FecB CARRIER DECCANI CROSSBRED EWES IN MAHARASHTRA, INDIA HAVE MODERATELY HIGHER LITTER SIZES THAN NON-CARRIER EWES

C. Nimbkar[1], P.M. Ghalsasi[1], S.W. Walkden-Brown[2] and J.H.J. van der Werf[2]

[1]Nimbkar Agricultural Research Institute, Animal Husbandry Division,
Phaltan 415 523, Maharashtra, India
[2]University of New England, School of Environmental and Rural Science,
Armidale, NSW 2351, Australia

SUMMARY

Litter size records of Deccani crossbred sheep with 0, 1 or 2 copies of the *FecB* mutation were analysed. *FecB* carrier ewes had higher live litter size per ewe lambed, at birth and at the age of 3 months than non-carrier ewes. Live litter size per ewe conceived, at birth and at 3 months age, of both $FecB^{B+}$ and $FecB^{BB}$ ewes was the same, weaning 50% more lambs per ewe conceived than non-carrier ewes. The dampened expression of the *FecB* mutation thus leads to less lamb losses and increased lamb production in the Deccan plateau production system.

INTRODUCTION

The Deccani is an indigenous Indian sheep breed reared on the semi-arid Deccan plateau with a total population of about 1.4 million (GOI 2019). Deccani sheep are grazed in smallholder flocks of 25 to 200 breeding ewes and mostly have single lambs. Most income is earned from the sale of 4-5 months old unweaned lambs weighing 10 to 15 kg. Lambs are reared with personal attention including cross-fostering. In meat producing species, the reproductive rate of breeding females is a key determinant of productivity. There is high local demand for lambs and sheep meat. A (cross)breeding program was established at the Nimbkar Agricultural Research Institute (NARI) at Phaltan in Maharashtra state of India in 1996 to develop a more prolific and productive sheep adapted to the Deccan plateau environment and local sheep owners' management. Nimbkar (2005) found the economic value of litter size in Deccani sheep to be positive after accounting for feed cost mainly because of the personal care of ewes and lambs and the practice of selling lambs early.

The *FecB* or Booroola mutation is an autosomal mutation that has a large additive effect on ovulation rate and is partially dominant for litter size (Davis *et al.* 1982). $FecB^{B}$ is the allele at this locus promoting higher fecundity while $FecB^{+}$ is the wild type allele. The breeding program at NARI introduced the *FecB* mutation from the prolific Garole (Bengal) sheep of West Bengal, India into the local Lonand strain of Deccani sheep. Two strains of *FecB* carrier sheep were developed: the NARI Suwarna with contribution from only Deccani and Garole breeds; and the NARI Composite with additional infusion of the indigenous Bannur, the improved Awassi from Israel and the taller and heavier indigenous Madgyal sheep. The proportion of the Garole breed was reduced deliberately in the cross as its small size, low growth rate and poor mothering ability were not found desirable by local sheep owners. The nucleus breeding flock is still maintained at NARI although with a reduction in the number of breeding ewes from >350 to around 250 in 2020 due to a labour shortage. Ewe and ram lambs are first selected at 4 months age based on their *FecB* carrier status determined by DNA test, their body weight and the reproductive performance and mothering ability of their dams. Ewes are culled for old age or poor reproductive performance. These *FecB* carrier sheep have become popular with sheep owners in Karnataka, Telangana and Maharashtra states and 900 $FecB^{BB}$ breeding rams and 1400 *FecB* carrier ewes have so far been supplied from NARI. This paper compares the reproductive performance of *FecB* carrier and non-carrier ewes in the nucleus at NARI from 2009 to 2022.

MATERIALS AND METHODS

Location, climate and animal management. Phaltan is situated at 18^0 N latitude and 74^0 E longitude and has a dry monsoonal climate with an average annual rainfall of 500 mm. Ewes in the nucleus breeding flock were grazed on crop residues, seasonal grasses, weeds and fallows and housed in open-sided sheds at night, similar to the management of local shepherds. They were given cut-and-carry fodder in the evenings during severe shortage of grazing. Ewes were supplemented with a concentrate feed containing 18% crude protein from 2 months before lambing until weaning of lambs at 15 kg weight at 3-4 months' age. The quantity of concentrate given was 200 g/day/head during 2009-16 which was increased to 300 g from 2017 as the average weight of breeding ewes increased from 28 to 32 kg. Ewes were divided into three flocks and each flock of about 100 ewes was bred every 8 to 10 months. Ewes which did not exhibit oestrus during a particular breeding period were moved to the flock next-in-line for breeding. During the breeding period which lasted one month, oestrus detection was done every morning with vasectomized rams. Ewes found to be in oestrus were artificially inseminated cervically using fresh, diluted semen (so that accurate pedigrees could be maintained). One ram was used only for 5 to 10 ewes and rams were used for a maximum of two years to limit inbreeding and shorten the generation interval. Ewes were ultrasound scanned on average 55 days after insemination. Lambs of dams which did not secrete sufficient milk were cross-fostered to ewes which had lost their lambs or had ample milk supply. All ewes and lambs were genotyped at the *FecB* locus using a forced PCR-RFLP direct DNA test.

Breed proportions. The range of proportions of different breeds in the ewes with records was 30 to 100% Deccani, 0 to 25% Garole and Bannur and 0 to 50% Awassi and Madgyal. The data from both NARI Suwarna and Composite strains were analysed together.

Description of data. Table 1 shows the number of lambing/abortion records of 1235 ewes (3.3 records per ewe on average) and Table 2 shows the number of lambs born alive for each *FecB* genotype of the dam.

Table 1. Classification of lambings/abortions according to *FecB* genotype of ewe

Records where ewes	***FecB* genotype of ewe**			**Total**
	$FecB^{BB}$	$FecB^{B+}$	$FecB^{++}$	
lambed with at least one live lamb	859	1859	578	3296
had stillborn lambs at completion of gestation	119	150	17	286
aborted before term	181	249	37	467
Total records	1159	2258	632	4049

Table 2. Distribution of live litter size according to *FecB* genotype of ewe

Number of lambs born alive	***FecB* genotype of ewe**			**Total**
	$FecB^{BB}$	$FecB^{B+}$	$FecB^{++}$	
1	386	802	540	1728
2	414	1008	38	1460
3	54	49	0	103
4	5	0	0	5
Total	859	1859	578	3296

Traits analysed. The following traits were analysed.

i. LBTOT/EL: Number of live and dead lambs born per ewe lambed (includes lambs which died soon after birth)
ii. LBA/ELA: Number of live lambs born per ewe giving birth to at least one live lamb

iii. LS3m/ELA: Number of live lambs at 3 months per ewe giving birth to at least one live lamb

iv. LBTOT/EC: Number of live and dead lambs born per ewe conceived (i.e. all records used for trait (i) above and zeros for ewes which aborted before completion of pregnancy. Abortions were recorded at visual signs in pregnant ewes such as vaginal discharge for early term abortions or aborted fetuses later in the term.)

v. LBA/EC: Number of live lambs born per ewe conceived (i.e. all records used for trait (ii) above and additionally zeros for ewes which aborted before completion of pregnancy.)

vi. LS3m/EC: Number of live lambs at 3 months per ewe conceived

Model of analysis. All traits were analysed using the Echidna mixed model software (Gilmour 2023) both as Poisson variables using a square root link and as normal variables. The Poisson analysis was used only for testing fixed effects and comparison with the linear model. The repeated observations in this data for all traits are expected to reconcile the relationship between the mean and variance for the Poisson-distributed traits.

The linear model used for all traits analyzed separately in single trait models was as follows.

$$y = \mu + Xb + Z_1 a + Z_2 pe + e$$

where y is a vector of observations on the ewe, μ is the overall mean, b is a vector of fixed effects (year of insemination and *FecB* genotype of the ewe as fixed effects and age and weight of the ewe at insemination as covariates), a is a vector of random additive genetic effects of the ewe, pe is a vector of the permanent environmental effects of the ewe and e is a vector of residuals. X is the incidence matrix of fixed effects. Z_1 and Z_2 are incidence matrices relating observations to the associated random effects. Breed proportions were not fitted as they were confounded with ewe weights. All available pedigree relationships were used in the analysis mainly in order to obtain accurate predictions of the *FecB* genotype effect.

RESULTS AND DISCUSSION

FecB genotype of the ewe, year of insemination and weight of the ewe were highly significant (P<0.001) for all five litter size traits analysed (results not shown). The weight of the ewe had a positive influence on all traits while age of the ewe did not have any influence. The predicted means for the year of insemination showed a downward trend for all analysed traits (0.02 to 0.04 lambs per year) from the year 2016. Inadvertent culling of ewes with larger litter sizes because of consistently higher lamb losses could be one of the reasons for this reduction.

Table 3. Predicted means (pmean) and standard errors (s.e.) for ewe's *FecB* genotype

Trait	Ewe's *FecB* genotype								
	FecB^{BB}			*FecB*$^{B+}$			*FecB*$^{++}$		
	records	pmean	s.e.	records	pmean	s.e.	records	pmean	s.e.
LBTOT/EL	978	2.02	0.03	2009	1.72	0.02	595	1.01	0.03
LBA/ELA	859	1.64	0.02	1859	1.58	0.02	578	1.00	0.03
LS3m/ELA	859	1.57	0.02	1859	1.51	0.02	578	0.99	0.03
LBTOT/EC	1040	1.90	0.03	2108	1.63	0.02	615	0.95	0.04
LBA/EC	1040	1.37	0.03	2108	1.38	0.02	615	0.90	0.04
LS3m/EC	1040	1.32	0.03	2108	1.32	0.02	615	0.88	0.03

LBA/ELA of ewes heterozygous and homozygous for *FecB* was 1.58 and 1.64 respectively compared to 1.00 in non-carrier ewes (Table 3). *FecB*$^{B+}$ and *FecB*^{BB} ewes had an advantage of 0.58 and 0.64 lambs at birth and of 0.52 and 0.58 lambs at the age of 3 months respectively over non-carrier ewes. This advantage declined slightly to 0.48 and 0.47 lambs at birth for *FecB*$^{B+}$ and *FecB*^{BB}

ewes respectively after considering ewes that aborted. The causes of abortions were not investigated and infectious causes cannot be ruled out. The LS3m/EC of *FecB*$^{B+}$ and *FecB*^{BB} ewes was still 50% higher than non-carrier ewes. This is mainly because of the low lamb mortality which can be attributed to good mothering ability of the ewes and good management. Loss of lambs from birth to 3 months' age per ewe conceived in *FecB*$^{B+}$ and *FecB*^{BB} ewes in this study was 19% and 30% respectively. In contrast, the losses between scanning and lamb marking were 64% and 89% respectively in the Booroola Merino (Walkden-Brown *et al*. 2007) due to the Australian commercial sheep rearing conditions not being conducive to multiple-born lamb survival.

The effect of *FecB* is reported to be additive on ovulation rate and varying from additive to dominant on litter size depending on the background genotype (Davis 2009), influenced by factors such as uterine capacity, perinatal survival, birth weight, level of neonatal husbandry and care. In this study, *FecB*^{BB} ewes lost 0.38 lambs while *FecB*$^{B+}$ ewes lost 0.14 lambs at birth. The exact causes of these losses are not recorded in this flock but they are likely to be related to insufficient uterine capacity. The losses rendered the effect of *FecB* on LBA and LS3m partially dominant. Similarly, first and second copies added 0.62 and 0.02 lambs respectively to the litter size of the Afec-Awassi (Gootwine 2009). The meta-analysis of litter sizes of Chinese sheep (Chong *et al*. 2019) indicated an additive influence of *FecB* in some breeds and a partially dominant effect in other breeds. The litter size at birth of Indian Avishaan sheep (comprising of Garole, Malpura and Patanwadi breeds) carrying 0, 1 and 2 copies of *FecB* was 1.04, 1.70 and 1.93 respectively, also indicating partial dominance and slightly higher than the litter sizes in this study (Sharma *et al*. 2022).

CONCLUSIONS

FecB^{B+} and *FecB*^{BB} NARI Suwarna and Composite ewes selected for higher lamb survival weaned 50% more lambs than non-carrier ewes, indicating that *FecB*^{BB} and *FecB*$^{B+}$ ewes perform similarly. Continued wider dissemination of *FecB* should be through *FecB*^{BB} rams to increase heterozygosity rather than homozygosity. The introduction of *FecB* appears to be an effective way of sustainable intensification of sheep rearing on the Deccan plateau. The effect of *FecB* in other Indian sheep breeds where it is being introgressed needs to be evaluated.

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