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A COMPARISON OF PROGENY OF SELECTED AND UNSELECTED SIRES WITHIN THE SETTING OF A COMMUNITY-BASED BREEDING PROGRAMME CATERING TO WOMEN SMALLHOLDER GOAT REARERS IN BIHAR INDIA

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SUMMARY

Phenotypic goat data is generated as part of a community-based breeding programme (CBBP) to select breeding sires at the age of 100 days according to a score derived from combining multiple selection criteria within a multifaceted women's empowerment project. This analysis primarily aimed to utilise this phenotypic data to establish the effect of selecting sires within the CBBP on average daily gain (ADG) up to 100 days. A secondary aim was to establish the effect birth year of kids fathered by unselected sires had on ADG thereby removing the influence of the CBBP. Analysis of the data using multiple linear regression models revealed an overall statistically significant result that progeny of selected sires had a superior mean ADG 13.6% ($P < 0.05$) higher than the mean ADG of kids of unselected sires. This trend did not translate unanimously to village specific results. Analyses of birth year effects of kids of unselected sires on ADG showed an incremental underlying trend in growth rate increasing by 2.4g/day ($P < 0.05$) each year. Though some of the village specific results are inconclusive, overall results support the wide popularity of using a CBBP as one component in a women's empowerment programme to provide economic benefits through goat rearing despite limitations in an analysis utilising a dataset designed for sire selection.

INTRODUCTION

Goat rearing provides support to approximately 70% of landless, marginal, and small farm households in rural areas of the Bihar state of India (Schurink *et al.* 2022). Goats, being smaller and easier to tend to than other livestock, are usually reared by women (Barooah *et al.* 2020) who live with their families in small villages of several hundred people interspersed among fields of row and tree crops. They commonly keep 1–2 breeding dams with their associated litters as a relatively liquid supplementary source of income (Kumar *et al.* 2018).

Traditionally, most sires were unselected roaming bucks that had the potential to breed with most does in a village over an extended period (Schurink *et al.* 2022) causing a considerable risk of some sires mating with their own progeny. Resultant inbreeding in ruminants can lead to stunted growth, reduced fertility, and higher mortality rates (Leroy 2014). To ameliorate this situation and to increase goat productivity through genetic improvement, the Aga Khan Foundation (AKF) introduced a community-based goat breeding programme (CBBP) as part of a women's empowerment programme called Project Mesha which also included other initiatives such as training women in animal husbandry to provide preventive healthcare for goats and providing entrepreneurial opportunities through tending for breeding bucks (Nimbkar *et al.* 2021).

Primarily, this study aims to establish if there is an effect of selecting sires based on a score derived from combining multiple selection criteria on the average daily gain (ADG) in grams per day of progeny in a CBBP through the analysis of a dataset designed for selecting sires. Secondarily, it aims to use the same dataset to uncover the underlying trend of a kid's birth year on its ADG without the influence of the CBBP.

MATERIALS AND METHODS

Programme management. Project Mesha is a multifaceted women's empowerment program which targets goat keeper women who are members of the self-help groups within the Bihar Rural Livelihood Mission (JEEViKA) (Schurink *et al.* 2022). Key components of Project Mesha include: pashu sakhis who are women trained in animal husbandry and deliver fee-based animal preventive healthcare such as vaccinations, deworming, castration, breeding expertise, and encouragement of performance recording to assist genetic evaluation (Schurink *et al.* 2022); creating entrepreneurial opportunities for women via becoming breeding buck keepers; and the development and day-to-day management of a CBBP (Nimbkar *et al.* 2021).

The CBBP was initiated in 2018, 2 years after the commencement of Project Mesha. Individual animal-level data from these villages, including pedigree, phenotypic and dam health data, were recorded and stored using the Dtreo flexible cloud database system (https://dtreo.io/). Kids were selected as potential breeding sires based on having a desirable combined score derived from the following selection criteria: fast-growth in the first 100 days; being a twin; and having dams with a lifetime record of good health and liked by their owners (a subjective score provided by the owner at doe evaluation). Primary selection was made by the Mesha field team using data in the form of Dtreo generated reports of selection indexes for male kids and observation for absence of phenotypic defects (Savoia *et al.* 2023). If a kid was selected, its owner's consent was obtained to keep it uncastrated until the point of secondary selection occurring at the age of 6 to 8 months (Nimbkar *et al.* 2021). Project Mesha purchases selected sires at a price premium over the market value for meat and transports them to villages at least 20 km away.

Statistical analysis. Kids included in the analysis: i) had a minimum of three weight records; ii) had a known sex either 'male' or 'female'; and iii) were not identified as outliers with consecutive weights resulting in ADGs 3 standard deviations or greater deviating than the average. This totalled 2,002 kids including 960 from selected sires.

Four linear regression models were used for the analysis of sire identity effect. These models were fitted to data from all 2,002 kids.

In Models 1–4 (Table 1) Y refers to the ADG estimates (g/day) obtained by linear regression; β_0 is the intercept term; K_h is the sire identity effect (h = 1 and 2) (1, unselected; 2, selected); V_i is the village effect (i = 1–18); S_j is the sex effect (j = 1 and 2) (1, Female; 2, Male); L_k is the litter size (k = 1–4); W_l is the season of birth effect (l = 1 and 2) (1, Dry (November to May), 2, Rainy (June to October)); and P_m is the dam parity effect (m = 1–3) (1, First Parity (1), 2, Second Parity (2), 3, Third Parity or above (≥ 3)). Lastly, e is a term representing the residual error. Additionally, Model 3 incorporates a new main effect: an unordered nominal calendar year of birth effect Q_n (n = 1–6) (1, Year 2018, 2, Year 2019, 3, Year 2020, 4, Year 2021, 5, Year 2022, 6, Year 2023) and Model 4 incorporates a continuous calendar year of birth effect Q.

Table 1. Models to analyse sire identity effect on ADG (g/day)

Model number	Model
1	$Y_{hijklm} = \beta_0 + K_h + V_i + S_j + L_k + W_l + P_m + e_{hijklm}$
2	$Y_{hijklm} = \beta_0 + (K_h \times V_i) + S_j + L_k + W_l + P_m + e_{hijklm}$
3	$Y_{hijklmn} = \beta_0 + (K_h \times V_i) + S_j + L_k + W_l + P_m + Q_n + e_{hijklmn}$
4	$Y_{hijklm} = \beta_0 + (K_h \times V_i) + S_j + L_k + W_l + P_m + Q + e_{hijklm}$

A further 2 linear regression models, Models 5 and 6 (Table 2), were designed to analyse the year effect on ADG of progeny fathered by unselected sires (1,042 kids). Variables were defined as in Models 1–4.

Table 2. Models to analyse birth year effect on ADG (g/day)

Model number	Model
5	$Y_{ijklmn} = \beta_0 + V_i + S_j + L_k + W_l + P_m + Q_n + e_{ijklmn}$
6	$Y_{ijklm} = \beta_0 + V_i + S_j + L_k + W_l + P_m + Q + e_{ijklm}$

RESULTS AND DISCUSSION

Primary objective – sire identity effect. Model 1 results analysing the difference in means show kids generated by selected sires grew 13.6% faster ($P < 0.05$) compared to kids of unselected sires. Model 2 village-specific sire identity effects translated into statistically significant ($P < 0.05$) improvements in mean ADG of progeny of selected sires for villages 3, 5, 8, 9, 11, and 13.

When categorical or continuous year effects were included (Models 3 and 4 respectively), both models resulted in the same statistically significant villages for sire identity effect. Villages 3, 5, and 8 results showed increased selected sire effects ($P < 0.05$). Villages 1, 2, and 10 results showed decreased selected sire effects ($P < 0.05$). Villages 9 and 11 which lost statistical significance from Model 2 ($P > 0.05$) had progressively increasing proportions of selected sires throughout analysed years potentially leading to unstable data structures which could promote multicollinearity.

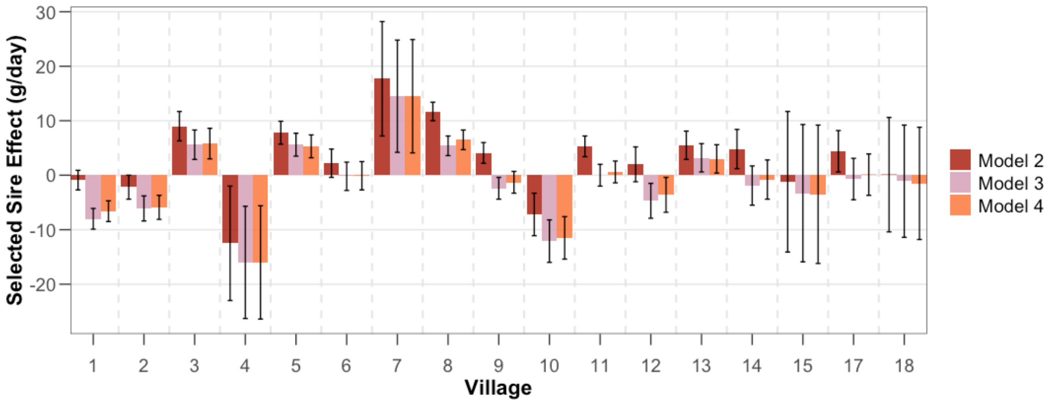

Figure 1. Mean selected sire effect on ADG (g/day) ± SE of recorded kids in Villages 1–18 in accordance with Models 2, 3, and 4

Secondary objective – birth year effect. Birth year effect on ADG was analysed using the kids of unselected sires only. Model 5 with the categorical year effect rendered the birth year effect on ADG insignificant ($P > 0.05$) for all years analysed, 2018 until 2023, when compared to the mean ADG of the reference year, 2018. Results from Model 6 designed to illustrate a continuous year effect on ADG indicated a statistically significant ($P < 0.05$) linearly increasing ADG with a gradient of 2.4g/day for each additional year within the study (standard error = 0.6 g/day).

Variability in ADG among progeny in this study was expected, as ADG was not the sole criterion for selecting young bucks as sires. In addition to growth potential, sires were chosen from healthy mothers deemed desirable by their owners and twinning was selected for (Nimbkar *et al*. 2021). This simultaneous incorporation of multiple traits within a breeding programme will mean that there are differences in rates of genetic gain for individual traits.

This analysis faced certain data structure limitations, i.e. using a dataset designed to select sires for a case control study and having gaps in progeny trait records. Future analyses could improve robustness of model outcomes by acknowledging confounding factors but that would not be practical when considering the primary purpose of this data is to select sires.

Despite these limitations in analysis, overall results from Model 1 are complementary to the substantial practical success the project has encountered. Currently, 150 villages have a selected breeding buck in residence, generating business income for women goat keepers and pashu sakhis. Some women, now recognised as 'buck entrepreneurs,' have expanded their operations to manage multiple breeding bucks. By sourcing sires from distant villages, the project effectively mitigates inbreeding, with each buck servicing approximately 20 does per month. Assured availability of high-quality breeding bucks has encouraged more women to engage in goat rearing, stimulating rural economic activity and enhancing women's financial independence which were the main considerations in this women's empowerment project.

CONCLUSION

Analysis of a dataset created to select sires for the CBBP component of a programme designed to create economic opportunities for women goat keepers indicated an overall significant increase in ADG for kids born to selected sires. This result didn't translate unanimously to village specific results. Analysis of only kids of unselected sires, and thus removing the influence of the CBBP, showed kids born in later years had statistically significant improved growth rates when treating the birth year effect as a continuous variable implying that factors like project management or environmental factors could also have contributed to improving progeny growth rates. Individual birth year effects on ADG fluctuated meaning more data is necessary to consider extrapolating this incremental trend. This analysis faced data structure limitations and considered only one of multiple breeding objectives of the CBBP. Other benefits of the project included economic opportunities and avoidance of goat inbreeding due to the CBBP leading to healthier progeny thereby improving the lives of women involved in this women's empowerment initiative.

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