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Multiplier flock scheme in Barbari goats: An entrepreneurship model for *in situ* breed conservation and improvement

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ABSTRACT

Barbari is a most preferred breed for commercial goat farming-under intensive management. However, pure-bred Barbari goats; especially buck's availability are meager due to indiscriminate castration which resulted in stagnation of genetic improvement and breed dilution. Multiplier Flock Scheme, an integrated genetic improvement model was initiated at ICAR-CIRG, Makhdoom to cater the need of pure-bred and high merit goats and to promote commercial goat farming. Trained farmers with adequate housing and know-how were registered under this scheme and they were provided a foundation stock of Barbari goat to multiply with all technical support. Currently, 50 such goat farms exist in India with flock size of 50 to 350 goats. Data was collected on animal performance and economic attributes from eight such farms. The least squares means of body weight of Barbari kids at birth, 3, 6, 9 and 12 months of age were 1.58, 7.22, 14.54, 20.01 and 25.76 kg, respectively. The average 60 and 90 days milk yield were 45.23 and 66.28 litre. The pre-weaning, post-weaning (3-12 month) and adult mortality were 9.03, 4.33 and 5.40% of flock strength. The net profit per goat/year ranged from ₹3800 to ₹13000 under various business models and the benefit:cost ratios ranged from 1.50 to 2.42 with mean and median value of 1.94 and 2.00, respectively. Present study concluded that multiplier flocks is efficient breeding model for improvement, conservation of goat breeds, promoting scientific goat farming at grass root level and very helpful to policymakers for small ruminant development.

Keywords: Breed dilution, Buck, Cost benefit ratio, Genetic improvement, Litter size, Intensive management, Multiplier flock, Lactation performance, Selection

Majority (76%) of goat keepers belong to marginal, small and landless farmer's categories. However, in recent past, goat farming is gaining popularity amongst prosperous farmers, retired officials and educated youth (Singh *et al.* 2022) on account of emerging demand in India and abroad. Higher chevon demand however, increased indiscriminate castration and slaughter of high potential males at young age by farmers, thereby leaving only impure and inferior bucks for its use as breeding animal, which contributes negatively in genetic improvement, and breed conservation (Singh and Rai 2006). Scarcity of potential pure-bred and high merit bucks along with poor adoption of technologies and subsistence production system are major challenges for lesser goat productivity and profitability (Singh *et al*. 2010) and limits the scope of establishing commercial farms. To address all these constraints, a programme was conceptualized as Multiplier Flock Scheme and implemented with Barbari breed in 2015 at ICAR-CIRG, Makhdoom, Mathura. This scheme was implemented with Barbari breed, initially in semi-arid regions in North India and subsequently extended to other climatic regions for multi-location testing. Barbari goat breed was chosen considering it's potential in commercial farming (Singh *et al.* 2021), better adoption for stall-feeding (Singh *et al.* 2022) and to stop the concurrent breed dilution by use of Sirohi on account of scarcity of pure-bred male in Barbari tract (Singh and Rai 2006). The progress was periodically monitored and more goats were provided to those farmers who were also involved in community breed improvement. The scheme has 50 multiplier flocks, located in six states with a flock size 50 to 350. Out of these, many such farmers have become an entrepreneur with multiple business models.

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MATERIALS AND METHODS

The program was implemented through identification of motivated farmers and technically made skilled in goat husbandry including shed constructions. Adopted farmer was provided with seed unit of 5 adult females, one buck, 5 males and 5 females of 3–6 months of age as foundation stock. Major thrust was given for sustainable breed improvement, *in situ* conservation, multi-location testing and supply chain of breeding goats through farmer's participation by promoting goat entrepreneur

models. Barbari goats at multiplier farmer's flock were maintained under semi-intensive and stall feeding systems and farmers also practised fattening of castrated males through supplementation of high protein concentrate feed, i.e. 400-600 g/d during 9-12 and 600-1000 g/d during 12-16 months of age. Some of these farms also kept goats on adequate khejri straw (*Prosopis cineraria*) and napier grass (*Cenchrus purpureus*) along with limited concentrate ration. The amount of green and dry fodder fed to adult goat ranged from 750-1500 g/d. These goats were housed separately in sheds with *kachcha* floor according to their sex, age, production and reproduction stages. The breeding is carried out seasonally, i.e. from April to June in summer and from September to November in autumn seasons. Each new born kid was assigned an identification number. Data was recorded for date of birth, sex and body weights up to 16 month at every 3 month interval. Kids were weaned at 2.5 to 3.0 months of age. Data were also recorded on type of birth/kidding, date of service and kidding, milk yield twice a day, i.e. morning and evening at every fortnightly interval. Farmers at most of the farms, identified male for future breeding at 3 months of age as they castrate remaining 30 to 50% males for sacrifice. Test day milk yield was recorded by farmers themselves at every 15 days interval up to 90 days of lactation. The dairy performances of animals for entire lactation period were clubbed together as large variations exist in number of animal's performance between farms. Data for present study was collected from eight multiplier flocks out of which five are located in Uttar Pradesh (Farm 1, 2, 4, 7, 8), two in Haryana (Farm 3, 6), and one in Rajasthan (Farm 5). Source of data were performance registers and obtained by conducting farm visits and also provided by farmers for the period from 2017 to 2020. Data on growth was analyzed by using following least square model :

$$Y_{ijkl} = \mu + X_i + P_j + S_k + e_{ijkl}$$

Where, Y_{ijklm}, Body weight of l^{th} kid of i^{th} farm j^{th} sex, k^{th} type of birth; μ, population mean and e_{ijkl} , residual random error associated with Y_{ijkl}.

Lactation, reproductive and survival traits were analyzed by calculating simple averages with standard error and range.

RESULTS AND DISCUSSION

Growth performance: The least squares means of body weight of Barbari kids at different ages are given in Table 1 and is in agreement with Singh *et al.* (2021). Large variation was observed in body weight of kids between farms and at different growth ages and attributed to feed and fodder quantity and quality, sale pattern, i.e. kids were sold on body weight, morbidity status and other management

Table 1. Factors affecting growth performance of Barbari goats at Multiplier farmers flock

Factor	Body weight (kg) at different ages				
	Birth	3-month	6 month	9 month	12 month
Overall Mean	1.58±0.01 (1571) (0.5-2.8)	7.22±0.04 (1429) (4.5-12.0)	14.54±0.07 (1044) (8.0-22.0)	20.01±0.13 (977) (12.0-32.5)	25.76±0.26 (910) (14.0-42.2)
Farm Effect					
Farm-1	1.53^{a}±0.04 (113) (0.6-2.4)	7.38^{a}±0.13 (94) (4.7-10.5)	12.44^{a}±0.23 (66) (9.5-19.5)	15.75^{a}±0.30 (60) (12.5-26.5)	20.36^{a}±0.35 (55) (17.0-29.5)
Farm-2	1.75^{b}±0.03 (214) (0.6-2.6)	7.21^{b}±0.10 (194) (4.8-9.6)	13.24^{b}±0.12 (145) (9.6-18.5)	16.86^{a}±0.14 (135) (14.0-22.5)	22.57^{b}±0.20 (120) (16.0-32.5)
Farm-3	1.68^{c}±0.02 (376) (0.8-2.8)	6.93^{c}±0.07 (346) (5.0-9.5)	14.29^{c}±0.13 (179) (8.4-22.0)	20.23^{b}±0.23 (165) (14.5-29.0)	25.72^{c}±0.28 (155) (18.0-35.9)
Farm-4	1.65^{c}±0.02 (372) (0.7-2.6)	7.60^{d}±0.08 (355) (4.5-11.8)	17.03^{d}±0.11 (302) (11.0-21.5)	25.07^{c}±0.19 (290) (15.4-32.5)	34.46^{d}±0.25 (280) (24.0-42.2)
Farm-5	1.47^{d}±0.02 (243) (0.6-2.2)	7.08^{c}±0.08 (223) (4.8-9.6)	14.31^{c}±0.14 (190) (9.5-18.5)	18.40^{a}±0.14 (183) (15.5-24.0)	24.13^{c}±0.32 (180) (19.2-34.0)
Farm-6	1.37^{c}±0.04 (110) (0.6-2.6)	7.17^{b}±0.16 (92) (5.0-10.6)	13.23^{b}±0.22 (58) (9.5-16.5)	17.54^{a}±0.28 (49) (12.1-24.0)	22.49^{b}±0.29 (40) (19.2-29.5)
Farm-7	1.28^{f}±0.05 (65) (0.5-2.5)	7.16^{c}±0.22 (55) (5.0-11.6)	12.76^{a}±0.37 (44) (7.5-15.5)	16.86^{a}±0.40 (40) (13.0-22.5)	21.80^{a}±0.62 (30) (16.0-29.5)
Farm-8	1.32^{g}±0.04 (78) (0.6-2.3)	7.10^{c}±0.21 (70) (5.0-12.0)	13.05^{b}±0.33 (60) (8.0-17.5)	17.24^{a}±0.35 (55) (12.0-23.0)	21.75^{ab}±0.40 (50) (14.0-29.5)
Effect of sex of kid					
Male	1.70^{a}±0.01 (838)	7.64^{a}±0.05 (777)	15.17^{a}±0.10 (580)	20.96^{a}±0.17 (543)	27.04^{a}±0.22 (503)
Female	1.45^{b}±0.02 (733)	6.72^{b}±0.05 (652)	13.77^{b}±0.10 (464)	18.79^{b}±0.16 (434)	24.13^{b}±0.21 (407)
Effect of type of birth					
Single	1.74^{a}±0.02 (589)	7.58^{a}±0.6 (544)	14.99^{a}±0.12 (349)	20.69^{a}± 0.22 (334)	26.53^{a}±0.27 (328)
Twin	1.69^{b}±0.01 (708)	7.42^{b}±0.05 (672)	14.74^{b}±0.09 (508)	19.88^{a}± 0.17 (467)	25.55^{a}±0.22 (423)
≥ Triplet	0.95^{c}±0.01 (274)	5.67^{c}±0.05 (213)	12.69^{c}±0.16 (187)	18.53^{b}± 0.31 (176)	24.39^{b}±0.46 (159)

**, Significant at P<0.01; *, significant at P< 0.05; Values in parenthesis are number of animals and range.

practices. The effect of farm, sex of kid and type of birth had significantly affected body weights. Farm located at Karnal (3), Vrandavan (4) and Dholpur (5) were better equipped for housing, feeding, health and access of market network, thus goats with them were fed concentrate diet adequately to get more productivity and profit. Single born kids and males were significantly heavier than their counterparts; however magnitude of differences between single and twins body weight was less compared with the triplets. The body weight of kids at multiplier farm 3, 4 and 5 from 6 months of age onwards was relatively higher than other farms and was attributed to rich concentrate diet with adequate green fodder, housing and healthcare. Present results revealed that Barbari goats can be reared under stall feeding system with higher weight gain and ideal breed for commercial goat farming in semi-arid regions. Karnal based farmers (3) also conducted a trial where growing kids (from 4 month to 9 month) are kept in different feeding regime with first group on maize silage, second on concentrate with dry and green fodder and third group on concentrate and dry fodder only and performances were almost same in all three groups. Present findings on Barbari growth performance under stall feeding were in agreement with those reported by Sahoo *et al*. 2015, Singh *et al.* 2020 and Singh *et al.* 2022. Average body weights of castrated males were 27, 43 and 52 per cent higher than non-castrated males at 6, 9 and 12 months of age and attributed to quantity/quality of feed inputs provided to harvest quicker weight gain and good body condition. Similar body weights in intact animals under stall feeding were also reported by Rajkumar *et al*. 2017 at Institute farm.

Reproductive performance: The overall means of different reproductive parameters are given in Table 2. Large variations within farms and between farms were observed for these reproductive traits and attributed to variations in feed-fodder quality-quantity and breeding practices being followed by farmers. Mostly farmers maintained minimum 70 days post-partum period however, data revealed that in nearly 20% cases the females were re-bred at shorter interval (<50 days). Similarly many records also showed that females were also mated in non-breeding season, thus created variations in reproductive performances. Present results on early reproductive traits were similar to those reported by Singh and Rai (2006) and Goel *et al*. (2013). However, more values for age at first conception and first kidding were reported in institute Barbari flock by Singh *et al*. (2021). Kids born as single, twin, triplet, quadruplet and quintuplets were 37.49, 45.07, 11.27, 4.58 and 1.59%, respectively. The litter size at these multiplier farms varied from 1.47 to 1.72 with an overall average of 1.62, whereas, lower litter size in Barbari goats was reported in farmers flock by Singh and Rai (2006) and Kumar *et al*. (2016). Thus, higher kidding percentage under different feeding management has made Barbari breed more demanding for commercial goat farming.

Lactation performance: The lactation performance of Barbari goats is given in Table 2. Large variation is attributed to differences in potential of genetic stock as >50% goats were initially purchased from other farmers' flock besides variation in their age, parity, feed-fodder and other management practices. Higher milk yield at Karnal based farms (Farm 3) might be due to availability of good quality green fodder such as smart napier, berseem and maize and high demand of milk on better prices (₹100 to 500 per litre) which has encouraged farmers for quality and quantity of ration to lactating goats. Farmers have

Table 2. Reproductive and lactation performance of Barbari goats at Multiplier farmers flock

Factor	Reproductive performance				Lactation performance (kg)	
	Age at first conception (day)	Age at first kidding(day)	Kidding interval (day)	Litter size	60d-Milk yield (kg)	90d-Milk yield (kg)
Overall Mean	317.64±1.51 (721)	463.67±1.52 (721)	277.76±1.13 (431)	1.62	45.23±0.24 (993)	66.28±0.38 (828)
Farm-1	317.48±3.94 (67) (223-400)	463.67±3.90 (67) (370-546)	268.02 ±4.44(52) (232-350)	1.47	36.52±0.29 (115) (23.3-44.4)	53.61±0.54 (100) (40.0-78.2)
Farm-2	310.47±4.67 (83) (235-439)	456.59±4.67 (83) (382-585)	287.21 ±1.79 (67) (257-309)	1.54	42.16±0.50 (120) (24.1-54.6)	60.59±0.95 (104) (47.0-78.2)
Farm-3	272.19±1.51 (103) (247-315)	417.95±1.51 (103) (393-461)	285.71±0.90 (79) (272-296)	1.66	48.76±0.27 (205) (32.1-54.3)	75.49±0.54 (167) (45.5-88.4)
Farm-4	347.25±2.33 (145) (303-390)	493.37±2.34 (145) (449-537)	276.87 ±1.85 (86) (234-302)	1.69	44.20±0.26 (115) (32.5-47.5)	64.47±0.64 (88) (54.5-75.5)
Farm-5	306.38±6.05 (106) (226-488)	452.23±6.04 (106) (371-633)	266.96±6.44 (53) (223-582)	1.72	51.29±0.90 (135) (27.5-68.7)	72.96±0.89 (112) (53.2-95.5)
Farm-6	327.27±1.52 (96) (312-402)	473.38±1.52 (96) (457-547)	277.26±0.99 (42) (249-282)	1.58	47.11±0.34 (193) (30.0-56.2)	67.78±0.77 (163) (40.2-92.5)
Farm-7	328.55±1.98 (55) (271-415)	474.75±2.00 (55) (460-562)	275.20 ±1.52 (25) (273-295)	1.63	42.43±0.58 (60) (30.0-45.5)	61.71±1.40 (52) (45.5-75.0)
Farm-8	327.73±1.91 (66) (314-402)	473.71±1.91 (66) (459-547)	276.96±1.41 (27) (249-282)	1.59	40.19±1.39 (50) (22.5-52.5)	59.76±1.43 (42) (45.5-74.5)

Values in parenthesis are number of animals and range.

Table 3. Mortality status at in Multiplier farmers flock during 2017 to 2020

Farm	Farm-1	Farm-2	Farm-3	Farm-4	Farm-5	Farm-6	Farm-7	Farm-8
Kids born	113	214	376	372	243	110	65	78
Pre-weaning mortality (%)	16.8	9.3	8.0	4.6	8.2	16.4	15.4	10.3
Kids available (3-12 month)	94	194	346	355	223	92	55	70
Post-weaning mortality (%)	7.7	3.8	3.5	3.0	6.6	6.3	5.45	5.5
Adult animal	162	424	488	501	418	240	84	90
Adult mortality (%)	9.87	5.42	5.12	4.60	6.0	5.83	2.38	1.1

recorded 3.0 L peak milk yield and 175 L milk in 90 days lactation period. Average milk yield of >75 kg in 90 days at farmers flock indicates good potential for milk in this breed and is in agreement with nucleus flock at Institute (Annual Report 2022, ICAR-CIRG). Present results on lactation performance were higher than those reported by Singh and Rai (2006) and Kumar *et al*. (2016) in Barbari goats. Lower milk yield at some farmers' flock is mainly attributed to inadequate feeding and breeding practices. Major challenges in goat milk procurement are uncertain demand, lower volume of disposable milk, unorganized collection and marketing structures (Singh *et al*. 2023). Involvement of milk cooperatives and public sector may be beneficial in creating milk storage and processing units likes cow and buffaloes milk procurement.

Survival performance: The overall mortality in pre-weaned, post-weaned and in adult goats over the farms is presented in Table 3. The farm 3, 4 and 5 encountered with 17 to 27% kid mortality in the first year of their establishment but succeeded to bring it down below 3% from the very next year. Maximum mortality particularly in pre-weaning and post-weaning kids occurred in the first year of farm establishment and is attributed mainly to kidding during inclement weather conditions, poor hygiene, inadequate protection against inclement weather, overcrowding and inadequate expertise to handle kids morbidity. High mortality in adult goats during the initial years of farm establishment was attributed to improper vaccination, and sudden changes in diet. However, most of farmers within a year improvised their skills and expertise, resulting in higher survival, both in kids and adult goats. Major kid diseases were pneumonia and diarrhea (enteritis). These results are in agreement of Singh *et al.* (2008) in Jamunapari, Chauhan *et al*. (2019) in Sirohi and Singh *et al.* (2022) in Barbari goats. The major diseases observed in adults were enterotoxaemia, diarrhea and pneumonia. Mortality rate at multiplier farms were lower than reported by Kumar *et al*. (2016).

Economic performance: The economic returns of the multiplier flocks have been calculated on per goat sold basis. The total returns obtained through the sale of total number of goats (one year old male and female, castrated male for sacrifice) was subtracted from total expenses spent for rearing them up to marketable age including the amount spent on breeding stock. The net profit per animal was obtained by dividing total net return by number of animals sold. The total expenditure for raising female goats from birth to saleble age of one year ranged from ₹5000.00 in farm 1 to ₹6200.00 in farm 4 and 5, respectively (Table 4). The net profit on per animal on sale basis ranged from ₹3800/- (farm 5) to ₹6800/- (farm 4) through sale of female goats and ₹4000/- (farm 1) to ₹8800/- (farm 8) by sale of male goats at one-year age. The cost:benefit ratio ranged from 1.66 to 2.42 in farm 1 to farm 8 through sale of one year old male goats and ranged from 1.61 (farm 5) to 2.18 (farm 8) by sale of one year old female goats. In addition to sale of one-year-old goats for breeding and slaughter purpose, farmers also sold castrated male

Table 4. Economic performance of Barbari goats under intensive management at multiplier farmers flock

Farm detail	Farm 1	Farm 2	Farm 3	Farm 4	Farm 5	Farm 6	Farm 7	Farm 8
Sale of Male animals at one year age								
Sale price per animal (₹)	10000	14000	13000	15000	12000	12000	15000	15000
Expenses per animal (₹)	6000	7000	6500	7400	7100	6500	6800	6200
Net profit per animal (₹)	4000	7000	6500	7600	4900	5500	8200	8800
Cost: Benefit ratio	1:1.66	1:2.00	1:2.00	1:2.03	1:1.69	1:1.85	1:2.21	1:2.42
Sale of Female animals at one year age								
Sale price per animal (₹)	9000	11000	11000	13000	10000	10000	12000	12000
Expenses per animal (₹)	5000	6000	5500	6200	6200	5700	6000	5500
Net profit per animal (₹)	4000	5000	5500	6800	3800	4300	6000	6500
Cost: Benefit ratio	1:1.80	1:1.83	1:2.00	1:2.09	1:1.61	1:1.75	1:2.00	1:2.18
Sale of Male animals 18 months of age for religious sacrifice								
Sale price per animal (₹)	14000	18000	20000	25000	20000	18000	22000	22000
Expenses per animal (₹)	8000	10000	9000	12000	10000	12000	12000	10000
Net profit per animal (₹)	6000	8000	11000	13000	10000	6000	10000	12000
Cost: Benefit ratio	1:1.75	1:1.8	1:2.22	1:2.08	1:2.00	1:1.5	1:1.83	1:2.2

goats during festivals like Eid for fetching very good prices. The net profit per goat/year through sale of male goats for religious sacrificial purpose at the age of 16-18 months ranged from ₹6000/year in (farm 1) to ₹13000/ year in (farm 4). The return through sale of males at one and half years for religious festivals may look lucrative in absolute terms but perusal of data showed that benefit cost ratio is almost comparable and it ranged from 1.50 in farm 6 to 2.22 in farm 3 and 8. The profit from sale of male goats for sacrificial purpose depends on the marketing skills of the farmers and local demands and varied over the years. It was observed that nearly 50% returns from multiplier flocks were through sale of animals for breeding and remaining 50% were through sale of animals for meat (sacrifice and market), sale of milk, manure, training/skill and consultancy.

Impact of multiplier flocks scheme: Establishment of multiplier flocks has played a vital role in promoting scientific goat farming as these farms also act as technology dissemination centres of ICAR-CIRG. Economic viability of these farms has attracted thousands of youths to adopt goat farming at commercial scale across India. Fifty multiplier flocks of Barbari goat established in seven states namely Uttar Pradesh, Madhya Pradesh, Rajasthan, Haryana, Uttarakhand, Karnataka and Bihar indicate adaptability attributes of Barbari goat. This programme has encouraged bottom-up approaches, where farmers participated actively in prioritization of selection goals and criteria. A large number of farmers are giving due weightage to morphological attributes which is helping in breed conservation, developing climate resilience and fulfilling aspiration of local farmers. These farms play significant role in meeting demand of pure-bred Barbari goats. Moreover, data/animals available from them may also be utilized in genomic or other advanced research programs for speedy improvement.

The results obtained in present study in adopted farmer's flocks indicate that Barbari is one of the most suitable breed for stall feeding system. Establishment of Multiplier flocks are found to be an innovative model for holistic and sustainable genetic improvement of small ruminant breed's and enhancing farmer's profitability.

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