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LE LAMENTIN Ville fertile

A MODEL FOR SUSTAINABLE GENETIC IMPROVEMENT OF BARBADOS BLACKBELLY SHEEP IN THE CARIBBEAN

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RESUME

Cette communication indique que plusieurs races de moutons prolifiques dans le monde possèdent un gène important pour la prolificité. Cependant, l'existence d'un tel gène chez les races prolifiques de mouton à poil dans la Caraïbe doit faire l'objet de recherche. Cette communication suggère que ce gène (F) existe chez le mouton Blackbelly de Barbade et développe les grandes lignes d'une stratégie pour l'exploiter au bénéfice du petit agriculteur, aussi bien que du gros producteur privé. La stratégie vise à développer un unique type de mouton pour le petit agriculteur par une réduction sélective dans la fréquence du gène F réduisant ainsi la fréquence de naissances multiples. Le développement d'un autre type de mouton hautement prolifique est suggéré pour une utilisation chez le gros producteur à travers une augmentation sélective dans la fréquence du gène F. L'on attend du gros producteur qu'il emploie de hauts niveaux d'alimentation et de gestion incluant l'élevage artificiel d'agneaux afin de diminuer les mortalités dues aux naissances multiples. La communication s'étend à la sélection pour l'amélioration génétique pour la rusticité du mouton à poil. A ce propos, le développement d'un noyau de sélection ouverte est suggéré entraînant la participation et la coopération parmi les petits exploitants.

ABSTRACT

This paper points out that several breeds of prolific sheep in the world possess a major gene for prolificacy. However, the existence of such a major gene in the prolific breeds of hair sheep in the Caribbean remains to be researched. This paper *assumes* that this gene (F) exists in the Barbados Blackbelly sheep and goes on to outline a strategy to exploit it for the benefit of the small farmer as well as the large private producer. The strategy aims at developing one type of sheep for the small farmer by selective reduction in the frequency of the F gene thereby reducing the frequency of multiple births. The development of another type of highly prolific sheep is suggested for use by the large producer through selective increase in the frequency of the F gene. Large producer is expected to employ high levels of feeding and management including artificial rearing of lambs so as to minimize mortality of multiplets. The paper further discusses within breed selection for genetic improvement in *general fitness* of hair sheep. In this connection, the development of an *open nucleus flock* is suggested involving cooperation among participant smallholders.

Keywords: Caribbean hair sheep; Genetic improvement; Within breed selection; Major, prolificacy gene.

INTRODUCTION

Hair sheep constitute an important genetic resource for the Caribbean region and for the tropical world in General. Moreover, these sheep are in great demand in temperate countries for crossing with wool sheep in order to infuse fertility and prolificacy genes. Since the late seventies, major advances have been made in elucidating genetic properties of Caribbean breeds of hair sheep (Mason, 1980; Bradford, 1983;Shelton and Fugueiredo, 1990; Wildeus, 1991; Ponzoni 1992; Fahmy, 1996).

Rastogi, Keens-Dumas and Lauckner (1993) reported results of a study comparing performance of several breeds of Caribbean hair sheep under purebreeding and crossbreeding. This study involved Barbados Blackbelly (BB), West African (WA), Virgin Islands White (VIW), Blackhead Persian (BHP), Blenheim Grade (BLG) breeds and various crosses between and among them. Several conclusions, including the ones listed below, were made:

- ✓ under an improved management system, where lamb survival can be optimized, BB should be the breed of choice;
- ✓ the possibility of a major gene controlling prolificacy in BB (and perhaps WA) sheep needs to be researched.

MAJOR GENES FOR PROLIFICACY

The Booroola (FecB) was proposed as the first major gene for prolificacy in Booroola strain of Merino sheep by Piper and Bindon (1982) and confirmed by Davis et *al.* (1982). Later, other major loci were suggested for the Javanese breed (Bradford et *al.,* 1986), the Icelandic breed (Jonmundsson and Adalsteinsson, 1985), the Cambridge and Belclare synthetic lines (Hanrahan, 1991) and the Romney breed (Davis et *al.,* 1991), in which the major locus (Inverdale gene) was located on the X Chromosome.

These major genes became evident by careful observation of prolificacy of animals in controlled flocks in which the genes were segregating and involved complex pedigree analysis of a population with a set of unrelated paternal half-sib families. Such genes appear to be inherited in a simple Mendelian mode. Thus, in principle, it should be possible to map, isolate and transfer such genes to other breeds or to other strains/subpopulations within the same breed that are not carrying the gene.

The existence of major gene(s) for prolificacy in the Caribbean hair sheep breeds remains to be investigated. However, for the subsequent presentation in this paper, it is *assumed that a major, completely dominant autosomal prolificacy gene (F) exists in Barbados Blackbelly sheep.*

GENETIC IMPROVEMENT

Strategy to exploit the F gene

BB ewes may give birth to one lamb or up to 4, 5 (or even 6) at one lambing. It is hypothesized that the major gene (F) present in this breed is responsible for much of this variation. Ewes may be classified on the basis of their prolificacy into one of the three genetic groups, with average number of lambs born, as shown in Table 1.

Table 1. Expected average litter size of ewes with different dosages of the F gene in their genotypes

	Ewes with no F gene (++)		Ewes with an F gene from one parent (F+)		Ewes with an F gene from both parents (FF)	
Ewes	**Av.**	**Range**	**Av.**	**Range**	**Av.**	**Range**
Young (First litters)	1.2	1 – 2	1.9	1 - 3	2.4	1 - 4
Mature	1.3	1 – 2	2.1	1 - 3	2.8	1 - 5

While there is variation due to ewe age and nutrition and among individual ewes within groups, there are very large differences in average prolificacy due to the presence or absence of the F gene.

The high prolificacy of the F+ and FF ewes may be desirable or undesirable, depending on the level of nutrition and management (e.g., artificial rearing of lambs) of the flock. For example, weight of lamb weaned per ewe giving birth to 1, 2, or 3 or more lambs can be estimated as per the Table 2.

Table 2. Expected average productivity of ewes with different litter sizes

Item	Av. quality forage only; no supplements during pregnancy and lactation; average care flock			Good quality forage; concentrate supplements in late pregnancy and lactation; extra care at lambing flock		
Lambs born	1	2	¤3	1	2	¤3
Av. Survival rate	0.82	0.70	0.40	0.90	0.85	0.70
Av. weight 56d (kg)	10	7	6	12	11	10
Lamb. wt. at 56d per Ewe lambing	8.2	9.8	7.2	10.8	18.7	21

In the hypothetical example in Table 2, under average nutrition and management, there is a small advantage for twins, and a disadvantage for triplets; under very good care and management, there is a 73% advantage to ewes with twins compared to those with singles, but little (≈ 12%) further advantage for ewes with more than two over those with twins. Actually, with special care and artificial rearing, higher prolificacy (3's, 4's) can lead to higher output per ewe, but this may or may not be economical.

As a reflection of favorable local and regional market opportunities, there is significantly increased interest in developing the sheep industry. In many cases, small farmers have already responded by augmenting the size of their flocks. In some instances, they have initiated fattening systems. Private and commercial companies are also getting involved in sheep enterprises. In such a context, some limiting aspects can be identified:

- ✓ the lack of quality breeding stock of superior genetic merit
- ✓ the lack of a hair sheep sire breed excelling in growth and carcass traits.
- ✓ the lack of breeding strategies suitable for bringing about genetic improvement at small farm and commercial levels, and
- ✓ the lack of a Caribbean-wide breeding programs in order to overcome the problem of small sheep numbers in one country.

As illustrated in Table 2, levels of prolificacy higher than 2 lambs per ewe lambing are also associated with relatively higher mortality rates. Therefore, unless environmental resources and management are extremely good, higher levels of prolificacy are rather disadvantageous. Assuming that the F gene is widely distributed in BB sheep populations, the approach to plotting of a breeding strategy should take into account this fact.

Where supplemental feeds are not available or are costly, the recommendation is to eliminate the F gene and keep flocks of ++ ewes only. All flocks should take advantage of the fact that BB sheep can lamb at intervals of 7 - 8 months. Ewes producing one healthy lamb every 8 months will raise 1.5 lambs per year, which is actually higher than in most high twinning flocks in temperate climate, with once-a-year lambing systems. With only singles and some twins, lamb mortality will be lower and lamb weaning weights more uniform than in most current flocks in Barbados, which are assumed to be a mix of ++, F+ and FF ewes.

For more intensive systems, where appropriate supplementary feeds are available and there is a good market for lambs, the F gene can be used to improve productivity substantially. Since F+ ewes have more twins and fewer litters of 3, 4 and 5 than FF ewes, F+ ewes are preferred.

Smallholder farmers

These farmers own small flocks consisting of a mix of ++, F+ and FF sheep. Two modules are suggested in order to limit the effects of the prolificacy gene.

Module 1 (Small Farm Intensive Production Scheme, SFIPS)

This module is to have the simplest organizational structure since its main aim will be to reduce the frequency of the F gene by eliminating the FF sheep from the breeding flock, such that the maximum level of prolificacy will be provided by F+ ewes only. F+ rams will also be eliminated from the breeding flock. Thus, only ++ rams will be mated to ++ and F+ ewes. ++ rams will eventually be distributed among participant farmers. The resulting progeny from these mating will consist of a mix of ++ or +F genotypes in 2:1 ratio. Female progeny can all be used for breeding purposes. The system will be initiated with the distribution of ++ rams which would have been born as singles to dams which were themselves born as singles. Close monitoring of production records may identify FF ewes which should be soon replaced by the young progeny of ++ and/or +F genotypes.

This module will target small farmers for the production of lambs for slaughter or for fattening by others at an average rate of one lamb per month per flock as a way to obtain a steady cash flow during the year. The participant farmers will be selected based on a careful inspection of available forage resources and willingness to be cooperative.

Module 2 (Smallholder Breeding Center, SBC)

The goal will be to eliminate the F gene and maintain flocks of ++ewes only. These flocks will target the production of improved breeding stock upon which the entire breeding program will be based. Production will therefore target the provision of ++ rams and ewes for the different modules of the entire programs.

Module 2 will be part of the *open nucleus* flock where selection will emphasize:

- ✓ Capacity of ewes for 3 lambings in 2 years, and
- ✓ High individual/litter weaning weights.

Once again, single born rams will be selected from single born dams that wean the most kg of lambs by 3 years of age (3 lambings).

Individually identified ewes will be screened for prolificacy based on their litter size over the first 3 lambings. Surplus ewes consistently producing 1 or 2 lambs will be assigned to selected farmers (++ flocks) who will use distributed ++ rams and will, in turn, provide breeding stock for the other participant farmers. Highly prolific ewes which consistently produce 3 or more lambs can either be culled or swapped with less prolific ewes from ++ flocks.

Large scale producers

For this category of producers, the production of F+ ewes will be targeted in a stratified program as described below.

Module 3 (Stratified Program to Produce F+ Ewes for Commercial Production)

Organization:

Flock A. ++ ewes mated to ++ rams.

Flock B. ++ ewes mated to FF rams (rams purchased from a separate FF flock kept solely to provide such breeding rams).

Flock C. (Commercial). All F+ ewes (produced in Flock B) mated to selected high growth ++ rams to produce lambs which are all sent for slaughter with the exception of ++ ram lambs which can be retained for breeding.

Flocks A, B and C might be a single integrated operation, or under two or three separate ownerships; *the example illustrated in Table 3 assumes a single integrated operation.* The system could also be implemented cooperatively by a group of smallholders.

Table 3 Summary of the stratified program for commercial production of F+ ewes

Flock	Ewe Genotype	No. Ewes	Sources of Rams	Sources of Ewes	Disposal of Ram lambs	Disposal of Ewe lambs
A	++	80	Within flock	Within flock	Select for A Select for C	Best 40% to A & balance to B
B	++	120	Purchase (FF)	A	Market	All to C
C	F+	300	From A	B	Market or purchase	Market

Sources of sheep and flock sizes

At present, flocks of FF and ++ sheep are not commercially available to initiate such a program and will have to be developed by the enterprise itself.

A separate FF sheep flock will be created, preferably at a Government Station, by purchasing mature ewes which consistently produce 3 or more lambs and rams born as multiplets (triplets and higher). This flock will supply F+/FF rams to Flock B.

The ++ ewe flock will be developed by the following procedure:

A flock of 200 to 400 ewes is suggested. These may be available or may have to be purchased. Initially, there may be no record on performance, so ewes will first need to be identified and their litter size recorded. Ewes which consistently give birth to 1 or 2 lambs will be assigned to this flock. If the services of a person who can perform laparoscopies can be obtained, the ewes' ovaries can be examined before mating, and a quicker, more accurate sorting of ewes into Flocks A and C can be done, but this is not essential.

Initially, the ++ ewes in Flock A could be mated to ++ rams which were born as singles. After the first generation, rams should be selected from within the Flock A on the basis of their growth rate and conformation and their dam's performance (frequent lambing, good lamb survival and kg of lamb weaned). A simple way to select for all of these traits would be to select rams from the dams that wean the most kg of lambs by a certain age, say 3 years. Selection of rams in Flock A is critical, because their daughters and granddaughters will largely determine the performance of Flock A, B, and C.

As soon as the Flock A is large enough, perhaps 80 ewes, surplus ++ ewes will be assigned to the Flock B, and mated to FF rams to produce F+ ewes for Flock C. The best ewe lambs from Flock A will be used as replacements in Flock A, and the remainder of the A ewe lambs (++) assigned to Flock B. Alternatively, all Flock A ewe lambs could be bred in Flock A for 2 or 3 seasons, and then all transferred to Flock B to be mated to FF rams. All male lambs in Flock B will be marketed, and all ewe lambs will go to Flock C.

The rams to be used in Flock C could be an imported terminal sire breed such as the Suffolk or Dorset, if such rams are available at moderate cost and exhibit high fertility. This may be an option in countries like Dominica with moderate climatic zones. However, a readily available and economical source of rams for Flock C would be Flock A rams, which would have been selected for growth rate and would be well adapted. Still another alternative could be the use of rams of West African breed which possess good growth characteristics.

The program as described would result in a Flock C which would consist initially of F+ and FF ewes, but this would be converted in one generation to a flock of all F+ ewes, for more uniform performance. F+ ewes in Flock C should wean 20 to 35% more total weight of lamb per year than Flocks A and B which comprise ++ ewes only. With selection in Flocks A and B (and in the flock producing FF rams), performance in all flocks should increase continuously overtime.

Module 3 will be implemented in commercial flocks owned by private individuals/companies.

Module 4 (++ Breeding Center)

In this Module, the production of highly selected animals will be targeted. If the Center possesses performance record of ewes, these will be used to screen the population of ewes. Lapraoscopy on breeding ewes will also be used in the screening exercise. Lapraoscopies should be performed by trained scientists/technicians.

Ewes that consistently produce 1 or 2 lambs will be kept and bred according to the selection criteria for Module 2.

The Center will be part of the *open nucleus* scheme and, in addition to Module 2, its surplus production will supply the demand for breeding stock within the region.

The Breeding Center will have a large size flock (over 250 breeding ewes) which will allow the application of a more rigorous selection plan. This will place the Center on top of the stratified selection scheme.

Module 4 will be implemented at one of the Government Stations and/or with companies which decide to start a ++ sheep production flock.

Module 5 (FF Breeding Center)

The production of FF rams initially will be the responsibility of this Center. As new research results contribute to better and faster identification of animal's genotype (for example, via DNA typing), the production of FF rams could be transferred to a more specialized commercial flock, perhaps in another island.

This Center will also produce, initially, ++ rams for the program. This activity will soon be transferred to Modules 2 and 4.

SEARCH FOR APPROPRIATE EXPERTISE

Scientists with expertise in sheep genetics/breeding will have to be sought and appointed to execute this plan. It is proposed that a sheep breeder will be allocated to each unit of the plan. Together they will have responsibility for the execution of the general breeding plan, the breeding policies, the collection of the information and the analysis of data. Computer databases will be created for the storage of all production information. Full formal compatibility among individual (or unit) databases will be ensured to allow cross tabulations and evaluations.

Data to be recorded as well as breeding policies per unit will be specified in the implementation phase of this plan.

A summary of the breeding plan and the structure of the open nucleus are presented in Figures 1 and 2.

Figure 1. General summary of the breeding program and the production outputs of the various modules

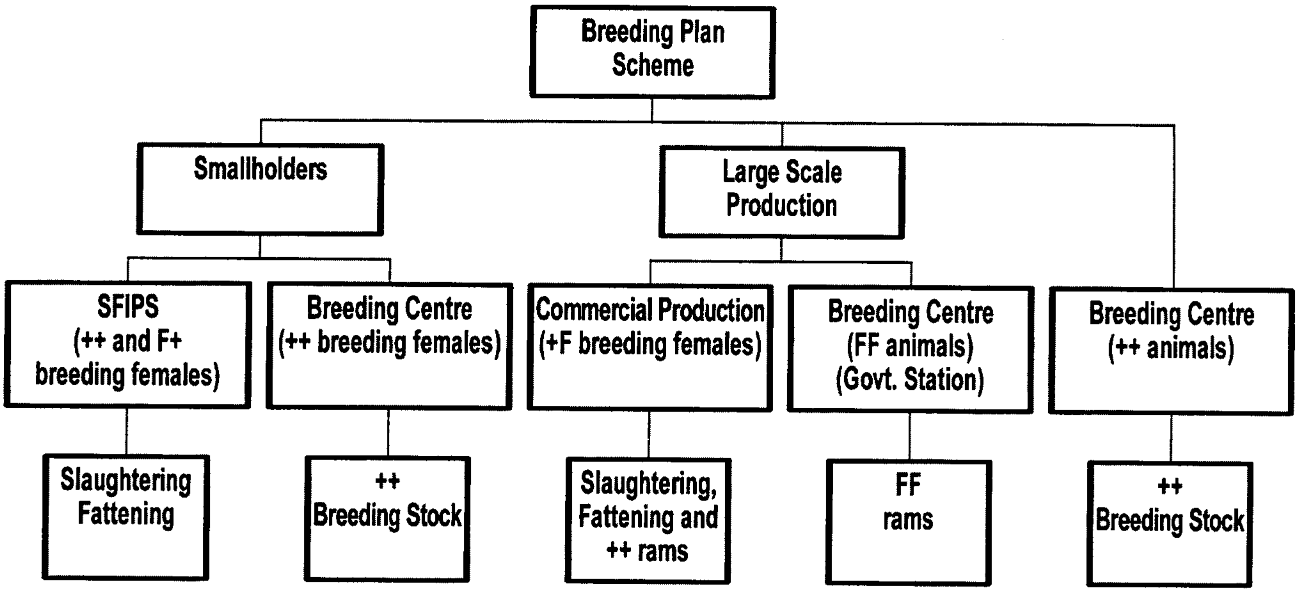
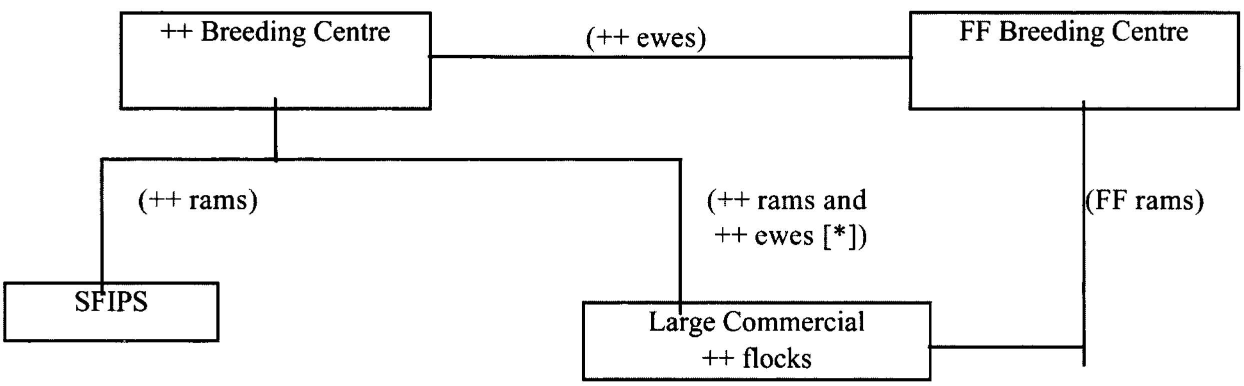


Figure 2. Structure and interrelationship of the *open nucleus* breeding system for prolific sheep



[*] Particularly in implementation phase

WITHIN BREED SELECTION

To the best of the author's knowledge, there are no reports of long-term selection experiments in tropical hair sheep. Most producers generally select for growth through visual appraisal of body size resulting in rather low selection intensity. However, selection for growth may not be the most desirable criterion as it may result in negative correlated response in the fitness traits of ewe conception and lamb survival. This points to the need for the development of a sire breed which may produce rams, excelling in growth and carcass traits, to sire prolific ewes in terminal crossing for the production of market lambs in commercial flocks. Even this option may not be very practical in much of the Latin America and the Caribbean due to small flock sizes and thus, the inability to make use of specific or terminal crossbreeding programs. Such specialized sire breed could be of much use to large sheep producers or plantation owners where hair sheep could make good use of forage growing under trees or of crop residues. It is suggested that the West African sheep at the Blenheim Sheep Station in Tobago should be used to develop such a ram breed.

The author has always maintained that the trait of major economic importance in the tropical hair sheep is general fitness, that is, the ability to survive, thrive well and reproduce. It is the general adaptability of hair sheep to varying environmental/climatic conditions which makes them so interesting for use in tropical as well as temperate countries.

Most hair sheep breeds in the Caribbean should be selected for some overall measure of productivity such as total weight of lamb weaned per ewe lambing per year. This is a composite trait combining prolificacy, lamb survival and growth, and lambing interval and is reported to have repeatability of 0.42 (no heritability given) in Morada Nova ewes (Figueiredo and Fernandes, 1990).

Within flock genetic progress from selection in hair sheep is constrained by many factors, including small flock size, lack of sire selection due to communal grazing, low selection intensity due to high lamb mortality from poor nutrition/management or inbreeding, and little recording of parentage or performance. However, production of superior *breeding value* stock requires effective within flock selection necessitating some type of cooperative breeding scheme. In such a scheme, a group of high performing ewes from different smallholder flocks are constituted into a nucleus flock. Such a flock can be maintained by one of the smallholders or, more likely, by a Government Station. Performance is recorded and selection is carried out for the most economically important traits. Chosen rams from the *nucleus flock* are made available to the cooperating farmers who, in turn, provide the nucleus herd with the next set of outstanding replacement ewes. This should lead to increased selection intensity and rate of genetic progress, and reduced inbreeding. Further details for the organization of such a cooperative breeding scheme can be found in the *Sheep Production Handbook* (1987).

The major reasons for failure of such a cooperative breeding scheme would be lack of cooperation among smallholders in the group and lack of enough sheep breeding and management expertise among individuals in charge of the nucleus flock.

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