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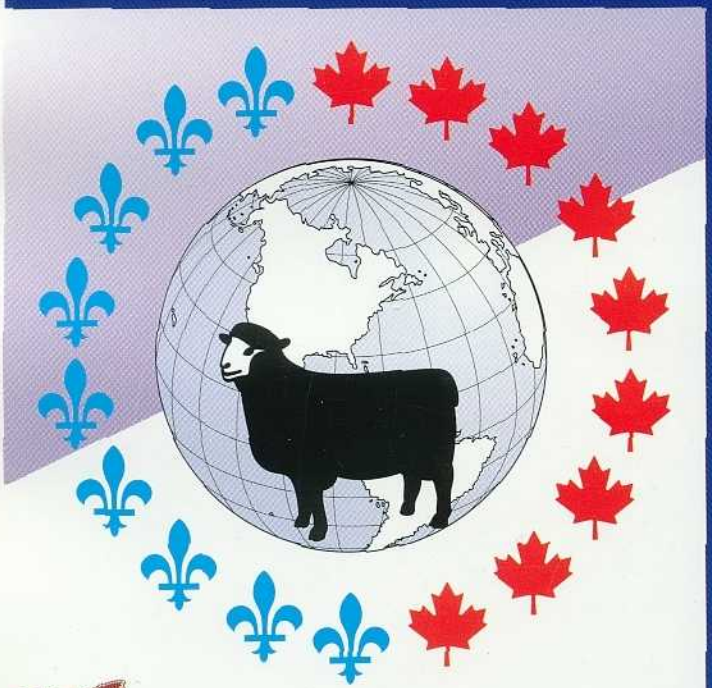

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NEW GENETIC RESOURCES AND MEANS OF THEIR USE TO IMPROVE PRODUCTIVITY IN CANADIAN SHEEP FARMING

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INTRODUCTION

There are no breeds of sheep native to Canada. The present sheep breeds were imported from Europe by the early settlers and these were mainly breeds of British origin brought mostly for their meat qualities and secondarily for their wool. In addition, wool producing breeds such as Merino and Rambouillet were imported from the European continent. For decades, no other breeds were imported from Europe as a precaution not to introduce some devastating diseases such as blue tongue and scrapie.

In the early 1960, Finnsheep, the newly recognized super prolific breed from Finland, became the first breed to enter Canada in decades. This importation opened the door to other successive importations in the following years from Europe, New Zealand and the United States. With increased information on the characteristics and attributes of native breeds world wide, and ease of restrictions on moving germplasm across borders, it became evident that several breeds have great potential to contribute to the Canadian sheep industry and importations of such germplasm in the form of semen, embryos and live animals is becoming increasingly easier and cost effective.

The purpose of this presentation is to give a quick overview of the newly imported sheep genetic resources in Canada (Finnsheep, though not newly imported, was also included), what these resources can contribute to the sheep industry and how to use them in an effective way.

NEWLY AVAILABLE BREEDS

Historically, sheep breeds were classified according to wool (fine, medium, long or carpet). Recently, classifying the breeds according to their purpose or production level i.e. wool, meat, and milk, has become more popular. In addition, with the identification of more prolific genotypes, sheep breeds can also be classified according to prolificacy into high (avg. > 2.2), moderate (avg. 1.6-2.2) and low (< 1.6). In describing the new breeds introduced into Canada, a combination of these classifications will be applied and those will be further classified into genotypes developed in Canada or imported from abroad. Table 1 summarizes the different genotypes presently available in Canada.

Prolific maternal breeds

Finnsheep

The Finnsheep breed is related to other Scandinavian short-tailed sheep. It is believed to have descended from the mouflon, which still lives in Sardinia and Corsica.

Finnsheep are usually white; however, some animals may be black and occasionally gray, brown, and even piebald or skewbald. The head is narrow, free of wool but covered with hair. The nose is straight. The ears are narrow, erect, and rather short; they are set horizontally but generally point upwards. Both sexes are hornless but a few rams may have light horns. The neck is rather long and narrow. The body is moderately muscled and rather long and narrow. The bones are usually long and light-to-medium in thickness. The body stands high from the ground. Bodyweight of ewes at 1, 2, and 3 years of age averages about 33, 47 and 55 kg, respectively. In Finland, mature ewes and rams weigh between 70-80 kg and 90-100 kg, respectively. The legs are long, bony, and thin covered with guard hair. The tail is short and averages 7.8 cm in length, and is covered with short hair. Head and legs are generally free of wool. Wool is usually of mixed composition. Some individuals have either only underwool or only guard hair.

Finnsheep mature early. Age at puberty was calculated at 210 days for ewes weighing 33 kg. Some lambs reach maturity at 5 months of age. Fertile matings of ewe lambs have occurred at less than 4 months. Longevity of Finnsheep ewes is about 11% less than in Suffolk or Targhee ewes. The breeding season of Finnsheep ewes is about 230 days. Ewes start their breeding season around the end of August, in July and August most ewes are in deep anestrus. Because the breeding season is long, two lambings per year are possible. In Finland, 45% of ewes lamb twice a year. Most Finnsheep can lamb at 12 months of age. The average age at first lambing of 378 days for yearlings was reported in Finland.

Fertility in Finnsheep is relatively low (about 70%) in out-of-season breeding. In season, fertility averages 94-96% for yearlings and 95-98% for adult ewes. Average litter size of yearling and older ewes is about 1.9 and 2.8 lambs, respectively. However, in Britain, 2- and 3-year-old ewes gave birth to 3.0 and 3.4 lambs,

respectively and in Norway, litter size averaged 3.1 lambs. Lambing is easy in Finnsheep, and ewes nurse their lambs well. About 5-6% of the lambs die at birth, and a further 4-5% die within 3 days of birth in Finland, however, in other countries, mortality at birth can be as high as 44%.

Birth weight of lambs varies according to size of litter. In Canada, average birth weight was 2.6 kg for lambs born in litters averaging 2.9 lambs. Seventy-day weaning weight was 15.4 kg. In Finland, live weight at 60 days of age was 20 kg and at 150 days of age, 45 kg (average gain of 284 g/day). Finnsheep lambs needed 4.5 kg of feed for each kilogram of grain. Dressing percentage of lambs slaughtered at 36 or 26 kg live weight is 45.4 and 47.7%, respectively. Leg comprised 31.4% of the carcass. Finnsheep carcasses are similar to other breeds in lean content but show smaller loin-eye area. Finnsheep usually deposit more fat in the body cavity around the kidneys than other breeds (18.6 g per kilogram of carcass weight compared with 10 g for Suffolks). Carcasses often lack proper fat cover and accordingly grade lower than other breeds.

Milk production of Finnsheep ewes averages 64 L during a 130-day lactation period. Milk contains 5.7% fat, 5.5% protein, and 4.8% lactose. Many Finnsheep ewes have more than two teats. Ewes produce annually about 2.8 kg of wool and rams 3.8 kg. Good animals can shear up to 6 kg. Finnsheep wool has a staple length longer than, or comparable with, other long-wooled breeds, with a fibre diameter of 25-28 µm. Fibres are medium in fineness (50-54 µm), particularly lustrous, elastic, soft, light, and firm.

Flocking tendency of Finnsheep is greater than in most British mutton breeds but is less developed than in range sheep. Finnsheep are quiet animals and are easy to handle.

Romanov

The Romanov breed originated in Russia in the 18th century, either from a cross between males imported from Silesia in 1720 or Holland in 1754, and females from a local breed, or by selection over many years of a short-tailed Nordic breed.

Romanov lambs are born black, later they turn gray as their wool becomes a mixture of black and white fibres. The head remains black and bears a characteristic white spot high on the forehead. The head is small and rounded, with upright and mobile ears and voluminous eyes. The males, with or without horns, have a more convex forehead than the females and the head is wider and shorter. In males, the long, narrow neck is covered with a hairy black mane that extends to the brisket. The body is of medium size; the ribs are rounded. Romanov animals stand high on their legs. The average body weight of mature ewes is 50 kg; that of mature rams is 70 kg. The long, fine legs are covered with short hair. The tail is short and characteristically pointed. Lambs are born with a pelt-like black cover similar to that of Karakul sheep but inferior in quality.

Sexual maturity is early in the Romanov. Males can mate at 3-4 months of age; some ewes lambed at 9 months of age. Well-fed females can reach 40 kg live weight in 6-8 months and can be bred at that age. The average number of reproductive years in the herd is 7.5 years. Mortality in adult ewes was estimated at 10-11% for ewes kept in confinement and 4-8% for those kept on ranges. The Romanov breed is characterized by an extremely long season of sexual activity. In many ewes, no anestrous period can be detected at all. Ewes return to estrus 30-40 days after lambing, and intensive breeding systems are possible with Romanovs. Most Romanov flocks are managed to lamb for the first time at 12 months of age.

Fertility is high (more than 95%) in Romanov during the normal breeding season (September to March) but declines to about 50% during the summer. Prolificacy is by far the most important characteristic of Romanov sheep. Some ewes give birth to seven or even nine lambs. In six flocks involving about 1400 births in France, prolificacy was 2.69 lambs for adult ewes and 2.07 for yearlings. In Canada, the average prolificacy of adult ewes ranged between 2.9 and 3.5, whereas it was 2.1 for yearlings. Lamb mortality depends greatly on management and may be as high as 50% in badly managed flocks. However, in well-managed herds, preweaning mortality was recorded at only 7%.

Lamb weight at birth and weaning is greatly influenced by the number of lambs born in the litter. The average in Canada was 2.9 kg, whereas in other countries it was about 2.5 kg. Weight of lambs at 70 days averages 20 kg for males and 18 kg for females. Dressing percentage varies with age and feeding conditions. In lambs 7-8 months old, a dressing of 49% could be expected. The high-priced cuts represent 60-70% of the carcass. It is estimated that 80% of the carcass is edible meat. Romanov carcasses are relatively heavier in the front, shoulder cuts represent 38-40% of the carcass compared with 33% for leg and 27-29% for loin-rack cuts. Internal fat is about 3-4% in noncastrated males, 5% in castrated males, and 7% in females.

During a lactation period of 100 days, ewes produce 110-160 kg of milk with 6.3-7.4% butterfat. Maximum milk production is attained at the 15th day of lactation and is highest in 6-7 year-old ewes. A study in the United States reported a 130-day production of 39 L of milk containing 6.4% fat, 6.1% protein, and 4.8% lactose. Some lines in the Romanov possess four functioning teats.

Grease fleece weight of Romanov lambs, shorn for the first time at 7-9 months of age, was 1.1 kg; those shorn at 10-12 and 13-15 months clipped 1.9 and 2.2 kg, respectively. Mature ewes shear between 2.2 and 2.5 kg for 12-month growth. Romanov fleeces are a mixture of fine, white, inner coat and coarse, black, outer coat. The combination of the two types of fibres gives Romanov sheep their gray appearance.

Romanov sheep on pasture usually stay together and can easily be handled. Ewes are known for the excellent care they give to their young. Romanov crosses are also remarkable in their mothering ability. Some breeders claim that some Romanov sheep are extremely nervous, others claim the opposite. Romanov sheep can jump high and require higher fences to contain them.

Booroola

The Booroola sheep originated in the early 1940s, probably by the mutation of a gene in a private Merino flock on a farm called Booroola in New South Wales, Australia. The Australian Ministry of Agriculture concentrated the breeding of animals carrying the fecundity gene and established a new strain of prolific Merino called Booroola Merino. The fecundity gene was later transmitted to other breeds by crossbreeding. The term Booroola is now applied to animals of any breed carrying the gene.

Booroola Merino sheep are white. The head is medium to short. In some animals the skin is loose and forms wrinkles. Males have big round horns, which sometimes have to be cut. The neck is rather short. The body is small, narrow, and low. Weight of ewes at 1, 2, and 3 years of age was reported at 38, 47 and 50 kg, respectively. Mature rams weigh 65-90 kg and mature ewes weigh 55-65 kg. The legs are relatively short. They are covered with wool down to the hooves. The tail is long and narrow. Fine wool covers the whole body and parts of the legs and face; some animals are wool blind.

Booroola Merino, like the other Merino strains, is characterized by late sexual maturity. Age at puberty was reported at 413 days. Less than 10% of the females reach puberty at 1 year of age. Ewe yearlings can be mated at 1 year of age if they weigh around 30 kg, but fertility at that age is low. Booroola Merino ewes are characterized by a long breeding season that extends for 8 months. Sixty percent of Booroola ewes ovulate in all months of the year. The common practice with Booroola ewes is to breed them at 18 months of age to lamb when they are about 2 years old.

Fertility of Booroola Merino is about 90%, however in Canada, fertility in ewes aged 18 months and older was 70-75%. The mean ovulation rate is 3.7 compared with 1.4 for the regular type Merino. Average litter size of Booroola ewes is reported at 2.3 (1-7) with 40% of litters being 3 or more. In New Zealand, litter size of Booroola was 2.1 whereas that for Merino was 1.4. In Canada, litter size at birth for ewes aged 18 months and older was 2.7 lambs. The percentage of ewes lambing quadruplets and triplets was 23 and 35%, respectively. Lamb mortality at birth is greatly influenced by litter size. In litters of 1, 2, 3, 4, 5, and 6 lambs, mortality was 10, 23, 45, 63, 70, and 72%, respectively. On average, mortality rate is about 38% compared with 15% for Merino. Lamb mortality is higher in 2-year-old ewes (46%) than in older ewes (28%).

Lamb birth weight varies with the number of lambs born in the litter, from 3.9-4.8 kg for single lambs to 1.9-2.6 kg for quadruplets (2.9-3.7 kg and 2.2-3.1 kg for twins and triplets). Weaning weight of Booroola lambs at 70 days of age was 13.5 kg in Canada and around 19 kg at 84 days of age in Australia. Lambs slaughtered at 35 kg live weight dress 47.8%. The area of loin-eye muscle in lambs slaughtered at 24 and 38 kg live weight averaged 8.3 and 11.8 cm^2, respectively. The carcasses are shorter than in other sheep breeds.

Studies have shown that when Booroola ewes were left with three or more lambs, most of the lambs died, which may indicate low milk production. Merino ewes raising twins and single lambs were reported to produce, respectively, about 100 and 70 kg of milk during a 70-day nursing period. Grease fleece weight of ewes raising one lamb is about 4.7 kg, whereas for ewes raising three lambs it is 4.1 kg. Clean scoured yield is about 70%. Fibre diameter varies between 19 and 26 µm; staple length varies between 9.1 and 10.4 cm.

Booroola, as a Merino strain, has a strong flocking tendency. Mothering ability is relatively poor in Booroola Merino. Milk production is often inadequate to feed a large litter, and no more than two lambs on the mother are recommended. Booroola are quiet, gentle, and easy to handle. Rams sometimes like to fight each other.

Arcott Outaouais and Rideau

The primary contributors of the Outaouais breed were the Finnsheep (49%), Shropshire (26%) and Suffolk (21%) breeds with minor contributions of 4% from Île-de-France, East Friesian, Dorset, North Country Cheviot, Leicester and Romnelet breeds. Outaouais are large sized, rapid growing, moderately muscled, fecund-type breed with high productivity under an accelerated lambing system or lambing at eight months intervals. The Outaouais was developed for producing hybrid ewes for crossing with meat-type sire breeds.

The primary contributors of the Rideau breed were the Finnish Landrace (40%), Suffolk (20%), East Friesian

(14%), Shropshire (9%), Dorset Horn (8%) breeds with minor contribution of 9% from Leicester, North Country Cheviot, Romnelet and Corriedale breeds. Rideau are large size, rapid growing moderately muscled, fecund-type breed with high productivity under an accelerated lambing system or lambing at eight months intervals. The Rideau was developed as a maternal breed for producing hybrid ewes for crossing with terminal sires from meat-type breeds.

The Outaouais and Rideau breeds were primarily selected on the basis of prolificacy of their dams, with lesser attention to individual lamb growth. After 1984, selection for prolificacy, was based on an index of lifetime performance of their dam and maternal and paternal grand dams. Performance of these two breeds and the two reciprocal crosses between them is presented in Table 2. Milk production of Outaouais and Rideau ewes machine-milked twice daily for about 120 days, following weaning at 30 days, was evaluated in a study in Minnesota. The two breeds produced 54 and 77 L of milk, containing 7.3 and 6.6% fat, 6.1 and 5.8% protein and 4.6 and 4.8% lactose, respectively.

Prolific meat-type breeds

Charollais

The Charollais was developed in the Nièvre region by a breeder named Benoit D'azy from a cross between Leicester Longwool (commonly called Dishley, at that time) and local breeds in 1825. For a long time these sheep were known as *"les mouton de pays"* (sheep of the country), renamed Charollais only in 1963 and was recognized as a distinct breed in 1974. Although the Charollais is recognised as a meat-type breed, with its high prolificacy and milk production it can also be considered as multiple-purpose sheep.

Charollais animals are rather large and heavy, the males weigh 100-150 kg and the females 75-95 kg. The head is clear of wool but sometimes has coloured hair with black tips. the front is large, ears are fine, long, mobile. The body is long with muscular belly, the chest is large and deep, and the shoulders are smoothly blended into the body. Legs are thick, rather short, coloured and void of wool The wool is short consisting of white fine fibres.

Sexual maturity is rather late in Charollais, only 43% of the ewes lamb between 12-15 months of age, and 39% lamb between 24-36 months. Prolificacy of ewes lambing for the first time vary between 1.37 to 1.72 according to age at lambing. The average for ewes lambing before 18 months of age is 1.41. Prolificacy of adult ewes averages 1.85 and can reach 2.23 in well run farms. About 60% of all the lambs are born twins, 30% singles and 10% triplets and quadruplets. Between birth and 30 days, single born male and female lambs gain on average, 285 and 271 g/day, while twins gain 230 and 220 g, respectively. From 30 to 70 days of age, daily gain of the four groups averages 325, 279, 278 and 274 g, and weight at 70 days, 26.5, 24.9, 22.3 and 21.2 kg, respectively. The Charollais is used intensively in crossbreeding to produce heavy market lambs. Lambs with Charollais ancestry excel in carcass conformation and lean content. They rank in the same order with Texel in carcass composition, but studies showed that they exceed the Texel crosses in conformation.

Rouge de l'Ouest

This open-air breed comes from north western France. Animals of that breed have red colour head and limbs, hence the name. Although this breed was created recently, its exact origin cannot be precisely established. It is believed that sheep breeds imported from Britain in the 19th Century contributed to this breed. Animals are polled; have wide forehead bare of wool; and a slight aquiline profile. They have prominent eye-sockets; wide nose; the long slim coloured ears are pricked up and placed high on the head. The body has average neck; well-muscled shoulders; wide and deep chest; straight regular back; long and wide pelvis. The tail-joint is well-blended in the croup and well-developed legs descending on the hocks. The wool is white, homogeneously tight, covering the whole body except the head, hocks and knees. The wool is average in length and fineness. Rams weigh 110 to 120 kg and ewes 80 to 90 kg.

The Rouge de l'Ouest sheep are well adapted to breed almost entirely in the open, on rich pastures. Only a few breeders shelter their ewes during the spring lambing season. Males and females are early maturing, 56 and 67 % lamb before 15 months and 84% lamb before 18 months of age. Prolificacy is high, only 15.4% of the ewes lamb singles, while 63.8% lamb twins, 19.3% triplets and 1.5% quadruplets. The average prolificacy is 1.5-1.6 for yearlings and 2.0 for adults. Prolificacy in well managed flocks can reach 2.38. One disadvantage is that animals have a short lambing season which extends from January to April with the highest concentration occurring in March, and thus, may not be suitable for accelerated breeding systems.

The ewes are good milkers, 90% of twin and 57% of triplet lambs are raised by their mothers. Total average yield of Rouge de l'Ouest ewes during an 87-day lactation was 102 L, with 6.3% fat and 5.0% protein. Male and female lambs gain about 296 and 272 g between 10-30 days of age while twins gain 241 and 234 g, respectively. Between 30-70 days of age male lambs gain about 300 g/day and females gain 270 g. Lambs can reach 37 kg weight by 90 days of age on pasture.

Meat-type terminal breeds

Texel

The Texel breed is native to The Netherlands, having evolved on the Isle of Texel. Its ancestors belonged to a group of white-faced, short-tailed marsh sheep that populated the coast from Denmark to northern France.

Texel sheep are characterized by a large head with a wide skull. The nozzle is dark in colour and wide. Ears are relatively thin, hairy and are slightly pointing up. The neck is short, and the body is thick-set, with solid loins, horizontal and square-shaped croup, the tail joint is high, the legs are well developed and low. Average weight of adult rams is 115-130 kg and ewes 75- 80 kg. The fleece is white in colour, semi tight, voluminous with long strands.

Because the Texel sheep were developed on rich pasture land, they need good feeding management. They can be raised on less favourable conditions provided that their alimentation is supplemented during hot and dry summers or exceptionally rigorous winters. Sexual maturity is relatively late, only 27% of ewes lamb at one year of age. However this percentage can be higher if they develop sufficiently before mating at 7-8 months. The breeding season of Texel ewes is short, about 93% of the ewes lamb within a 75 day period (February to mid-April). The breeding season of ewe lambs averages 63 days, compared to 114 days for 18-month-old ewes and 150 days for mature ewes. Natural out-of-season breeding in this breed is not possible.

Prolificacy is 1.2 in yearlings, 1.5 in 2-year old and ranges between 1.6 to 1.75 in mature ewes. Flock average can reach 1.6 from 28% single, 64% twin and 9% triplets. Single and twin born lambs weigh 9 and 7 kg at 10 days, and 35 and 30 kg at 90 days, respectively. Twin lambs gain 283 g/day from 10 to 30 days of age which indicates a remarkable milking capacity. Actually, some Texel ewes are milked for cheese manufacturing. Post weaning growth rate of lambs is also remarkable, single lambs grow 320 g/day compared with 293 g for twins.

The Texel breed has been evaluated as a terminal sire breed in numerous studies in which the performance of progeny by 21 sire breeds was compared. Results indicated that Texel-sired lambs grew less rapidly than Oxford- and Suffolk-sired lambs, but excelled in percentage carcass lean (+ 4%), percentage carcass fat (- 4%), lean-to-bone ratio, and loin eye.

Île-de-France

The Île-de-France breed was developed in France from a cross between Dishley Leicester and Rambouillet Merino. The development began in 1832 and the first breed Society was established in 1922 in France. The main purpose of the breed is to use as terminal sire. Because of their exceptional carcass quality manifested in higher killing out percentage, well-muscled legs, large muscle area of their lambs, Île-de-France rams are used intensively as terminal sires in crossbreeding schemes all over the world. Rams of that breed were used in developing the Arcott Canadian.

Île-de-France is a heavy breed suitable for meat and wool production. It is characterized by a strong and large hornless head, face is medium in length, lips and nose are rather thick, straight profile or slightly round in males. The body is long with rounded ribs, and muscled and well developed legs. Adult weight varies between 70-90 kg for ewes and 110-150 kg for rams. As a result of the Merino ancestors, the fleece of Île-de-France is heavy (6-7 kg for males and about 4 kg for females) and the wool is fine (23-27 microns), strong and elastic with no kempy fibres and no yellowing.

Sexual maturity is rather late in Île-de-France, ewe lambs born in autumn are not usually bred before they are 10-12 months of age, unless they have attained 45 kg live weight. In such case, they can be bred at 7-8 months. Île-de-France is characterised by a long breeding season. Rams have a high libido and can mate all year round. About 60% of the lambs are born between September and November. Purebred and first-cross Île-de-France ewes have a long breeding season and are suitable for accelerated lambing systems.

Prolificacy is moderate, averaging 1.15 in yearlings, 1.2 in 2-year old and 1.3-1.35 in mature ewes. Ewes lambing in February-April average about 1.5 lambs. In general, 54, 43 and 3% of the lambings are single, twins and triplets, respectively. Well managed flocks were reported to average 2.4 lambs born. Ewes lamb easily and newly born lambs are vigorous. Single and twin lambs weigh 30 and 27 kg at 90 days, respectively. The expensive cuts account for 55% of the carcass.

Berrichon du Cher

This breed resulted from crossing Merino, Berry and Dishley breeds in France. The breeding society was formed in 1914 and flock book in 1934. Continuous selection and improvement resulted in a breed with very good conformation and good growth rates in

addition to high fertility and out-of-season breeding. The breed is found mainly in central and south-western parts of France and was imported into Canada in 1996 as embryos.

Berrichon du Cher are white sheep whose head is broad without folds, protruding orbital arch, with wide muzzle and straight profile. The body is characterised by a rather short and broad neck, wide chest, straight, broad and long back, thick rump and blocky well conformed leg. The wool is white, forming a semi-closed fleece, covering part of the belly but leaving the head clean of wool. Average fleece weight is 4 kg for rams and 3.5 kg for ewes. Average mature weight is 90-110 for rams and 70-80 kg for ewes.

Berrichon du Cher sheep are hardy and adapt well to unfavourable conditions. Although sexual maturity is relatively early, few breeders mate their ewes to lamb at one year of age. Prolificacy in yearling is 1.05, it is 1.2 in 2 year old, and varies in adult ewes between 1.3 and 1.35, the overall average is about 1.3, resulting from 54% singles, 45% twins and 1.5% triplets. Lambings between mid February and April are more prolific (1.5-1.6) and those between October and December are the least prolific (1.2).

Single- and twin-born lambs weigh 34 and 30 kg at 90 days of age. The leg, loin, fillet and best end of neck represent about 55% of the total carcasses weighing 16-18 kg. Berrichon du Cher rams are recommended for use as terminal sires on ewes from prolific breeds and crosses to insure top grading of the lambs.

Dorper

Dorper sheep were developed from a cross between Dorset Horn x Blackhead Persian. Dorper or Dorper crosses account for one-third or the 30 million sheep in South Africa, and has been exported to many countries including Canada.

The typical Dorper sheep is white with black head and often black neck. Some breeders concentrated on breeding white sheep derived from either Dorset Horn x Blackhead Persian or Dorset Horn x Van Rooy crosses. The ratio of Black-headed to white-headed Dorpers is 3:1.

Sexual maturity is early, ram lambs should be separated from ewe lambs and their mothers by 100 days of age. The Dorper sheep is known for its high reproduction rate and multiple births are common under good pasture conditions. A lambing percentage of 150% is average and with better pasture and environmental conditions, 180% can be achieved. Only 3.2% of lambs are stillborn and 10% die before weaning. Dorper ewes show extended breeding season and applying good management, they can lamb 3 times in 2 years naturally. Dorper ewes produce good quality milk, are instinctively fond of their lambs, and can care for and rear their offspring without much intervention. The udder is highly attached, and has a large capacity for milk storage. Teats are correct in size and well-placed in the udder.

Dorper lambs weigh about 4.3 kg at birth and 36.3 kg at 100 days with an average daily gain of 320 g under normal conditions and 45 kg under good feeding conditions. Lambs reach slaughter weight in 190 days and dress 49.1%. Dorper sheep are renowned for their hind quarters. Ninety percent of the carcasses of well-grown Dorper lambs grade Choice. The meat is juicy and tender.

Dorper sheep are well adapted to a variety of climatic and grazing conditions, and has done well in hot and wet environments. The Dorper does well in various range and pasture conditions and performs well under intensive feedlot conditions. The Dorper can be integrated into a well-planned range management system of mixed grazing with cattle, goats or other livestock.

The Dorper sheep produces fleece of kempy-type fibre, the hairy-type Dorper has more subcutaneous body fat and is better adapted to semi-desert conditions than the woolly type.

DLS

The objective of developing the DLS sheep was to create sheep that can breed all-year-round and produce fast growing lambs with good carcass quality, and thus can be used in intensive sheep production systems. To achieve this, three breeds were chosen, Australian Dorset to contribute genes of long breeding season, Leicester for its prolificacy and mothering ability, and Suffolk for its excellent growth rate and superior carcass quality of its lambs. The breeding plan was the following: mate Dorset rams to both Leicester and Suffolk ewes to produce Dorset x Leicester, and Dorset x Suffolk crosses, then mate rams from both crosses to ewes from the other crosses to obtain a population with 1/2 Dorset, 1/4 Leicester and 1/4 Suffolk, hence the name DLS.

DLS ewes mature sexually at about 7 months of age and 32 kg liveweight and they show a long breeding season (203-222 days) with 7% of the ewes cycling year round. Fertility ranges between 87 to 98% depending on age and season of mating. Litter size is about 1.2 for yearlings and 1.5 for older ewes. In well managed flocks, ewes averaged 1.8 lambs born.

The DLS was recognized as a breed in 1991 and is now available on several comm-ercial farms in Quebec, and semen of DLS rams are available in artificial insemination centres.

Arcott Canadian

The primary contributors were the Suffolk (37%), Île-de-France (28%), Leicester (14%), North Country Cheviot (7%) and Romnelet (6%) breeds with minor contributions of 8% from Shropshire, Lincoln, Southdown, Dorset, East Friesian, Finnsheep and Corriedale breeds. The Canadian breed was selected for lean muscle mass and growth rate primarily on individual lamb growth basis with lesser emphasis on litter size. After 1984, an index which also included full and half-sib's growth performance was used to select the lambs. Canadian are large size, rapid growing and heavy muscled sheep, developed as a specialized meat-type sire breed for crossing with commercial ewes to produce market lambs. The performance of the Canadian breed is summarized in Table 2.

Callipyge

The callipyge is the newest major gene discovered by chance in a commercial flock of Dorset sheep in the USA. The origin of the name *callipyge* is the Greek words calli-, meaning beautiful; and pyge, meaning buttocks. The callipyge gene appears to act like an autosomal dominant gene, with an exceptional effect on the degree of muscling in sheep. A preliminary study estimated the increase in dressing percentage at 6%, and the loin-eye muscle at 75%, while reducing body fat by 21%. A recent study showed that animals carrying the gene had 7-8 cm^2 more loin-eye area (34%) and 0.5-0.7 mm less backfat (32%) than non-carriers.

Evaluation of the gene's effect on lamb growth and carcass characteristics indicated that the callipyge gene did not have an effect on rate of gain nor on feed efficiency. The major influence of the gene is seen in carcass characteristics. Presence of the gene causes a significant increase (9-16%) in the weight of leg and loin muscles, an increase of 22-34% in the area of loin-eye muscle, thus improving the most valuable retail cuts on a lamb carcass. Measures of subcutaneous and intermuscular fat suggest that total fat decreases significantly as muscle mass increases. The callipyge gene can potentially have a very large economic impact on the value of lamb carcass, and may be of value to other meat-producing livestock.

Comparisons of carcass characteristics in lambs carrying the gene versus normal lambs slaughter at approximately 54.5 kg showed the following: dressing percent increased by 5-8%, backfat depth decreased by 25-32%, seam fat score decreased by 44% loin-eye area increased by 22-34% in callipyge-type individuals. Weight of the leg, sirloin and loin retail cuts from callipyge lambs were larger than those from normal lambs, and accordingly, a significant improvement in yield grade was observed.

The quality of cooked meat from lambs expressing the callipyge gene compared to meat of normal half-siblings showed greater differences between carrier and non-carrier carcasses in tenderness of loins than for any other quality characteristic. Mean tenderness scores of loins from carrier lambs were significantly lower than the scores of loins from normal half-sibs. Significant differences were also measured in the flavour, juiciness, and overall acceptability scores of carrier lambs loins and legs compared to those from normal half-sibs.

Dairy Breeds

East Friesian

The East Friesian breed developed from sheep native to the coasts and islands of the North Sea, from Holland to Denmark, particularly in the East Friesland region in northern Germany. The breed is described as a growthy, longwoolled sheep, white in colour, with a thin, long woolless tail. The head is polled, somewhat long with slightly Roman nose and is free of wool and covered only with fine hairs. Ears are long, thin and pointing forward. The back is solid, long and broad. The udder has wide attachment, is quartered and has strong teats which should point downward. The wool is a medium crossbred.

East Friesian ewe lambs born in March reach puberty around 7 months of age and continue regular cyclic activity for about 5 months. East Friesian is moderately prolific. When proper care is provided, lambing rates of 210 to 230% are expected. The highest lambing rate reported is 32 lambs in 10 years. This breed requires good care to express its full reproductive potential. Lambing rates ranging from 140 to 170% are encountered when the level of care is low. Lamb mortality from birth to 120 days of age in large flocks averages 24.0% in East Friesian compared with 23.5% in Finnsheep and 14.5% in Romanov whereas in small flocks of 5 to 20 ewes/flock. The mortality averages 7.5% in East Friesian, compared with 10.1 and 5.8% in Finnsheep and Romanov, respectively.

East Friesian lambs are rather heavy at birth, weighing between 4.0 and 5.2 kg. Mature ewes weigh 57 to 75 kg depending on the stage of production and level of nutrition. Mature rams weigh between 90 and 120 kg. Carcasses of East Friesian have lower subcutaneous fat, higher body cavity fat, and thus leaner carcasses compared with those of meat-type breeds.

East Friesian is recognized as one of the best dairy breeds in the world, some ewes can produce up to 1498 kg in one lactation. Yearly average milk production was 540-650 kg in Germany, 250-350 kg in Swe-

den and 450 L in U.K. In Bulgaria, average milk production under experimental conditions was 292 L (343 L in first and 311 L in second lactation). In Poland, East Friesian produced 375 mL/day.

Lactation period ranges between 180 and 210 days, however, some ewes can produce for up to 260 days, well into their next pregnancy. In dry areas, milk production is lower and lactation period is shorter. For example in Greece East Friesian ewes produced 178 to 183 kg of milk during a 140 to 170 days lactation period.

East Friesian yearlings produce approximately 3 kg of wool whereas 2-year-old and older ewes produce about 3.6 to 6.2 kg of wool. East Friesian fleece is classified as crossbred wool.

The East Friesian breed has been kept in small flocks for centuries. Accordingly, their herding instinct is not well developed and they would not perform well when kept in large flocks or when added to an existing flock of other breeds. However, as a dairy breed, East Friesian ewes are handled frequently, and therefore show less defensive reaction compared with breeds that have less contact with humans. East Friesian sheep are gentle, have a trusting nature, a docile temperament, and bond with their keepers.

Lacaune

The breed takes its name from a mountainous region of France where it originated. The origin of this breed is not fully established. The name Lacaune includes populations of several closely related breeds which share a common type and show little differences among each other in appearance and performance, caused mainly by differences in environmental conditions they are exposed to and differences in the milking management they are subjected to over a long period of time. Over the years, this population received a limited infusion of Merino and Southdown blood. However, since 1870, several breeders applied vigorous selection for milk production, and the fact that the first installation of the Roquefort cheese industry was installed in the region helped intensify selection for milk production in these breeds. In 1902, the characteristics of the Lacaune breed was established and by 1905, exposition and judging of the breed started. The Regional Federation of Lacaune Breeders Syndicate was formed in 1922 to group producers from five provinces where the breed was popular. National individual milk control was established in 1947 and presently, about 800,000 ewes are milked yearly.

Lacaune sheep are considered semi open-air, they can be raised on pasture and also intensively indoors. They are usually kept indoors during winter, lambing and the first stage of lactation, and allowed to graze during summer, but are returned to the barns for the night. Lacaune used for meat production are usually subjected to a system of three lambings in two years.

Lacaune ewes produce on average 146 L in 139 days in their first lactation and 188 L in 170 days in later lactations. The flock with the highest average in France produced 256 L per ewe.

About 75% of yearlings lamb for the first time before 18 months of age. Ewes can lamb year-round but there are two peaks in November-December and in March-April. About 20% of the ewes lamb twice per year but in 60% of these cases, the ewes should be treated with hormones. Prolificacy varies with month of lambing and age: yearlings average 1.4 and mature ewes 1.6 lambs. The averages for lambings in March are 1.54 and 1.81, respectively. Well managed flocks can average up to 1.9 lambs.

About 94% of the lambs born twins and 70% of those born triplets are raised by their mothers, and those make good gain indicating the superior milking ability of the ewes. Male and female lambs born simple gain 307 and 287 g per day between 10 and 30 days, whereas those born twins gain 254 and 238 grams, respectively. Growth of lambs between 30 and 70 days averages 385 and 331 for males and females born single, and 357 and 312 for those born twins. At 70 days of age single lambs average 28.5 kg and twins 25.1 kg in liveweight. The ewes have a superior longevity and can produce up to 12 years of age.

Multiple purpose breeds

Polypay

The development of the Polypay breed was initiated in 1968 at the USDA Sheep Experimental Station in Dubois, Idaho. The objective was to create a breed with high lifetime prolificacy, a large lamb crop at 1 year of age, ability to cope with intensive systems, rapid growth rate of lambs and desirable carcass quality, by combining genes from four breeds each contributing 25%. First, the Finnsheep x Rambouillet and Dorset x Targhee crosses were obtained, then the Polypay was made from mating the two crosses.

Polypay sheep are white. The head is free of horns and has an open, white face. The neck is smooth from head to shoulder, with no excessive wrinkles. The body is characterized by a strong, level back along with a thick fleshing chest and trim brisket. Body weight of rams and ewes at 1 year of age is 65 and 46 kg, respectively, and for ewes 3 years old and older is 65 kg. Legs are medium in proportion to size. The body is completely covered by a dense fleece of average staple length, with uniform fibre quality. Wool covers most of the belly and legs.

Sexual maturity is early, many lambs can breed at 5 months of age and most conceive at 7 months and lamb for the first time at 1 year. Polypay ewes have an extended breeding season and can be bred successfully every 6, 7, or 8 months. In the United States, Polypay ewes were subjected to twice-a-year lambing, resulting in 1.78 lambs (58.6 kg) weaned. In Canada, Polypay ewes subjected to five matings in three years averaged 1.5 litters per year. Conception rate is high for ewes mated in the normal breeding season (96%) and out of the breeding season (88% in one study 50% in another). Conception rate of ewe lambs mated at 7-8 months is 89%.

Ovulation rate of 2.68 resulting in 2.08 lambs born and 1.94 resulting in 1.88 lambs born have been reported. Lambs born per mature Polypay ewe exposed was reported at 1.8 lambs for once-a-year lambing and 2.1 for twice-a-year lambing in the United States (46.5 and 57.1 kg weaned lambs at 120 days, respectively). Ewes exposed to intensive systems of 3 matings in 2 years (3/2) or 5 matings in 3 years (5/3) averaged 1.5 lambing per year. Yearly production under the 3/2 and 5/3 systems was 2.77 and 2.11 lambs born and 2.53 and 1.79 lambs weaned, respectively.

Lamb mortality averages 7.3% at birth and a further 8% between birth and weaning. Milk production is high, ewes lambing singles and twins produce 2.88 and 3.54 kg/day at 28 days of lactation. Persistency is also high, at 56 days of lactation, ewes produce 1.95 and 2.52 kg/day and at 98 days, 0.41 and 0.87 kg/day, respectively.

Polypay lambs weigh 4 kg at birth, 20.5 kg at 50 days, and 34.2 kg at 100 days. In another study, lambs averaged 3.8, 33.7, and 48 kg at birth, 120 days, and 1 year of age, respectively. Lambs slaughtered at 46, 49 or 56 kg liveweight dressed 49.4, 52.6, or 53.6%, respectively. They had 4.5, 4.7, or 5.2% kidney fat; 7.7, 8.3, or 10.9 mm back-fat thickness; and 12.7, 14.8, or 16.7 cm^2 rib-eye area, respectively. It is not recommended to feed Polypay wethers to weights over 52 kg.

Polypay yearling males and females produced 5.2 and 3.8 kg of wool, respectively, whereas 2-year-old and older ewes produced about 4.2 kg and only 2.84 kg in another study. The fibres range between half and quarter blood in fineness.

Flocking tendency is judged to be good in Polypay sheep. They appear to herd well on desert and mountain ranges. They maintain flock integrity on fenced ranges. Some ewes lambing as lambs at 1 year of age need attention. Mature Polypay ewes are exceptionally good mothers and take adequate care of their lambs.

Coopworth

The Coopworth breed was developed at Lincoln College, New Zealand, by Professor Ian Coop. The work to develop the breed began in 1958 by mating of stud Border Leicester rams to Romney ewes over 3 years. The crossbred rams and ewes were interbred. During its development, the Coopworth breed was selected severely to emphasize prolificacy and wool production. Once increased prolificacy had been established in the breed, increased selection pressure was placed on fleece weight and the growth of lean meat.

Coopworth sheep are white. Some animals have black spots on the skin. The head is relatively big, wide between the ears, and free of wool with the exception of a top knot. The ears are short and erect, and some are pigmented. The neck is short and wide whereas the body is relatively large with a straight back. Ewes weigh 60-70 kg and rams 80-100 kg. Legs are usually bare, short, and thick. Long, dense wool covers the whole animal and extends to the belly.

Rams are sexually mature at 7-8 months. Ewe lambs are usually bred between 9 and 11 months of age. Up to 70% of ewe lambs (if well grown) will conceive at about 9 months and lamb at 14 months of age. The breeding season of Coopworth ewes varies between 5 and 6 months. Fertility is high in Coopworth sheep. In certain flocks, up to 95% of ewes lambs within 21 days. Litter size increased gradually with selection from 1.43 in 1968 to 1.9 lambs born in 1985. In Canada, ewes averaged 1.95, lambs. Because of heavier weights at birth and good milking ability of ewes, lamb mortality is rather low.

Weight of lambs at birth averages 4.5 kg for males and 4.1 kg for females. Weight at weaning (50 days) averages 20 kg for males and 17 kg for females. Coopworth ewes are excellent as prime lamb mothers. They produce lambs that are heavy at birth and that grow and mature fast. Carcasses of Coopworth are comparable to those of other breeds in fat thickness over the body and in chemical composition. Coopworth have slightly longer legs and marginally poorer conformation. The percentages of wholesale cuts are 36.9% shoulder, 29.5% loin-rack, and 33.7% leg. Coopworth had 2.6% pelvic and kidney fat.

At peak lactation ewes nursing single lambs and twins produced 2.24 and 2.85 L of milk per day, respectively. Coopworth yearlings weighing 36 kg gave 3.1 kg wool of average grade. Coopworth ewes weighing 55-60 kg gave fleeces weighing 4-4.5 kg. In Canada, adult ewes and rams sheared 5.8 and 8.3 kg, respectively, for 12 months wool growth. Fibre diameter of

Coopworth animals ranges between 33 and 37 μm. Staple length in male and female lambs average 13.4 and 12.4 cm, respectively.

Tendency to flock is not highly developed in Coopworth, but the animals are quite easily handled. Coopworth ewes are superior in ease of lambing and mothering ability and assistance needed at lambing is much reduced. The sheep are quiet, easy to handle, and pleasant to work with.

Hair-type sheep

Katahdin

This breed was developed in Maine, USA by Michael Piel starting in 1957. Its ancestry includes hair sheep imported from the Virgin Islands crossed with a variety of standard wooled breeds, along with a later contribution from the Wiltshire Horn breed. Twenty years of intense selection for hair coat, growth rate, mutton performance, and prolificacy and against wool and horns produced the Katahdin breed.

Animals of this breed have a hair coat with an undercoat of fine wool which is shed in the spring. The predominant colour is white but many animals show different types of coloration. Most of the animals are hornless, only 5% of the males may have horns. Mature body weight ranges from 50 to 75 kg for ewes and 90 to 110 kg for rams.

Sexual maturity is attained at a young age, ewe lambs begin estrus cycling by 6 months of age. Ewes have an extended breeding season and some can breed year- round. Well-selected ewes average 2.0 lambs per litter. Lambing is easy and cases of dystocia are rare. Lambs are strong at birth and thrive without assistance. Milk production is sufficient to feed the lambs born, and performance is strong on good quality forages.

Average daily gain of lambs is 267 g and feed conversion ratio is 6.63. Lambs slaughtered at 46 kg dress at 65.1% with rib-eye muscle of 14.1 cm2 and 5.2% internal fat. The Longissimus dorsi muscle contains 72.4% moisture, 19% protein and 11.8% fat.

Katahdin sheep have a good flocking instinct and tend to be efficient grazers. They can tolerate high and low temperatures and show high tolerance to internal and external parasites.

HOW TO USE VARIOUS GENOTYPES

Before the breeder decides on which breeding system to apply, he must clearly establish his or her objective in terms of the type of animal to produce and the performance level to achieve. Determining the objective also has an immediate influence on which breed to use and in which order. There are several factors which determine to a great extent what type of production and what system to adopt to achieve the producers' goals. To list a few, the following are the most important: markets and customers' preference (continuous market demand, heavy or light lambs, degree of fatness, etc. and for seedstock, demand for superior breeding stocks), and production goals that are appropriate to available resources (availability of feed labour and capital which may determine management, expected weaning and marketing rates, and frequency of lambing, etc). Once the objectives are set, the breeder can apply any of the following systems that suits his or her particular case.

Purebreeding

Used mainly by seedstock producers to insure the continuation, improvement and survival of the breed and produce animals to use in crossbreeding programs. Of course both males and females should be available and progeny should be continuously selected for type and performance.

Crossbreeding

The majority of commercial breeders embark on a crossbreeding programs to use the imported breeds on their base population of native sheep either pure or crossed. There are several ways of crossing sheep to maximize the performance. These can be broadly classified into various categories.

Terminal crossbreeding systems

All lambs produced from terminal crossbreeding systems are sent to slaughter and none is used for replacement. These systems are easy to utilize since usually only one flock of females is maintained and sires are purchased as required. The other advantage

is that the breeds of sire can be chosen to complement the weak traits from the dam side. The disadvantage is that since the replacement ewes and the sires are not produced on the farm, they have to be purchased, or a population must be kept solely to produce them with possible negative effect on the overall flock productivity. As a rule of thumb, one third of the flock should be used for replacement and the remaining two thirds for producing terminal market lambs. This arrangement works well in relatively large flocks but is not practical in small flocks.

a. Two-breed crosses. A population of purebred ewes (B), preferably prolific, is mated to rams from another pure breed (A) preferably from a terminal sire breed, to produce a first cross (F_{AB}) generation which is sent to market. The F_{AB} individuals exhibit maximum individual heterosis, but since the ewe is a purebred, there is no maternal heterosis exhibited.

b. Three-breed crosses. The first generation crossbred females (F_{AB}) produced from two-breed crosses as above (preferably a prolific cross), are crossed with terminal sires of a third breed (C), to produce three-way crossbred animals all slaughtered for market (Figure 1). This method capitalizes on the full potential of maternal and individual heterosis and takes full advantage of breed complementarity. First, by using crossbred female and capitalizing on maternal heterosis in traits related to reproduction, survival and fitness; second through expressed individual heterosis in growth and carcass quality traits in the three-way cross progeny. Three-way crosses can also be done by mating crossbred rams to purebred ewes and capitalize on the hybrid vigour of the crossbred rams in libido and sperm production. The third procedure, seldom used in practice, is to cross first cross parents which has one type in common, for example $M_{AB} \times F_{AC}$. The progeny would benefit from paternal and maternal heterosis, and to a lesser extent from individual heterosis.

c. Four-breed or double crosses. Populations A and B are first crossed with each other, and so are C and D, to obtain the F_1 generations F_{AB} and F_{CD}. These are then crossed together to give the "double hybrids", $F_{(ABCD)}$. This method capitalizes on the full potential of maternal, paternal, and individual heterosis, but is difficult to practice on farms (Figure 2).

Rotational crossbreeding systems.

Breeders weary of the prospect of introducing new replacement ewes and rams continuously, and who do not wish to keep pure populations for producing replacement animals, may consider the alternative system called rotational crossing. As the name implies, the crossbred replacement ewes are mated with males from one of the parental breeds, then the breed of sire is alternated for each new generation. The following types of rotational crossbreeding are common.

a- Two-breed rotational (Criss-crossing). Breeds A and B are crossed to produce an F_1 generation, then F_{ab} females are back-crossed to males from breed B, the $F_{(ab.b)}$ females are then mated back to males from breed A and so on (Figure 3). The method has advantage over the two-way cross, that one can continue to use the crossbreed females for breeding and it is necessary to purchase only purebred males.

b- Three-breed rotational. F_{ab} females are mated with males from a third breed C. Rams from breed A are used on the next generation of females and rams from breed B on the following generation of females, then rams from breed C on the following, and so on (Figure 4).

c- Four-breed rotation. Males from a fourth breed D are used on females of the combination $F_{(ab.c)}$. Thereafter males from breeds A, B, C and D are used in succession for each new generation.

After rotational crossing has been applied for a number of generations, a situation of equilibrium is reached with respect to the proportions of the different breeds in the genetic constitution of the crossbreds. In two-way crosses, equilibrium means that 67% of the genes of the progeny come from the breed to which backcrossing last took place, and 33% from the other breed. In three-way crosses, 57% of the genes come from the breed of the last used male, 29% from the previous breed and 14% from the third breed, which would be used for the next crossing. After equilibrium is reached, the highest proportion of genes in the genetic make-up of the progeny come from the males of the breed last used. The advantage of rotational crossing is that the females are always generated from within the flock and the breeder exploits continuously the maternal heterosis of the crossbred females and the individual heterosis of the progeny. The disadvantage is the need to acquire the rams, or the cost of keeping small purebred flocks to produce them. Also, the breeds implicated must play multiple roles in the system, since they contribute replacement ewes and market animals. Therefore, the breeds must be reasonably compatible and capable of producing both acceptable replacement ewes and desirable market lambs. Breeders using prolific breeds in rotational crossing should expect reduced prolificacy as the proportion of prolific genes in the replacement ewes decreases following crossing with other breeds.

d- Modified rotational-terminal system. Large flocks (300+ ewes) can adopt a combination of rotational and terminal crossing system. One third of the flock consisting of the best ewes in terms of fertility, prolificacy and mothering ability is used in a rotational system as mentioned above, whereas the remaining two thirds

are mated to terminal sire breed to produce market lambs (Figure 5). This system capitalizes on the advantages of both terminal and rotational systems.

Other crossbreeding systems

a- Back-crossing and grading-up. The first cross females (F_{ab}) are backcrossed to males of one of the parental breeds involved in producing them (a or b), thus producing animals with 75% of the genes from one breed and 25% from the other. Animals produced from this method are usually used for meat. The advantage of this method is the full use of maternal heterosis and especially when the F_1 females, are better mothers than females from either of the parent populations. The disadvantage of the method is the discontinuity and need to keep two separate breeds in the flock.

Grading-up is to backcross to the same breed, generation after generation (Figure 6). The result is a gradual change after which the population can be considered as a "pure breed". With each generation, the proportion of genes from the original population decreases to half the proportion present in the previous generation. For example after four generations it decreases to 6.25% (1/16) and after five generations to 3.125% (1/32). A recent example of the application of this method, was the development of American Finnsheep, where the breed was considered pure after four generations of grading-up. The advantage of this system is that a breeder raising any breed or even commercial ewes, can end with a flock of superior breed within a few generations by using only males from an improved or exotic breed. It is important to change the sires every generation to avoid inbreeding, caused by using the sire on his daughters or granddaughters.

Combining crossing and selection

a- Crossing with recurrent reciprocal selection. This complicated system can be used if the objective is to produce parents from two breeds which give excellent performance when crossed. The idea of the system is to cross males from breed A with females from breed B and vice-versa. Then, evaluate the crossbred progeny for the important traits to be considered in the selection. Finally, use the selected parents whose crossbred progeny gave the highest performance to mate with animals of their own breed. The outcome of such system is a gradual change in both populations to give better results in crosses with each other (Figure 7).

b- Crossing for the production of new breeds. The great majority of our present day breeds of farm animals have been founded by crossing different breed types with each other in an attempt to combine their desirable traits in the new breed. Recent examples of this, has been the development of the DLS breed from simple crossing of Dorset, Leicester and Suffolk breeds, each breed contributing favourable characteristics to the cross (Figure 8). The crossing can also be more complicated such as the crossing to develop the three Arcott breeds where numerous breeds were involved. In either case. after the initial crossing, the populations are then closed and mated from within. Selection is often applied to maintain high level of the desirable traits.

RECOMMENDED USE OF THE NEWLY INTRODUCED OR DEVELOPED BREEDS

It is obvious that since the newly imported or developed breeds have certain characteristics and attributes which favour one or more type of production, the way these genotypes should be used would vary accordingly. All these breeds should be raised pure by seedstock breeders to populate, maintain and improve the national flock. The next parts deal mainly with commercial breeders involved in one or more system of crossbreeding.

Prolific breeds

Romanov, Finnsheep, Rideau and Outaouais ewes can be used in:

a) A two-breed-cross system in mating with terminal sire breeds.

b) A three-breed-cross system producing crossbred ewes for mating with terminal breed rams. (Prolific x Suffolk, Dorset, Hampshire)

c) A two or three breed rotational cross, or rotational-terminal system.

Booroola is best used in:

a) Grade-up with selection on wool-type breeds to improve prolificacy.

b) Develop a new prolific genotype by specific crossing and selection.

c) Use in producing crossbred ewes for three-breed-cross system.

Prolific meat-type breeds

Charollais and Rouge de l'Ouest ewes can be used in

a) A two-breed-rotational system.

b) A two-breed cross system.

Meat-type breeds

Texel, Île-de-France, Berrichon du Cher, Canadian, DLS rams are used in:

a) Terminal sires in two- and three-breed crossing, rotational and cross-rotational systems.

b) Backcrossing on crosses with prolific breeds.

Multiple-purposes breeds

Polypay and Coopworth breeds are relatively complete all-around breeds and using them in either cross-breeding systems may not be advantageous.

Dairy-type breeds

The best way to use *East Friesian, Lacaune, and Rideau* breeds is to raise one third pure to produce replacement ewes and mate the remaining two thirds to a terminal sire breed to produce superior lambs for slaughter. Rams of these breeds can be used to cross with other breeds or crosses to increase milk production. They can also be used in three- or four-breed rotational crossing to improve this aspect.

CONCLUSION

The fast increase in the diversity of the genetic resources available to Canadian breeders, generates tremendous opportunities and potential to increase production and revenue from Canadian sheep enterprises. Farms can be specialised in one commodity or diversified in several commodities as desired. To be successful the breeders should have a profound knowledge about the different production systems to suite their genotypes to the appropriate breeding system to achieve maximum profits.

Table 1. Newly imported and developed genotypes of sheep in Canada

	Developed in Canada	Imported into Canada	Country of origin
1- Prolific maternal breeds	Rideau	Finnsheep	Finland
	Outaouais	Romanov	Russia
		Booroola (major gene)	Australia
2- Prolific meat-type		Charollais	France
		Rouge de l'Ouest	France
3- Meat-type terminal breeds	Canadian	Texel	The Netherlands
	DLS	Île-de-France	France
		Berrichon du Cher	France
		Dorper	South Africa
		Callipyge (major gene)	U S A
4- Milk breeds	Rideau	East Friesian	Germany
		Lacaune	France
5- Multiple purpose		Coopworth	New Zealand
		Polypay	U S A
6- Hair-type breeds		Katahdin	U S A

Table 2. Performance of Canadian, Rideau and Outaouais breeds and crosses

Trait	Canadian	Rideau	Outaouais	O × R	R × O
Fertility, %	75	80	79	72	68
Fecundity, %	149	205	206	177	167
Prolificacy	1.9	2.6	2.6	2.5	2.4
Lamb survival, %	69	77	77	76	75
Ewe weight at breeding, kg	80.7	74.4	71.2	65.8	66.8
Total lamb weight/ewe lambing					
At birth, kg	8.4	8.8	8.5	8.5	8.5
At 21 days, kg	18.1	20.5	20.1	19.0	18.2
At 91 days, kg	54.8	67.0	65.5	65.0	62.5
Individual lamb weight					
At birth, kg	4.02	3.40	3.26	3.28	3.11
At 21 days, kg	10.0	9.1	9.0	8.9	8.5
At 91 days, kg	30.8	28.8	28.3	29.5	28.6

Table 3. Characteristics of new breeds in Canada

	Sexual maturity	Prolificacy	Adult weight		Growth of lambs	Carcass quality	Wool production	Milk production
Rv, Finn	H	H	M-	H	L	L	L	M-
Booroola	L	H	M-	H	L	L	H	L
Rideau	H	H	M+	M	M-	M-	M-	M+
Outaouais	H	H	M+	M	M-	M-	M-	M
Charollais	L	M+	H	M	H	H	M	M+
Rouge de l'Ouest	H	M+	M	L	M+	M+	M-	M+
Canadian	M	M	M+	M	M+	M+	M	M
Texel	L	M	M+	L	H	H*	M	M
Berrichon	M	M-	M	L	H	H	M	M
Dorper	H	M	M	M+	M+	M+	M-	M
Île-de-France	L	M-	M+	H	M+	M+	H	M
DLS	M	M-	M	H	M+	M+	M-	M
East Friesian	M	M+	M+	L	M+	M	M	H
Lacaune	B	M-	M-	H	M+	M+	M-	H
Coopworth	M-	M	H	M-	M+	M	M+	M
Polypay	M+	M+	M+	M+	M	M	M	M

Figure 1. Three-breed crosses.

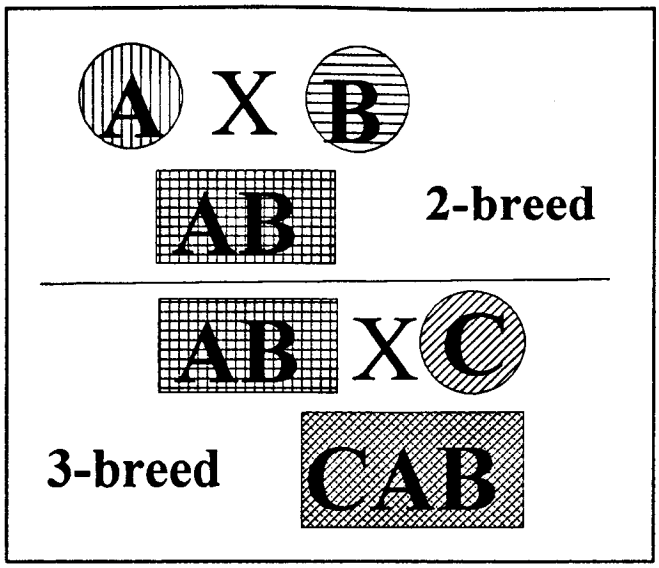

Figure 2. Four-breed or double crosses.

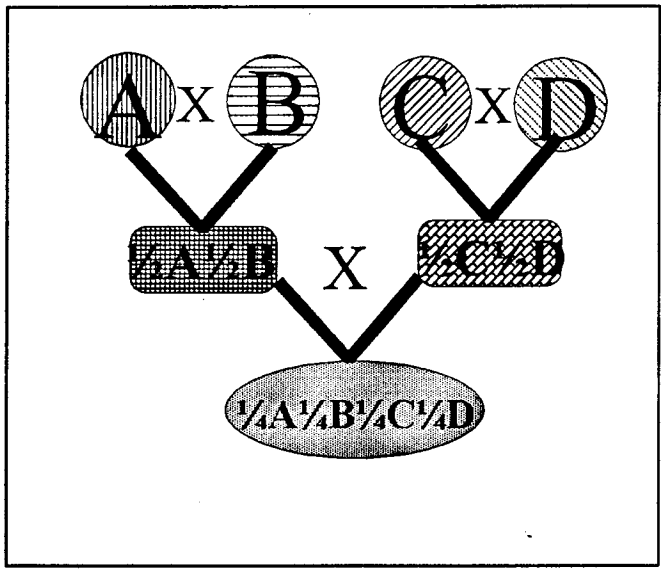

Figure 3. Two-breed rotational or criss-crossing.

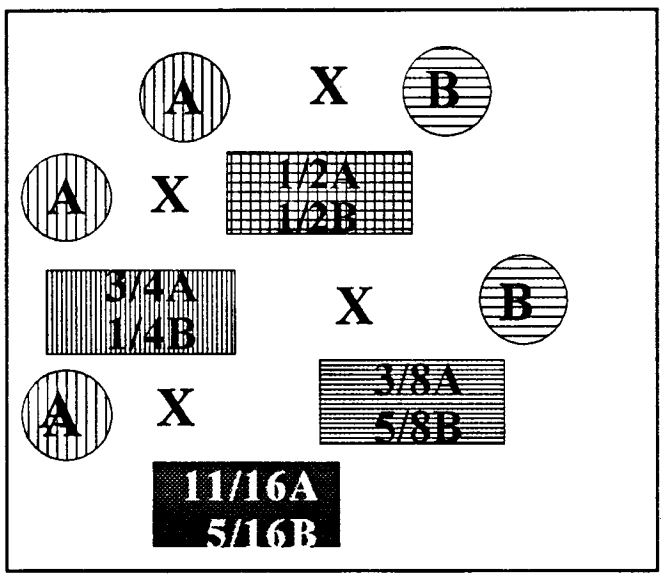

Figure 4. Three-breed rotational

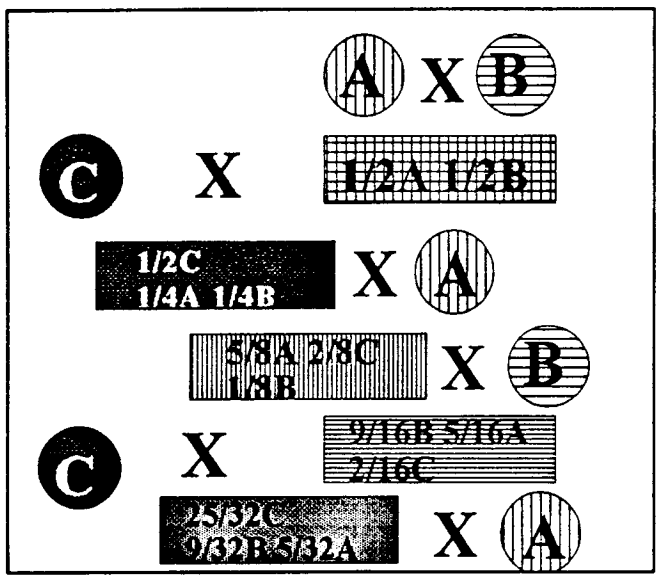

Figure 5. Modified rotational-terminal system.

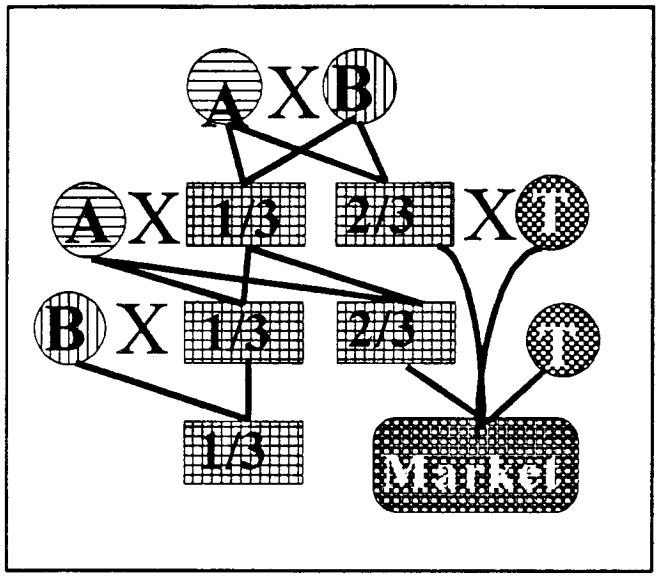

Figure 6. Back-crossing and grading-up.

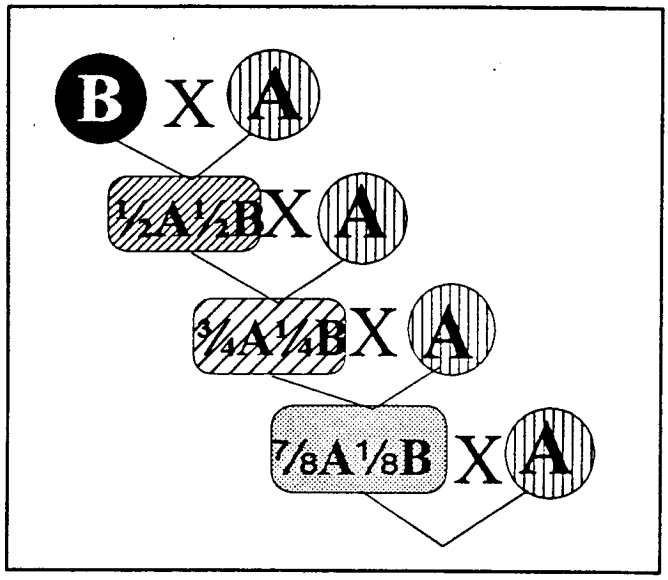

Figure 7. Crossing with recurrent reciprocal selection.

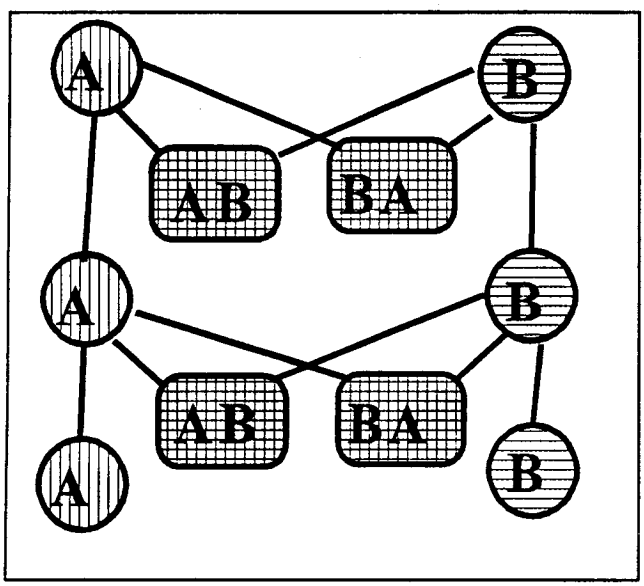

Figure 8. Crossing for the production of new breeds.