals combined.
3. Disease not described in the present leaflet because it is infrequent. See the corresponding fact sheet on the website of the CFIA.

Source: http://www.inspection.gc.ca

CONCLUSION

This factsheet presents a summary of the principal diseases that affect cervids, together with the known treatments. Note however that few livestock medicines have been registered for treating cervids. Their use depends on the experience of veterinarians who work with these animals.

BIBLIOGRAPHY

Canadian Food Inspection Agency. http://www.inspection.gc.ca (accessed March 21, 2011).

Haigh, J.C. and R.J. Hudson. 1993. *Farming Elk and Red Deer*. Mosby Yearbook, Missouri. 369 pp.

Martineau, D. 2003. *Pathologie de la faune et de l'environnement* [online]. http://www.medvet.umontreal.ca/etudes/EnseignementLigne/ptm4411/patho_faune_2003.rtf (accessed March 21, 2011).

Miller, F., I. Barker, J. Williamson and B. Tapscott. 1998. *A Review of the Diseases and Parasites of Farmed Cervids* [online]. Ontario Ministry of Agriculture, Food and Rural Affairs http://www.omafra.gov.on.ca/english/livestock/alternat/facts/info_diseases.htm (accessed March 21, 2011).

Epidemiological Review of Wildlife Diseases [online]. Extract from the report of the meeting of the OIE Working Group on Wildlife Diseases, which took place on February 14-16, 2005 at OIE headquarters in Paris. ftp://ftp.oie.int/sam/2004/faune_a.pdf (accessed March 21, 2011).

Production Guide

DOMESTIC GAME FARM ANIMALS

Principal Diseases of Bison

CRAAQ

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INTRODUCTION

A bison farm must be equipped with good restraint facilities for handling the animals, both for the animals' safety and that of the operator. With a crowding pen to guide the bison in the desired direction, and a squeeze to immobilize them, administering preventive and curative treatments is relatively straight forward.

Bison can be affected by a variety of health related problems that are often seen in domestic cattle, including nutritional, parasitic, bacterial and viral diseases. With good husbandry, regular vaccination and proper de-worming, many of these problems can be avoided, while others will only occasionally appear if the animals are raised in good conditions.

Drawing primarily on literature on the main cattle diseases that can also affect bison, this leaflet describes disease symptoms and treatments that can be administered by the veterinarian.

NUTRITIONAL DISEASES

Among the most frequent problems encountered by veterinary practitioners are nutritional diseases (Table 1), caused by poor feed management, whether at the feeder or on pasture

Table 1. Nutritional diseases

Disease	Cause(s)	Symptoms	Treatment
Bloat or tympanitis	Feed overload either on pasture or at the feeder	• Swelling on the left side • Abdominal pains (the animal gets up and lies down repeatedly)	• Intubation (insertion of a tube through the mouth into the lungs to assist breathing) • Trocarization (incision of the gastric wall) in severe cases • Anti-foaming agent
Déficience en cuivre	• Nutritional deficiency • Sulfur water	• Stiff gait • Tendency to stay lying down • Diarrhea • Discoloured hair	• Mineral supplement
Muscular dystrophy	Vitamin E and selenium deficiency	• Sudden death • Difficult gait • Inability to get up • Respiratory distress	• Supplement of vitamin E and selenium, injectable or oral
Indigestion from acidosis	Grain overload in the stomach	• Swelling on the left side • Abdominal pains • Diarrhea • Recumbency (lying position)	• Intubation • Surgery in severe cases (rumenotomy) • Fluid therapy

PARASITIC DISEASES

Parasitic diseases (Table 2) are among the most common herd diseases encountered in bison. Poor pasture management is usually the prime culprit. Inadequate pasture rotation, the presence of pools of stagnant water and the cohabitation of adult bison and young animals, will all predispose a herd to parasitic infestation.

Table 2. Parasitic diseases

Disease	Causal agent(s)	Symptoms	Treatment
Anaplasmosis[1]	*Anaplasma marginale*	• Anemia • Depression, weakness • Listlessness	• Follow Canadian Food Inspection Agency (CFIA) guidelines • Long-acting tetracyclines
Babesiosis[2]	*Babesia major,* *B. bigemina*	• Intravascular hemolysis • Fever, jaundice, anorexia, hemoglobinuria Never reported in North America	• Diminazene aceturate: 3 mg/kg • Amicarbalide: 5 g/adult
Coccidiosis	Especially genus *Eimeria*	• Bloody diarrhea Clinical signs not reported in bison	• Amprolium • Sulfamethazine
Distomiasis	*Fasciola hepatica* (intermediate host: snails)	• Sudden death • Anemia, oedema, ascitis • Hepatitis	• Trichlabendazole
Demodectic mange	*Demodex* spp.	• Pus nodules around the eyes and perineum • Underside of the tail	• Ivermectin
Warble fly	*Hypoderma bovis,* *H. lineatum*	• Stunting • Skin irritation	• Ivermectin before the end of November
Hydatid cyst	*Echinococcus granulosis* *Taenia hydatigenia*	• Cysts in the liver and lungs, without clinical signs in bison	• No treatment recognized for bison
Lice (suckers or biters)	Transmission by direct or indirect contact	• Skin irritation • Hair loss	• Ivermectin • Permethrine 1 %

Table 2 (continued). Parasitic diseases

Disease	Causal agent(s)	Symptoms	Treatment
Sarcocystosis	*Sarcocystis* spp.	• Anemia, anorexia, lethargy, high temperature (observed in experimental conditions) Absence of signs in bison herds, even though the parasite is present in the muscles of 94% of bison in Alberta	• Amprolium • Salinomycin
Lungworm	*Dictyocaulus filaria, D. hadvveni* and *D. viviparus*	• Respiratory distress • Coughing, fever • Nasal discharge	• Ivermectin • Albendazole • Oxfendazole • Febantel • Fenbendazole • Levamisole
Stomach wormc	Especially *Ostertagia* in the abomasum	• Anorexia • Weight loss • Weakness • Severe diarrhea • Anemia	• Ivermectin transcutaneously[3] : 1 ml/10 kg
Tick	*Dermacentos andersoni*	• Various stages of paralysis caused by a neurotoxin The tick is a disease vector and is found especially on young animals	• Avermectin • Organophosphate • Pyrethroid

1. This disease must be reported to the CFIA. For information on treatment, see the fact sheet provided on the CFIA's website at http://www.inspection.gc.ca.
2. This disease must be reported immediately to the CFIA.
3. Transcutaneous: applied locally on the back of the animal, the drug is absorbed through the skin (pour-on product).

BACTERIAL DISEASES

More or less severe bacterial diseases are occasionally encountered in bison (Table 3). While most bacterial diseases can be treated fairly effectively with antibiotics, the swift progression of some diseases can, if they are detected too late, quickly lead to death.

Table 3. Principal bacterial diseases likely to affect bison[1]

Disease	Causal agent(s)	Symptoms	Treatment
Anthrax[2]	*Bacillus anthracis*	• Rapid death • Septicemia, depression, staggering, teeth grinding • Bloody exudate after death from the mouth, anus and nose	• Follow CFIA guidelines
Brucellosis[2]	*Brucella abortus*	• Male: orchitis, epididymitis • Female: abortion, placentitis • In both sexes: arthritis	• Follow CFIA guidelines
Colibacillosis	*Escherichia coli*	• Diarrhea • Arthritis • Pneumonia • Septicemia • Dehydration	• Parenteral antibiotics • Electrolytes, intravenously or orally
Blackleg	*Clostridium chauvoei*	• Sudden death • Muscular gangrene with gas, producing a crackling sound when touched • Depression, anorexia, fever	• Very disappointing due to the swift progression of the disease (8 to 12 hours) • High-dose penicillin
Histophilosis	*Histophilus somnus*	• Septicemia • Meningitis • Bronchopneumonia • Myocarditis • Otitis	• Long-acting tetracycline: 1 ml/10 kg • Florfenicol: 3 ml/45 kg intramuscularly
Infectious keratoconjunctivitis (Pink eye)	*Moraxella bovis* (12,7 % of bisons are carriers)	• Tearing • Conjunctivitis • Corneal ulcer • Corneal opacity	• Subconjunctival injection of penicillin and corticosteroids • Topical antibiotic
Listeriosis	*Listeria monocytogenes*	• Encephalitis • Septicemia • Abortion in the last trimester	• Long-acting antibiotic • Often permanent damage when encephalitis occurs

Table 3 (continued). Principal bacterial diseases likely to affect bison[1]

Disease	Causal agent(s)	Symptoms	Treatment
Leptospirose	*Leptospira* spp.	• Abortion • Hemoglobinuria • Jaundice • Nephritis, hepatitis Primarily affects young animals	• Streptomycin: 25 mg/kg/day for 4 days • Long-acting tetracycline: 1 ml/10 kg • Fluid therapy
Necrobacillosis	*Fusobacterium necrophorum*	• Anorexia, depression, drooling • Protrusion of the tongue • Ulcers in the mouth and on the tongue	• Broad-spectrum antibiotic therapy • Corticosteroid therapy to treat swelling in the larynx from other lesions
Paratuberculosis	*Mycobacterium paratuberculosis*	• Chronic diarrhea • Emaciation Observed in bison over 2 years	• Ineffective • Considered an incurable disease • Identification of carriers
Pasteurellosis	*Mannhemia hemolyticum* *Pasteurella multocida*	• Respiratory distress • Fever, anorexia • Depression, drooling • Nasal discharge	• Long-acting tetracycline: 1 ml/10 kg • Florfenicol: 3 ml/45 g intramuscularly every 48 hours
Foot rot	*Fusobacterium necrophorum*	• Lameness with interdigital swelling • Complication: septic arthritis	• Long-acting tetracycline: 1 ml/10 kg • Long-acting penicillin • Copper sulfate
Salmonellosis	*Salmonella* spp.	• Anorexia, depression, septicemia • Profuse diarrhea	• Ampicillin • Trimethoprim-sulfa • Gentamycin
Tuberculosis[2]	*Mycobacterium bovis*	• Chronic weight loss • Chronic cough • Swollen ganglions, especially in the head and thorax	• Follow CFIA guidelines

1. Other bacterial diseases not listed here can also affect bison, but are much rarer.
2. This disease must be reported to CFIA. For information on treatment, see the fact sheet provided on the CFIA's website at http://www.inspection.gc.ca

VIRAL DISEASES

Bison can present viral diseases similar to those encountered in cattle, yet there is little documentation on them. Antibodies against some have been found in bison, but with no associated clinical signs.

Table 4. Principal viral diseases that can affect bison

Disease	Causal agent	Symptoms	Treatment
Bovine viral diarrhea (BVD)	Togavirus	• Severe diarrhea • Fever • Abortion • Congenital anomalies Antibodies present in bison	• Supportive treatment: 1. Fluid therapy 2. Antibiotic therapy • Prevention: vaccination
Neonatal diarrhea	Rotavirus (role proven in bison)[1]	• Associated with overcrowding • Liquid diarrhea • Depression, dehydration • Increased mortality in bison calves Disease associated with overcrowding	• Parenteral antibiotic therapy • Fluid therapy • Prevention: vaccination
Malignant catarrhal fever[2]	Ovine herpes virus type 2 Carriers: sheep and goats (observed in bison since 1973 in North America)	• Corneal opacity • Conjunctivitis • Nasal discharge • Drooling • Ataxia, circling • Oral ulcers • Mortality from 3% to 100% Occurs especially in winter in animals over 6 months	• Follow CFIA guidelines • Corticosteroid therapy can slow the progression of the disease

Table 4 (continued). Principal viral diseases that can affect bison

Disease	Causal agent	Symptoms	Treatment
Parainfluenza 3	Virus PI3	• Part of bovine respiratory disease complex (coughing, respiratory problems, nasal and ocular discharge) in cattle and bison, but its role in the expression of the disease is unknown Antibodies present in 36% of Yellowstone bison	• Supportive antibiotic therapy
Infectious bovine rhinotracheitis (IBR)	Herpesvirus	• Fever, anorexia • Nasal ulcer • Nasal and ocular discharge • Anorexia, coughing • Abortion Antibodies present in 31% of Yellowstone bison	• Supportive antibiotic therapy • Prevention: vaccination

1. Though in some species the role of rotavirus in neonatal diarrhea has not been defined or proven, it has been in bison.
2. This disease must be reported to the CFIA. For information on treatment, see the fact sheet provided on the CFIA's website at http://www.inspection.gc.ca

PRION DISEASES

Although spongiform encephalopathies like those described in cattle, sheep and cervids have not been reported in the literature on bison, the latter are indeed susceptible to this incurable disease. Spongiform encephalopathies must be reported to the CFIA. The main symptom is gradual paralysis starting in the hindquarters, progressing to death.

REPORTABLE DISEASES AND IMMEDIATELY NOTIFIABLE DISEASES IN CANADA

A number of diseases are listed as either reportable or immediately notifiable under Canada's *Health of Animals Act*. Table 5 presents all such diseases that may affect bison. The CFIA is the authority responsible for updating and administering the Act.

Reportable diseases present a danger to human or animal health and can have a significant economic impact on international trade. Animal owners, veterinarians and laboratories are required to immediately report the presence of an animal that is contaminated or suspected of being contaminated with one of these diseases to a CFIA district veterinarian. Control or eradication measures will be applied immediately.

In general, immediately notifiable diseases are diseases exotic to Canada for which there are no control or eradication programs. Only laboratories are required to contact the CFIA regarding the suspicion or diagnosis of one of these diseases.

Table 5. Reportable and immediately notifiable diseases that may affect bison[1, 2]

Diseases reportable by animal owners, veterinarians and laboratories	• Anaplasmosis (15 in 2010, 6 in 2011) • Brucellosis • Bovine cysticercosis[3] (parasite) (1 in 2010) • Bovine spongiform encephalopathy (associated with the presence of an abnormal protein) (1 in 2010, 1 in 2011) • Foot-and-mouth disease[3] (virus) • Bluetongue (virus) • Anthrax (5 in 2010) • Rift Valley fever[3] (virus) * • Rinderpest[3] (virus) * • Sheep and goat pox[3] (virus) * • Contagious bovine pleuropneumonia (bacterium)[3] • Pseudorabies[3] (virus) * • Rabies[3] (123 in 2010, 115 in 2011) • Vesicular stomatitis[3] (virus) • Bovine tuberculosis (1 in 2011)
Disease that is immediately notifiable by laboratories	Babesiosis *

1. Diseases with an asterisk have never been declared in Canada.
2. Figures in parentheses indicate the number of infected herds reported in 2010 and 2011 in Canada, for all farmed livestock combined.
3. Disease not described in this leaflet because it is infrequent. See the corresponding fact sheet on the website of the CFIA.

Source: http://www.inspection.gc.ca

CONCLUSION

Most of the diseases mentioned in this leaflet are well known in cattle, but have not been described for bison. Similarly, the treatments indicated are those advocated for cattle that have been used to some extent on bison by veterinarians working with bison. However, it should be remembered that bison are largely unaffected by disease, and when proper husbandry is practised veterinary care is rarely required.

BIBLIOGRAPHY

Beregorvski, J. *A Literature Review of Diseases in Bison* [online]. Specialized Livestock Health and Production, Western College of Veterinary Medicine, Saskatoon http://www.usask.ca/wcvm/herdmed/specialstock/bison/ (accessed March 15, 2011).

Canadian Food Inspection Agency [online]. http://www.inspection.qc.ca (accessed March 16, 2012).

Haigh, J.C., C. Mackintosh and F. Griffin. 2002. *Viral, Parasitic and Prion Diseases of Farmed Deer and Bison* [online]. Rev. sci. tech. Off. int. Epiz. 21(2): 219-248. http://www.oie.int/doc/ged/D511.pdf (accessed March 15, 2011).

Haigh, J.C., C. Mackintosh and F. Griffin. 2002. *Bacterial Diseases of Farmed Deer and Bison* [online]. Rev. sci. Tech. Off. int. Epiz. 21(2):249-263 http://www.oie.int/doc/ged/D512.pdf (accessed March 15, 2011).

Woodbury, M. 2007. *The Control of Internal Parasites in Bison* [online]. Canadian Bison Association Annual Convention, November 17-20, Regina, Saskatchewan http://www.canadianbison.ca/producer/documents/ParasitePresentation.pdf (accessed March 15, 2011).

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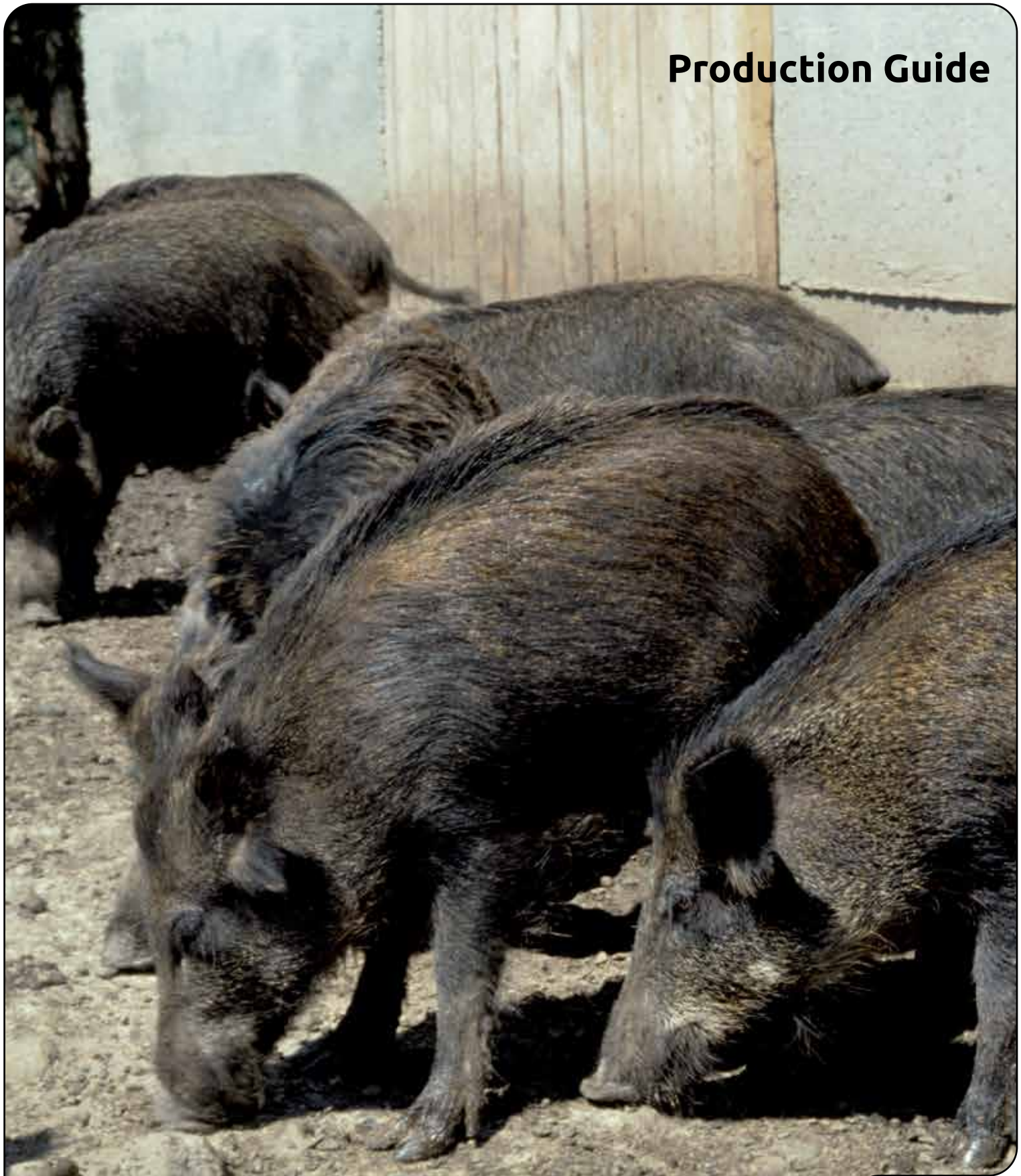

DOMESTIC GAME FARM ANIMALS

Principal Diseases of Wild Boar

CRAAQ

CULTIVER L'EXPERTISE
DIFFUSER LE SAVOIR

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INTRODUCTION

This section is provided as a summary of the principal diseases that may appear in a wild boar herd. It does not describe every possible problem, such as reproductive disorders in sows. It is important that the herd be seen regularly by a veterinarian, both for prevention and treatment if needed. The veterinarian will prepare a herd health program including advice on biosecurity, worming and vaccination, to avoid problems that can be costly or difficult to treat. The veterinarian can also provide advice on which animals to purchase or not, and can verify whether the health status of those being considered is compatible with the herd.

PARASITOSES

Parasitosis is an infestation or infection with parasites. Parasitic infection is the one problem most often encountered in wild boar, due to how they are raised: outdoors, where surfaces cannot be cleaned effectively. Infestations must be prevented by treating new animals infected with parasites (whether internal or external) before introducing them into the herd, to avoid contaminating other animals, enclosures or buildings. Good anti-parasite management is therefore essential from the start, before any infection has occurred.

Table 1. Causes, symptoms, treatments and prevention of the principal parasitic diseases affecting wild boar

Parasitic diseases	Causal agent(s)	Symptoms	General treatment and prevention
Pediculosis (fleas)	*Haematopinus suis* (specific to pigs)	Fleas visible to the naked eye Itching, hair loss, anaemia Serious growth loss if contamination is severe	Ivermectin in feed or injectable Ideally treat sows before farrowing to avoid contaminating piglets during lactation
Sarcoptic mange	*Sarcoptes scabiei var. suis* (specific to pigs)	Itching, hair loss, anaemia Serious growth loss if contamination is severe	Ivermectin in feed or injectable Ideally treat sows before farrowing to avoid contaminating piglets during lactation
Coccidiosis	*Isospora suis* (specific to pigs)	Diarrhea occurring after 5 days of age	Painting may be useful for certain types of floors Prevention: toltrazuril (Baycox®) orally at 3 days
Helminthiasis	Contamination from ingesting eggs (*Ascaris, Trichuris*) or larvae (*Oesophagostomus, Hyostrongylus*) Ingestion of the intermediary host (*Metastongyus, Stephanurus*) Penetration through skin (*Strongyloides, Stephanurus*) Transplacentary passage (*Strongyloides*)	Stunted growth Pneumonia Weight loss Skin rashes Vomiting Diarrhea Constipation	Ivermectin (Ivomec®, Bimectin®, Noromectin®) (or equivalent) to simultaneously treat external and internal parasites. Can be administered in feed or by injection. Pyrantel tartrate (Pro-Banminth®): product added to feed over 5 to 7 weeks to prevent migration of worms (*Ascaris* and *Oesophagostomum*) Fenbendazole (Safeguard®): in parasite larval stage and in adult form; can be administered in feed or water. Others: piperazine (in water, for adult roundworms only), fenbendazole (Safeguard®) or pyrantel tartrate (Pro-Banminth®) added on food (top dressing): for adult worms only
Trichinosis (zoonotic[1])	*Trichinella spiralis*	These roundworm larvae are found in muscles, notably at the tendinous insertion Polysystemic disease (affects various systems)	Transmission by uncooked, contaminated meat and occasionally by certain rodents (outdoors) Never feed with table scraps Prevention is the only possible recourse. If the problem is detected at the slaughterhouse, the animal will be condemned and the herd examined.

1. Disease transmissible to humans.

BACTERIAL DISEASES

Bacterial diseases can be treated with antibiotics, but often a lab analysis is required to identify the pathogen involved and prescribe the right antibiotic(s) to ensure effective treatment.

Certain bacterial diseases are polysystemic, affecting various systems (Table 2), while others specifically affect the digestive system (Table 3) or the respiratory system (Table 4). Digestive problems are relatively frequent in young animals.

Table 2. Causes, symptoms, treatments and prevention of the principal polysystemic bacterial diseases

Name	Causal agent	Symptoms	General treatment and prevention
Streptococcus suis infections	*Streptococcus suis*	Meningitis Arthritis Septicaemia Pneumonia	Antibiotic therapy: penicillin In meningitis cases it is also recommended to administer anti-inflammatory drugs
Glässer's Disease	*Haemophilus parasuis*	Polyserositis Arthritis Peritonitis Pneumonias Meningoencephalitis Decline and wasting with cyanosis of the extremities	Antibiotic therapy Prevention : Vaccination can be used for some strains
Erysipelas	*Erysipelothris rusiopathiae*	Diamond shaped red patches on the skin (difficult to see on wild boar because of the hair) High fever Joint problems Cardiac problems Stillborn	Antibiotic therapy Vaccination (injectable or in water)

Table 3. Causes, symptoms, treatments and prevention of principal digestive diseases due to bacteria

Name	Causal agent(s)	Symptoms	General treatment and prevention
Neonatal diarrhea			
Colibacillosis	*Escherichia coli*	Diarrhea appearing in piglets during the first week of lactation More frequent in less immunized litters (first litters and old mothers)	The ideal is preventive vaccination before farrowing Natural vaccination can be used (feed gestating mothers intestines from piglets that died of neonatal diarrhea in the first week) Potato starch Antibiotic therapy
Clostridium	*Clostridium perfringens* type C *Clostridium perfringens* type A *Clostridium difficile*	Neonatal diarrhea appearing in piglets during the first two weeks Occasional hemorrhagic diarrhea for type C	Vaccination of mothers for type C Potato starch An oral antibiotic (penicillin) or injectable one (spectinomycin) can work on piglets Natural vaccination is not recommended Preventive probiotics and prebiotics
Post-weaning diarrhea and fattening			
Post-weaning Colibacillosis	*Escherichia coli* with intestinal adhesion factor	Diarrhea in the piglets during the weeks following weaning, occasionally causing death in healthy subjects in the acute stage	Live oral vaccine (*E. Coli* strain F4, non-pathogenic) Antibodies from chicken egg yolks immunized to adhesion factor F4 Feed restriction High level of zinc oxide in feed Acidification of feed Probiotics Potato starch Antibiotic therapy

Table 3 (continued). Causes, symptoms, treatments and prevention of principal digestive diseases due to bacteria

Name	Causal agent(s)	Symptoms	General treatment and prevention
Dysentery and other spirochetoses	*Brachyspira hyodysenteriae* and other *Brachyspira*	Dysentery: diarrhea with blood and mucus between 7 and 18 weeks of age Chronic diarrhea during finishing	Antibiotic therapy A hygiene program and a control program against rodents are very important prevention factors
Salmonella[1] (zoonotic)	Salmonella	Occurs at 8 to 20 weeks, attacks the small and large intestine Causes slight diarrhea Occasional fever	Antibiotic therapy Prevention: vaccine in water
Proliferative enteritis	*Lawsonia intracellularis,* a bacterium that infects the epithelium of crypts in the ileum, caecum and proximal colon	Anorexia Apathy Stunted growth Tarry diarrhea	Antibiotic therapy Prevention: oral vaccine

1. Apart from the fact that Salmonella is transmissible to humans, another problem arises from the fact that a contaminated animal excretes the microbe for a short time but remains a healthy carrier. When subjected to stress (weighing, transportation, etc.) it will again start excreting the bacteria.

Table 4. Causes, symptoms, treatments and prevention of principal respiratory diseases due to bacteria

Name	Causal agent(s)	Symptoms	General treatment and prevention
Bronchopneumonia	*Mycoplasma hyopneumoniae*	Coughing (usually animals over 12 weeks old) Stunted growth	Vaccination Antibiotic therapy
Pasteurellosis	*Pasteurella multocida*	Coughing Pneumonia Weight loss	Individual antibiotic therapy in feed or water
Pleuropneumonia	*Actinobacillus pleuropneumoniae*	Pneumonia Anorexia Sudden death	Individual antibiotic therapy
Rhinitis	*Pasteurella multocida* serotype D toxigenic strain (toxin that destroys nasal passages) *Bordetella bronchiseptica*	Sneezing Groin deviation Stunted growth	Vaccination Antibiotic therapy

VIRAL DISEASES

Viral diseases cannot be treated, but a blanket antibiotic treatment can be administered to avoid secondary bacterial infections. Prevention by vaccination is possible for certain viruses.

Over the last few years, and as in pork production, wild boar production has suffered the ravages of porcine circovirus (see page 9). This virus is present in all herds and is impossible to eradicate. Often, vaccination is essential to avoid losses.

As with bacterial diseases, viral diseases can be polysystemic (Table 5), affecting the digestive system (Table 6) or the respiratory system (Table 7).

Table 5. Causes, symptoms, treatments and prevention of the principal polysystemic viral diseases

Name	Causal agent(s)	Symptoms	Prevention
Porcine Reproductive and Respiratory Syndrome (PRRS)	Arterivirus (in saliva and nasal discharges, semen): predilection for microphages; induces their destruction, rendering animal susceptible to secondary infections There are numerous strains (the virus mutates easily) of variable severity, some causing mostly reproductive problems, others respiratory problems.	Reproductive problems in maternity: - anestrus (sows do not go back into heat after weaning); - lower farrowing rate, increased rate of return into heat; - abortion (generally in last third of gestation); - premature deliveries with weak piglets at birth; - presence of stillborn and mummified foetuses (different stages) Anorexia: many sows stop eating Hyperthermia: fever (> 40 °C or 104 °F) in sows and nursing piglets Nursing piglet: - presence of pneumonia (panting); - frequent increase in neonatal diarrhea In the nursery: increase in pneumonias and mortality Finishing: pneumonias, mortality, occasional partial anorexia	Supportive treatment with antibiotic therapy if needed for secondary infections Vaccination: modified live vaccine; it is not recommended to vaccinate sows at the end of gestation, nor males in service. Results may vary according to the strain present in the herd. Reduce adoptions (fostering to other sows) except at 1 day of age Washing and disinfection Avoid introducing new strains (biosecurity); do not change source of sires
Porcine Circovirus Associated Disease (PCVAD) New disease appearing in Western Canada in the early 1990s	Type 2 Circovirus (very resistant virus in the environment)	Progressive wasting of weaned piglets, or later at finishing: - weight loss; - diarrhea; - difficulty breathing; - jaundice This virus is often associated with other pathogenic agents (bacteria, viruses and protozoa). It causes interstitial pneumonia, sometimes accompanied by hepatitic and renal problems. Reproductive problems are also reported	Vaccination of piglets and reproducing animals

Table 5 (continued). Causes, symptoms, treatments and prevention of the principal polysystemic viral diseases

Name	Causal agent(s)	Symptoms	Prevention
Foot-and-mouth disease[1]	Aphthovirus (generally non-lethal) The incubation period (time between infection and the appearance of clinical symptoms) varies from 18 hours to 14 days depending on infectious dose, host's susceptibility and viral strain	Fever up to 41 °C (106 °F) Loss of appetite Sudden lameness (the animals refuse to get up and move around) Pain Vesicles on the hooves, groin, tongue, mouth or teats	Since this disease is subject to mandatory reporting[1], do not move or sell the animal before a diagnosis is made Prevention: - biosecurity measures: deny access to anyone from, or having visited, countries where these diseases are present; - never feed the animals table scraps containing meat
Swine vesicular disease[1]	Enterovirus The importance of this acute viral disease specific to swine is essentially due to the fact that it can be confused with foot-and-mouth disease, though the causal agent is less pathogenic	Fever up to 41 °C (106 F) Loss of appetite Sudden lameness (the animals refuse to get up and move around) Pain Vesicles on the hooves, groin, tongue, mouth or teats	See foot-and-mouth disease
Vesicular stomatitis[1]	Rhabdovirus This disease is of great importance by virtue of its resemblance to foot-and-mouth disease	Mild fever Vesicles inside the mouth, on the lips, groin, hooves and teats	See foot-and-mouth disease
Classic swine fever[1] (also known as swine cholera or swine fever)	Pestivirus Highly contagious disease that affects domestic and wild pig populations	Acute form: - fever up to 42 °C; - pathy, conjunctivitis, purulent tearing; - digestive, respiratory and nerve problems; - eath from 4 to 14 days after appearance of symptoms Benign or asymptomatic form: - reproductive problems; - high post-weaning mortality	See foot-and-mouth disease

Table 5 (continued). Causes, symptoms, treatments and prevention of the principal polysystemic viral diseases

Name	Causal agent(s)	Symptoms	Prevention
African swine fever[1]	Asfivirus Highly hemorrhagic and contagious disease in wild and domestic swine, transmissible by ticks or uncooked scraps	High fever (41-42 °C) Depression Loss of appetite Rapid respiration Vomiting Constipation to bloody diarrhea Signs of nervousness Abortion at different stages of gestation Death from 1 to 7 days after appearance of symptoms	See foot-and-mouth disease (page 10)
Pseudorabies (Aujeszky's disease)[1]	Herpes virus (porcine virus 1)	Animals less than 7 days old: high mortality Older subjects: fever, loss of appetite, signs of nervousness, respiratory troubles Finishing: respiratory troubles Reproductive troubles	See foot-and-mouth disease (page 10)

1. Mandatory reporting disease requiring swift notification of a district veterinarian of the Canadian Food Inspection Agency (CFIA) by owners, veterinarians and laboratories, whether for observation (stricken animal) or suspicions related to an animal. Such diseases have significant economic impact on international trade and present a danger to the population. Control or eradication measures will be taken immediately. The producer must notify the veterinarian if the herd has a high mortality rate or displays unusual clinical signs.

Table 6. Causes, symptoms, treatments and prevention of the principal viral diseases causing diarrhea

Name	Causal agent(s)	Symptoms	Prevention
Transmissible gastroenteritis (TGE)	Coronavirus	Diarrhea at any age, occasionally accompanied by vomiting. When it occurs in acute form in a herd that tested negative, morbidity and mortality of young piglets under 15 days is nearly 100%.	No effective cure. In the acute phase, the most effective treatment is natural vaccination (i.e. with intestines from piglets that died from diarrhea). To break the disease cycle, it is best to contaminate the entire herd to avoid having animals that have never encountered the virus.
Rotavirus diarrhea	Rotavirus	Occurs at 1 to 5 weeks, low morbidity and mortality	Preventive vaccination of sows before farrowing (this works well). Commercial vaccines or natural vaccination can be used.

Tableau 7. Causes, symptômes, traitement et prévention de l'influenza porcin (virus)

Name	Causal agent(s)	Symptoms	Prevention
Porcine influenza	Influenza H1N1 Influenza H3N2	Coughing Fever (> 40 °C or 104 °F) Decrease of appetite Spreads swiftly: less than 1 week	Aspirin in water Blanket antibiotic therapy against secondary bacterial infections, in feed or water Vaccination

CONCLUSION

Since wild boar are in the same family as pigs, they are subject to most of the diseases of their cousins. The risk of a herd being contaminated is therefore higher if it is located near a hog farm.

On wild boar farms, younger subjects (piglets) generally display more clinical signs than adult wild boar because their immune systems are weaker.

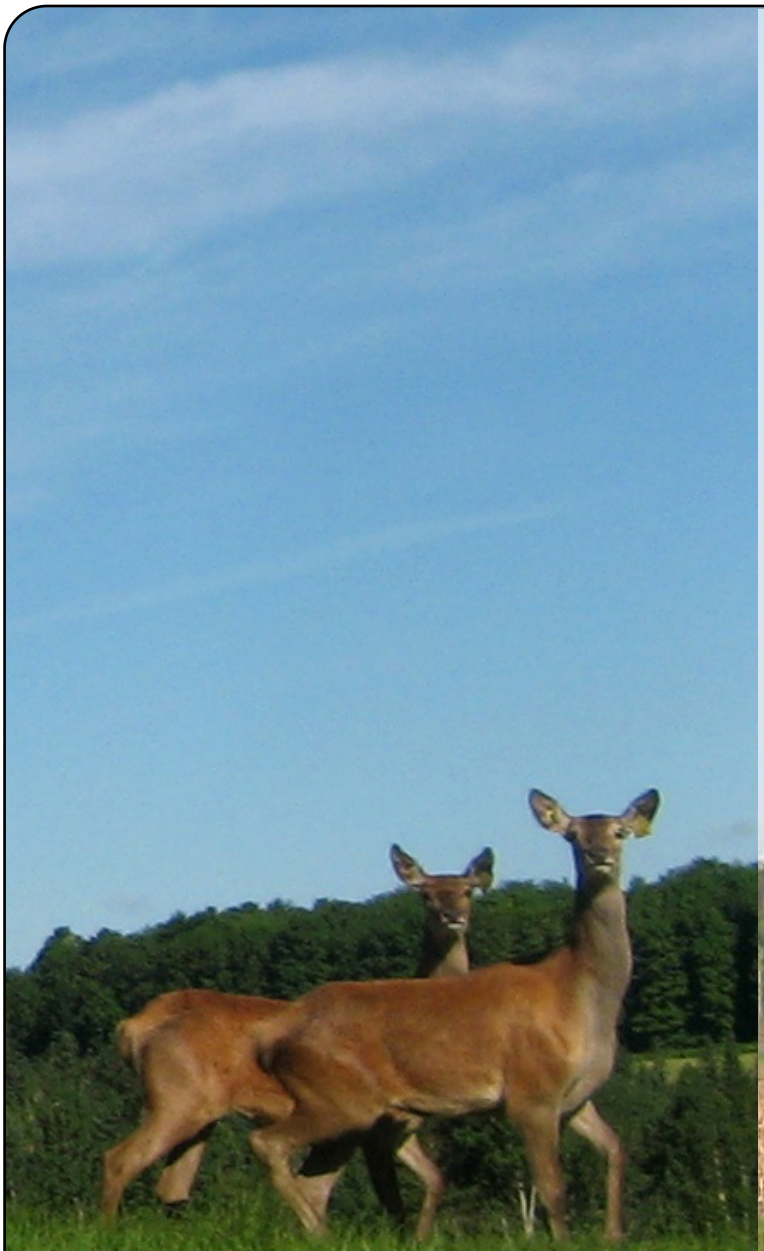
BIBLIOGRAPHY

Eich, K.-O. 1987. *Manuel pratique des maladies du porc*. France Agricole.

Martineau, G.P. and H. Morvan. 2010. *Maladies d'élevage des porcs, 2e édition*. France Agricole.

Straw. B.E. , S. D'Allaire, W.L. Mengeling and D.J. Taylor. 1999. *Diseases of Swine, 8th Edition*. Blackwell Pub.

Production Guide



DOMESTIC GAME FARM ANIMALS

Livestock Production Equipment for Cervids – Key Concepts

CRAAQ
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INTRODUCTION

This factsheet presents several types of equipment that can be used for cervids. It draws in part on information in the literature, but mostly from producers who agreed to share their experience.

Before cervids are delivered to a production site, you must have:

- the basic facilities to keep them there (fences);
- a system for handling the herd in small groups (the corral);
- facilities to sort the animals in each group into stalls before introducing them one at a time into the restraining equipment (squeeze);
- a means to ship and receive animals easily (the loading chute).

This document brings together a number of interesting concepts. Anyone who is interested in raising cervids should, before anything else, spend some time visiting several farms, partly to get familiar with the animals' behaviour, but also to see how all the equipment is set up and how it works. It's a good way to learn the practical details of certain equipment and get some ideas for how each farm could be improved. Your best source of information will always be an actual farm and of course the farmer.

While consulting the documentation available, especially the videos produced by the *Fédération des éleveurs de grands gibiers du Québec* on the handling of cervids (FEGGQ, 2008a and b), interested persons can also communicate with the *Association des éleveurs de wapitis du Québec* or the *Association Cerfs rouges du Québec*. You can also contact an Agriconseil network to find an advisor in your region.

To design and operate functional equipment that is safe for both workers and animals, an understanding of cervid behaviour is essential. You will be more efficient, there will be less stress on the animals, and the general well-being of all will be ensured.

CERVID BEHAVIOUR

The domestication of cervids is relatively recent, going back about 350 years for red deer and 100 years for wapiti (often referred to as "elk" outside of Québec). This means they must be handled with greater care than traditional livestock.

Return to the start. Instinctively, when cervids are fleeing a stress factor, they will try to return to where they came from. Pens should be designed to take advantage of this behaviour. For example, a pen with a single gate is preferable to one with a separate entry and exit.

Security is in the group. Cervids are usually gregarious animals, meaning they live in a group. Consequently, an animal should not be left alone for very long. Avoid narrow alleys in which the animals cannot move as a group, since they will become anxious and try to return to the herd.

Feet on the ground. Cervids are stressed by having anything above them. Although catwalks alongside the crowding alleys can be useful, they should be avoided since they make the animals nervous. If catwalks are to be used, install high sides to conceal the workers from the animals.

Dark means a hole. Dark areas are perceived by cervids as being dangerous. Cervids will see a hole where there is a shadow, a roofed working area or a dark chute. They will often balk and refuse to move forward.

We turn for you. When cervids feel trapped, they will mill in a circle to look for an exit. Sharp corners in traffic areas should therefore be avoided, since the animals can bunch up violently and injure themselves. Curved alleys encourage movement. Gates should be easy for them to see, located in a corner of the pen rather than in mid-fence, so the animals are easily encouraged to move towards and through the gate.

All-weather facilities

Besides considering how cervids naturally behave, remember that your facilities will be used year-round. To avoid shovelling snow, either provide the facilities with a roof or leave enough room for a tractor and snow blower to get around. An enclosed area, protected from the weather, can also be used to store records and electronic equipment (scales, tag readers, computer, etc.).

Let's walk in the woods. A wooded place, even some distance away, represents security for cervids. For this reason the sorting facility should be located so the animals can simultaneously see both the woods and the facility, instead of having to leave the woods behind them.

PADDOCKS

The ideal stocking density (the number of animals per unit of paddock area) depends on the genetics of the herd, feed management, the soil type and plant cover, and the region. In pastures, the animals' weights and growing rates must also be considered. In non-grazing paddocks, the most common densities range from 4 to 60 animals per hectare. With forages used for grazing, densities range from 3 to 10 animals per hectare for red deer, or from 1 to 6 per hectare for wapiti.

Fencing

In Québec, the *Regulation respecting animals in captivity* sets out rules for the keeping of animals like cervids. In the 2012 version, the Regulation (division III, section 9) defines the fencing equipment required for raising cervids:

> *9. Anyone who keeps cervidae listed in Schedule II in captivity without a licence shall erect and maintain an enclosure surrounded by a game fence at least 2.4 m high, having square meshes not larger than 15 cm between the vertical strands and at least 20 horizontal strands; the outside and inside lateral clearance of that perimeter fence must be at least 3 m from any obstacle that could reduce the minimum height of 2.4 m and the fence must be stretched tight near the ground so that no cervidae may pass under it; the distance between the posts of the fence may not exceed 8 m.*

Furthermore, the perimeter fence must have no trap or barrier to capture animals outside the enclosure; in addition, the gates of the perimeter must remain closed, even in the absence of animals.

Depending on the budget available, fence posts can be of metal or treated or non-treated wood. In the short term, cedar posts are the most economical solution. Treated posts are more durable, but more expensive. Metal posts have the advantage of being more durable, easier to repair (they can be straightened if bent) and smoother, reducing the risk of animals snagging on them. However, metal posts cost more than twice as much as wooden posts.

Electric fences have not been found effective in Quebec, since cervid antlers can easily get tangled in them.

Figure 1. Example of game fencing
Photo: Juan Pablo Soucy

FEEDING

Water troughs

Water is the most important food to provide for cervids. In winter they can eat snow, but a heated trough (Figure 2) should be provided for growing calves to minimize energy losses. All watering systems, whether heated or not, should be regularly inspected throughout the winter to make sure they are working properly. In early spring and late autumn, when snow in the paddocks tends to be mixed up with animal waste and so on, it is important to provide the animals with good quality water in sufficient quantity.

Water troughs of the type equipped with a float valve (Figure 3), which always contain water, are vastly preferable to the water bowls used for cattle (Figure 4). The animals will drink more water because the trough lets them drink as they would in nature. Since trough water is stagnant however, in warm weather the troughs should be regularly cleaned to avoid the proliferation of microorganisms.

Figure 2. Example of a heated water trough
Photo: Juan Pablo Soucy

Figure 3. Examples of water troughs
Photos: Juan Pablo Soucy

Figure 4. Example of a water bowl for cattle (less effective in summer, ineffective in winter)
Photo: Juan Pablo Soucy

Some tips

- If water pipes cannot be buried, run them along the base of the fence so they are shaded by the forages to keep the water cooler.
- When designing pens, locate water troughs at the junction of two or more pens. This lowers costs since you can install a single water pipe, perhaps even a single trough serving more than one pen.
- Make sure there is good flow at the delivery end of the water line.

Feeding racks

Forage losses can range from 10 to 40% depending on the type of feeding rack and the season. The best way to reduce such feed losses is to not set the forage directly on the ground.

Here are the main points to consider when choosing a feeding rack:

- the space between bars should be wide enough (20 cm for red deer, 40 cm for wapiti) for the head of a single animal;
- vertical bars are preferable to bars at an angle;
- round bars are preferable to square bars;
- a roof will protect forage from the weather, but should not interfere with filling;
- solid sides at least 30 cm high will save some of the hay that would otherwise be lost on the ground (10 to 30%);
- the rack should be easy to move.

Figure 5 presents several rack designs: a classic open rack, a roofed rack and a rack with a trough to reduce waste and provide supplements.

Classic rack

Roofed rack

Rack with a trough

Figure 5. Different types of feeding rack
Photos: Juan Pablo Soucy

Feeding troughs

To avoid problems related to herd hierarchy, provide about 1 m of trough length per wapiti, or 60 cm of trough per red deer. This lets the animals eat whenever they wish, without having to compete with each other.

The type of trough to use depends on the chosen feeding method. A mobile trough (Figure 6) is more suited to ad lib feeding, while a trough along a fence (Figure 7) is more suited to a system with mechanized feed delivery. Trough systems protected by a barrier and placed directly in the paddock provide a good length of trough without requiring more fence alongside the farm road.

As for minerals, there are many distribution systems. Some producers put minerals in the feeding troughs, while other attach them to the rack. There are also feeders made just for minerals (Figure 8), with a flexible cover to protect the contents from the weather while allowing easy access. Whichever system you choose will be better than setting out mineral blocks on the ground.

In paddocks near a building, the low side of the building can be used to feed the animals under eaves while also protecting the feed from the weather.

Figure 6. Examples of mobile troughs
Photos: Juan Pablo Soucy

Figure 7. Troughs installed along the fence
Photos: Juan Pablo Soucy

Figure 8. Mineral trough
Source: Juan Pablo Soucy

Creep feeding

Creep feeding is reserved exclusively for young animals, access being restricted by the judicious use of barriers. Creep feeding offers a ration that complements maternal milk and any feed already in the paddock, to improve weight gain before weaning. Make sure however that the extra weight gain is profitable, since there will be less compensatory gain (catch-up growth) in the spring. This can vary considerably from herd to herd.

With creep feeding, the feeding area (whether trough or pasture) is reserved for the calves by a barrier that only they can get through. Metal posts are best, spaced 20 cm apart for red deer or 40 cm apart for wapiti. If using wood posts, they should be 20 cm in diameter and set to a depth of 1.6 m (40% of their length), rising at least 2.4 m above the ground. A sturdy barrier is needed because the mothers will be very tenacious about trying to reach their young.

There are also portable creep feeders with barriers that can be lowered into position once the trough is in the pen. They are more expensive, but more versatile.

Wooden barrier (more economical)

Metal barrier (more durable)

Figure 9. Barriers for creep feeding
Photos: Juan Pablo Soucy

CORRAL

The corral is where the herd or part of the herd (i.e. animals from one paddock) is collected and sorted. It consists essentially of a collecting yard and an area where the animals are sorted for handling. For information on various aspects of corral design, including details on construction that can be very useful when building new facilities or modifying existing ones, see the document entitled *Aménagement pour l'élevage des grands cervidés* (MAPAQ, 2005), available online (in French only) from Agri-Réseau. Information in English is available from several sources, especially for wapiti (elk), such as the Government of Saskatchewan website at www.agriculture.gov.sk.ca/Ground_Level_Elk_Handling_Facilities.

Collecting yard

Before the herd can be moved into the sorting area, you must first be able to get the animals out of their paddock. Providing food and water in the collecting yard will draw the animals into the yard and keep them there awhile. The yard should be large enough to contain a complete group of animals. Depending on the size of your herd you may need several yards of different sizes, but all should be suitable for a stay of several days. For wapiti, the ideal seems to be 25 m^2 per adult head, while for red deer it seems to be 12 m^2 per adult head. Allot half those areas for young animals.

Sorting area

The sorting area comprises the crowding alley, stalls (Figure 10) and squeeze.

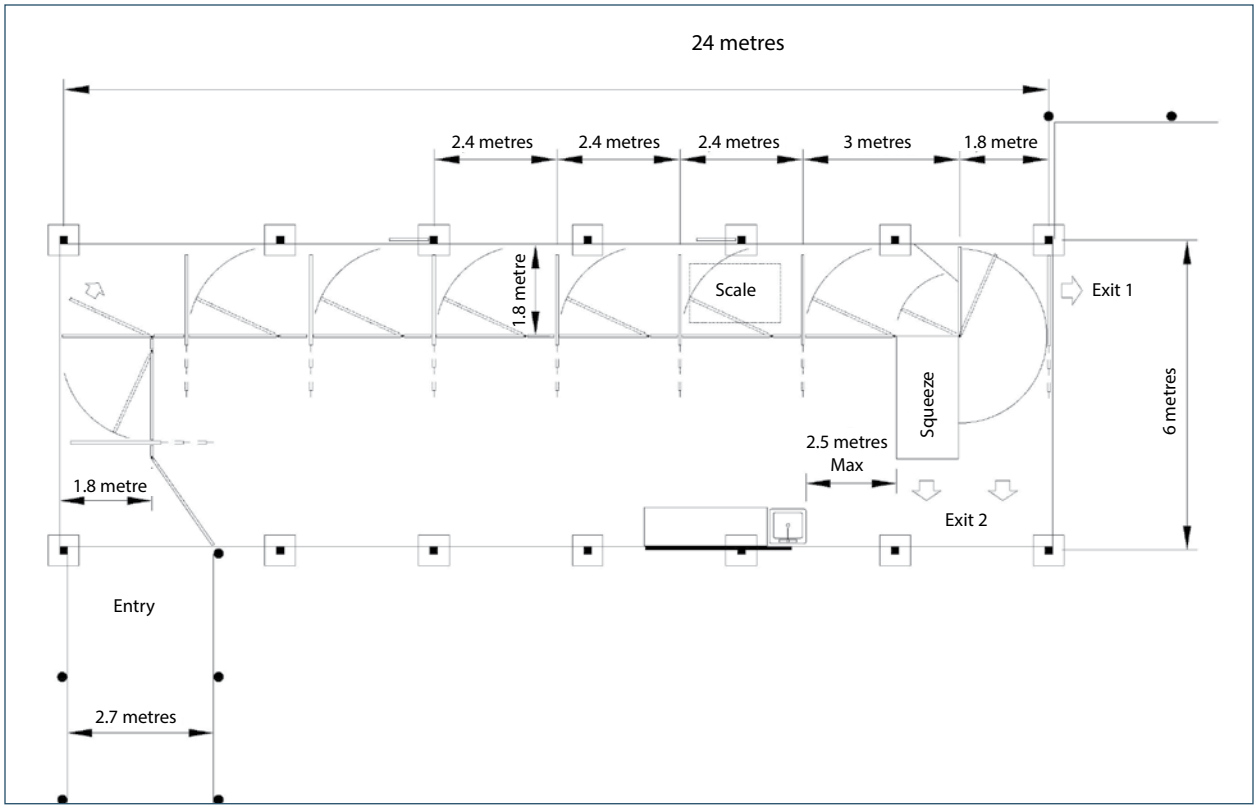

Figure 10. Sorting area for cervids (plan 80203, modified)
Source: Sébastien Cartier

The crowding alley (Figure 11) is used to guide the animals from the collecting yard into the stalls. It gradually narrows the space available, leading the animals quickly but without jostling to where they can be separated into smaller and smaller groups in the stalls. From there they enter the squeeze, which holds just one animal at a time.

Since animal density is higher in the sorting area than in the yard, its sides should be even sturdier and preferably solid or opaque. Tarps or plastic sheeting can be used to make slatted walls opaque, firmly attached to avoid flapping in the wind. A low-cost yet sturdy solution is to use 2x4 or 2x6 wooden slats, set horizontally (ideally) to avoid injury to the animals' shoulders. A few openings at man height allow the animals to be observed and flags to be waved to move them along.

The crowding alley should have safety exits every 3 metres, so workers can get out quickly in case of danger. A safety exit can be as simple as a place where the fence itself can serve as a ladder.

Figure 11. Example of a crowding alley
Photo: Juan Pablo Soucy

Stalls consist of a series of sliding horizontal doors by which the animals can be separated into smaller and smaller groups (Figure 12). Guillotine doors are easier to construct, but less practical and more dangerous to operate. Sliding doors ride on a rail that should be protected from the weather, easy to maintain and silent. Door stops and rubber wheels (Figure 13) help to reduce any sounds that could make the animals nervous. When the stall doors close they should lock automatically to avoid undesired movement, reducing the risk of injury. As shown in Figure 12, doors should be solid at the bottom to avoid hoof injuries, while from 1.5 m up they can be open with horizontal bars.

The last stall before the squeeze should have a scale. Plan for enough space for a scale to be installed, so that each animal can be weighed before it enters the squeeze.

Also very important is to have an emergency exit from each stall into an alley leading to a temporary pen. If an animal becomes sick or panicky, the emergency exit allows it to be redirected elsewhere without having to move any other animals first, and without having to force it through the squeeze.

Red deer (stalls 1.5 m wide)

Wapiti (stalls 1.8 m wide)

Figure 12. Examples of stalls for red deer and wapiti
Photos: Juan Pablo Soucy

Figure 13. Rubber wheels on the rail
Photo: Juan Pablo Soucy

Squeeze

The squeeze serves to immobilize the animals one at a time so that various interventions can be performed (identification, vaccination, veterinary tests, semen collection, insemination, etc.). There are numerous suppliers in North America for both hydraulic and manual models. Immobilization is achieved by either of two principles: horizontal cushions or a V shape with drop-out floor.

The squeeze with horizontal cushions (Figures 14, 15 and 16) is very effective for all cervids. It is more expensive to purchase, but can be used for handling cervids of all sizes in all situations. The cushions immobilize the animal without harming it, holding the animal along the length of the body with only its head above the cushions. Access ports allow all the necessary handling and treatments to be performed. When the squeeze is opened the animal can easily exit.

Figure 14. Squeeze with horizontal cushions, wide open
Photo: Juan Pablo Soucy

Figure 15. A calm animal safely immobilized in a squeeze with horizontal cushions
Photo: Juan Pablo Soucy

Figure 16. Taking a blood sample from an animal immobilized in a squeeze with horizontal cushions (interior view)
Photo: Juan Pablo Soucy

For smaller cervids (calves, red deer without antlers), a V-shaped squeeze called a drop-floor chute (Figure 17) is more economical and faster to operate. This is a raised squeeze with tapering sides. The floor swings down when the animal is inside, leaving the animal suspended (Figure 18) by the shoulders, abdomen and hips. This type of squeeze is operated manually.

Whichever type of squeeze is used, it should have the following characteristics:

- adjustable width and height to accommodate cervids of different sizes;
- multiple openings (ports) in the upper part to allow various interventions without opening the entire unit, and regardless of the animal's position;
- one or two ports in the lower part for treating hooves and collecting semen;
- self-locking gates;
- preferably a lighting system inside (protected by a wire grill) so the animal will not be afraid to enter. The light should be easy to switch off, to calm the animal once it is inside. A head gate with a translucid or slotted section could also help;
- a safety mechanism allowing for quick opening in case of emergency (e.g. animal in a bad position or too excited);
- easily accessible levers that do not impede operator movement around the unit.

Figure 17. Two examples of drop-floor chutes, exterior and interior views
Photos: Juan Pablo Soucy

Figure 18. Feet of an animal immobilized in a drop-floor chute
Photo: Juan Pablo Soucy

At the exit from the squeeze, it is important to have a system of yards or alleys that can be easily reconfigured to direct the animals into different pens. This can be useful at weaning for example: one pen for the mothers, separate pens for male and female calves. While it is initially cheaper to use exterior gates for directing the animals, it is much more practical to have multiple exit alleys leading directly away from the squeeze.

Loading area

On cervid farms, the loading area is often just a loading chute with a horizontally sliding gate that can open and close quickly when shipping animals. Receiving is generally done directly at the receiving yard, but can also be done at the corral if the animals are to be treated first.

The loading area should be:

- easy to access from the sorting area;
- bright and well-lit, since shipping is often done in the early morning;
- curved in shape (ideally);
- easy to clear of snow in winter, or protected by a roof.

GATES AND LATCHES

All gates on a game farm must be easy to open, and ideally should latch automatically on closing. When working with cervids, it is often necessary to close a gate quickly to prevent them from going back and forth (a cause of stress).

Latch mechanisms (Figure 19) should be located at middle height instead of at ground level, where litter, ice and dirt could prevent them from functioning properly.

A variety of latches are available, but whichever you choose they should:

- latch securely as soon as the gate closes;
- open with one hand, even with gloves on;
- not be susceptible to being opened by animals;
- not be susceptible to jamming with frost or rust.

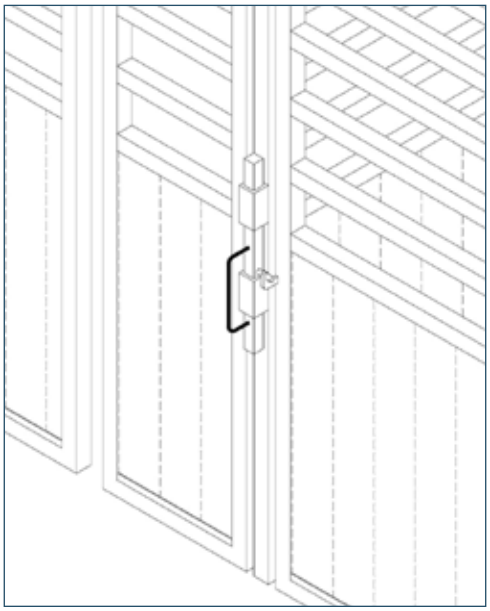

Figure 19. Latch mechanism located at middle height
Source: Sébastien Cartier

It goes without saying that gates should be adjustable so they can swing over snow, and should open in the direction where the animals are moving, e.g. from the pen into the alley where they will be led to the collecting yard, and so on.

CONCLUSION

At first glance, all of the foregoing may seem very complex. But it is precisely these small, down-to-earth details, combined with a design that takes into account the natural behaviour of cervids, that will make for safe equipment and an efficient, satisfying work environment.

BIBLIOGRAPHY

FEGGQ. 2008a. *La manipulation du cerf rouge*. DVD (39 minutes). Fédération des éleveurs de grands gibiers du Québec. Distributor: Centre de référence en agriculture et agroalimentaire du Québec.

FEGGQ. 2008b. *La manipulation du wapiti*. DVD (39 minutes). Fédération des éleveurs de grands gibiers du Québec. Distributor: Centre de référence en agriculture et agroalimentaire du Québec.

MAPAQ. 2005. [online]. Factsheet 80203. 8 pp. http://www.agrireseau.qc.ca/banqueplans/feuillets/Feuillet%2080203.pdf (accessed December 10, 2010)

Production Guide

DOMESTIC GAME FARM ANIMALS

Livestock Production Equipment for Bison – Key Concepts

CRAAQ

CULTIVER L'EXPERTISE
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INTRODUCTION

This leaflet presents several types of equipment that can be used for bison. It draws in part on information in the literature, but mostly from producers who agreed to share their knowledge and experience.

Before bison are delivered to a farm, you must have:

- the basic facilities to keep them there (fences);
- a system for handling the bison in small groups (the corral);
- facilities to sort the bison in each group into stalls before introducing them one at a time into the squeeze;
- a squeeze to restrain individual bison for closer observation or treatment;
- facilities for shipping and receiving the bison (a loading chute).

This document brings together a number of interesting concepts. Anyone who is interested in raising bison should, before anything else, visit several bison farms, partly to get familiar with the animals' behaviour, but also to see how the farms are set up and how the equipment works. This is the best way to learn the practical details and get ideas for setting up and even improving the equipment on your farm. Your best source of information is usually another bison farmer and of course his or her farm.

While consulting the other resources available, especially the videos produced by the *Fédération des éleveurs de grands gibiers du Québec* on the handling of bison (FEGGQ, 2008), interested persons can also contact the *Union québécoise du bison*. You can also contact an Agriconseil network to find an advisor in your region.

To design and operate equipment that is safe for both workers and animals, an understanding of bison behaviour is essential. Everything will run more efficiently, there will be less stress on the animals, and the general well-being of both workers and bison will be protected.

BISON BEHAVIOUR

Unlike cattle, bison have only recently begun to be domesticated. Bison behaviour is quite different from that of conventional livestock, requiring a different approach to handling the animals and designing facilities for them.

Return to familiar territory. Instinctively, when bison are fleeing a stress factor, they try to return to where they came from. Pens should be designed to take advantage of this behaviour. For example, a pen with a single gate is preferable to one with a separate entry and exit.

Security is in the group. Bison are gregarious animals, meaning they live in a herd. Consequently, a bison should not be left alone for very long. Avoid narrow alleys in which the animals cannot move as a group, since they will become nervous and try to return to the herd.

Feet on the ground. Bison are stressed by having things above them. Although catwalks alongside crowding alleys can be useful, they should be avoided since they can make the bison nervous. If catwalks are to be used, install high sides to conceal the workers.

Dark means a hole. Dark areas are perceived by bison as dangerous. Where there is a shadow, a roofed working area or a dark chute, bison will perceive it as a hole. They will often balk and refuse to move forward.

We turn for you. When bison feel trapped, they will mill in a circle looking for a way out. Sharp corners in traffic areas should therefore be avoided, since the animals can bunch up and injure themselves. Gently curved raceways or alleys encourage bison to move. Gates should be easily visible to them, located in a corner of the pen rather than in mid-fence, so the bison will be more likely to move towards and through the gate into the raceway.

All-weather facilities

Besides considering the bison's natural behaviour, remember that the facilities will be used year-round. To avoid having to shovel snow, either build roofed facilities or leave enough room for a tractor and snow blower to get around. An enclosed area, protected from the weather, can also be used to store records and electronic equipment (scales, tag readers, computer, etc.).

Feed and calm, please! Almost no fence can stand up to a fleeing bison. The best way to keep your bison on the farm, and your facilities in good condition, is to keep the animals well fed and watered, to raise them in conditions that respect their natural behaviour, and to handle them calmly so as to minimize stress.

PENS

The ideal stocking density (number of bison per unit of pen area) depends on the animals' weight, feed management and the rate of forage growth if pasture is used. Without pasture, the density generally ranges from 2 to 140 bison per hectare. In contrast, where bison are grazing during the growing season the density generally ranges from 0.25 to 6 bison per hectare, depending on the region and type of soil. The impact of trampling on plant growth will depend on the climate and the nature of the soil.

Fencing

Different kinds of fence posts can be used depending on budget, personal preferences and program specifications (for farmers seeking certification). In the short term, untreated cedar posts are the most economical choice. Treated posts are more durable but more expensive. Metal posts have the advantage of being more durable, easier to repair (they can be straightened if bent) and smoother, reducing the risk of bison snagging on them. However, metal posts cost more than twice as much as wooden posts.

For bison, the fencing most often used is wire game fencing, 1.8 to 2.4 m high for the perimeter fence and 1.5 to 2.0 m high (Figure 1) for interior fences dividing pens, raceways, etc. Cattle fencing is also common, while 12.5 gauge (2.5 mm) high-tension galvanized steel wire (Figure 2) is occasionally used

as well. Six to eight horizontal wires are enough for a serviceable fence, even without being electrified. Electric fencing is very effective, but is generally only used in summer. It is often installed as a complement to an existing fence to prevent the main fence from being damaged. For electric fencing to be effective, the energizer must be sufficiently powerful, the wire must conduct electricity well, and the system must be properly grounded and maintained (e.g. clip grass so electric wires do not short out).

Figure 1. Example of game fencing
Photo: Juan Pablo Soucy

Figure 2. Example of a fence made with high-tension steel wire
Photo: Juan Pablo Soucy

FEEDING

Water troughs

At all times, the most important feed to provide bison is water. In the winter, bison can use snow as a source of water, as long as it is not contaminated or trampled. However eating snow takes energy, and the

animals will do better if they have access to a water trough where they can always obtain liquid water. All watering systems, whether heated or not, should be regularly inspected throughout the winter to make sure they are working properly. Water troughs equipped with a float valve, which always contain water, are preferable to the water bowls often used for cattle.

Some tips

- If water supply pipes cannot be buried, run them along the base of the fence: growing forages will shade the pipe and keep the water cooler in summer. In winter, a properly installed heating wire inside the pipe will help keep the water from freezing, but this is only effective over short distances, and not in areas of severe cold.
- When designing pens, locate water troughs at the junction of two or more pens to lower costs: a single water pipe or even a single trough can serve multiple pens.
- Make sure there is good water flow at the delivery end of the water line.
- Both in summer and winter, it is important to regularly clean troughs of stagnant water to avoid the proliferation of microorganisms.

Feeding racks

Forage losses can range from 10 to 40% depending on the type of feeding rack and the season. The best way to reduce such feed losses is to not set forage directly on the ground.

The main points to consider when choosing/building a feeding rack (Figures 3 and 4) are:

- the space between bars should be wide enough (40 to 50 cm) for the head of a single animal;
- round bars are preferable to square bars;
- a roof will protect forage from the weather, but should not interfere with filling;
- a floor with solid sides at least 30 cm high will save some of the feed that would otherwise end up on the ground;
- the rack should be easy to move.

Figure 3. Classic hay rack
Photo: Juan Pablo Soucy

Figure 4. Mobile feed rack with roof
Photo: Juan Pablo Soucy

Feeding troughs

The best type of feed trough to use will depend on which method of feeding is chosen. A mobile trough (Figure 5) is better suited to ad lib feeding, while a trough along a fence (Figure 6) is more suited to a system with mechanized feed delivery. Trough systems protected by a barrier and placed directly in the pen provide a good length of trough without requiring more fence along the farm road (Figure 7).

If using linear feed troughs, allow for about 1 m of trough per head, which lets the bison eat whenever they wish, without having to compete with each other.

Another type of feed trough (normally used for large bales of hay/haylage), circular in shape and 2.4 to 3 m in diameter, lets a dozen or so bison feed at the same time, without needing to be refilled as frequently.

Where a pen adjoins a building, the low side of the building can be extended and the resulting sheltered area used to feed the animals while also protecting the feed from the weather (Figure 8).

As for salt and minerals, there are many distribution systems. Some producers place salt and minerals in the feeding troughs, while other attach them to the rack. There are also feeders made just for salt and minerals; a flexible cover protects the contents from the weather while allowing the bison easy access (Figure 9). Whichever system is chosen, it will be better than setting out salt and mineral blocks on the ground. Allow one mineral feeder per group of 25 to 40 bison depending on the size of the feeders.

Figure 5. Mobile feed troughs in the pen
Photo: Juan Pablo Soucy

Figure 6. Feed trough installed along the fence
Photo: Juan Pablo Soucy

Figure 7. Mobile feeding trough inside the pen
Photo: Juan Pablo Soucy

Figure 8. Feeding area set up under the low side of a building
Photo: Juan Pablo Soucy

Figure 9. Mineral/salt feeder
Source: Juan Pablo Soucy

Creep feeding

With creep feeding, the feeding area (whether trough or pasture) is reserved for the calves by a barrier that only the calves can get through (Figure 10). Metal posts are best, spaced 45 cm apart, or wood posts 20 cm in diameter, set to a depth corresponding to 40% of their height and rising at least 2 m above the ground. The barrier must be very sturdy, since the mothers will be tenacious about trying to reach their calves.

There are also portable creep feeders with barriers that can be lowered into position once the trough is in the pen. This concept, used by certain beef producers, is more expensive but more versatile. It can easily be adapted to the natural behaviour of a group of bison.

Figure 10. Barrier limiting entry to the creep feeding area
Photo: Juan Pablo Soucy

CORRAL

The corral is where the herd is assembled and sorted (Figure 11). The corral consists essentially of one or more collecting yards or temporary pens, and a sorting area.

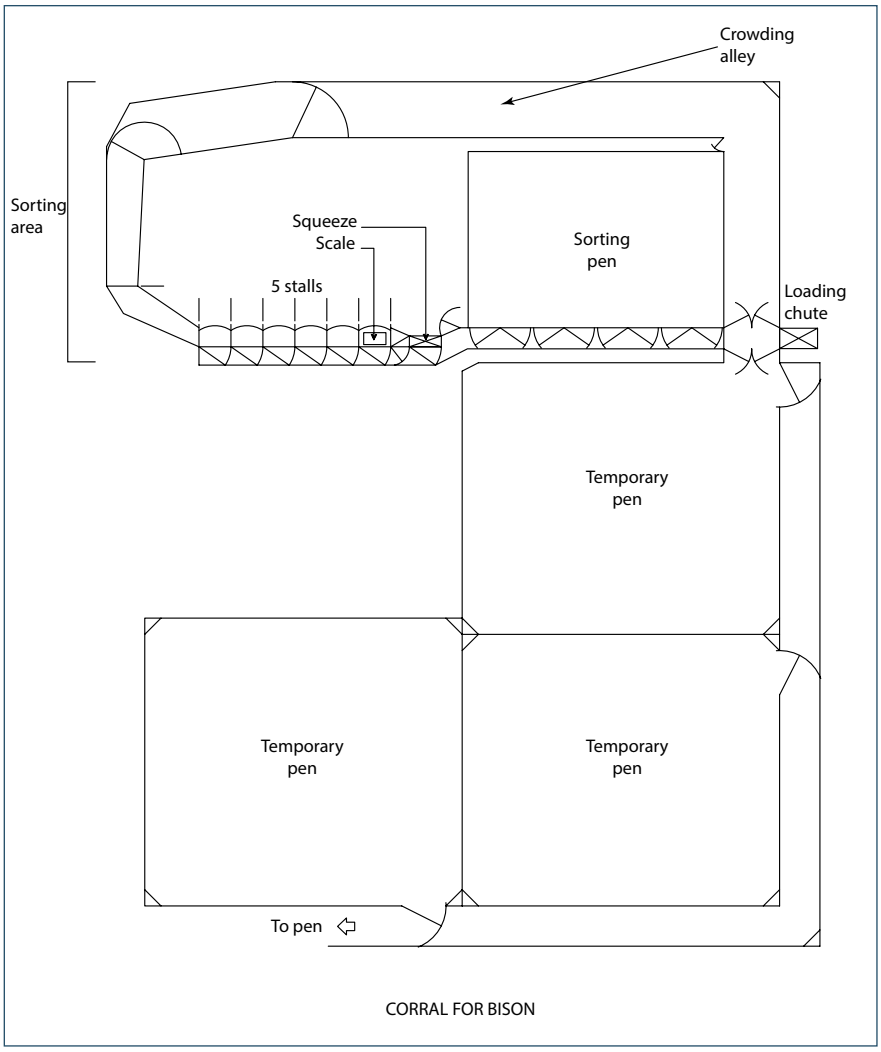

Figure 11. Example of a corral for bison
Source: Sébastien Cartier

Collecting yard

Before the bison can be led, one at a time, into the squeeze, you have to be able to get a group of them out of their pen. Providing feed and water in the collecting yard will draw them into the yard, which should be large enough to hold a complete group of bison. Depending on the size of your herd you may need several yards of different sizes, but all should be suitable to hold the animals for several days if needed. The ideal stocking density seems to be 25 m^2 per adult bison and 12 m^2 per head for young bison.

Figure 12. Examples of a collecting yard or temporary pen
Photos: Juan Pablo Soucy

Sorting area

The sorting area is made up of the crowding alley (Figure 13) and stalls. The crowding alley is used to move the bison from the collecting yard into the stalls. The crowding alley gradually narrows, leading the animals quickly and smoothly, without jostling, to where they can be separated into smaller and smaller groups in the stalls. The last step is the squeeze, which holds just one animal at a time.

Since animal density is higher in the sorting area, its walls should be sturdier and preferably solid or opaque, starting from the crowding alley. A low-cost yet sturdy solution is to use 3'' x 6'' wooden planks, set horizontally to avoid injury to the animals' shoulders. With a few openings at eye height for the workers, the animals can be observed and flags can be waved to urge them along if necessary.

Normally, no one should be in a pen or corral where there are bison, unless separated from them by a securely closed gate. Nonetheless, the crowding alley should have safety exits every 3 metres for workers to take in case of danger. These can be as simple as places where the horizontal planks are far enough apart to serve as a ladder.

Figure 13. Example of a crowding alley
Photo: Juan Pablo Soucy

The crowding alley can also be made of cement or a metal frame covered with plywood or sheet metal, but these options are more expensive. If sheet metal is used, it is important that the sheets be welded to the frame with no exposed edges, to avoid injury to the bison (Figure 14).

Figure 14. Example of a dangerous sheet metal joint
Photo: Juan Pablo Soucy

Stalls consist of a series of sliding horizontal doors by which the bison can be separated into smaller and smaller groups. Guillotine doors (Figure 15) are easier to construct, but less practical and more dangerous to operate. Sliding doors ride on a rail that should be protected from the weather, easy to maintain and quiet. Door stops and rubber wheels (Figure 16) help to reduce any sounds that could make the bison nervous.

Figure 15. Example of a guillotine door
Photo: Juan Pablo Soucy

Figure 16. Rubber wheels on the rail
Photo: Juan Pablo Soucy

Square/rectangular stalls (Figure 17) are easier to construct, but less appropriate for bison, which need to be able to turn easily. Round stalls (Figure 18) and semi-round stalls (Figure 19) are therefore preferable. The sides of the stalls should be solid at the bottom to avoid injuries to hooves and legs, but above 1.5 m they can be partially open with horizontal bars.

Figure 17. Example of square/rectangular stalls
Photo: Juan Pablo Soucy

Figure 18. Example of rounded stalls
Photo: Juan Pablo Soucy

Figure 19. Example of semi-round stalls
Photo: Juan Pablo Soucy

The last stall before the squeeze should be reserved for the scale. Each animal can then be weighed before entering the squeeze.

It is also very important to have an emergency exit from each stall into an alley leading to a temporary pen. If a bison becomes sick or overly nervous, the emergency exit allows it to be redirected elsewhere without having to move other bison first, and without having to force it through the squeeze.

Squeeze

The squeeze can immobilize each bison individually so that various interventions can be performed (identification, vaccination, veterinary tests, semen collection, insemination, etc.). Some squeezes designed for cattle can be used for bison, but for the greatest safety and effectiveness, a squeeze designed specifically for bison is the best option. The squeeze can be hydraulic or manual, and there are numerous North American suppliers.

Figure 20. Example of a manual squeeze
Photo: Juan Pablo Soucy

Figure 21. Example of a hydraulic squeeze
Photo: Juan Pablo Soucy

Whichever type of squeeze is used, it should have the following characteristics:

- adjustable width to accommodate adult bison of different sizes;
- multiple openings (ports) in the upper part of the squeeze to allow various interventions without opening the entire squeeze, regardless of the animal's position (Figure 22);
- one or two ports in the lower part of the squeeze for treating hooves/legs and collecting semen (Figure 23);
- self-locking gates;
- a secure yoke and head gate that can be opened and closed quickly;
- an end door that ideally has a translucent or slotted section to let light into the squeeze, so the animal doesn't balk at entering a dark space;
- one or two sides that can be opened quickly in case of emergency, to let out an animal that is in a bad position (a bison may roll onto its back in the squeeze);
- easily accessible levers that do not impede operator movement around the squeeze.

Figure 22. Multiple upper ports
Photo: Juan Pablo Soucy

Figure 23. Lower port
Photo: Juan Pablo Soucy

Loading chute

It is important to have a good loading chute to safely and efficiently load and unload bison. The chute should:

- be easy to access from the sorting area;
- have an anti-slip floor, and ideally high side walls;
- be adjustable to the type of vehicle (small truck or semi-trailer);
- be bright and well-lit, since loading and unloading are often done in the early morning;
- be gently curved in shape (ideally);
- be easy to clear of snow, or have a roof.

Figure 24. A simple and effective loading chute
Photo: Juan Pablo Soucy

Figure 25. A more sophisticated and curved loading chute
Photo: Juan Pablo Soucy

GATES AND LATCHES

All gates on a bison farm must be easy to open, and ideally should latch automatically on closing. When working with bison, it is often necessary to close a gate quickly to prevent the animals from trying to go back where they came from, which could cause stress.

All gates used for bison should:

- be easily visible to the bison;
- be located in the corners of pens or yards;
- be adjustable in height so they can swing open over snow, and horizontally adjustable in case a post goes askew due to freezing;
- open at least to the inside of the pen, but ideally in both directions.

A wide variety of latches are available, but whichever you choose they should:

- latch securely as soon as the gate closes;
- open with one hand, even with gloves on;
- be designed so they cannot be opened by the bison;
- continue to work properly despite frost or rust;
- be recessed into the wall or post (ideally) to avoid risk of injury to the bison.

Figure 26. Example of a closing mechanism (latch)
Photo: Juan Pablo Soucy

CONCLUSION

At first glance, all of the foregoing may seem very complex. But it is precisely these small, down-to-earth details, combined with a design that takes into account the natural behaviour of bison, that will make for safe equipment and an efficient, satisfying work environment.

BIBLIOGRAPHY

FEGGQ. 2008. *La manipulation du bison*. DVD (39 minutes). Fédération des éleveurs de grands gibiers du Québec. Distributor: Centre de référence en agriculture et agroalimentaire du Québec.

Gagnon, A. 2006. *Comment réaliser une bonne clôture électrique?* [online]. http://www.mapaq.gouv.qc.ca/fr/Regions/chaudiereappalaches/journalvisionagricole/autresarticles/genierural/Pages/cloture.aspx (accessed December 22, 2011).

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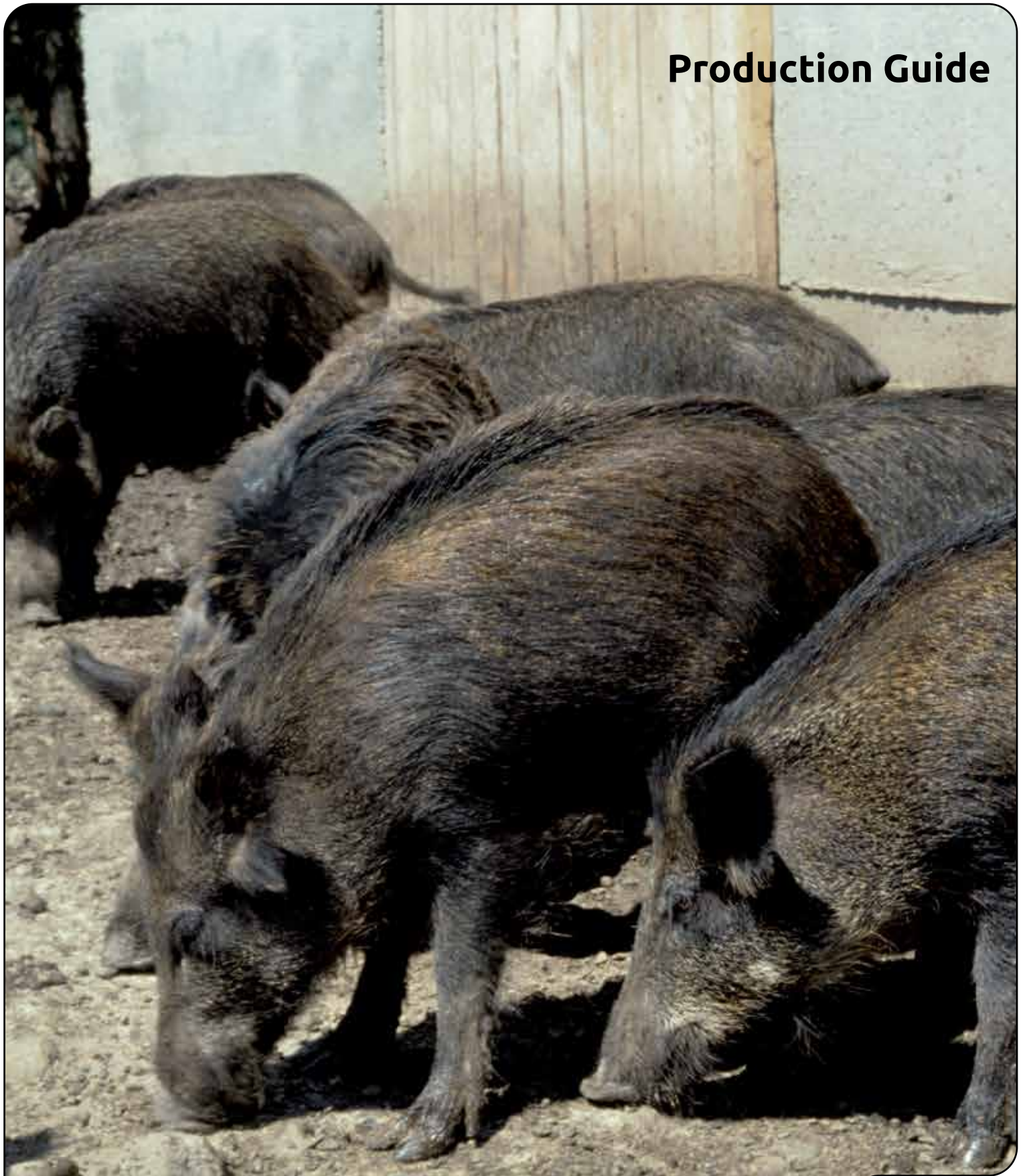

DOMESTIC GAME FARM ANIMALS

Wild Boar Facilities – Overview

CRAAQ
CULTIVER L'EXPERTISE
DIFFUSER LE SAVOIR

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INTRODUCTION

The wild boar is a close relative of the domestic pig, and much of the equipment designed for hog operations can be adapted to wild boar. The behaviour of wild boar is significantly different however (they are more nervous, more agile and quicker) and they spend most of their lives outdoors. Wild boar cannot be handled like domestic pigs, so for production facilities to be functional and safe they must be built for the particular characteristics of the species.

Generally speaking, wild boar facilities include breeding pens, growing pens and feeding and watering areas. Farrowing should take place in isolation. Producers must be able to handle wild boar safely, so it is essential to have a system, however simple, for receiving, sorting and shipping.

This document is based on comments from producers who have agreed to share their acquired expertise. Wild boar farming is a recent development compared to domestic hog production, and in Québec is still in its infancy. Many of the methods currently in use are the result of much trial and error. Improvements on the concepts outlined in the present document will undoubtedly become available in the coming years.

Visiting existing farms is a good way to benefit from the experience of other producers, to learn how one's own operation could be improved. Such hands-on information sharing is not always possible however. Another solution is to seek help from an advisor through the Agriconseils network, or to contact the Association des producteurs de sangliers du Québec (APSQ). A wealth of information on wild boar is provided in a DVD produced by the Fédération des éleveurs de grands gibiers du Québec (FEGGQ, 2008).

BEHAVIOUR

Designing appropriate production facilities for wild boar, and handling the animals properly, requires a good understanding of wild boar behaviour. The facilities as a whole must:

- minimize stress;
- maximize safety;
- increase efficiency;
- ensure the overall safety and well-being of animals and workers.

The main aspects of wild boar behaviour are described below.

Herd mentality. Wild boar dislike being separated from the herd. Individuals should not be left alone for too long during handling; otherwise they become nervous and will try to escape by any means possible.

Agility. Wild boar can jump over 1.5 m obstacles with surprising ease. Their agility should be taken into account in designing facilities and planning transportation.

Rooting behaviour. Wild boar naturally root, digging up earth and uprooting obstacles. Their rooting behaviour should be taken into account in planning and building fencing, production, housing and transportation equipment.

BREEDING PEN

Wild boar should be raised in outdoor pens with access to shelter, meeting their behavioural needs while providing the optimum conditions for meat production.

The ideal stocking density (number of animals per unit of pen area) depends on how much vegetation cover is desired, the type of soil, and weather conditions (precipitation, wind, temperatures). Generally, with a density of 50 adults (or 125 young) per hectare, the vegetation cover will deteriorate rapidly, though it is adequate space for the animals' well-being. To maintain ground cover, the ideal density is no more than 35 growing animals or 15 adults per hectare. It is recommended to have extra pens available to reduce density when the soil is saturated (spring, fall and periods of heavy rainfall).

All-weather facilities

Remember that the facilities will be used year-round. To avoid having to shovel snow, either build roofed facilities or leave enough room for a tractor and snow blower to get around. A small heated room can be used for storing medication, records and so on.

Allowing wild boar to range in forested areas is possible, but at much lower densities, since the soil is more fragile. Meat production is more complex and expensive when the animals are kept this way. However, a copse of trees within a pen provides shade and protection from the wind. To protect the trees, fencing should be installed at least two metres from their base.

Fencing

In Québec, the *Regulation respecting animals in captivity* sets out provisions for the keeping of wild boar. Section 10 of the Regulation defines the required infrastructure as follows:

> *10. Anyone who keeps peccaries or boar in captivity without a licence shall erect and maintain an enclosure surrounded by a fence at least 1.8 m above ground level made of*
> *(1) steel chain links of minimum 13 gauge, 1.24 m high including 30 cm in the ground; the 86 additional centimetres may be made of game fence; or*
> *(2) steel chain links of minimum 13 gauge, from 92 cm to 1.24 m high and the 88 or 56 additional centimetres may be made of game fence; the enclosure must be fitted on the inside with an electric wire running between 15 and 45 cm above ground level situated 30 cm from the fence, and the minimum tension in the wire must be 10 joules.*
>
> *Furthermore, the perimeter fence of the enclosure must have no trap or barrier to capture animals outside the enclosure; in addition, the gates of the perimeter fence must remain close, even in the absence of animals.*

A chain-link Frost fence (Figure 1) is recommended, at least 1.8 m in height, ideally 2.4 m for perimeter fencing. The fence should extend at least 30 cm into the ground to prevent the wild boar from digging under it. At the top of a slope it should extend at least 60 cm into the ground, since the animals' rooting will tend to level the grade.

Figure 1. Chain-link fencing

Source: Juan Pablo Soucy

It is recommended to install one to three electrical wires at different heights from 15 to 40 cm above the ground, depending on the size of the animals, to prevent them from looking for weak spots in the fencing during the summer. Wires should be properly grounded and the electrical system checked regularly. If kept running over the winter, the posts should be tall enough for the height of the wires to be adjusted to the snow cover. It is possible to electrify rather than bury a fence, but this requires added vigilance when snow accumulates and before the ground is frozen.

FEEDING

Water

Clean, good quality water is the most important part of any animal's diet. In winter, wild boar can obtain adequate water by eating snow if there is enough of it. In a commercial operation however, fresh water is essential to achieving weight gain targets. In winter, readily available liquid water helps the animals conserve energy, while avoiding the consumption of soiled snow. An investment in quality, continuous-flow, heated water troughs will also save time and money, eliminating the labour of keeping water bowls filled, while preventing health problems caused by dirty water. The area around water troughs should be surfaced with stone, concrete or wood to avoid rooting and the accumulation of mud.

All watering systems, whether heated or not, should be regularly inspected throughout the winter to make sure they are working properly.

Tips

- In pens that are not used in winter, water supply pipes should be buried to 30 cm (or ideally below the frost line) to prevent the animals from digging them up. If they cannot be buried, run them along the base of the fence: growing forages will shade the pipe and keep the water cooler in summer.
- In areas that are used in winter, water pipes must be buried below the frost line (1.0 to 1.5 m, depending on the region).
- When designing pens, locate water troughs at the junction of two or more pens to lower costs: a single water pipe or even a single trough can serve multiple pens.
- Consistent flow along the pipe is necessary for all the animals to have ready access to water. Sometimes water can be very slow to reach the furthest point from the source. In hot weather, animals that are low in the hierarchy may lack adequate access to water.
- If standing water bowls are used, it is important to clean them regularly to avoid bacterial growth.

Feed troughs and feeding areas

If the feeding area is limited, animals that are low in the hierarchy will have difficulty accessing feed. To avoid this problem, it is recommended to allow about 40 cm of trough per head.

The most appropriate type of trough will depend on the feeding method chosen. A portable feed hopper (Figure 2) is best in a free-choice system, while a fence line trough is best for a mechanical or rationing system. Portable hoppers should be roofed to protect feed from the elements.

Figure 2. Portable feed hopper
Source: Juan Pablo Soucy

With a fully covered feeding area (Figure 3) the animals can be fed more easily, and monitoring the herd is simple. Watering facilities and fixed feed hoppers commonly used for hogs can be used for easier management and maintenance (Figure 4).

Feed troughs and hoppers are preferable to setting feed directly on the ground, where much feed would be wasted.

Figure 3. Covered outdoor feeding area
Photo: Juan Pablo Soucy

Figure 4. Fixed feed hopper
Photo: Juan Pablo Soucy

FARROWING

Sows must be separated from the rest of the herd during farrowing, and preferably sheltered. Simple outdoor shelters can be used (Figure 5) if they are well stocked with bedding (preferably straw) to allow the sows to nest. Access to a cold or heated barn (Figure 6) is the other option.

Figure 5. Simple outdoor farrowing shelter
Photo: Juan Pablo Soucy

Figure 6. Cold farrowing barn

Photo: Juan Pablo Soucy

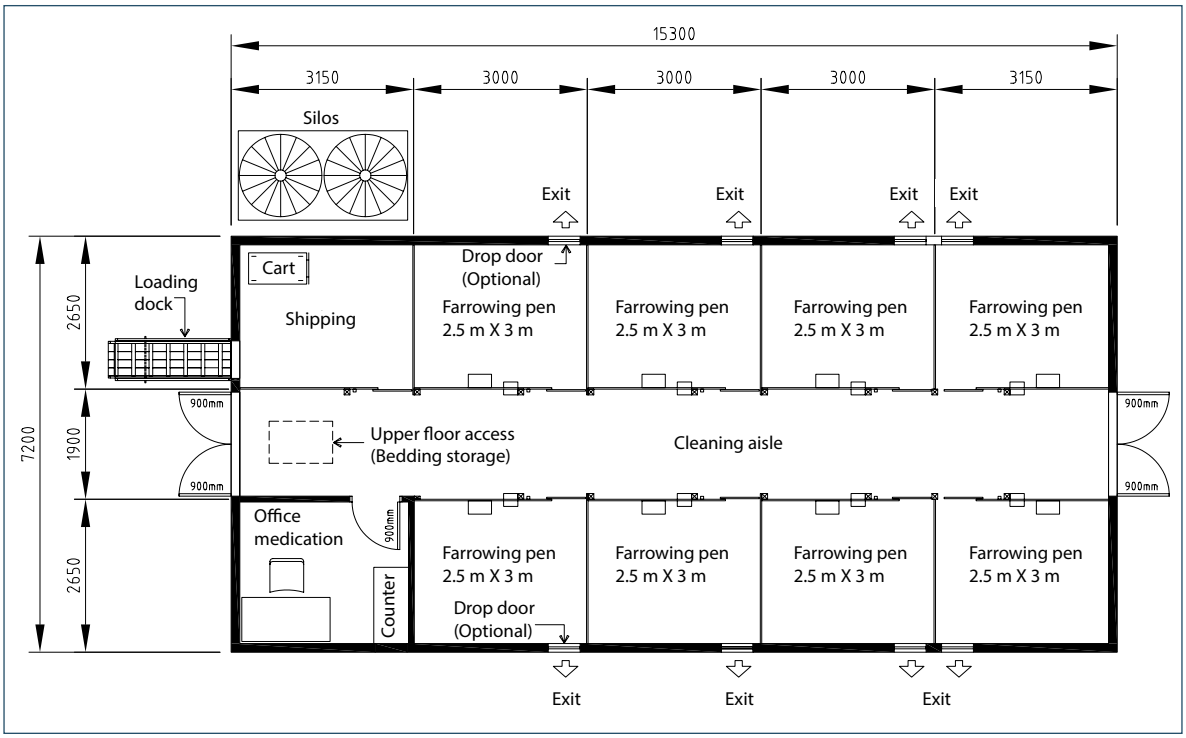

Figure 7. Farrowing barn

Source: Sébastien Cartier

The farrowing shelter or barn must include individual farrowing pens (Figures 7 and 8) providing at least 4 m² (ideally 6 m²) of floor space, with concrete, wood or plastic partitions at least 1.8 m high and 40 mm thick.

Floors should be sloped slightly, to ensure dry areas for piglets to lie down. The drinking trough or water bowl should be in the lower part of the pen. Whether heated or unheated, the trough or water bowl should be close to the door to allow for easier cleaning or ice removal in winter.

A wooden platform in the higher part of the pen will often encourage sows to nest there, especially since the ground will be warmer. The platform should be well anchored to prevent the sows from overturning it.

Providing access to outdoor runs and pens gives the animals an opportunity for exercise, but could increase drafts. With a small swinging door, they can go in and out at will while drafts are kept to a minimum.

In the farrowing barn, aisles can be narrow if they will cleaned by hand, but should be wide enough for a small tractor bucket if they will be cleaned mechanically.

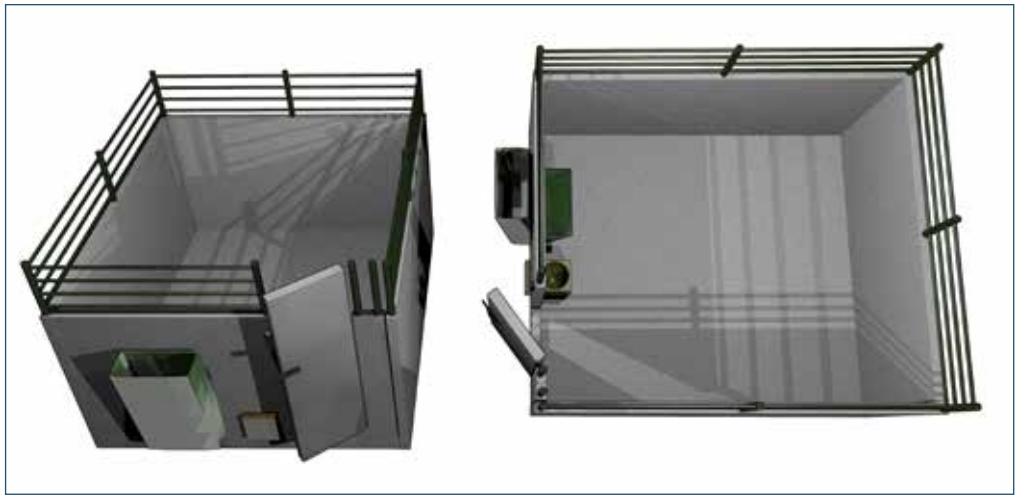

Figure 8. Farrowing pen
Source: Juan Pablo Soucy

NURSERY

A partially sheltered outdoor pen (Figure 9), or a cold barn opening onto one, can be used as a nursery for piglets between weaning and fattening. Since the piglets will be handled frequently (for tagging, treatments, etc.), the nursery should be designed to facilitate gathering the piglets and performing these interventions.

At this stage in the animals' life it is especially important that they have access to lots of good quality water, along with bedding and a dry resting area.

Figure 9. Basic outdoor shelter
Photo: Juan Pablo Soucy

HOLDING CRATE

The holding crate (Figure 10) immobilizes the animal for handling (tagging, vaccination, veterinary examination, etc.). Though some crates lack a stanchion and openings for handling, they may be suitable for weighing (Figure 11). Several models of hog crates can be adapted for use with wild boar, but so far none are available that were designed for that purpose.

Figure 10. Holding crate
Photo: Juan Pablo Soucy

Figure 11. Basic weigh crate
Photo: Juan Pablo Soucy

The ideal holding crate should:

- be of variable width to accommodate different-sized animals;
- have multiple openings in the top to allow handling without opening the top of the crate;
- lock automatically;
- have a self-latching door with an open section for light to get in and to allow the animal to see out;
- have multiple, easily accessible levers, for quick access by those working around the crate.

SORTING PENS

The sorting pen is an important component in any wild boar operation. In Québec, sorting pens usually consist of a single narrow aisle with one or two openings through which the animals can be directed toward handling pens and loading chutes.

A more advanced sorting pen is recommended in operations where a larger number of animals must be sorted, or where more contact with the animals is required.

LOADING DOCK

To facilitate shipping and receiving, producers should invest in a well-designed loading dock (inside width at least 45 cm; maximum floor slope 20 degrees). The loading dock must:

- be easy to access from the sorting pen;
- have anti-skid flooring to prevent slipping and falling;

- be adjustable to different vehicles (small trucks, semis, etc.);
- be well lit, since shipping is often done in the early morning;
- be curved if longer than 3 m;
- have high sides and a roof that lets light in (to avoid frightening the animals);
- be covered, or easy to clear of snow in winter.

SHIPPING CRATE

Not all shippers are equipped for wild boar. Producers should have their own shipping crates, whether of wood or metal, large enough to accommodate one or more wild boar, and easy to load on a van or trailer (Figure 12).

Figure 12. Shipping crate on a trailer
Photo: Juan Pablo Soucy

GATES, DOORS AND LOCKS

Doors and gates on all buildings and fences must be easy to open, and should latch automatically when closed. Gates must close quickly to prevent animals from returning or escaping.

Gates must:

- be visible to the wild boar;
- be located in the corners of pens;
- be adjustable in height so they can swing open over snow;
- open toward the outside of the pen, or ideally in both directions. If there is snow in the pen, start by removing snow from the outside, then open the gate to get in, close it, and finish snow removal inside.

Gates and drop doors are effective and easy to build, but should be equipped to lock into position securely whether open or closed. Always remember that wild boar are extremely strong and can lift heavy objects or pry open doors.

A variety of latches are available, but whichever you choose they should:

- latch securely as soon as the gate closes;
- open and close with one hand, even with gloves on;
- be designed so they cannot be opened by wild boar;
- continue to work properly despite frost or rust.

SHIELD

The use of a shield is strongly recommended when moving wild boar, for ease of handling and for the handler's protection. Shields can be made from 12 mm (½") thick plywood, with handles on both sides or on the back as preferred. Shield dimensions can vary depending on the width of aisles, but 60 to 90 cm (width) by 1.2 to 1.5 m (height) is usually effective, and light enough to be easy to use.

CONCLUSION

At first glance, all of the foregoing may seem very complex. But it is precisely these small, down-to-earth details, combined with a design that takes into account the natural behaviour of wild boar, that will make for safe equipment and an efficient, satisfying work environment.

BIBLIOGRAPHY

CPAQ. 1997. *Le Sanglier: guide d'élevage*. Conseil des productions animales du Québec. 113 pp.

FEGGQ. 2008. *La manipulation du sanglier*. DVD (42 min). Fédération des éleveurs de grands gibiers du Québec. Distrib. : Centre de référence en agriculture et agroalimentaire du Québec.

Gazette officielle du Québec. *Regulation respecting animals in captivity*. Act Respecting the Conservation and Development of Wildlife, Chap. C-61.1.

Keuling, O. 2009. *Managing wild boar – Considerations for wild boar management based on game biology data*. Ph.D. diss., Dresden University of Technology, Dresden, Germany.

Pinet, J.M. 2005. *L'élevage du sanglier de race pure*. ADEPRINA, Paris. 170 pp.

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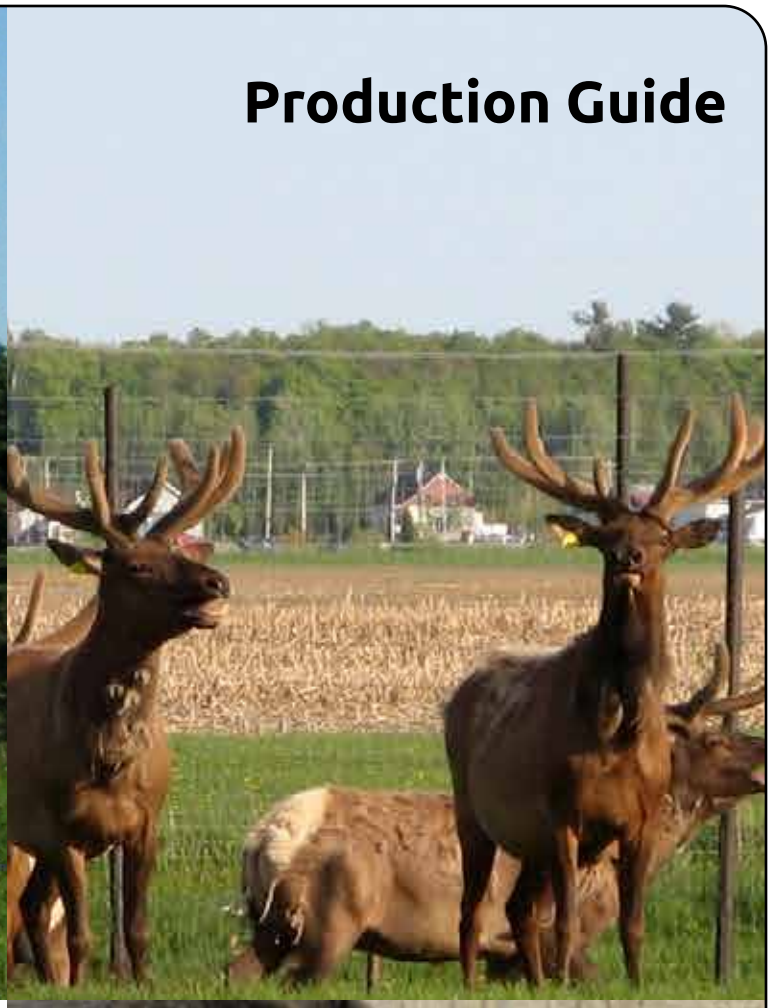

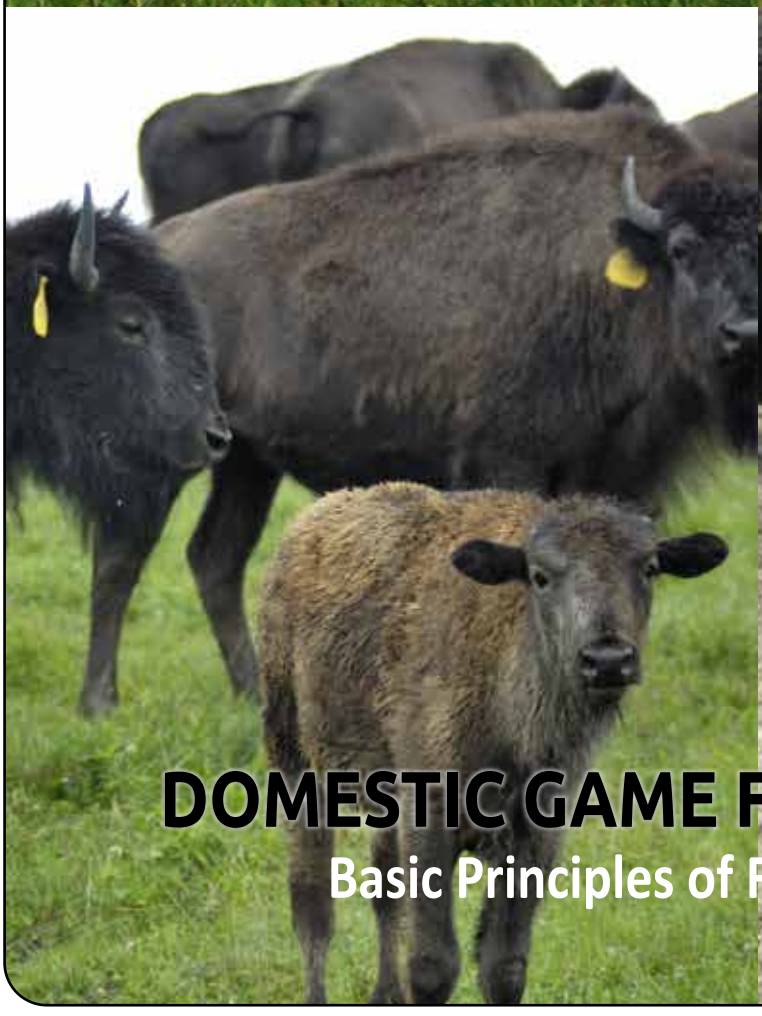

DOMESTIC GAME FARM ANIMALS

Basic Principles of Feeding and Nutrition

CRAAQ
CULTIVER L'EXPERTISE
DIFFUSER LE SAVOIR

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Juan Pablo Soucy (red deer and wapiti)
© **Etienne boucher**, MAPAQ (bison)
© **Michel Langlois**, MAPAQ (wild boar)

INTRODUCTION

Bison, wapiti (often called elk outside of Québec), red deer and wild boar are four species of large game that are raised in Québec for meat and other purposes. The same basic nutritional principles apply, whether to monogastrics like wild boar or to ruminants like bison, wapiti and deer: the animal ingests a given quantity of food composed of water and dry matter, the latter providing nutrients (energy, protein, minerals and vitamins). The importance of drinking water must be emphasized.

"DRY MATTER," "AS FED," "VOLUNTARY DRY MATTER INTAKE"

The percentage of water and dry matter (DM) in food varies widely. Hay for example is made up of 15% water and 86% DM. Ten kg of hay is therefore 8.5 kg of DM (the hay minus its moisture content), plus 1.5 kg of water, for a total of 10 kg. Concentrates (grain and commercial feed) contain less than 12% water, and thus over 88% DM. In contrast, forage can contain up to 80% water, for only 20% DM.

In animal nutrition, particularly for herbivores, nutritional value is expressed on a 100% DM base. A herbivore diet can include grazing, grass silage and hay, all of which have different moisture contents. Different food sources are therefore more easily comparable on a common basis of 100% DM.

Nutritional values can also be expressed on an "as-fed" basis (i.e. the nutrient content of the feed as it is fed). As for food intake, it is defined in terms of voluntary dry matter intake (VDMI), i.e. the quantity of dry matter voluntarily ingested by the animal over a given period.

NUTRIENTS

Energy

Food provides animals with energy essential to maintenance, growth and activity. The energy is obtained from food through the body's digestion of various elements, such as structural and non-structural carbohydrates (cellulose, hemicellulose and starch), fats (lipids) and proteins.

The energy content of food is expressed in calories (cal) or joules (J). One calorie is equivalent to 4184 joules. The terms kilocalorie (kcal), megacalorie (Mcal), kilojoule (kJ) and megajoules (MJ) are often used:

1 Mcal (or MJ) = 1000 kcal (or kJ) = 1 000 000 cal (or J).

Total energy intake is called gross energy (GE), and is not fully used by the body. Subtracting the energy excreted in the feces leaves the digestible energy (DE), which is used to calculate rations for wild boar. Apparent metabolizable energy (ME), which is used to calculate deer rations, is the digestible energy minus the energy lost in urine and gas. Lastly, the measurement used for calculating bison rations is net energy (NE), which takes into account the thermic effect, or "specific dynamic action" (SDA) of digesting food. Particularly in ruminants, a significant amount of heat can be produced during digestion. The efficiency with which NE is produced depends on the food source. NE can be subdivided in terms of how

the animal uses it; for example, NE can serve for maintenance (NEm), lactation (NEl), weight gain (NEg), and so on (Figure 1).

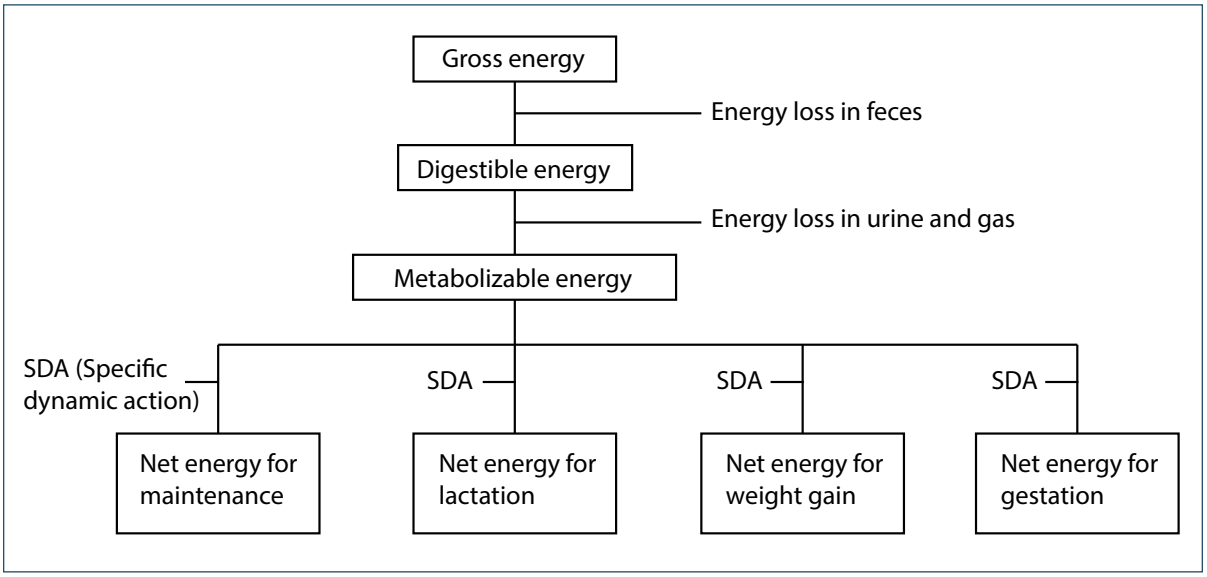

Figure 1. Energy use

Adapted from St-Pierre and Bouchard, 1980

Protein

Like energy, proteins are essential to maintenance, as well as for muscle and bone growth and for tissue repair. Besides playing a structural role, proteins also serve metabolic functions (enzymes, immunoglobulin, etc.). All proteins are composed of a series of peptides, which in turn are made up of combinations of the 20 amino acids involved in protein formation:

Aspartic acid	Isoleucine
Glutamic acid	Leucine
Alanine	Lysine
Arginine	Methionine
Asparagine	Phenylalanine
Cysteine	Serine
Cystine	Threonine
Glutamine	Tryptophan
Clycine	Tyrosine
Histidine	Valine

Monogastrics like wild boar digest the protein in food to extract amino acids, which are then absorbed and reassembled according to the animal's needs. While the body can synthesize some amino acids,

others (known as "essential" amino acids) are only available from food. "Limiting" amino acids are those that are not present in food in sufficiently high quantities (as in the case of lysine, for wild boar).

Gross protein (%GP) refers to the protein content of a given food. In ruminants (deer and bison), a significant portion of the gross protein can be degraded by rumen bacteria, and is therefore referred to as rumen degradable protein (RDP). The resulting microbial proteins then supply the animal's protein requirements. Other proteins, called non-degradable proteins, arrive intact in the abomasum (or rennet-bag), and are digested as they are in monogastrics. Finally, proteins that are not degraded in the rumen or digested in the abomasum are eliminated in the feces. Rumen bacteria can also transform nitrogen from non-protein sources such as urea into microbial protein.

Minerals

Major minerals and trace elements (i.e. dietary minerals that are needed in very small quantities) are integral nutritional components involved in structural and metabolic functions (Table 1). Most minerals are obtained from food sources. Intake of calcium and phosphorus, significant amounts of which are needed by the body, must be monitored particularly closely. Deficiencies in iodine and selenium may also occur, due to the low levels of these trace elements in Québec soil.

Note that there are both positive and negative interactions between various elements, and that cervids are sensitive to copper deficiency.

Table 1. Basic functions of minerals

Mineral	Primary functions
Major minerals	
Calcium (Ca)	Bone and tooth formation, muscle contractions, milk production
Phosphorus (P)	Bone and tooth formation, energy metabolism, enzyme activity, DNA
Magnesium (Mg)	Bone development, enzyme activator (reduction of blood pressure)
Sodium (Na)	Cellular acid/base balance, muscle contractions, bile production
Chlorine (Cl)	Cellular acid/base balance, gastric juices (HCl)
Potassium (K)	Cellular osmotic pressure, muscle tone, enzymes, carbohydrate metabolism
Sulphur (S)	Sulphur-containing amino acids, lipid and carbohydrate metabolism
Trace elements	
Cobalt (Co)	Ruminants: vitamin B_{12} synthesis by rumen bacteria
Copper (Cu)	Hemoglobin formation, enzyme activity, hair, bone development
Iodine (I)	Thyroxin production by the thyroid
Iron (Fe)	Transports oxygen in the blood (hemoglobin)
Manganese (Mn)	Bone formation, growth and reproduction, enzyme activity, amino-acid and energy metabolism
Selenium (Se)	Antioxidant (with vitamin D), fertility, immune system
Zinc (Zn)	Enzyme activity for protein synthesis

Adapted from Saskatchewan Agriculture, 2000

Vitamins

Vitamins are organic compounds classified as either water-soluble (vitamins C and B-complex) or fat-soluble (vitamins A, D, E and K). Vitamins serve various metabolic functions (Table 2). Most are obtained from food, while some are synthesized by the body (notably vitamin D, synthesized with the help of sunlight, and vitamin K). In ruminants, rumen bacteria synthesize the B-complex.

Table 2. Basic functions of vitamins

Vitamins	Primary functions
Fat-soluble vitamins	
A	Vision, integrity of mucous membranes, immunity
D	Calcium and phosphorus metabolism
E	Cellular respiration, antioxidant, membrane integrity
K	Normal blood clotting
Water-soluble vitamins	
Thiamine (B_1)	Nervous system, carbohydrate and protein metabolism
Riboflavin (B_2)	Antioxidant, ligament integrity
Niacin (B_3)	Carbohydrate, protein and lipid metabolism, cellular respiration, skin integrity
Pantothenic acid (B_5)	Amino-acid metabolism (coenzyme A), skin integrity
Pyridoxine (B_6)	Protein metabolism
Biotin (B_7)	Carbohydrate, protein and lipid metabolism
Folic acid (B_9)	Methyl-group reactions
Choline	Phospholipid metabolism
Cobalamine (B_{12})	Protein metabolism
Ascorbic acid (C)	Antioxidant, Vitamin D metabolism

Sources: Nutrient Requirements of Swine (NRC, 1998); Nutrient Requirements of Beef Cattle (NRC, 2000)

Water

Water is essential to life, milk production and nutrient absorption. Free access to good quality water at all times is crucial, and all the more so in the warm summer months. Troughs should be cleaned as often as possible. Creeks, ponds and dugouts should not be used as sources of water, since animal activity along the edges causes erosion (increasing the risk of injury to limbs), and pollutes the water (increasing the transmission of water-borne disease). It is prohibited in Québec for livestock to have access to bodies of water.

Water should be monitored frequently for clarity, odour and taste. If any of these become abnormal, and/or as part of the annual prevention protocol, chemical and bacteriological analyses should be done. Table 3 outlines the basic water quality guidelines for livestock.

Water pH is also important. On a scale from 1 to 14, with neutral pH being 7, acidity increases as pH drops (from 7 to 1), while alkalinity increases as pH rises (from 7 to 14). The acceptable range for water pH is 6.5 to 8.5.

For sound water management, the flow of water in the troughs should be monitored regularly, and their height adjusted if the animals are on accumulated litter. Troughs that are too low will become contaminated, which will ultimately reduce performance.

Daily water consumption varies depending on the water content of feed, water temperature, ambient temperature, animal weight, trough type, etc.

Table 3. Water quality guidelines for livestock

Substance	Maximum recommended amount (mg/L)
Aluminium (Al)	5.0
Arsenic (As)	0.5
Beryllium (Be)	0.1
Boron (B)	5.0
Cadmium (Cd)	0.02
Calcium (Ca)	1 000.0
Chromium (Cr)	1.0
Cobalt (Co)	1.0
Copper (Cu)	0.5 - 5.0[1]
Fluorine (F)	2.0
Mercury (Hg)	0.003
Molybdenum (Mo)	0.5
Nickel (Ni)	1.0
Nitrate and nitrite	100.0
Nitrite alone	10.0
Lead (Pb)	0.1
Selenium (Se)	0.05
Sulphate	1 000.0
Uranium (U)	0.2
Vanadium (V)	0.1
Zinc (Zn)	50.0
Total Dissolved Solids (TDS)	3000.0

1. 0.5 mg/L for sheep; 1.0 mg/L for cattle; 5.0 mg/L for swine and fowl.

Sources: Manitoba Agriculture, Food and Rural Initiatives; FAO, 2002

CONCLUSION

It is important to understand that an animal ingests a certain quantity of food on an "as-fed" basis, and the dry matter contained in that food is what provides the nutrients it needs (energy, protein, minerals and vitamins). Also, we must always remember that water is an essential nutrient, one to which producers must pay special attention.

BIBLIOGRAPHY

Deerfarmer.com. 2003. *Nutrition requirements for deer and elk* [online]. http://www.deer-library.com/artman/publish/article_117.shtml (accessed December 1, 2010).

FAO. 2002. *Agriculture drainage water management in arid and semi-arid areas* [online]. ftp://ftp.fao.org/agl/aglw/docs/idp61e.pdf (accessed April 1, 2011).

Manitoba Agriculture, Food and Rural Initiatives. *Evaluating water quality for livestock* [online]. http://www.gov.mb.ca/agriculture/livestock/nutrition/bza01s06.html (accessed March 31, 2011).

NRC. 2000. *Nutrient Requirements of Beef Cattle*. 7th Revised Edition (updated 2000). Washington, DC: National Research Council, The National Academies Press. 248 pp.

NRC. 1998. *Nutrient Requirements of Swine*. 10th Revised Edition. Washington, DC: National Research Council, The National Academies Press. 212 pp.

Saskatchewan Agriculture. 2000. *Basic Nutrition of Bison* [online]. http://www.agriculture.gov.sk.ca/Default.aspx?DN=a9cc6e39-55ae-4a69-8cc9-4e9f03cab44f (accessed December 1, 2010).

St-Pierre, N. and R. Bouchard. 1980. *Nouveaux concepts utilisés dans le calcul de la ration laitière*. Dairy Cattle Symposium. Conseil des productions animales du Québec. pp. 53–67.

Production Guide

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Feeding and Nutrition – Red Deer and Wapiti

CRAAQ

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INTRODUCTION

Deer are the ruminants that make up the family Cervidae, which includes several species, among them red deer and wapiti (often referred to as elk outside of Québec). They are raised primarily for meat and breeding stock, and to a lesser extent for hard-horn and velvet antlers. Some producers also raise deer specifically for hunting.

The species differ in size and feeding behaviour, and specific nutritional requirements must be met to ensure optimum breeding and growth. There are two basic principles of deer nutrition. First, as ruminants, deer mostly consume forage material, along with grain supplements. Second, feeding must be planned in keeping with seasonal reproductive patterns.

DIGESTIVE SYSTEM AND FEED INTAKE

There are many categories of herbivores. Most prefer grasses, others eat leaves, twigs and bark, and still others, like wapiti and red deer, are well adapted to a range of vegetable matter. Wapiti and red deer are able to digest plants with extremely high fibre content.

Rumen bacteria digest fibre and starch to produce volatile fatty acids (VFAs): acetic acid, propionic acid, and butyric acid. VFAs pass through the rumen walls, and are absorbed into the blood and converted into energy in the liver. Forage contains higher amounts of fibre than starch. Starch-rich grain increases VFA levels in the rumen. Premature introduction in feed may result in liver abscesses, rumen ulcers and acidosis.

SEASONAL PHYSIOLOGY

The metabolic rates and feed intake of deer and wapiti fluctuate seasonally. As the days get shorter, after the rut (in late fall and winter), metabolic rates slow by 40% to 60%. The slower metabolism leads to lower energy needs and therefore reduced feed intake, an adaptation to the lack of available food in the natural habitat. A decrease in winter weight is normal and even inevitable, sometimes in animals as young as 18 months. Rutting males (in the fall) stop feeding almost entirely. For these reasons, a well-planned annual feeding schedule is important to avoid excessive and potentially harmful weight loss. Underweight females will have more difficult gestations and lower conception rates. Also, feed costs will be higher for animals (whether male or female) that were underweight at the start of winter.

During the rutting period, weight loss of up to 30% is not unusual in dominant males; the weight is regained in spring. Voluntary Dry Matter Intake (VDMI) drops from approximately 2.5% of live weight to 1% during rutting season, and increases slightly to 1.6% in winter.

Red deer hinds and wapiti cows also go through seasonal fluctuations. The VDMI of gestating females increases to nearly 3% of live weight in the spring, not only as a response to the change of seasons, but also to the nutritional needs of the fetus, generally born in May or June. Excessive feeding of females in the winter, as an attempt to avoid complications during calving, is not recommended. Feeding that meets

maintenance requirements is sufficient. After calving, the nutritional requirements of females remain high – approximately 3.55% of live weight – to ensure adequate lactation. A decrease in the energy requirements of lactating females around July allows hinds and cows to regain weight. A consistent increase in body weight is necessary to return to estrus. Underweight females may risk lower conception rates. After mating, females will have until December to regain their ideal winter weight.

NUTRITIONAL NEEDS AND FEEDING

The nutritional needs of deer differ from those of other domestic ruminants (such as dairy cattle) in three ways. First, though deer and wapiti are selective and prefer higher-protein over fibrous food, they do have the ability to digest high-fibre foods, which are less digestible.

Second, their slower winter metabolic rate means any feed program must be based on two periods: the summer grazing season from May to October, and the farm-feeding winter months, from November to April. Winter feed consists particularly of forage, the nutritional value of which varies widely (Table 1). On-farm forage analyses are critical to ensure the needs of each operation are adequately met. During the summer, lactating females and breeding males, because of their higher energy needs, must be monitored closely. In the fall, preparations in anticipation of winter are essential.

Finally, deer are more sensitive than other ruminants (such as sheep) to copper (Cu) deficiencies. Rations with less than 5 ppm of Cu may have harmful consequences on the nervous system. Deer tolerate concentrations of copper up to 30 ppm. As well, because of the frequent selenium (Se) deficiencies seen in Québec soils, ration levels of Se should be monitored.

Tables 2 and 3 outline the nutritional values of various grains, by-products, fruits and vegetables that may be fed to deer.

Table 1. Sample nutritional value analysis – forages (100% DM)

Description	DM (%)	ME (Mcal/kg)	GP (%)	ADF Fibre (%)	Ca (%)	P (%)	Mg (%)	K (%)	S (%)	Fe (mg/kg)	Cu (mg/kg)	Se (mg/kg)	Zn (mg/kg)	Mn (mg/kg)	Co (mg/kg)
HAY															
Legumes 100%															
Green	88.1	2.29	21.1	30.3	1.60	0.35	0.32	2.56	0.33	213	10.0	0.20	26	49	0.65
Vegetative	88.1	2.16	18.7	34.0	1.33	0.29	0.28	2.45	0.31	207	9.0	0.20	24	46	0.65
Mature	88.1	2.03	16.4	37.5	1.04	0.25	0.20	2.38	0.23	250	9.0	0.20	24	44	0.65
Grain 100%															
Green	88.4	2.30	14.5	34.9	0.73	0.29	0.20	2.57	0.24	199	9.0	0.06	27	84	
Vegetative	88.4	2.18	12.3	37.5	0.58	0.23	0.19	2.13	0.24	194	9.0	0.06	25	72	
Mature	88.4	2.07	10.1	40.1	0.43	0.20	0.12	1.97	0.17	180	8.0	0.06	25	90	
Legumes 60%															
Green	88.1	2.33	19.1	32.0	1.37	0.34	0.30	2.41	0.20	167	10.0	0.15	24	58	
Vegetative	88.1	2.21	16.6	35.0	1.07	0.28	0.25	2.34	0.26	141	9.0	0.15	24	49	
Mature	88.1	2.08	14.2	38.3	0.83	0.24	0.18	2.23	0.26	141	8.0	0.15	24	43	
Grain 60%															
Green	88.3	2.17	16.5	36.0	1.03	0.32	0.26	2.83	0.28	117	9.0	0.09	25	53	
Vegetative	88.3	2.15	14.2	36.5	0.70	0.25	0.21	2.45	0.27	358	9.0	0.09	26	75	
Mature	88.0	2.03	11.8	39.5	0.56	0.22	0.14	2.09	0.29	124	8.0	0.09	24	74	
SILAGE															
Legumes 60%															
Green	40.0	2.34	19.9	31.8	1.44	0.35	0.30	2.95	0.32	279	11.0	0.17	36	70	
Vegetative	40.0	2.21	17.6	35.0	1.12	0.30	0.24	2.88	0.25	244	9.0	0.17	28	64	
Mature	40.0	2.09	15.2	38.0	0.90	0.26	0.18	2.77	0.26	339	9.0	0.17	29	66	
Grain 60%															
Green	38.0	2.33	18.2	32.0	1.22	0.34	0.27	2.88	0.27	234	9.0	0.11	27	74	
Vegetative	38.0	2.18	15.7	35.7	0.78	0.27	0.21	2.64	0.25	264	9.0	0.11	30	78	
Mature	38.0	2.05	13.2	39.0	0.64	0.24	0.15	2.50	0.34	241	9.0	0.11	28	73	
Corn	33.0	3.15	8.0	28.0	0.20	0.19		1.20	0.14	104	5.7	0.04	24	36	
PASTURE															
Grain	26.1	2.68	21.3	31.0	0.55	0.45	0.32	3.16	0.20				21		
Legumes	19.3	2.46	25.8	33.0	1.27	0.35	0.42	2.40	0.16				20		

Sources: NRC, 2000; CPAQ, 1997

DM = Dry Matter; ME = Metabolizable Energy; GP = Gross Protein; Ca = Calcium; P = Phosphorus; Mg = Magnesium; K = Potassium; S = Sulfur; Fe = Iron; Cu = Copper; Se = Selenium; Zn = Zinc; Mn = Manganese; Co = Cobalt

Table 2. Sample nutritional value analysis – grains and by-products (100% DM)

Description	DM	ME	GP	ADF Fibre	Ca	P	Mg	K	S	Fe	Cu	Se	Zn	Mn	Co	Mo
	(%)	(Mcal/kg)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
Oat																
Grain	89.20	2.78	13.6	14.0	0.01	0.41	0.16	0.51	0.21	94.1	8.6	0,24	40.8	40.3	0.06	1.70
Wheat																
Grain	90.2	3.18	14.2	4.2	0.05	0.44	0.13	0.40	0.14	45.1	6.48	0,05	38.1	36.6		0.12
Bran	89.0	2.53	17.4	14.0	0.14	1.27	0.63	1.37	0.24	163	14.2	0,57	110	134	108	
Flour by-product	89.3	2.50	18.7	11.7	0.17	1.01	0.40	181	0.19	170	12.6		102	124		2.10
Corn																
Grain, cracked	88.1	3.25	9.4	3.4	0.04	0.30	0.12	0.42	0.10	54	3.0	0,07	27	11		0.60
Grain, ground	88.1	3.25	9.1	3.4	0.04	0.30	0.12	0.42	0.10	54	3.0	0,07	27	11		0.60
Grain, flaked	88.1	3.25	9.4	3.4	0.04	0.30	0.12	0.42	0.10	54	3.0	0,07	27	11		0.60
Gluten	86.4	3.22	65.0	8.2	0.06	0.60	0.14	0.46	0.86	138	4.0	0,34	49	15		0.94
Ethanol by-product	90.2	3.18	29.7	19.7	0.22	0.83	0.33	1.10	0.44	178	8.0	0,39	65	27		1.80
Barley																
Grain	88.1	3.03	13.2	5.77	0.05	0.35	0.12	0.51	0.15	59.5	5.3		13	18.3	0.35	1.16
Soy																
Whole grain	86.4	3.40	40.3	11.1	0.27	0.65	0.27	2.01	0.35	182	14.6		59.0	345		3.98
Soymeal	90.9	3.04	51.8	7.0	0.46	0.73	0.32	2.42	0.46	277	19.1	0,46	68	48		6.67
Brewer's grain																
Dried	90.7	2.39	29.2	22.2	0,.0	0.67	0.26	0.50	0.38	224	11.0	1,06	85	45		
Wet	21.8	2.39	28.4	23.1	0.35	0.59	0.21	0.47	0.33	247	9.0	1,06	91	49		

DM = Dry Matter; ME = Metabolizable Energy; GP = Gross Protein;
Ca = Calcium; P = Phosphorus; Mg = Magnesium; K = Potassium; S = Sulfur; Fe = Iron; Cu = Copper; Se = Selenium; Zn = Zinc; Mn = Manganese; Co = Cobalt; Mo: Molybdenum
Sources : NRC, 2000; NRC, 2001

Table 3. Sample nutritional value analysis – fruits and vegetables

Description	DM (%)	ME[1] (Mcal/kg)	GP (%)	ADF Fibre (%)	Ca (%)	P (%)	Mg (%)	K (%)	Fe (mg/kg)
Vegetables									
Artichoke	13.0		17.5	20.7			0.06	0.35	12.50
Asparagus	7.0		19.9	12.4			0.01	0.20	7.77
Broccoli	10.0		31.2	14.6			0.02	0.32	6.52
Cabbage	9.0	3.04	20.6	10.4	0.64	0.35	0.02	0.25	5.41
Carrot	12.0	3.04	9.9		0.40	0.35	0.01	0.32	3.28
Cauliflower	6.0		26.5	17.2			0.02	0.30	3.77
Celery	5.0		17.2	12.6			0.01	0.26	2.50
Cucumber	4.0		16.8	15.5			0.01	0.14	3.57
Lettuce	4.0		21.9	13.1			0.01	0.14	3.45
Mushroom	7.0		31.0	10.6			0.01	0.31	5.56
Onion	10.0		9.1	7.4			0.01	0.14	2.44
Pea	12.0	2.68	30.8				0.02	0.17	10.00
Potato	23.0	2.93	9.5		0.04	0.24	0.03	0.54	10.98
Squash (butternut)	8.0		26.0	14.7			0.03	0.29	5.56
Squash (spaghetti)	11.0		17.2	24.2			0.01	0.12	3.66
Spinach	9.0		38.7	11.70			0.08	0.55	28.13
Sweet potato	33.0	2.93	5.0		0.10	0.15	0.02	0.38	6.58
Tomato	13.0	2.24	21.7				0.01	0.24	2.44
Zucchini	4.0		24.9	10.2			0.02	0.26	2.50
Fruits									
Apple	13.0		3.0	6.0				0.11	1.45
Banana	19.0		5.4	4.5			0.03	0.35	2.54
Cantaloupe	8.0		13.1	20.4			0.01	0.27	2.35
Grape (green)	16.0		3.6	1.8			0.01	0.19	4.00
Grape (red)	14.0		2.7	8.5			0.01	0.19	4.00
Grapefruit	15.0		4.8	6.1			0.01	0.13	0.81
Orange	16.0		6.0	7.1			0.01	0.18	0.76
Pear	13.0		3.7	8.1			0.01	0.12	1.81
Plum	10.0		6.1	3.6			0.01	0.16	1.52
Watermelon	7		7.8	9.9			0.01	0.11	2.50

1. The energy content of certain foods is not currently available in existing reference tables.
DM = Dry Matter; ME = Metabolizable Energy; GP = Gross Protein; Ca = Calcium; P = Phosphorus; Mg = Magnesium; K = Potassium; Fe = Iron
Sources: NRC, 2000; Health Canada, 2008

Breeding

A number of factors, including nutrition, affect reproductive performance and therefore profitability.

Females

The nutritional needs of red deer hinds and wapiti cows vary depending on their physiological stage (Tables 4 and 5).

More than two-thirds of birth weight is gained over the last 2 months of pregnancy. Hind/cow nutrition is crucial, especially because this period follows the end of winter, during which gestating females will have lost weight and fat stores. High-quality forage must be freely available, with mineral supplements added as necessary. Grain or meal can be introduced 2 weeks prior to calving, with quantities adjusted depending on the nutritional value of forage. Development of a nutrition program by a qualified professional is key in establishing the specific needs of each operation.

Lactation begins immediately after calving. At this stage, the nutritional requirements of hinds and cows are at their highest, all the more so because the milk of these species is richer than that of other ruminants. Despite adequate feed and abundant pastures, females may lose weight at the start of lactation. Excessive weight loss will delay the return to estrus. Calves should ideally be weaned prior to the rut, to allow females to recover from the stress of weaning and restore good body condition. Excessive weight loss during the winter and at the start of lactation will result in reduced fertility. Lactating females should have access to the highest quality pasture and forage, with supplemental feed as necessary. Flushing is also recommended for adult breeding stock (male and female) 6 to 8 weeks prior to mating; this high-energy, high-protein concentrated intake improves conception rates and gets the younger animals used to eating feed, which reduces weaning stress.

During the winter, minimal fetal needs mean lower appetites in gestating females. Except in cases of excessive weight loss, maintenance feeding is sufficient. High-quality forage should be made freely available.

Replacement females

Replacement females especially require fine-tuned nutrition programs. Reproductive maturity is determined by weight rather than age. Rapid growth will lead to early reproduction, and therefore to increased productivity and profitability. As in most ruminants, females are considered sexually mature once they have reached at least 66% of their adult weight. The ideal conception weight is 75% of adult weight. As a general rule, females are ready for mating at 2 years of age.

The nutritional needs of replacement females are greater (maintenance, growth, gestation and lactation) during their first gestation and lactation, because they are still growing. High-quality forage should be freely available. Underweight females will be unable to conceive.

Males

The nutritional requirements of breeding males increase seasonally (Tables 4 and 5), notably during rutting season.

Males are generally fed medium-quality forage-based maintenance rations. Males should be neither overweight (which could cause low libido and fertility, limb and liver problems) nor underweight (which could cause a lack of energy during the rut). In late summer, during the rut, stags have increased nutritional requirements but lower appetites due to mating-related activities. As with hinds/cows, it is recommended that males be flushed 6 to 8 weeks prior to the mating period, taking care to avoid excessive fat accumulation. Males may lose up to 30% of their live weight during the mating period. Following mating, high-quality forage with 500 g/day of supplemental feed will allow males to recover body condition before winter.

Antler growth begins in spring, when testosterone levels are at their lowest, and continues all through summer. Once the antlers have hardened, testosterone levels once again begin to rise, and the rut begins. Antler growth does not entail significant nutritional requirements, although underfed animals will produce smaller, lower-quality antlers. Animals suffering from mineral imbalances or calcium and phosphorus deficiencies may also draw the required elements from bone mass.

Velvet antler harvesting, in May and June, involves cutting the antlers. Wapiti antlers should be harvested after reaching 55% of their total size (approximately 60 to 80 days of growth), at which point they will weigh from 3 to 15 kg, depending on the animal's age. Red deer antlers should be harvested at the same growth stage (after approximately 50 to 60 days), when they will weigh from 1 to 8 kilograms.

Table 4. Energy, protein, mineral and vitamin requirements of red deer (est.)

Age	VDMI (% LW)	ME (Mcal/d)	GP (%)	Ca (%)	P (%)	Mg (%)	K (%)	S (%)	Fe (ppm)	Cu (ppm)	Se (ppm)	Zn (ppm)	Mn (ppm)	Co (ppm)	Vit. A (IU/kg)	Vit. D (IU/kg)	Vit. E (IU/kg)
Females																	
3-6 months	2.1	11.2	20	0.60	0.30	0.20	0.65	0.50	50	15	0.20	50	40	0.10	4000	800	30
6-12 months	1.9	7.1	16	0.60	0.30	0.20	0.65	0.50	50	15	0.20	50	40	0.10	4000	800	30
12-18 months	1.9	8.1	14	0.50	0.30	0.20	0.65	0.50	50	15	0.20	50	40	0.10	3000	600	30
Pre-reproduction (Sept.-Oct.)	2.0	7.1	10	0.50	0.40	0.20	0.65	0.50	50	15	0.20	50	40	0.10	3000	600	30
End of gestation (April-May)	2.1	7.1	14	0.50	0.40	0.20	0.65	0.50	50	15	0.20	50	40	0.10	5000	1000	40
Lactation (June-Aug.)	3.0	8.7	15	0.65	0.40	0.20	1.00	0.50	50	15	0.20	50	40	0.20	5000	1000	40
Maintenance (winter)	1.8	4.3	8	0.35	0.25	0.20	0.65	0.50	50	15	0.20	50	40	0.10	3000	600	30
Maintenance (summer)	1.9	5.5	10	0.35	0.25	0.20	0.65	0.50	50	15	0.20	50	40	0.10	3000	600	30
Mâles																	
3-6 months	2.0	11.2	20	0.60	0.30	0.20	0.65	0.50	50	15	0.20	50	40	0.10	4000	800	30
6-12 months	1.9	7.1	16	0.60	0.30	0.20	0.65	0.50	50	15	0.20	50	40	0.10	4000	800	30
12-18 months	1.7	8.1	14	0.50	0.30	0.20	0.65	0.50	50	15	0.20	50	40	0.10	3000	600	30
Antler growth	1.8	11.2	8-10	0.70	0.40	0.40	1.00	0.50	50	15	0.20	50	40	0.20	5000	1000	40
Maintenance (winter)	1.8	8.7	6	0.35	0.25	0.20	0.65	0.50	50	15	0.20	50	40	0.10	3000	600	30
Maintenance (summer)	1.8	11.2	9	0.35	0.25	0.20	0.65	0.50	50	15	0.20	50	40	0.10	3000	600	30

VDMI = Voluntary Dry Matter Intake; LW = Live Weight; ME = Metabolizable Energy; GP = Gross Protein; Ca = Calcium; P = Phosphorus; Mg = Magnesium; K = Potassium; S = Sulfur; Fe = Iron; Cu = Copper; Se = Selenium; Zn = Zinc; Mn = Manganese; Co = Cobalt; ppm = Parts Per Million; IU = International Unit

Adapted from Saskatchewan Agriculture, 2008; NRC, 2007; Wapiti.net, 2000; CPAQ, 1997

Table 5. Energy, protein, mineral and vitamin requirements of wapiti (est.)

Age	VDMI (% LW)	ME (Mcal/d)	GP (%)	Ca (%)	P (%)	Mg (%)	K (%)	S (%)	Fe (ppm)	Cu (ppm)	Se (ppm)	Zn (ppm)	Mn (ppm)	Co (ppm)	Vit. A (IU/kg)	Vit. D (IU/kg)	Vit. E (IU/kg)
Females																	
3-6 months	2.1	11.2	20	0.60	0.30	0.20	0.65	0.50	50	15	0.20	50	40	0.10	4000	800	30
6-12 months	1.9	7.1	16	0.60	0.30	0.20	0.65	0.50	50	15	0.20	50	40	0.10	4000	800	30
12-18 months	1.9	8.1	14	0.50	0.30	0.20	0.65	0.50	50	15	0.20	50	40	0.10	3000	600	30
Pre-reproduction (Sept.-Oct.)	1.8	10.5	9	0.50	0.40	0.20	0.65	0.50	50	15	0.20	50	40	0.10	3000	600	30
End of gestation (April-May)	1.7	12.8	14	0.50	0.40	0.20	0.65	0.50	50	15	0.20	50	40	0.10	5000	1000	40
Lactation (June-Aug.)	3.0	15.5	16	0.65	0.40	0.20	1.00	0.50	50	15	0.20	50	40	0.20	5000	1000	40
Maintenance (winter)	1.8	8.2	6	0.35	0.25	0.20	0.65	0.50	50	15	0.20	50	40	0.10	3000	600	30
Maintenance (summer)	1.8	10.5	9	0.35	0.25	0.20	0.65	0.50	50	15	0.20	50	40	0.10	3000	600	30
Mâles																	
3-6 months	2.0	11.2	20	0.60	0.30	0.20	0.65	0.50	50	15	0.20	50	40	0.10	4000	800	30
6-12 months	1.9	7.1	16	0.60	0.30	0.20	0.65	0.50	50	15	0.20	50	40	0.10	4000	800	30
12-18 months	1.7	8.1	14	0.50	0.30	0.20	0.65	0.50	50	15	0.20	50	40	0.10	3000	600	30
Antler growth	1.8	11.2	8-10	0.70	0.40	0.40	1.00	0.50	50	15	0.20	50	40	0.20	5000	1000	40
Maintenance (winter)	1.6	12.1	6	0.35	0.25	0.20	0.65	0.50	50	15	0.20	50	40	0.10	3000	600	30
Maintenance (summer)	2.0	15.5	7	0.35	0.25	0.20	0.65	0.50	50	15	0.20	50	40	0.10	3000	600	30

VDMI = Voluntary Dry Matter Intake; LW = Live Weight; ME = Metabolizable Energy; GP = Gross Protein; Ca = Calcium; P = Phosphorus; Mg = Magnesium; K = Potassium; S = Sulfur; Fe = Iron; Cu = Copper; Se = Selenium; Zn = Zinc; Mn = Manganese; Co = Cobalt; ppm = Parts Per Million; IU = International Unit

Adapted from Saskatchewan Agriculture, 2008; NRC, 2007; Wapiti.net, 2000; CPAQ, 1997

Meat production

Breeding stock and game meat (venison) are the main commercial products of deer farming. The nutritional requirements of animals raised for meat production are different from those of animals raised as breeding stock, so they must be kept separate.

Animals destined for meat production are fed on the basis of target slaughter weights at different ages. In Québec, red deer and wapiti are usually slaughtered at 6 to 26 months, with live weights varying from 90 kg to 136 kg for red deer, and 90 kg to 250 kg for wapiti. Producers should exercise caution in providing supplemental feeding: since deer are sensitive to acidosis, concentrates should be added gradually.

Feed for breeding stock should be less rich, since excessive feeding can be harmful to both males and females (causing low libido and fertility, limb and liver problems).

Offspring

The first few hours after birth are critical. Colostrum (the first maternal secretion) is essential to the survival of newborn fawns and calves, providing the first antibodies for their immune systems, since no antibodies are transmitted from the mother: at birth, offspring lack any immune protection. In the 6 hours after calving, newborns should consume the equivalent of at least 5% of their live birth weight in colostrum. After this initial period, the mother's colostrum production and the ability of the offspring's intestine to absorb antibodies are significantly reduced. Frozen cow colostrum may also be fed to newborns in the event of the mother's death or if her milk does not come in. The colostrum should be thawed at room temperature (never in the microwave, which would deactivate the antibodies). Bottle-fed newborns' defecation reflex must be artificially stimulated by massaging the edge of the rectum with a wet towel. Meconium (first feces) should be evacuated in the first few hours following birth.

A few months after birth, creep feeding may be introduced. It has been found that offspring with exclusive access to feed designed for their needs will show better growth and undergo less weaning stress. Creep feeding is best introduced as early as possible, at least 3 to 4 weeks prior to weaning, to reduce weaning stress.

Fawns and calves may be weaned before or after the rutting season. High-quality forage and concentrates should be freely available, to maintain growth in spite of stress in deer that were weaned before the rut.

CONCLUSION

Annual nutrition planning must take into account the time of year and whether the animals are intended for meat or breeding. Quality forage is the foundation of cervid nutrition, and supplemental feed should only be used in particular situations.

A qualified agronomist can prepare a nutrition program adapted to each physiological stage, based on an analysis of the available forage.

BIBLIOGRAPHY

CPAQ. 1997. *Le Cerf rouge: Guide d'élevage*. Conseil des productions animales du Québec. 131 pp.

Deerfarmer.com. 2003. *Nutrition requirements for deer and elk* [online]. http://www.deer-library.com/artman/publish/article_117.shtml (accessed December 1, 2010).

Health Canada. 2008. *Nutrient Value of Some Common Foods*. Ottawa: Publications – Health Canada. 66 pp.

Kime, L.F., R.S. Burry and J.K. Harper. 2007. *Elk Production* [online]. Agricultural Alternatives series. Penn State College of Agricultural Sciences, and U.S. Department of Agriculture. http://agalternatives.aers.psu.edu/Publications/elk.pdf (accessed June 22, 2011).

NRC. 2000. *Nutrient Requirement of Beef Cattle.* 7th Edition. Washington, DC: National Research Council, The National Academies Press. 248 pp.

NRC. 2001. *Nutrient Requirements of Dairy Cattle.* 7th Edition. Washington, DC: National Research Council, The National Academies Press. 408 pp.

NRC. 2007. *Nutrient Requirements of Small Ruminants: Sheep, Goats, Cervids and New World Camelids*. Washington, DC: National Research Council, The National Academies Press. 384 pp.

Saskatchewan Agriculture. 2008. *Pasture and Forages for Wapiti* [online]. http://www.agriculture.gov.sk.ca/Default.aspx?DN=8828aef0-6983-42fb-89df-159699b2c7da (accessed December 1, 2010).

Saskatchewan Agriculture. 2008. *Pasture and Forage for White-Tailed Deer* [online]. http://www.agriculture.gov.sk.ca/Default.aspx?DN=93f55328-8b9c-43eb-871e-1c603d2cf8e4 (accessed December 1, 2010).

Shaffer, D., L.F. Kime and J.K. Harper. 2005. *Red Deer Production* [online]. Agricultural Alternatives series. Penn State College of Agricultural Sciences, and U.S. Department of Agriculture. http://agalternatives.aers.psu.edu/Publications/reddeer.pdf (access June 22, 2011).

Wapiti.net. 2000. *Health and Feeding Needs for Wapiti* [online]. http://www.wapiti.net/feed.cfm (accessed January 10, 2011).

Westendorf, M.L. and B. Altizio. 2000. *Deer and Elk Farming*. Rutgers Cooperative Extension, New Jersey Agricultural Experiment Station. New Brunswick, NJ: Rutgers University.

Production Guide

DOMESTIC GAME FARM ANIMALS

Feeding and Nutrition – Bison

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INTRODUCTION

Bison are ruminants raised for meat production. The species is known for its considerable energy efficiency and its ability to survive in difficult conditions. Basic survival does not lead to productivity or profitability, however. Specific nutritional requirements must be met to ensure optimum breeding and growth. There are two basic principles of bison nutrition. First, since bison are ruminants they mostly consume forage material, with grain supplements. Second, feeding must be planned around unavoidable periods of weight loss.

DIGESTIVE SYSTEM AND FEED INTAKE

Like all ruminants, the bison has a 4-compartment stomach. Bison, however, have unusually large rumens (accounting for nearly 25% of live weight), which retain food for long periods of time. As well, the orifice between the rumen and the omasum is small, and fibre therefore moves more slowly through the digestive system. These anatomical peculiarities entail a different feeding behaviour, consisting of 4 to 9 large meals per day, and account for the animal's energy efficiency (Table 1).

Table 1. Comparison of total digestive system forage retention time and dry matter digestibility in cattle and bison

	Bison	Cattle
Total retention time in the digestive system (hours)	78.8	68.7
Dry Matter Digestibility (%)		
- Hay sedge (carex)	64	58
- Grass hay	74	62
- Alfalfa and bromegrass hay	50	52

Source: Feist, 2000

Rumen bacteria digest fibre and starch to produce volatile fatty acids (VFAs): acetic acid, propionic acid, and butyric acid. VFAs pass through the rumen walls, and are absorbed into the blood and converted into energy in the liver. Forage contains higher amounts of fibre than starch. Starch-rich grain increases VFA levels in the rumen. The premature introduction of grain in feed may result in liver abscesses, rumen ulcers and acidosis.

SEASONAL PHYSIOLOGY

The metabolic rates and feed intake of bison fluctuate seasonally. As the days get shorter, in late fall and winter, metabolic rates slow significantly. The slower metabolism means reduced energy needs and therefore reduced feed intake, an adaptation to the lack of available food in the natural habitat. A decrease in winter weight is normal and even inevitable, sometimes in animals as young as 18 months. For these reasons, a well-planned annual feeding schedule is important to avoid potentially harmful weight loss.

Underweight females will have lower conception rates and be less likely to have successful pregnancies. Also, feed costs will be higher for animals (both male and female) that were underweight at the start of winter.

During the mating season (late July to early October), weight loss of 10% to 15% is not uncommon in bison bulls. High-energy nutritional supplementation prior to the mating season is a sound nutritional strategy to avoid excessive weight loss. Bulls with good body condition at the start of the mating period will regain weight more easily before winter. Without adequate nutrition and pre-winter conditioning, an adult bison can lose from 10% to 20% of pre-winter weight between December and April, a decrease of one body-condition point on a scale of 1 to 5. A drop from 3 or 3.5 to 2 or 2.5 over the winter is considered normal. Voluntary Dry Matter Intake (VDMI) drops from approximately 2.5% of live weight in the fall to approximately 1.6% in winter.

Weight loss of over 20% in pregnant bison cows increases the risk of abortion, still birth, or low birth weight. Metabolism increases as the days lengthen in spring. The VDMI of gestating females increases to nearly 3% of live weight in the spring, not only as a response to the change of seasons but also to the nutritional needs of the fetus, generally born between April and June. After calving, the female maintains a high feed intake to ensure adequate lactation. A decrease in the energy requirements of lactating females around July allows them to regain weight. A consistent increase in body weight is necessary to return to estrus. August mating is ideal, for births the following May. Underweight or overweight females tend to have lower conception rates. After mating, females will have until November or December, depending on the year, to regain their ideal winter weight.

NUTRITIONAL NEEDS AND FEEDING

The nutritional needs of bison are similar to those of beef cattle, with two notable distinctions: the bison's considerable energy efficiency and its seasonal (winter) metabolic decrease.

There are two key periods around which a nutritional program should be planned: the summer grazing season (mid-May to mid-September), followed by the farm-feeding winter months, which to protect pastures should extend from mid-September to mid-May. Winter feed is mostly forage, but its nutritional value can vary widely (Table 2). To meet the needs of a given farm, it is critical to have an analysis done of the forages available at that farm.

In the summer, lactating females and breeding males should be monitored closely, for their energy needs are higher. In the fall, preparations for winter are essential. It is also important to consider the different requirements of each group: breeding animals, meat bison, growing calves, etc.

Table 2. Sample nutritional value analysis – forages (100% DM)

Description	DM	NEm	NEg	GP	ADF Fibre	Ca	P	Mg	K	S	Fe	Cu	Se	Zn	Mn	Co
	(%)	(Mcal/kg)	(Mcal/kg)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
HAY																
Legumes 100%																
Green	88.1	1.41	0.83	21.1	30.3	1.60	0.35	0.32	2.56	0.33	213	10,0	0,20	26	49	0.65
Vegetative	88.1	1.30	0.73	18.7	34.0	1.33	0.29	0.28	2.45	0.31	207	9,0	0,20	24	46	0.65
Mature	88.1	1.16	0.60	16.4	37.5	1.04	0.25	0.20	2.38	0.23	250	9,0	0,20	24	44	0.65
Grain 100%																
Green	88.4	1.31	0.74	14.5	34.9	0.73	0.29	0.20	2.57	0.24	199	9,0	0,06	27	84	
Vegetative	88.4	1.32	0.75	12.3	37.5	0.58	0.23	0.19	2.13	0.24	194	9,0	0,06	25	72	
Mature	88.4	0.95	0.40	10.1	40.1	0.43	0.20	0.12	1.97	0.17	180	8,0	0,06	25	90	
Legumes 60%																
Green	88.1	1.37	0.80	19.1	32.0	1.37	0.34	0.30	2.41	0.20	167	10,0	0,15	24	58	
Vegetative	88.1	1.35	0.77	16.6	35.0	1.07	0.28	0.25	2.34	0.26	141	9,0	0,15	24	49	
Mature	88.1	1.13	0.57	14.2	38.3	0.83	0.24	0.18	2.23	0.26	141	8,0	0,15	24	43	
Grain 60%																
Green	88.3	1.35	0.77	16.5	36.0	1.03	0.32	0.26	2.83	0.28	117	9,0	0,09	25	53	
Vegetative	88.3	1.20	0.64	14.2	36.5	0.70	0.25	0.21	2.45	0.27	358	9,0	0,09	26	75	
Mature	88.0	1.05	0.49	11.8	39.5	0.56	0.22	0.14	2.09	0.29	124	8,0	0,09	24	74	
SILAGE																
Legumes 60%																
Green	40.0	1.39	0.81	19.9	31.8	1.44	0.35	0.30	2.95	0.32	279	11,0	0,17	36	70	
Vegetative	40.0	1.26	0.69	17.6	35.0	1.12	0.30	0.24	2.88	0.25	244	9,0	0,17	28	64	
Mature	40.0	1.12	0.56	15.2	38.0	0.90	0.26	0.18	2.77	0.26	339	9,0	0,17	29	66	
Grain 60%																
Green	38.0	1.38	0.80	18.2	32.0	1.22	0.34	0.27	2.88	0.27	234	9,0	0,11	27	74	
Vegetative	38.0	1.23	0.66	15.7	35.7	0.78	0.27	0.21	2.64	0.25	264	9,0	0,11	30	78	
Mature	38.0	1.07	0.52	13.2	39.0	0.64	0.24	0.15	2.50	0.34	241	9,0	0,11	28	73	
Corn	33.0	1.60	0.90	8.0	28.0	0.20	0.19	--	1.20	0.14	104	5,7	0,04	24	36	
PASTURE																
Grain	26.1	1.76	1.14	21.3	31.0	0.55	0.45	0.32	3.16	0.20				21		
Legumes	19.3	1.57	0.97	25.8	33.0	1.27	0.35	0.42	2.40	0.16				20		

Source : NRC, 2000

DM = Dry Matter; NEm = Net Energy for Maintenance; NEg = Net Energy for Gain; GP = Gross Protein; Ca = Calcium; P = Phosphorus; Mg = Magnesium; K = Potassium; S = Sulfur; Fe = Iron; Cu = Copper; Se = Selenium; Zn = Zinc; Mn = Manganese; Co = Cobalt.

Breeding

A number of factors, including nutrition, affect reproductive performance and therefore profitability.

Females

The nutritional needs of bison cows vary depending on their physiological stage (Table 3).

More than two-thirds of birth weight is gained over the last 2 months of pregnancy. Good nutrition during this period is crucial, especially because it follows the end of winter, during which gestating females will have lost weight and fat stores. High-quality forage must be freely available, with mineral supplements added as necessary. Grain or meal can be introduced in the last 6 weeks prior to calving if necessary, otherwise 2 weeks prior to calving.

Lactation begins immediately after calving. At this stage, the nutritional requirements of females are at their greatest. Despite adequate feed and abundant pastures, bison cows may lose weight at the start of lactation. Excessive weight loss will delay calf growth and return to estrus. In order to produce one calf per year, mating must take place in the 3 months after calving. Excessive weight loss during the winter and at the start of lactation will result in reduced fertility. Lactating females should have access to the highest quality pasture and forage, with supplemental feed as necessary. Flushing is also recommended for adult breeding stock (male and female) 6 to 8 weeks prior to mating; this high-energy, high-protein concentrated intake improves conception rates.

In early pregnancy, minimal fetal needs lead to decreased milk production, which can negatively affect the growth of unweaned calves. Creep feeding can ease the weaning process and reduce the cow's efforts to meet her calf's needs. Creep feeding consists of providing exclusive access to feed that is specifically for the calves, such as commercial meal or grain. Barring excessive weight loss, maintenance feed should be sufficient for the mothers. The best period to allow bison cows to recover body condition is during weaning (in November), when the demands of gestation are still low and when food intake has not yet diminished in anticipation of winter.

Replacement heifers

Replacement heifers especially require fine-tuned nutrition programs. Reproductive maturity is determined by weight rather than age. Rapid growth will lead to early reproduction and therefore to increased productivity and profitability. As in most ruminants, female bison are considered sexually mature when they have reached at least 66% of their adult weight. The ideal conception weight is 75% of adult weight. As a general rule, they are ready for mating at 2 years of age.

The nutritional needs of replacement females are greater (maintenance, growth, gestation and lactation) during their first gestation and lactation, because they are still growing. High-quality forage should be freely available. An underweight cow will be infertile or less fertile and may not reach her target adult weight. From 6 months to 1 year, rations are generally supplemented with 1 to 2 kg/day of commercial meal or grain. From 1 year of age, the cow is able to consume sufficient forage to meet her own needs (Table 3), as long as there is enough pasture forage. Good pasture management is therefore important.

The height of plant cover should be monitored to determine when to move the animals into a pasture. The growth stage of the plants will have a significant effect on pasture productivity over the course of the season. If pasture is grazed before the 2-leaf stage, root reserves will be destroyed, which will slow future growth. Letting pastures get a good start early in the season will make them more productive for the rest of the year.

To ensure enough plant cover for rapid re-growth, plant height should be maintained at around 7.5 to 10 cm. It takes about 5 days for plants to start growing again after they have been grazed. This corresponds to the amount of time pastures should be given for maintaining reserves and a healthy growth rate, whence the importance of pasture rotation. By moving the herd every 5 days at least, producers can be sure their pastures will remain productive for longer periods.

Males

The nutritional requirements of breeding bulls increase seasonally (Tables 4 and 5), notably during rutting season.

Bull bison are generally fed medium-quality forage-based maintenance rations. The bulls should neither be overweight (low libido and fertility, limb and liver problems) nor underweight (lack of energy during the rut). In late summer, during the rut, the nutritional requirements of breeding stock increase. As with bison cows, it is recommended that the bulls be flushed 6 to 8 weeks prior to the mating period. High-quality forage with 500 g/day of supplemental feed will meet the increased nutritional requirements of bulls before and throughout the mating period.

Vitamin A is important for sperm quality. Pasture and green forage naturally contain vitamin A, but amounts diminish drastically in preserved forage such as hay. If the basic feed does not fully meet nutritional requirements, mineral blocks containing vitamin A should be used, or vitamin A supplements added to feed. The same is true for other vitamins and minerals such as selenium. On-farm forage analyses are recommended to ensure adequate vitamin and mineral supplementation.

Table 3. Energy, protein, mineral and vitamin requirements of breeding bison (est.)

Age	VDMI (% LW)	NEm (Mcal/d)	TN[1] (Mcal/d)	GP (%)	Ca (%)	P (%)	Mg (%)	K (%)	S (%)	Fe (mg/kg)	Cu (mg/kg)	Se (mg/kg)	Zn (mg/kg)	Mn (mg/kg)	Co (mg/kg)	Vit. A (IU/kg)	Vit. D (IU/kg)	Vit. E (IU/kg)
Females																		
6 months-1 year	2.0-3.0	2.44-4.1	3.44-5.78	12-14	0.70	0.65	0.10	0.4-0.6	0.15	50	10	0.10	30	20	0.10	2200	275	50
1 year	2.0-2.5	4.1-5.55	5.37-7.27	10-12	0.70	0.65	0.10	0.4-0.6	0.15	50	10	0.10	30	20	0.10	2200	275	50
1.5 year	1.8-2.2	5.55-5.98	7.27-8.31	10-12	0.50	0.45	0.10	0.4-0.6	0.15	50	10	0.10	30	20	0.10	2200	275	50
2 years	1.6-2.2	6.77-6.89	9.03-10.55	10-12	0.45	0.40	0.12	0.5-0.7	0.15	50	10	0.10	30	20	0.10	2800	275	50
2.5 years	1.6-2.2	7.23-7.52	9.85-15.35	6-7	0.35	0.25	0.12	0.5-0.7	0.15	50	10	0.10	30	20	0.10	2800	275	50
End of gestation (April-May)	2.0-2.5	8.54	10.62-13.91	8-10	0.40	0.35	0.12	0.5-0.7	0.15	50	10	0.10	30	20	0.10	2800	275	50
Lactation (May-November)	2.5-3.0	10.25	15.03-12.64	8-10	0.40	0.35	0.20	0.80	0.15	50	10	0.10	30	20	0.10	3900	275	50
Maturity (maintenance)	1.6-1.8	8.54-10.25	8.54-10.25	8	0.35	0.25	0.10	0.4-0.6	0.15	50	10	0.10	30	20	0.10	2200	275	50
Males																		
6 months-1 year	2.0-3.0	2.44-4.1	3.44-5.78	12-14	0.70	0.65	0.10	0.4-0.6	0.15	50	10	0.10	30	20	0.10	2200	275	50
1 year	2.0-2.5	4.1-5.55	5.37-7.27	10-12	0.70	0.65	0.10	0.4-0.6	0.15	50	10	0.10	30	20	0.10	2200	275	50
1.5 year	1.8-2.2	6.38-7.92	8.1-10.05	10-12	0.50	0.45	0.10	0.4-0.6	0.15	50	10	0.10	30	20	0.10	2200	275	50
2 years	1.6-2.2	9.36-10.73	11.88-13.62	10-12	0.45	0.40	0.10	0.4-0.6	0.15	50	10	0.10	30	20	0.10	2200	275	50
2.5 years	1.6-2.2	12.05-13.32	15.3-16.91	8	0.35	0.25	0.10	0.4-0.6	0.15	50	10	0.10	30	20	0.10	2200	275	50
Maturity (maintenance)	1.6-1.8	13.32	13.32	8	0.35	0.25	0.10	0.4-0.6	0.15	50	10	0.10	30	20	0.10	2200	275	50

1. TN = NEm + NEg = Net Energy for Gain
VDMI = Voluntary Dry Matter Intake; LW = Live Weight; NEm = Net Energy for Maintenance; TN = Total Net Energy; GP = Gross Protein; Ca = Calcium; P = Phosphorus; Mg = Magnesium; K = Potassium; S = Sulfur; Fe = Iron; Cu = Copper; Se = Selenium; Zn = Zinc; Mn = Manganese; Co = Cobalt
Adapted from Feist, 2000 and NRC, 2000

Meat production

Bison should be slaughtered at approximately 575 kg for a carcass yield of 275 kg, the average yield ranging from 53% to 56% of live weight. Bison generally reach their slaughter weight at 18 to 22 months. The younger the animal, the better (more tender) the meat. It is generally recommended that rations with 75% grain be fed for the 100-day period preceding slaughter, for fat coverage and marbling.

For maximum meat production, bison should be exposed to as little stress as possible during finishing. It is recommended that animals be housed in a building that has been cleaned and kept free of other animals for several days. This all-in/all-out approach allows for better hygiene and better management of the groups and their environment. With optimal nutrition, bison can achieve weight-gain targets of 350 g per day at the age of 6 months, and up to 450 g to 500 g per day at 2 years.

The nutritional requirements of meat bison are outlined in Table 4.

Table 4. Energy, protein, mineral and vitamin requirements of meat bison (est.)

Weight (kg)	VDMI (% LW)	NEm (Mcal/d)	TN (Mcal/d)	GP (%)	Ca (%)	P (%)	Mg (%)	K (%)	S (%)	Fe (mg/kg)	Cu (mg/kg)	Se (mg/kg)	Zn (mg/kg)	Mn (mg/kg)	Co (mg/kg)	Vit. A (IU/kg)	Vit. D (IU/kg)	Vit. E (IU/kg)
200	2.45	4.10	1.27	12-14	0.40	0.25	0.1	0.4-0.6	0.15	50	10	0.1	30	20	0.1	2200	275	50
250	2.32	4.84	1.50	12-14	0.35	0.20	0.1	0.4-0.6	0.15	50	10	0.1	30	20	0.1	2200	275	50
300	2.20	5.55	1.72	12-14	0.30	0.20	0.1	0.4-0.6	0.15	50	10	0.1	30	20	0.1	2200	275	50
350	2.14	6.23	1.90	12-14	0.30	0.15	0.1	0.4-0.6	0.15	50	10	0.1	30	20	0.1	2200	275	50
400	2.05	6.89	2.14	10-12	0.25	0.15	0.1	0.4-0.6	0.15	50	10	0.1	30	20	0.1	2200	275	50
450	2.00	7.52	2.33	10-12	0.25	0.15	0.1	0.4-0.6	0.15	50	10	0.1	30	20	0.1	2200	275	50

VDMI = Voluntary Dry Matter Intake; LW = Live Weight; NEm = Net Energy for Maintenance; TN = Total Net Energy GP = Gross Protein; Ca = Calcium; P = Phosphorus; Mg = Magnesium; K = Potassium; S = Sulfur; Fe = Iron; Cu = Copper; Se = Selenium; Zn = Zinc; Mn = Manganese; Co = Cobalt

Adapted from Feist, 2000 and NRC, 2000

Calves

The first few hours following birth are critical. Since no antibodies are transmitted from the mother, newborns start out with no immune protection. Colostrum (the first maternal secretion) is therefore essential to the survival of newborn calves, providing the first antibodies for their immune systems. In the 6 hours after calving, newborns should consume the equivalent of at least 5% of their live birth weight of colostrum. After this initial period, the mother's colostrum production and the ability of the newborn's intestine to absorb antibodies are significantly reduced. Extremely maternal heifers can be dangerous to humans who try to approach their young, so if the calf is too weak to drink the colostrum, it should be isolated if one hopes to bottle-feed it colostrum.

Frozen bovine colostrum may also be fed to newborn bison in the event of the mother's death or if her milk does not come in. The colostrum should be thawed at room temperature (never in the microwave, which would deactivate the antibodies). Bottle-fed newborns' defecation reflex must be artificially stimulated by massaging the edge of the rectum with a wet towel. Meconium (first feces) should be evacuated in the first few hours following birth.

A few months following birth, creep feeding may be introduced. It has been found that calves with exclusive access to feed that is specifically for them will show better growth and undergo less weaning stress. Creep feeding is best introduced as early as possible, at least 3 to 8 weeks prior to weaning, to reduce weaning stress. Creep feeding can be introduced during flushing, while the adults are being conditioned for mating. Producers who prefer not to use concentrates can let the calves graze in a pasture reserved for their use. When they are not in competition with adults the calves will be more selective, eating only nutrient-rich plants.

Calves are weaned in November. The process of tagging and providing veterinary care is a good opportunity to separate calves from their mothers. Because of the heifers' strong maternal instinct, the calves should be moved to where they cannot be seen, smelled or heard by their mothers. To facilitate the provision of tailored nutritional programs, and to avoid competition, the calves should be grouped according to weight and sex.

CONCLUSION

Annual nutrition planning must take into account the time of year and whether the animals are intended for meat or breeding (Table 5). Quality forage is the foundation of bison nutrition, and supplemental feed should only be used in particular situations.

A qualified agronomist can prepare a nutrition program adapted to each physiological stage, based on an analysis of the available forage.

Table 5. Bison nutrition by development stage and season for meat production and breeding stock

	Feed	Additional Information
Pre-weaned calves	Creep feeding	Commercial meal or grain
Calves	High-quality forage 1 to 2 kg supplemental feed/day (commercial meal or grain)	Separated by weight and sex for profitability; can gain weight even in winter if adequately fed
May	Pasture	Pasture rotation required
Finishing pen	High-quality forage ration containing 75% grain (100 days prior to slaughter)	Slaughter expected at 18 to 22 months for carcass weight of approx. 275 kg
Second winter Replacement heifers (1 ½ to 2 years)	High-quality forage	Conception at 75% of adult weight (approx. 2 years)
Breeding bulls	Good forage Supplemental feed (grain or meal) if necessary (1-2 kg/day)	Assess body condition Flush 6 to 8 weeks prior to mating
Heifers	Good forage Mineral supplement as needed Supplemental feed (grain or meal) in late gestation (2 to 6 weeks prior to calving)	Assess body condition Flush 6 to 8 weeks prior to mating

BIBLIOGRAPHY

Bison Producers of Alberta. 2000. *Feeding Bison Bulls for Meat* [online]. http://www.bisoncentre.com/index.php?option=com_content&view=article&id=299&Itemid=148 (accessed December 1, 2010).

Feist, M. 2000. *Basic Nutrition of Bison*. Saskatchewan Agriculture. 20 pp.

Kyle, J. 2008. *Pasture Management Tips for the Coming Season* [online]. http://www.omafra.gov.on.ca/english/livestock/beef/news/vbn0208a3.htm (accessed January 16, 2012).

Manitoba Agriculture, Food and Rural Initiatives. *Starting and Managing a Bison Operation* [online]. http://www.gov.mb.ca/agriculture/livestock/bison/bca01s01.html (accessed December 1, 2010).

NRC. 2000. *Nutrient Requirements of Beef Cattle*. 7th Edition. Washington, DC: National Research Council, The National Academies Press. 248 pp.

Rutley, B.D. and R.J. Hudson. 2000. *Seasonal energetic parameters of free-grazing bison (Bison bison)*. Can. J. Anim. Sci. 80: 663–671.

Union québécoise du bison [online]. http://www.bisonquebec.com/portrait.html (accessed May 10, 2011).

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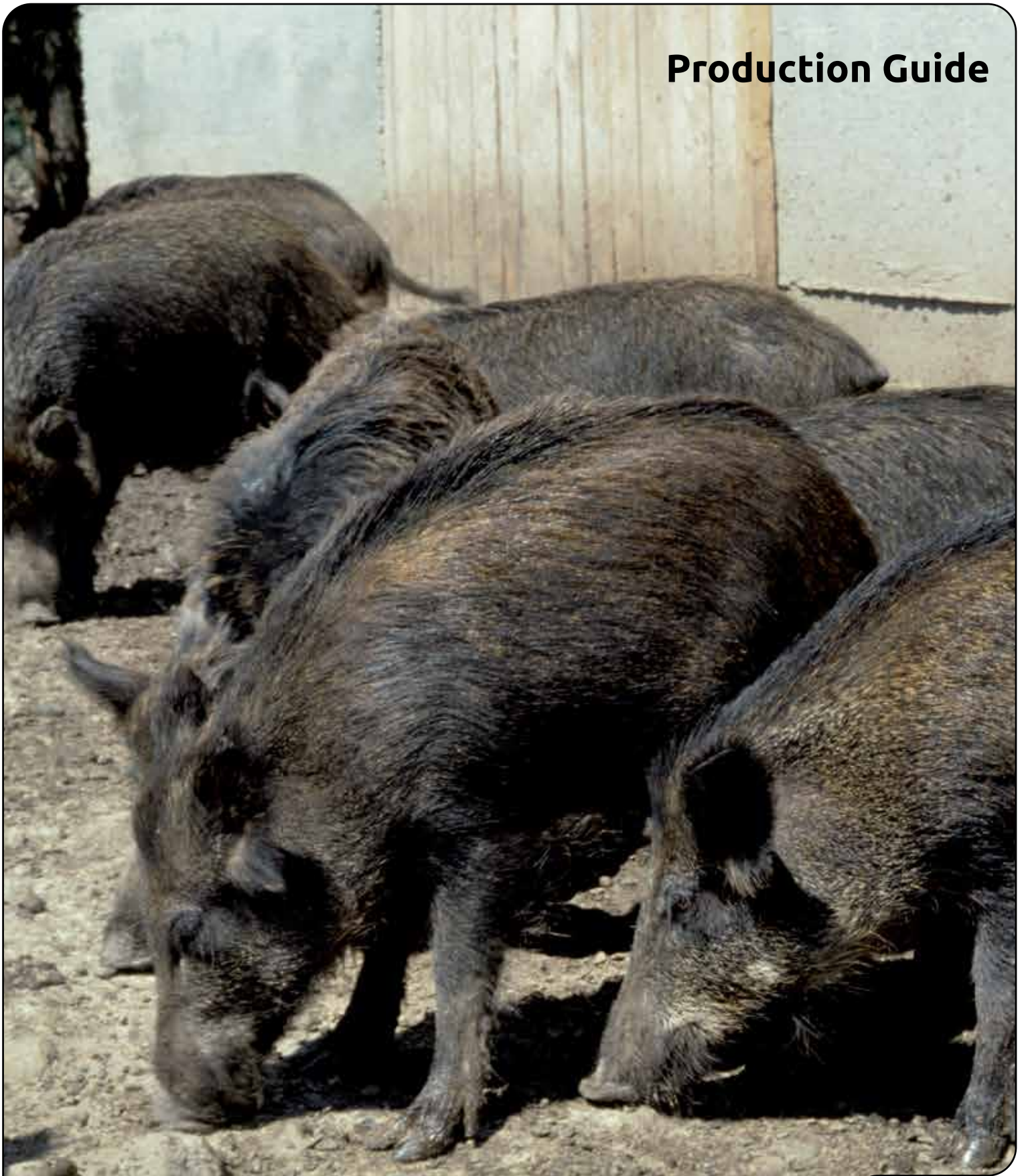

DOMESTIC GAME FARM ANIMALS

Feeding and Nutrition – Wild Boar

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INTRODUCTION

The information and recommendations in this leaflet were produced by a committee, based on the authors' expertise in animal nutrition and wild boar farming in Québec, and drawing from various publications on wild boar nutrition.

WILD BOAR AND FARMED WILD BOAR

In their natural habitat, wild boar are opportunistic omnivores. Depending on seasonal availability and what they find, their diet may include acorns, beechnuts, nuts, bulbs, mushrooms, fruit, grain, potatoes, roots, greenery, insects, worms, bird eggs, amphibians, reptiles, small mammals and even animal carcasses.

In Québec, for the most part wild boar farming is practised intensively on farms with outdoor pens, for meat production. Occasionally wild boar are also raised for hunting. The feeding of wild boar must prioritize muscle development, carcass quality (lean, fat) and gain rates (growth). Because the animal is omnivorous, unlike ruminants its ability to digest fibre is extremely limited. Wild boar must therefore be fed grain primarily, with protein supplementation. Forages should not be used as a complement, and should only account for a small portion of the total ration.

GROWTH OBJECTIVES AND ZOOTECHNICAL PERFORMANCE

There is little information about the nutritional needs and feeding protocols for wild boar. Data are often extrapolated from the needs of domestic pigs. However, over the past few years the monitoring of wild boar operations in Québec has allowed a growth curve to be determined (Figure 1).

Currently, the target slaughter weight for wild boar is about 90 kg, which is reached at 450 to 550 days. Some producers achieve their targets at 450 days, suggesting an average gain of 200 g/day between weaning and slaughter, with dual phase feeding and weaning at around 40 days. This target is realistic in a commercial production context. For hunting, the target weight is 45 kg to 50 kg, reached at approximately 250 days (from 200 to 300 days depending on genetics and nutrition).

Growth and performance data from three different lines were assessed at the Deschambault research facility, and compared until slaughter at approximately 70 kg (Cormier and Bergeron, 2002). Animals achieved average daily gains of 320 g per animal between weaning (5.3 kg) and 70 kg (Table 1). This information provides producers with a basis for comparison, while giving nutritional experts the basic information needed to develop nutritional programs and feed specifications. The results also suggest that in ideal conditions, producers should be able to achieve gain improvements.

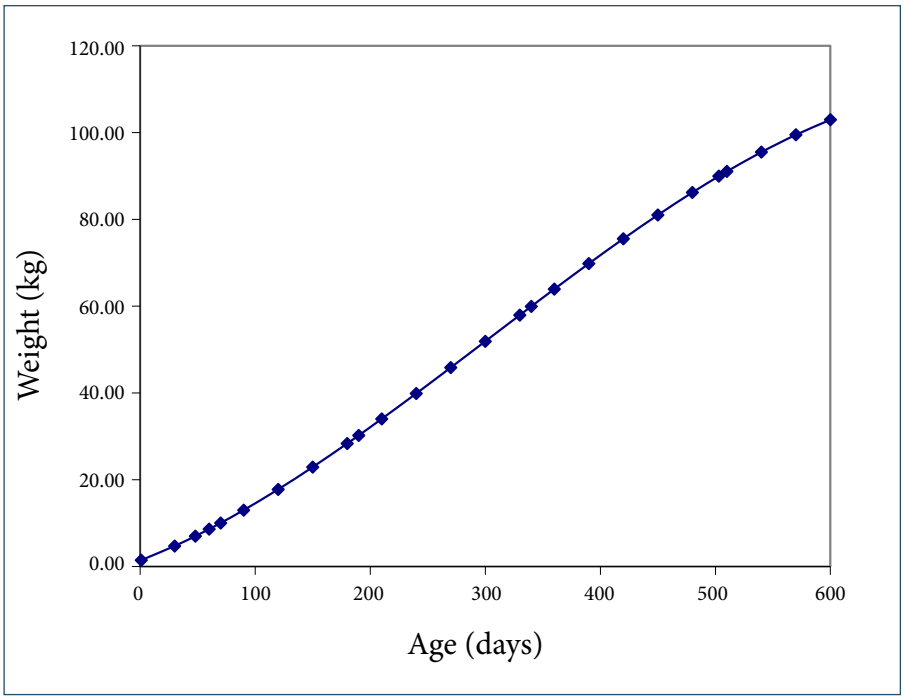

Figure 1. Growth curve derived from wild boar farming operations in Québec (based on 473 data points from six farms)

Source: Soucy, 2008

Table 1. Growth of three wild boar lines[1]

Criterion	Line		
	San Diego	Peter Kalder	Scandinave
Food intake (kg/day)	1.44[b]	1.32[b]	1.65[a]
Average daily gain (kg/day)	0.29[b]	0.29[b]	0.39[a]
Feed efficiency (kg food/kg weight gain))	4.94[a]	4.60[b]	4.20[c]

1. In the same line, the monitored values vary significantly ($P<0.05$).

Adapted from Cormier and Bergeron, 2002

Table 2 outlines current zootechnical performance in Québec.

Table 2. Current zootechnical performance of wild sows and boars in Québec

Performances	
Lactation	
Birth weight	1.4 kg
Weaning weight (42 to 50 days)	5 à 7 kg
Weight of sows at farrowing	125 kg
Average daily food intake of lactating sows	3 à 5 kg/day
Average daily food intake of pregnant sows	1.6 - 2.2 kg/day depending on season and gestation stage
Growth	
Weight at slaughter	90 kg
Average daily intake weaning-to-slaughter	1.2 kg/day
Age at slaughter	450 à 550 days
Average daily gain weaning-to-slaughter	165 à 200 g/day
Feed efficiency weaning-to-slaughter	4.6 kg feed/kg weight gain

NUTRITIONAL RECOMMENDATIONS

The nutritional needs of wild boar vary depending on their stage of development, and feed should be adapted to the needs of each. Table 3 outlines the recommended feed for each stage.

Fresh-cut grass may be fed to pregnant sows to complement high-quality meal. Fibre-rich feed (herbage) fed at weaning will ease the transition to breeding rations or to a moderate diet. Practical experience has shown that it is challenging for producers to manage more than three separate rations. In this case, wild boar piglets and juveniles should be fed wild boar piglet rations, growers and finishers should be fed finishing rations, and all breeding animals should be fed breeding rations. However, this feeding spectrum will not lead to optimum performance.

Current observations suggest that sows may experience significant weight loss during lactation. As with other lactating females, such weight loss can be expected to interfere with reproductive capacity (return to estrus, litter size) for subsequent litters, as well as hierarchical position in the group. Lactating sows should therefore be given free access to feed designed for their needs, i.e. that is rich in energy and protein. Sows that are extremely underweight at weaning should be temporarily overfed.

While a complete feed incorporating vitamins and mineral concentrates will meet the animals' nutritional needs, salt or mineral blocks can be provided to wild boar that are on pastureland or in large pens. Urea-free blocks are preferable, as are those without molasses, which tend to promote over-consumption. Clean, good-quality water should always be available, in winter as in summer, whether the animals are housed indoors or kept in outdoor pens.

In Québec, certain feed mills offer complete boar rations, and some even sell tailor-made mixes on request when volumes warrant. The animal nutritional experts at these mills can help producers develop the best feed for their animals.

Table 3. Nutritional recommendations for farmed wild boar, by growth stage

Animal Category	Description[1]	Weight (animals)	Recommended feed	Feeding method
Unweaned wild boar piglets	Piglets with their mother until weaning (42 days)	Approx. 5 – 7 kg	Piglet prestarter Iron injections recommended	Free access
Weaned wild boar piglets	Weaning to 70 days	7 – 10 kg	Wild boar piglet rations	Free access
Growing juveniles	70 – 190 days	10 – 30 kg	Wild boar piglet rations	Two meals
Growth	190 – 355 days	30 – 60 kg	Growth rations	Two meals
Finishing	355 days to slaughter (approx. 450 days)	60 kg to slaughter (approx. 90 kg)	Finishing rations	Two meals
Pregnant sows and males	Between mating and farrowing		Breeding rations	Once per day
Lactation	Between farrowing and weaning		Breeding rations or ideally feed developed for lactating wild sows	Two times per day, free access

1. Depending on production conditions and genetics, growth rate may vary ±25%. The recommendations in this table apply to a target of 90 kg in 450 days.

FEEDING PROGRAM AND PERFORMANCE

Table 4 outlines a model weaning-to-slaughter feeding program for wild boar. It was developed on the basis of the growth objectives in Figure 1, but with a target weight of 90 kg after 450 days.

Table 4. Model weaning-to-slaughter feeding program for wild boar

	Unweaned wild boar piglet ration[1]	Wild boar piglet ration	Growth ration	Finishing ration	Total[2]
Starting weight (kg)		7	30	60	7
Weight at end of growth phase (kg)	7	30	60	90	90
Duration of growth phase (days)	Based on age at weaning	148	130	130	408
Age at end of growth phase (days)	42	190	320	450	450
Meal throughout growth phase (kg/animal)	8	78	140	165	383
Daily meal (kg/animal/day) (excl. waste)[3]	Variable	0.53	1.08	1.27	0.94
Average daily gain (kg/animal/day)	0.132	0.155	0.231	0.231	0.203
Feed efficiency (kg feed/kg weight gain)	Variable	3.40	4.67	5.50	4.62

1. Piglet prestarter.
2. Excl. unweaned wild boar piglet ration.
3. Approximately 5% to 20% of feed is wasted; rations should be increased accordingly.

Unweaned wild boar piglet rations should be offered to piglets and sows at about one week prior to weaning, to transition the piglets onto solid food. To adapt to solids, piglets need to see their mother eating the same food; this also seems to facilitate dry-up and promote a healthy return to sexual activity.

To be able to define nutritional specifications for each growth stage, one must first establish a deposition curve for lean and fat in carcasses throughout the animals' growth. Since there is no such information for wild boar, specifications must be derived from information currently available in the literature.

Table 5 presents the main nutritional characteristics of wild boar rations. The crude protein levels are minimums, and assume ideal amino-acid intake. Table 6 outlines the vitamins and minerals usually added to feed, depending on growth stage. Table 7 provides recommended ratios between the primary amino acids and lysine for ideal lean growth (meat production) and milk synthesis (lactating sows). Protein (muscle, milk) has a relatively constant amino-acid composition, reflected by ideal protein. Due to its limited contribution to metabolic processes other than those involved in body protein, lysine serves as a stable reference to express relationships between amino acids.

Note that standards may vary between providers, and will be fine-tuned as new research results become available. It is always recommended that producers consult nutritional experts to verify feed specifications. Note too that many producers provide vegetables or grain as complements, in which case rations should be adjusted accordingly.

Table 5. Recommendations for wild boar feed, by nutritional profile

Food	Digestible energy, per kg feed[1]	Crude protein (%)	Total lysine / digestible energy	Calcium (%)	Phosphorus (%)	Sodium (%)
Start	3 200 kcal (13.3 MJ[2])	18.5	3.45	0.70	0.55	0.19
Growth	3 050 kcal (12.7 MJ)	15.5	2.80	0.60	0.50	0.17
Finishing	3 050 kcal (12.7 MJ)	13.0	2.20	0.52	0.45	0.15
Breeding-specific	3 050 kcal (12.7 MJ)	15.0	2.55	0.90	0.55	0.22
Lactation	3 150 kcal (13.2 MJ)	15.5	2.70	0.90	0.55	0.22

1. Minimum guidelines; may be exceeded depending on grain and other feed source market conditions.
2. Megajoule.
Adapted from Pinet, 2005 and CRAAQ, 2003

Table 6. Vitamins and minerals added to commercial feed[1]

Nutrient	Typical dosage – Growth	Typical dosage – Reproduction
Vitamin A (IU/kg)	7 500	10 000
Vitamin D (IU/kg)	1 000	1 500
Vitamin E (IU/kg)	30	50
Selenium (mg/kg)	0.3	0.3
Zinc (mg/kg)	100	150
Manganese (mg/kg)	40	60
Copper (mg/kg)	20	25
Iron (mg/kg)	75	100
Iodine (mg/kg)	0.5	2
Cobalt (mg/kg)	0.25	0.5

1. Other vitamins added: vitamin K, choline, thiamine (B1), riboflavin (B2), niacin, pantothenic acid, pyridoxine (B6), vitamin B12, biotin and folic acid.

Table 7. Lysine: amino acid ratios for protein deposition (meat production) and milk synthesis

Amino acids	Protein deposition	Milk synthesis
Lysine	100	100
Methionine	27	26
Methionine + Cysteine	55	45
Threonine	60	58
Tryptophan	18	18
Valine	68	85

Adapted from NRC, 1998

COMPLETE RATION RECIPES

Complete, milled rations include several ingredients: grain, protein-rich meal, fibrous by-products, minerals, vitamins and salt. In Québec, producers certified by the *Grands Gibiers du Québec certifiés*™ program must also comply with animal feed standards. For example, nutritional programs must be approved by a professional, and growth enhancers, sub-therapeutic (preventive) doses of antibiotics, flours, animal fats or urea are prohibited.

Though feed recipes can vary from one supplier to the next, an assortment of formulas for wild boar feed are presented here as a reference (Table 8), all being in line with the nutritional recommendations in Table 5. Producers who prefer to obtain their own grain and mix their rations themselves can work from the formulas below and use macro-premixes for hogs to add vitamins and minerals. Two energy levels are presented, to allow producers to lower feed costs by using less expensive ingredients when available and advantageous (good nutrient/price ratio). For example, for wild boar piglet rations either formula may be used, or combined 50-50 etc., to obtain an intermediate formula. Large quantities of energy-rich feed can help improve weight gain or produce fatter carcasses. Producers should adjust the formulas based on their own production targets, and if need be can discuss energy levels or nutritional program adjustments with a nutritional advisor.

Table 8. Examples of feed formulas for wild boar

	Piglets		Growing Boars		Finishers		Breeders	
	Low energy	High energy	Low energy	High energy	Low energy	High energy	Lone	Lactation
Ingredients per 1000 kg mix (kg)								
Corn[1]	361	677	163	755	437	817	228	393
Barley	361		675		436		600	393
Soybean meal	250	295	137	220	105	161	137	179
Macro-premix Grower 25	28	28	25	25	22	22		
Macro-premix Breeder 35							35	35
Typical nutrient profile (as-fed)								
Crude protein[2] (%)	18.6	19.4	15.4	16.0	13.1	13.6	14.9	15.7
Digestible energy per kg feed	3 210 kcal (13.4 MJ[3])	3 385 kcal (14.2 MJ)	3 060 kcal (12.8 MJ)	3 365 kcal (14.1 MJ)	3 055 kcal (12.8 MJ)	3 360 kcal (14.1 MJ)	3 055 kcal (12.8 MJ)	3 155 kcal (13.2 MJ)
Crude fibre (%)	3.6	2.7	4.3	2.7	3.7	2.0	4.1	3.6
Calcium (%)	0.7	0.7	0.6	0.6	0.5	0.5	0.9	0.9
Phosphorus (%)	0.55	0.55	0.50	0.50	0.45	0.45	0.55	0.55
Sodium (%)	0.20	0.20	0.17	0.17	0.15	0.15	0.22	0.22
Vitamin A (IU/kg)	8 400	8 400	7 500	7 500	6 600	6 600	12 000	12 000
Vitamin D (IU/kg)	1 125	1 125	1 000	1 000	880	880	1 500	1 500
Vitamin E (IU/kg)	38	38	35	35	30	30	65	65
Lysine (%)	1.11	1.16	0.86	0.95	0.70	0.77	0.78	0.85

1. One of corn, wheat or barley may be used in a feed formula as the sole source of energy.
2. Takes into account the synthetic lysine found in the premix.
3. Megajoule.

DEVELOPMENTS IN WILD BOAR NUTRITION

In swine production there is a clear connection between carcass quality and nutrition, and the same is almost certainly true for wild boar. Since feed accounts for a significant portion of production costs (50% to 75%), studies are being done in Québec toward developing rations that would lower feed costs without compromising carcass quality and meat yield. Over the next few years, precise recommendations should emerge that will benefit the entire industry.

BIBLIOGRAPHY

Animaux.org. Sanglier [online]. http://animaux.org/sanglier.htm (accessed April 15, 2011).

Baudet, E. 2007. *Alimentation naturelle ou artificielle: quels effets sur la dynamique de populations de sangliers?* [online]. Symposium on wild boar management, March 1 and 2, 2007, Reims, France. Office national de la chasse et de la faune sauvage et Fédération nationale des chasseurs. http://www.colloque-sanglier.com/documents/acte%20baubet%202.pdf (accessed April 18, 2011).

Belzile, M. 1991. *Généralités sur l'élevage du sanglier*. Working document. Ministère de l'Agriculture, des Pêcheries et de l'Alimentation.

Brandt, S., E. Baudet, J. Vassant and S. Servanty. 2006. *Régime alimentaire du sanglier en milieu forestier de plaine agricole*. Faune Sauvage 273: 20–26.

Cormier, I. and R. Bergeron. 2002. *Évaluation en station de trois lignées de sangliers au point de vue productivité, qualité de la viande et comportement*. Colloque sur les grands gibiers, February 16, 2002, Drummondville, Québec. Centre de référence en agriculture et agroalimentaire du Québec. p. 75–80.

CRAAQ. 2003. *Le sanglier*. Centre de référence en agriculture et agroalimentaire du Québec.

Fédération des éleveurs de grands gibiers du Québec. *La certification Grands gibiers du Québec certifiés*[MD] *(Résumé pour les éleveurs intéressés à adhérer au programme)* [online]. http://www.grandsgibiers.com/meganet/media/docs/pdf/resume_certification_eleveurs.pdf (accessed April 18, 2011).

Ferme d'élevage Sangliers des Bois [online]. http://www.sanglier.qc.ca/sangliersdesbois (accessed April 15, 2011).

Fillion, R. 1997. *Nutrition et alimentation*, in "Le sanglier: guide d'élevage". Collection grands gibiers domestiques. Conseil des productions animales du Québec. p. 73–86.

Hodgkinson, S.M., I.F. López and S. Navarrete. 2009. *Ingestion of energy, protein and amino acids from pasture by grazing European wild boar in a semi-extensive production system*. Livestock Science 122: 222–226.

Hodgkinson, S.M., M. Schmidt and N. Ulloa. 2008. *Comparison of the digestible energy content of maize, oats and alfalfa between the European wild boar (Sus scrofa L.) and Landrace x Large White pig* (*Sus scrofa domesticus*). Animal Feed Science and Technology 144: 167–173.

Kapela ski, W., L. Costanza, M. Bocian, K. Siemieniecka and G. Maiorano. 2007. *Nutritional and physico-chemical meat properties of wild boar (Sus scrofa ferus) x Duroc pig slaughtered to different live weights*. Ital. J. Anim. Sci. 6 (Suppl. 1): 691.

L'alimentation du sanglier [online]. http://www.chasseacrw.be/Gibier/Sanglier08.asp (accessed April 15, 2011).

Le sanglier [online]. http://www.jyrousseau.com/sanglier.shtml (accessed April 15, 2011).

Long, D.B., T.A. Campbell and G. Massei. 2010. *Evaluation of Feral Swine – Specific Feeder Systems*. Rangelands 32(2): 8–13.

Marché de fournitures courantes et services – Cahier des clauses techniques particulières (aliments pour les sangliers) [online]. 2010. Établissement public du Domaine national de Chambord. http://www.chambord.org/upload/pagesstatiques/fichiers//2009-26/ccpt2010_3.pdf (accessed April 18, 2011).

NRC. 1998. *Nutrient requirements of swine. 10th Revised Edition*. Washington, DC: National Research Council, The National Academies Press. 189 p.

Pépin, D. 1991. *Alimentation, croissance et reproduction chez la laie: études en conditions naturelles et en captivité*. INRA Prod. Anim. 4.2: 183–189.

Pépin, D., and R. Mauget. 1989. *The Effect of Planes of Nutrition on Growth and Attainment of Puberty in Female Wild Boars Raised in Captivity*. Anim. Reprod. Sci. 20: 71–77.

Pinet, J.M. 2005. *L'alimentation*, in "L'élevage du sanglier de race pure". Paris: Editions de l'ADEPRINA. p. 77–95.

Pinet, J.M. 1990. *Analyse stratégique de la filière venaison*. Institut national agronomique. Paris: Laboratoire de la faune sauvage.

Schley, L. and T.J. Roper. 2003. *Diet of Wild Boar Sus scrofa in Western Europe, with particular reference to consumption of agricultural crops*. Mammal Rev. 33(1): 43–56.

Soucy, J.P. 2008. *L'alimentation du sanglier* (*Sus scrofa*) [online]. Literature review. Agronor Services Agronomiques S.A. 15 pp. http://www.agronor.ca/media-agronor/uploads/files/revuecorr-feb2011.pdf (accessed April 18, 2011).

Teillaud, P. 1986. *Stratégies alimentaires et statut social chez le sanglier en captivité*. Behavioural Processes 12: 327–347.

Van Wieren, S.E. 2000. *Digestibility and voluntary intake of roughages by wild boar and Meishan pigs*. Animal Science 71: 149–156.

Weiler, U., R. Claus, S. Schnoebelen-Combes and I. Louveau. 1998. *Influence of age and genotype on endocrine parameters and growth performance: a comparative study in Wild Boars, Meishan and Large White boars*. Livestock Production Science 54: 21–31.

Wild boar production [online]. CALU Technical Notes. http://www.calu.bangor.ac.uk/Technical%20leaflets/040901%20wildboar.pdf (accessed April 18, 2011).

Wolkers, J., T. Wensing, G.W. Groot Bruinderink and J.T. Schonewille. 1994. *The effect of undernutrition on haematological and serum biochemical variables in wild boar (Sus scrofa)*. Comp. Biochem. Physiol. Comp. Physiol. 108(2/3): 431–437.

Wolkers, J., T. Wensing, J.T. Schonewille and A.T. van't Klooster. 1994. *Undernutrition in relation to changed tissue composition in wild boar (Sus scrofa)*. Comp. Biochem. Physiol. Comp. Physiol. 108(2/3): 623–628.