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THE Fec*B* MUTATION INCREASES LAMB PRODUCTION IN SMALLHOLDER SUBSISTENCE FLOCKS IN MAHARASHTRA STATE OF INDIA

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SUMMARY

Introduction of the *FecB* mutation through heterozygous *FecB* carrier crossbred ewes was successful in increasing lamb production in nine smallholder sheep flocks managed traditionally. One copy of $FecB^B$ increased the number of live lambs born per lambing by 48% from 1.03±0.05 to 1.52±0.08, the number of lambs surviving at 3 months age from 0.96±0.07 to 1.42±0.13 and the weight of 3-months old lamb produced per lambing by 22% from 13.2±0.4 to 16.2±0.6 kg. Heterozygous ewes had a 36 days shorter lambing interval. Such strategies increase the efficiency and profitability of sheep production in the changing socio-economic and environmental milieu.

INTRODUCTION

About 100,000 smallholder sheep owners rear approximately 3.7 million non-prolific Deccani sheep on the dry, monsoonal Deccan plateau in Maharashtra State, India, as a source of livelihood. Lambs are usually sold at 3 months age in groups to butchers who pay a price based on a visual assessment. As a result, a sheep owner's income depends largely on the number of saleable lambs produced per ewe per year. The sheep production system is shepherded grazing on fallow and harvested fields, public (often degraded) lands, road and canal verges and farm bunds. Sale price of lambs has increased by 10 to 20 percent per year over the last 10 years due to the increases in the human population, urbanization, incomes and the gap between demand and supply.

A breeding program to increase the efficiency and profitability of lamb production by introgression of the *FecB* (Booroola) mutation which increases ovulation rate, from the small Garole breed into the Lonand Deccani breed type and a composite was established at the Nimbkar Agricultural Research Institute (NARI), Phaltan in south-western Maharashtra (Nimbkar *et al*. 2002). The new *FecB* carrier crossbred type comprised of only Deccani and Garole breeds was termed 'NARI Suwarna' (NS) and the composite comprised of Bannur and/or Awassi breeds additionally was termed 'NARI Composite' (NC).

The *FecB* mutation was introduced into nine smallholder flocks in January 2010 through the purchase of 94 pregnant heterozygous ($FecB^B/FecB^+$) crossbred ewes (comprising both NS and NC ewes) by flock owners from NARI with bank loans. Two of these flocks already had 27 $FecB^B/FecB^+$ ewes from earlier introductions of heterozygous and homozygous rams or semen. This study assesses the benefits of *FecB* carrier ewes in a largely traditional, low input subsistence farming system.

MATERIALS AND METHODS

Location. Performance records were collected in smallholder flocks in Bhadali village, 10 km south of Phaltan in Satara District, Maharashtra State, India (latitude 18^0 N and longitude 74^0 E).

Ewes. The smallest flock had 11 adult ewes; four flocks had 21 to 26 ewes each while the number of ewes in four flocks ranged from 35 to 46 each. Lambing and abortion records from the last quarter of 2009 to first quarter of 2012 were collected in nine smallholder flocks from 248 pregnant, non-carrier ($FecB^+/FecB^+$) ewes (482 records) and 114 crossbred $FecB^B/FecB^+$ ewes (244 records). Ewes purchased by flock owners from NARI in January 2010 provided 87 of the records of $FecB^B/FecB^+$ ewes and 26 of the records of non-carrier ewes while the remaining

records were from ewes already in the flocks at the end of 2009. Existing non-carrier ewes in the flocks were of the Lonand Deccani breed type with unknown admixture of the Madgyal breed, a hair sheep breed, taller, larger and faster growing than the Deccani, from southern Maharashtra and adjoining Karnataka state. The ewes purchased from NARI were crossbreds comprising of 40 to 94% Lonand Deccani, 6 to 28% Garole, 0 to 28% Bannur and 0 to 36% Awassi breeds. Seven $FecB^{B}/FecB^{+}$ ewes sourced from NARI had 50% Madgyal breed proportion. For about the last 10 years, Deccani sheep flock owners have been crossbreeding with Madgyal rams to improve lamb growth and adult size. The Deccani ewes already present in smallholder flocks were assumed to be non-carriers of *FecB* based on earlier studies (Pardeshi *et al*. 2005). The ewes introduced by NARI and those born in smallholder flocks from earlier carrier ram introductions were genotyped for the *FecB* locus at NARI using the PCR-RFLP direct DNA test (Wilson *et al*. 2001).

Animal management and records. All flocks were grazed by their owners under the traditional sheep-rearing system practised on the Deccan plateau. Some flocks migrated over approximately 50 km during the dry season between November and June. *FecB* carrier breeding rams were continuously run with the ewes. Lambs were not weaned; female lambs that were retained as replacements often suckled their dams until the dams naturally ceased lactating. Some flock owners provided supplementary feeding to lambs and lambed ewes. Cross-fostering was practised for twin-born lambs to other ewes in the flock, if the lambs' dam did not produce enough milk to maintain twin lambs. The only management interventions made by NARI were tagging, flock vaccination and treatment of sick ewes and lambs during routine visits. All ewes and lambs in the nine flocks were individually identified with ear tags. The flocks were visited once or twice a month and lambing (and abortions reported by flock owners), deaths, sales and lamb weights were recorded. Three month weight records were available for approximately half the total number of lambs surviving to 3 months as the flock owners sold lambs between NARI visits.

Traits analyzed. The ewe traits analyzed using the ASReml program (Gilmour *et al*. 2002) were:

1. Number of lambs born alive per lambing (NLBL): Zero if both lambs were stillborn (born dead on completion of full term) or one if one was alive and the other stillborn.
2. Number of lambs born alive per pregnancy (NLBP): Zeros for ewes that aborted (before term).
3. Number of lambs surviving to 3 months age per lambing (NL3M).
4. Weight of 3 months old lamb/s produced per lambing (WT3M).
5. Interval in days, between two lambings (LINT).

The traits NLBL, NLBP and NL3M were analyzed as Poisson variables with a log link while WT3M and LINT were analyzed as normal variables. Only fixed effects were fitted in univariate models for all variables. Fixed effects tested were flock or owner (9 classes), mating year-season for NLBL and NLBP (8 classes – summer, rainy and winter in 2009 and 2010 and summer and rainy in 2011), lambing year-season for NL3M (8 classes – rainy and winter in 2009 and summer, rainy and winter in 2010 and 2011), ewe breed type (Deccani vs. crossbred), ewe's *FecB* genotype (heterozygous carrier vs. non-carrier), the interaction of flock and ewe's *FecB* genotype and the covariable ewe's age in days. Garole breed proportion was additionally fitted for WT3M and LINT and age of the lambs at weighing was fitted for WT3M. An alternative model was fitted for WT3M using the fixed effect 'total number of lambs born per lambing' and for LINT using the fixed effect 'total number of lambs born in the ewe's previous lambing' instead of the ewe's *FecB* genotype. This was done because of the confounding between the ewe's *FecB* genotype and the two alternative fixed effects respectively. Least squares means (LSM) were estimated with only significant fixed effects in the model.

RESULTS AND DISCUSSION

Significance of fixed effects. The only fixed effect that was significant for the variables NLBL (P<0.001), NLBP (P<0.001) and NL3M (P=0.002) was the *FecB* genotype of the ewe. The P values of all other fixed effects and covariables were greater than 0.08 for these variables. However, for WT3M, the fixed effects of owner, lambing year-season, *FecB* genotype of the ewe, interaction between owner and ewe's *FecB* genotype, and the covariables age of the ewe, age of the lambs at weighing and Garole proportion of the ewe were all significant (P<0.012). Lambing year-season, *FecB* genotype of the ewe, Garole proportion of the ewe and age of the ewe were significant for LINT. Ewe's *FecB* genotype became non-significant for WT3M when the total number of lambs born was fitted as a fixed effect. Similarly, ewe's *FecB* genotype became non-significant for LINT when the number of lambs born in the previous lambing was fitted for LINT.

It thus appears that the differences in management among flock owners, annual or seasonal differences in feed availability did not influence ewe prolificacy or lamb survival significantly but they had a significant effect on WT3M and seasonal differences had a significant effect on LINT. Older ewes produced higher WT3M and had lower LINT. Garole breed proportion in the ewe had a negative effect on lamb weight but ewes with higher Garole proportion had lower LINT. Ewes that had twins in the previous lambing had a 12% shorter LINT than ewes that had singles. Almost all (89%) of these ewes were *FecB* carrier.

Effects of one copy of $FecB^B$. LSM of NLBL, NLBP, NL3M, WT3M and LINT for the fixed effect of ewe's *FecB* genotype, LSM of WT3M for the fixed effect of total number of lambs born per lambing and LSM of LINT for the number of lambs born in the previous lambing are reported in Table 1. One copy of $FecB^B$ increased NLBL by 48% from 1.03±0.05 to 1.52±0.08. Only two of the heterozygous ewes had triplets. The increase in NLBP was found to be 43% when the ewes that aborted were accounted for. Survival up to 3 months of both single and twin-born lambs was 94% leading to a 48% increase in NL3M with one copy of $FecB^B$ (1.42±0.13 vs. 0.96±0.07). The increase in WT3M due to one copy of $FecB^B$ was 22% and the reduction in LINT was 14%.

Table 1. Least squares means (LSM) and standard errors (SE) for all variables for the fixed effect of *FecB* genotype of the ewe and for the variables WT3M and LINT for the alternative models fitted using the fixed effects of total number of lambs born per lambing and total number of lambs born in the ewe's previous lambing respectively (n = number of records)

Variable	Fixed effect: Ewe's *FecB* genotype					
	$FecB^+/FecB^+$			$FecB^B/FecB^+$		
	n	LSM	SE	n	LSM	SE
NLBL	470	1.03	0.05	229	1.52	0.08
NLBP	482	1.00	0.05	244	1.43	0.08
NL3M	470	0.96	0.07	229	1.42	0.13
WT3M (kg)	228	13.23	0.36	122	16.20	0.60
LINT (days)	144	308.1	6.9	68	271.9	11.7
	Fixed effect: Total number of lambs born per lambing					
		1			2	
	n	LSM	SE	n	LSM	SE
WT3M (kg) (alternative model)	266	12.9	0.3	84	19.0	0.4
	Fixed effect: Total number of lambs born in the ewe's previous lambing					
		1			2	
LINT (days) (alternative model)	168	300.7	7.7	44	261.0	12.4

It therefore appears that smallholders managed to keep lamb mortality low and benefited from the moderate increase in NLBL. This is in contrast to the results of the ewe introduction in smallholder flocks in 2003 and 2004 (two of the flocks were the same as in 2010) when NLBL was 34% higher for heterozygous ewes compared to non-carrier ewes and NL3M was only 11% higher due to higher lamb mortality (Nimbkar *et al*. 2006). Some of the differences between the two introductions were that in the earlier introduction the ewes were given away while in 2010 the flock owners purchased ewes albeit at a subsidized rate and selected the ewes themselves. Additionally, the ewes introduced in 2003-04 were at least 25% Garole while in 2010, only 10% of the introduced *FecB* carrier ewes had more than 25% Garole proportion and 20% had less than 10% Garole proportion. Negative direct and maternal effects of the Garole on lamb survival and weight have been reported (Nimbkar 2006).

Ewes that had twin lambs produced 47% higher total weight of 3-months old lamb/s compared to ewes that had singles. It was unexpected that ewes producing twin lambs had a shorter lambing interval than single-bearing ewes as dams of twin lambs could be expected to undergo greater nutritional stress than dams of single lambs during lactation. Most (89%) of the ewes with twin lambs in their previous lambing and shorter lambing intervals were, however, heterozygous for $FecB^B$ suggesting a possible link between higher ovulation rate and quicker return to oestrus after lambing. Increased supplementary feeding to twin-bearing ewes before and after lambing and to their lambs is likely to maximize the benefits of the increased prolificacy and prove to be cost-effective.

CONCLUSIONS

Introgression of the *FecB* mutation into the Lonand Deccani strain of sheep while retaining the larger body size, hardiness, adaptation to harsh conditions and good mothering ability of the Deccani was found to be successful in sustainable improvement of sheep production in smallholder sheep flocks. This strategy is likely to be useful in the changing sheep production system due to declining grazing lands and increasing sedentarization.

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