ORGANISATION OF SELECTION PROGRAMMES FOR DAIRY GOATS

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INTRODUCTION

According to FAO (2002), world goat population increased from 677 million animals in 1995 to 720 million in 2000, and world goat milk production increased from 11.8 millions tons in 1995 to 12.3 million tons in 2000. In 2000, 95.8% of world goat population was in developing countries and 4.2% in developed countries. Developing countries produced 80.5% of world goat milk production, and developed countries 19.5%. The five countries with higher goat milk production in 2000 were India, Bangladesh, Sudan, Pakistan and France accounting for 55.4% of total world goat milk production. Southern Asian countries and the Mediterranean region of Europe are particularly important regarding milk production and goat milk products (Boyazoglu and Morand-Fehr, 2001). In the Americas, Brazil and Mexico account for about 80% of total regional production. Evolution of milk production (1995-2000) was positive for India (9.9%), Bangladesh (11.7%) and Sudan (0.5%), but negative for Pakistan (10.7%) and most European countries excepting France, with an increase of 12%. In Latin-America, Brazil registered no change and Mexico a decrease of 5.1%.

Phenotypic variation and heritability estimates in goats indicate the possibility for changing several important traits using genetic selection (Ricordeau, 1981). Reproductive characteristics of the species allow to create populations with the desired genetic characteristics in a relatively short time span (Montaldo *et al.*, 1994). This paper intend to give information about production systems, genetic features of goats and technologies available for the design and operation of dairy goat selection programmes, including some documented experiences available worldwide.

SELECTION OBJECTIVES

Very different levels of milk production specialization are observed from region to region and even among countries in a region (Morand-Fehr and Boyazoglu, 1999). Also, a great variety of products are observed: cheeses, sweets such as caramel and a variety of other industrial and local products such as yoghurt, ice cream, butter, and butter products, acidified milk products and dried skimmed milk. In the Mediterranean and most Latin-American countries, goat milk is used mainly for cheese production. In Africa and South Asia, milk is consumed raw or acidified, as an important source of good quality protein for low income rural population in low- input systems. In Norway, the main goat product is Geitost made from whey (lactose and fat) (Ådnøy *et al.*, 2000). This heterogeneity of production systems and products, suggests the need of developing several different selection programmes involving specific objectives.
In countries with traditional markets for milk goat products such as France, Greece, Italy, Spain, Norway and Latin-America, composition and flavour of milk, associated to the quality

and yield of these products are an important part of the selection objectives. In some countries, economic or ad hoc indices to combine milk production with fat and protein contents have been developed. The ICC or caprine combined index is used in France to optimum economic selection of superior male and female for breeding on the basis of these traits (Piacère *et al*., 2000). Complementary traits, such as ease of milking and resistance to mastitis, measured with the aid of somatic cell counts and udder conformation, are important also. Type traits are thought to be indicators related with physiological functions, having importance for hardiness, health and length of productive life. More research on this subject in the line of those performed in dairy cows' (e.g., Groen *et al*., 1997) is required to prove these associations and to find their optimum values for insertion in the selection objective.

In less specialized systems where both milk and meat production are important, inclusion of meat production traits could be an option for developing a double-purpose population. More research on possible unfavourable genetic correlations between milk and direct and maternal traits for meat production efficiency is required because negative associations across breeds have been reported (Montaldo and Meza, 2000).

For all production systems, traits related to reproductive efficiency, adaptation and longevity, and animal health are important components of quality and safety of products, production costs and animal welfare. Due to lack of information on genetic variation or scarcity of data available for selection, these traits are rarely used as criteria in current dairy goat selection programmes. Male and female fertility have low heritabilities (Ricordeau, 1981) but they could be included for accurate selection of males based on progeny information. In some regions and production systems, non-seasonal breeding could have an added value for the farmer via better seasonal milk prices and management of food resources. Adaptation traits of resistance to particular conditions in medium- to low-input systems are important, but necessary data for such selection are usually unavailable. Genetic variation for longevity may be an alternative in order to select indirectly for adaptation and health.

Direct improvement of animal health is a major challenge for goat genetic programs and efforts should be done to improve disease prevention and control, and to search for genetic resistance. In medium- to low- input systems, major interactions of genetic programmes with some diseases suggest to do simultaneous work in health programmes such as brucellosis control to avoid spreading diseases when selected males are used extensively for natural matings. For some diseases, such as parasitisms (Mandonnet et al., 2000), scrapie (Goldmann, 1999) and the caprine arthritis-encephalitis virus (CAEV; Obexer-Ruff *et al*., 2000), traditional prevention and control measures have been ineffective or very expensive, and the search for genetic resistance represents an interesting alternative.

GENETIC VARIATION

Most recent heritability estimates for milk yield in dairy goats from farm records are in the range of those obtained for dairy cows (0.20-0.40), some estimates of heritability for milk production, however, have been higher (over 0.5). Reasons could be related to deficiencies of data and methods of estimation to separate genetic from herd-year-season influence or artificially standardized environmental conditions of measurement in research stations.

Heritabilities for fat, protein and milk yield are generally similar and frequently heritabilities of components are higher or similar to those for yields. Negative correlations between milk production yield and contents indicates that a compromise must be found if selection is oriented toward milk production and contents (Barillet *et al.*, 1998). The coefficient of variation for milk production in goats is generally higher than in dairy cows, the generation interval shorter and female reproductive efficiency of females greater. All this factors creates a biological potential for a higher selection progress for milk production traits in goats than in cattle (Montaldo *et al*., 1994). Type traits have moderate heritabilities allowing genetic changes (Luo *et al*., 1997; Manfredi *et al*, 2001).

No large scale QTL programs using markers to scan the whole genome have been reported so far in dairy goats. Instead, effects of known and unknown QTL have been documented for dairy traits such as solid contents of milk and milking speed. Using analysis of pedigreed data, the segregation of a major gene for milk flow was detected in Alpine goats (Ricordeau *et al.*, 1990). The partially dominant gene explains about 60% of total genetic variation (total heritability of 0.65 and polygenic remanent heritability 0.30) (Ilahi, *et al*., 2000). Polymorphisms of the α-s1 casein locus control the rate of casein synthesis and thus protein production in goats. The difference between extreme genotypes homozygous for alleles A (high protein content) and F (low protein content) is about 4.5 g/kg in the Alpine breed, which represents 3 genetic standard deviations (Barbieri *et al.*, 1995). Similar effects on casein production has been found in other goat breeds such as the Malagueña breed from Spain (Angulo *et al*., 1996).

SELECTION PROGRAMMES FOR DAIRY GOATS

Characteristics of selection programmes are the result of the characteristics of the production system and their associated economic requirements, the knowledge obtained on the genetic variability and genetic control of production traits and the resources available for running the programme.

Basic requirements. Basic requirements for the organization of any selection programme for dairy goats are the identification of the animals, the genealogical control and the measurement of important traits for the production system. Primarily traits are generally those related to milk yield and contents, mainly fat and protein. These traits are directly related to farmer income, cheese yield and in general the production of the useful mater of milk frequently defined as the milk protein plus fat. Complementary characteristics related to mastitis resistance and milking ability, such as somatic cell counts, udder conformation and milking ability are recorded routinely in some programmes (Manfredi, *et al.*, 2000).

Genetic evaluation and selection programmes. Recorded populations for a sample of European and North American countries with official milk and genealogical recording and routine genetic evaluations for dairy goats in 1999-2000 are shown in table 1. All countries included milk yield and many have milk composition and conformation traits recorded as well. Excepting France, Spain and Norway, recorded number of goats are somewhat small on each breed for an efficient progeny testing programme to operate. Efforts are made to reduce milk recording costs in several countries by promotion of alternate AM/PM recording or by limiting the number of measurements, as in Norway were goats are evaluated with five tests for milk and with three for components (Ådnøy *et al*, 2000).

Table 1. Number of recorded goats in a sample of countries 1999-2000

	Breed			
Country	Alpine	Saanen	Other	Traits[A]
Canada	1 485 (all breeds)			M,F,P,C
France	149 000	125 000	4 300	M,F,P,C
Italy	12 000 (all breeds)			M,F,P
Norway			19 666 (local breed)	M,F,P,L,T
Spain			28 000 (Murciana-Granadina)	M,F,P,L,T
Switzerland	2 929	3 269	1 435	M,F,P
USA	2 194	933	2 138	M,F,P,C

[A]M=Milk; F=Fat%;P=Protein%; L=Lactose%; C=Conformation (Type traits);T=Milking traits.

Table 2 summarises characteristics of the selection organisation and genetic evaluation in several countries (Ådnøy *et al*, 2000; Clement *et al*, 2000; Hagger, 2000; Nazzari *et al*, 2000; Serradilla and Falagan, 2000; Sullivan, 2000; Sullivan and Wiggans, 2000; Wiggans *et al.*, 1999). Use of artificial insemination (AI) is still limited in most countries and research on techniques for semen production and insemination (Leboeuf *el al.*, 1998) is continued to increase the reproductive efficiency of frozen semen and to diminish AI costs. The French selection scheme is based on the widespread use of AI with frozen semen and oestrous synchronization (60 000 goats inseminated/year) allowing selection of dams of bucks across genetically connected herds, planned matings, and progeny test based on at least 40 recorded daughters/sire, as in typical dairy cattle programmes. In Norway, progeny test of bucks is based on the rotation of natural mating sires in several herds (buck circles) to create genetic connexions among herds.

In most programmes, genetic values are predicted using an animal model- BLUP (Best Linear Unbiased Prediction). France and USA evaluation programmes use univariate models for milk, fat and protein for total production, and multivariate models for conformation (type). In both countries, the evaluation models involves the combined analysis of all breeds, allowing the improvement of the statistical estimation of genetic and herd-year-season contemporary group effects in mixed breed herds. In France the evaluation model currently accounts for heterogeneous variances, allowing a more accurate selection of females (Robert-Granié, *et al.*, 1999). Single-trait (Canada) and multiple-trait (Norway) test-day models are also used for genetic evaluation of production traits. When properly applied, this model allows a more efficient comparison between goats with different number of measurements and removal of environmental factors associated with different stages of production within a lactation. The use of test-day models seems particularly useful for optimum use of data from flexible or simplified testing systems for milk production and milk components.

Table 2. Features of a sample of selection programmes in goats

Country	Genetic evaluation of production traits[A]	Genetic evaluation of conformation or other secondary traits[A]	Use of AI	Organised progeny testing programme[B]
Canada	AM,ST,TD	AM,ST	scarce	no
France	AM,ST	AM,MT	generalised	yes
Italy	AM,ST	--	scarce	no
Norway	AM,MT,TD	--	not used	yes (buck circles)
Spain	AM,ST	--	scarce	no
Switzerland	CC,ST	--	scarce	no
USA	AM,ST	AM,MT	scarce	no

[A]AM=Animal model-BLUP;CC=contemporary comparison;ST=Single trait;MT=Multiple trait;TD=Test-day-model.
[B]Planned matings for young sires, distribution or semen or use of sires in several herds.

Goat selection programmes benefit also from molecular information. As the αs1-casein polymorphism is a precocious partial indicator of progeny test results for protein yield and protein contents (Manfredi *et al.*, 1995), it is used for preselection of males entering progeny testing and for planned matings in France (Piacère *et al.*, 2000). Preselection of males is within family such that polygenic background and inbreeding are not adversely affected by major gene selection. This first use of the polymorphism will be followed by the inclusion of major genotypes in the genetic evaluation procedure allowing for across families preselection of males.

Emerging programmes. Many organisational and logistic issues need to be addressed to obtain the genealogical and measurement data required to obtain reliable genetic evaluations of animals and organise selection. In developing countries, most problems are related with general lack of clear conscience on the importance of reliable genealogical and measurement data for animal improvement. This problem is aggravated when governments or the private sector lack initiative to promote and finance these activities, there is no organization of breeders, the formal educational level of breeders is low, there are no training programmes in animal breeding for farmers and communication of academia with real world problems is frequently limited. All or many of this problems are present in many developing countries and explain the lack of more improvement programmes operating in countries that hold most of the world goat population.

Consider the emerging dairy goat selection scheme in the State of Guanajuato (Mexico). Several preliminary steps were sequentially done to develop a safe system of animal identification accepted by breeders, to start milk recording (reproductive data and milk yield), and to organise collection and analyses of milk samples for determination of milk components. In January 2002, the first genetic evaluation involving 12 herds and 1 045 animals was released using an animal model- BLUP for total milk production. Next step involve the evaluation of animals for fat, protein and conformation (Montaldo *et al*., 2001).

In some situations where organisation of on-farm milk recording is difficult, starting programmes can concentrate efforts to control genealogies and milk recording in closed nucleus breeding. In the absence of any biotechnology it is still possible to obtain genetic progress by selecting only the best females to produce both males and female replacements with an expected annual genetic progress of about 1% of phenotypic mean for milk yield (Montaldo *et al*., 1994). Later evolutions for this starting programme could be to intensify sire identification and reproductive techniques in the nucleus (AI and multiple ovulation and embryo transfer (MOET)) or to increase population size by progressively develop an open nucleus. Theoretical prediction of genetic gains for milk yield for an adult MOET nucleus of 512 goats based on combined pedigree-sib selection was similar to figures of an efficient progeny testing programme (2% of phenotypic mean; Montaldo *et al*., 1994). However, open nucleus, with a larger population spread in several herds, eventually leading to a progeny testing system, offers more flexibility to control inbreeding and to select in several environments.

Contributions from selection programmes. Within breed, positive genetic trends have been reported for yields and contents in pure breed schemes (Table 3; Clément *et al.* , 2002; USDA, 2001). Estimated genetic gains/year for milk yield vary from 14 kg to 0.59 kg. In the Alpine breed, estimated annual gain for milk yield attains about 0.18 σ_g (genetic standard deviation) and corresponding values for fat and protein yields are 0.18 and 0.22 σ_g. These results indicate that dairy goat populations are attaining satisfactory rates of genetic progress which could be further improved by increasing AI use and the number of young bucks entering progeny test.

Table 3. Genetic trends per year for production traits in several dairy goat populations

Country and period	Breed	Milk (kg/year)	Fat (kg/year)	Protein (kg/year)
France 1990-2000	Alpine	13.65	0.55	0.50
France 1990-2000	Saanen	12.53	0.48	0.46
USA 1995-2000	Alpine	8.63	0.19	0.11
USA 1995-2000	Saanen	6.99	0.32	0.23
USA 1995-2000	Toggenburg	0.59	0.04	0.06

Some high producing breeds such as Alpine and Saanen have been introduced as exotic breeds in a variety of environments. As a general trend, these exotic breeds exhibited higher levels of milk yield and lower solid contents than local breeds (Serradilla, 2001). However, before deciding the absorption of local by exotic breeds, it is recommended to evaluate the possibilities of selection of local breeds and to consider not only milk production but also adaptation traits to the local environment in breed comparisons, by using, for instance, bio-economic indexes as proposed by Meza and Montaldo (2000).

CONCLUSION

Most dairy goats are in developing countries; however, operating breeding programmes are concentrated mainly in Europe and North America. The French selection programme, based on the AI cattle model, and the Norwegian programme, based on natural mating and buck circles, are two recognisable organised progeny testing programmes, including a formal definition of the selection objective and organized matings to produce young sires and their progeny. In other countries, milk recording, genealogical control and genetic evaluation using animal model-BLUP are the major features of the programmes. Positive genetic trends for milk, fat and protein production have been found in France and USA, but most programmes involves a relatively limited number of records and a relatively scarce use of AI. For already established programmes, perspectives include consideration of new traits among the selection criteria, automatic performance recording, a generalised use of test-date models and insertion of molecular information in genetic evaluation procedures.

Opportunities exists to create genetic progress in local breeds well adapted to medium- to low-input systems, using basic recording systems and selection only of the female side. These simple programmes could be used at a low cost in developing countries and may avoid importation of breeding animals selected for different production systems and markets. Also, these programmes are the basis to make a rational use of more advanced techniques. Major difficulties for the development of efficient genetic improvement programmes in developing countries are mainly of cultural, educational and organisational nature.

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