

Goat Genetic Resources of India

JAKHRANA

- A high potential milch goat breed of semi arid region



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(Indian Council of Agricultural Research)

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NBAGR

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FOREWORD

Goats form an integral part of animal husbandry and contributes significantly to the Indian economy. This species has been in the human service even before the other livestock species. The goats have been preferred by the small, marginal farmers and landless labourers because they need no special food, house and supervision. The goat population touching the figure of 120 million share 24.8% of the total livestock population of the country. Among the twenty distinct breeds of goat of the country each inhabits a particular region and has developed and adapted to survive and perform best under the existing agro climatic conditions of that region. In addition to the product (milk, fiber) for which they are reared meat provides an added value. Milch goat breeds generally inhabit the North Western part of the country. Among other breeds Jamnapari has been considered to be the best milch goat breed but unfortunately the breed has been declining in number since last few years and the reasons are unknown. Only a small population of less than 5000 animals are being reported which are spreaded here and there in and nearby areas of its native tract. Under such alarming condition it is our duty to save such a useful germplasm and conserve it for future use. In addition to this it is of utmost importance to promote such breeds which are at par with the Jamnapari breed in terms of growth and milk potential. The scientists of National Bureau of Animal Genetic Resources, Karnal have under taken a studies on phenotypic and genetic characterization by conducting the surveys in the breeding tract of Jakhrana breed. The information generated and collected on body biometrics, management, production and reproduction aspects have been compiled and presented in the form of this bulletin. I hope that the bulletin "Jakhrana- A high potential milch goat breed of semi arid region" will be useful to the researchers, surveyers and policy planners in taking up the research and development programmes for the further improvement of this breed. I wish to congratulate all the authors for their endeavour to bring out this bulletin.



Dr. S.P.S. Ahlawat
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PREFACE

Goat is one of the smallest domesticated ruminants and is probably the first animal to be domesticated around 9000 to 7000 BC (Zeuner, 1963). This species has served the mankind earlier and longer than cattle and sheep. Goats form an important constituent of Indian livestock and are reared mainly by the small and marginal farmers. Because of its economic importance, low input resources, small generation interval, higher prolificacy, goats have earned a special place among the poor farmers and landless labourers hence also known as "Poor man's Cow". The importance of this species has been well understood by our national leader, The Father of Nation, who made the goat a part of his limited belongings and its milk an essential component of his diet. Goats are reared mainly for meat, milk and fiber production. They contribute significantly to the income of the poor families through their production and reproduction performances. Goat milk being rich in immunoglobulins has high medicinal value. Goat keeping is a sort of insurance against all type of natural hazards like drought, famine, floods etc. which destroy the agriculture and thus affect the farmer's economy severely. Goat belongs to either of the six species of genus 'Capra'. *Capra aegagrus* is believed to be the ancestor of presently existing breeds of goats. *Capra falconeri* also contributed some traits in these breeds. The other four species are *C. ibex*, *C. caucasica*, *C. cylendricornis* and *C. pyrenaica*.

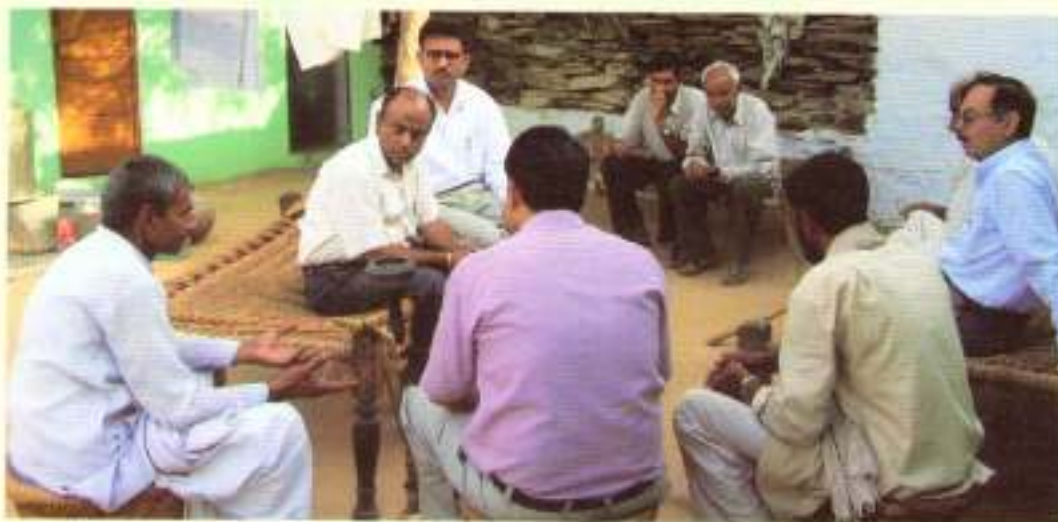
Goat population of India is about 120 millions which is 24.8% of total livestock population (482.77) in the country (Livestock Census, 2003). There are 20 distinct breeds of Indian goats inhabiting various regions of the country (Acharya, 1982). Apart from these breeds some more breeds/strains of goats with the variable physical conformations and utility have been reported which are essentially non distinct but may have local name given to breed by the people of that region. As per FAO watch list total 29 goat breeds have been identified in the country. Each breed has its own utility in its native tract where they have adapted to perform to the best. Goats can sustain themselves on sparse forage and extreme climatic conditions where other species fails to survive (Boyazoglu and Morand - Fehr, 1987). This characteristic of the goats have made the species popular among the poor and marginal farmers. The increasing growth in goat population since 1951 can be a sufficient evidence for increasing popularity of this species. This has happened inspite of human bias against them as destroyer of vegetation and causing desertification.

The Jakhrana goats are reared mainly for milk production. They can easily survive under harsh tropical climatic conditions and poor availability of feed and fodder resources. In spite of their ecological and economic importance, the Jakhrana goats are inadequately characterized. A project was, therefore,

undertaken to determine geographic distribution, establish breed characteristics, study the existing management practices and estimate the approximate population of Jakhrana breed in its breeding tract. The genetic variation within the breed was also studied using microsatellite markers. The resulting information from this study may be useful for planning sustainable improvement, conservation and utilization of the breed.

Any accomplishment requires the efforts of many people and this work is not different. The authors thank the Director NBAGR for providing all the facilities to carryout this work. Thanks are due to Dr(Ms.) S. Bhatia and Dr. B. Prakash for providing the cytogenetic information on the goats. The authors take this opportunity to thank Dr R.A. Yadav, Veterinary Hospital, Narnaul (Haryana) and his staff, Dr Vivek Sharma, National Dairy Research Institute, Karnal, and staff of the Chilling Centre, Narnaul for their help at various stages of generating the information. The assistance rendered by Sh Subhash Chander, Immunogenetics Lab, NBAGR, Karnal in collection of blood samples, field data and preparation of this manuscript is gratefully acknowledged. Wae are indebted to the farmers especially Sh Umed Singh, Pappu Yadav of Jakhrana village , and Barwari Lal of Nayasarana for their cooperation and assistance in the collection of valuable information on the breed, milk samples and blood samples. It is impractical to provide an accurate acknowledgment because all the sources of help and cooperation while working in field are not recorded. Regardless of the sources we wish to express the gratitude to those who have contributed directly or indirectly to this work.

– Authors



NBAGR survey team interacting with the farmers in Jakhrana village



SOME FACTS ABOUT GOATS

Gary, P. Goat facts – Goats & Health – good world.com

- Goat has been the first animal among ruminants to be reared by human being.
- There are over 210 breeds of goat in the world.
- Goats occur in varied colours. Indiscriminate breeding has led to mixing of colours resulting in more number of colour combinations within the same breed.
- Goats can eat each and every vegetation.
- Goats are intelligent animals and can learn how to open latches of farm gates. They can climb, run, crawl under fences and jump upto over 5 feet. They can also stand on their hind legs to reach tree branches and shrubs.
- In a mixed herd, goat prefer to live with goats of same breed. Kids prefer to remain nearby their mother even if separated for years and reintroduced.
- Goat kids have eight small, sharp teeth in their lower front Jaw which fallout and are replaced by permanent teeth. The age of a goat can be closely determined by their teeth.
- Like males, females also grow beard in some breeds of goats.
- The pupil of a goat's eye is rectangular in shape. The animals can see sharply in the night.
- Unlike other animals, goat's tail is upright.
- Goats are ruminants having four stomach compartments namely the rumen (paunch), the reticulum (honey comb), the omasum (maniply) and the abomasum (true stomach). The elementry canal is about 25 times the body length of a goat. The total blood volume is about 1 / 12 of animals body weight. It takes 14 seconds for goat blood to complete one circulation. The Red blood cells are smaller in size.
- Goats can encounter the same diseases as cattle and sheep. Coccidiosis and priemunonia can bring sudden death to the animals.
- Goats of some breeds (Jamnapari, Jakhrana) may yield upto 5 litres of milk per day. The goat milk has more medicinal value than that of cow and buffalo.
- Goaty odour of milk is produced by the presence of the buck at the time of milking whose scent glands are adoriferous. Milk produced in the absence of buck does not bear the goaty odour.
- Goat generally lives upto 10-12 years.

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1 Introduction

1.1 History

Goats belong to the Bovidae family within the suborder of ruminants. They have evolved 20 million years ago in the Miocene Age, much later than horses, donkeys, Zebras, Tapirs, rhinoceroses. The goats are herbivorous mammals i.e. they live on plants and nurse their youngs with milk from the mammary glands after they are born. Goats and sheep make up a tribe within the bovidae family 'Caprini' that included following six goat species. The six species of goats can be distinguished by their horn shapes.

- i) *Capra aegagrus*, the wild goat of East Asia has scimitar shaped horns with a sharp anterior keel and a few knobs interrupting it.
- ii) *Capra ibex*, the ibex of the Alps, Siberia and Nubia has scimitar shaped horns with a flatter front and many transverse ridges.
- iii) *Capra falconeri*, the markhor of Central asia has sharp keeled horns that are twisted into open or tight spirals.
- iv) *Capra pyrenaica*, the spanish goat has outward-upward curving horns with a sharp posterior keel.
- v) *Capra cylindricornis*, the Dagestan tur of the Caucasus mountains has round outward-back inward curving horns.
- vi) *Capra hircus*, the domestic goat evolved principally from *capra aegagrus*, except for Angora, Cashmere goats, and Damascus types who descended from *capra falconeri*.

Capra aegagrus is believed to be the ancestor of presently existing breeds of goat of India. *Capra falconeri* also contributed some traits in these breeds. These breeds are classified into large, medium and small according to their body size. Beetal, Jamnapari and Jakhrana are the large sized where Black

Bengal, Barbari, Changthangi, Chegu, Chogarakha belong to small size category. Another classification has been made according to the eco-zones in which they are occurring. India has been divided into four eco-zones for the purpose of description of goats. The goats of temperate Himalayan region, where the rain fall is scanty, grow fibers of good quality and have finest undercoat called 'Cashmere' or Pashmina'. Chegu and Changthangi are good fiber producing goats of this region. The goat breeds like Beetal, Jamnapari and Jakhrana having good milking potential are found in the North-western region of the country. The dual purpose animals which are used for milk as well as meat exist in the Southern and Western region. Eastern region has small but highly prolific breeds like Black Bengal which are reared for meat purpose. The region wise distribution of goats all over the country is 2.4% in temperate Himalayan region, 39.3% in North Western region, 32.1% in Eastern region and 26.2% in Southern region.

The important breed of milch goat generally inhabit the North Western part of the country. Some of these milch breeds of goat even compete with the cows in the milk production. Jamnapari breed of goat is considered the best milch breed of goat among goat breeds of the country. However, there is another important goat breed, which possess genetic potential equal to Jamnapari breed of goat for milk production and better adaptability under different management systems in the native tract. The breed is known as Jakhrana, which is a large sized milch breed of goat. It derived its name from 'Jakhrana' village of Behror Tehsil in Alwar district in North Eastern region of Rajasthan state. These goats are reared mainly for milk production. They can easily survive under harsh tropical climatic conditions and poor availability of feed and fodder resources. In spite of their ecological and economic importance, the Jakhrana goats are inadequately characterized. A systematic survey was, therefore, undertaken to determine geographic

distribution, establish breed characteristics, study the existing management practices and estimate the approximate population of Jakhrana breed in its breeding tract.

1.2 Methodologies

Three survey visits were undertaken by the project workers in the breeding tract of Jakhrana goats. During the survey, information on seven body biometric characteristics viz. body length, chest girth and height at wither, height at hip bone, tail length, face length, horn length, and qualitative conformation attributes and body weight of 153 animals were recorded. The animals included both males and females. The information on feed, management and breeding practices, flock size and its structure, productive and reproductive performance and disease prevalence in the breeding tract was collected through formal interview with farmers who were chosen at random. In total 50 goat breeders across 12 villages were interviewed and the information recorded. The additional information on health aspects of Jakhrana goats were also collected from the veterinary hospital of the village.

Since the breed is found in a small cluster of few villages, therefore, it is of imperative need to assess the genetic variability in the breed. Moreover, there is a worldwide recognition of the need for conservation of livestock diversity (FAO, 1995), and for the characterization of breeds and populations including their genetic differentiation and relationship. Currently, microsatellites are widely used to assess the genetic variability at the DNA level since they are numerous, randomly distributed in the genome, highly polymorphic and show co - dominant inheritance. In the present study, an attempt was also made to find out within breed genetic diversity using a battery of recommended microsatellite molecular markers.

Blood samples (approx. 5 ml each) were collected at random from 50 unrelated animals of Jakhrana breed. Genomic DNA was isolated from these samples using standard protocol (Sambrook *et al.*, 1989). A battery of 23 microsatellite markers viz. ILST008, RM 088, ILSTS087, ILST005, ILST019, ILSTS058, OarFCB304, OarJMP29, Oar FCB48 ILSTS30 OarHH64, ILSTS033, ILSTS049, ILSTS059, ILSTS034, ILSTS065, OarAE129, RM4, ILSTS029, ILSTS087, ILSTS044, ILSTS002 and ETH225 were selected based on the guidelines of ISAG and FAO to generate the data in a panel of 50 animals.

PCR reactions were carried out as per standard protocol with minor modifications. Amplified PCR products were separated on 6% denaturing polyacrylamide gels along with standard DNA markers for sizing. The gels were silver stained following standard protocol of Bassam *et al.* (1991).

The size of the alleles was estimated using 'INCHWORM' software which estimates the length of the molecules, based on their electrophoretic mobility (<http://www.molecularworkshop.com>). The statistical analysis was carried out using POPGENE software (Yeh *et al.*, 1999). The heterozygosity was calculated using the following formula given by Nei (1978). In order to estimate the genetic variation, the observed and expected heterozygosity were calculated for all microsatellite loci.

The observed/direct count heterozygosity was calculated as :

$$\text{Heterozygosity} = 1 - \sum_{i=1}^{k-1} X_i^2$$

$$\text{Expected heterozygosity (H)} = 2n/2n-1 \left[1 - \sum_{i=1}^{k-1} X_i^2 \right]$$

The PIC values (polymorphic information content) was calculated using the formula given by (Botstein *et al.*, 1980)

$$\text{PIC} = 1 - \left(\sum_{i=1}^k X_i^2 \right) - \sum_{i=1}^{k-1} \sum_{j=i+1}^{k-1} 2X_i^2 X_j^2$$

The effective number of alleles (n) was calculated as $n = 1/F$ (Kimura and Crow, 1964).

Where F is the sum of squares of allele frequencies ($\sum X_i^2$), k = no. of alleles, X_i = frequency of i^{th} allele and X_j = frequency of j^{th} allele.

The cytogenetic information on the chromosomal complement were obtained from the laboratories at NBAGR.

2. Habitat and body bio-metrics of the breed

2.1 Native tract

The Jakhrana goats are found within $27^{\circ} 34'$ N latitude and $76^{\circ} 38'$ E-longitude. The breeding tract is limited to a cluster of few villages in Behror Tehsil of Alwar district of eastern Rajasthan state (Fig. 1.). The breed has derived its name from the 'Jakhrana' village where it is found in its purest form. The Jakhrana village is 73 kms away from Alwar and 13 kms from Behror en route to Narnaul (Haryana). Yadav community followed by Brahmins and Bavaria communities dominate the village. The whole village land is under either cultivation of food and cash crops or under forest. Jakhrana village is famous for Three 'Bs' i.e. Ber, Bakri and Bajra (anonymous, 1994). The Jakhrana goats are found in nearby villages of Jakhrana like Jatgawra, Naysarana, Guwana, Bhagwarikala, Kurali, Balpura, Gugadia, Doomroli, Kaysa, Nibhor and Anantpura etc and are also seen in the adjacent parts of the Haryana state. The Jakhrana breed of goat is a small population of about 7000 to 8000 animals. The Yadav and Bavaria communities of these villages generally rear the goats. The females are reared for milk whereas small number of males are reared for breeding but majority of them are sold for meat purpose. Those, which are reared for meat, are generally castrated so that they gain the faster growth rate. The animals are sold to meet the immediate need in the market or at the time of festivals like 'Id' at the rate approximately Rs. 100 per kg of the meat or Rs. 50 per kg live weight.

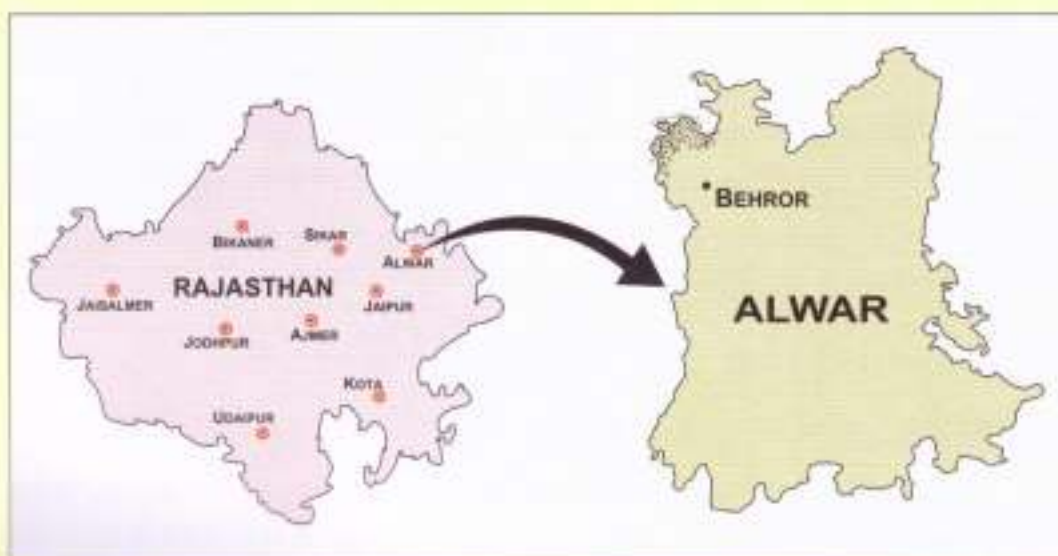


Fig. 1 : The marked area in Alwar district showed the breeding tract location of the breed

2.2 Climatic conditions of the region

The natural habitat of this breed lies in the semi-arid region having very low and erratic rainfall. The average annual rainfall in the region is about 60 cm. The temperature reaches as low as 8.3°C in winter and as high as 45°C in summer. Due to low rainfall and high temp, good green pastures are not available but the animals of this breed have well adapted to the semi arid climatic conditions of the region. The grazing area of the goats includes the nearby hill pastures, forest and wasteland having small trees and bushes. During the rainy season green pastures and fodders are available for these animals. The shift of these animals from their natural habitat showed a decline in their performance as observed by the farmers.

2.3 Body conformation traits

The animals are fairly large in size and uniformly black coat coloured (Fig. 2, 3) except white colour on ears (Fig. 4) however, few animals with white patches on body have also been seen. The area around mouth is white

(Fig 5). Because of its black colour, this goat is also locally known by the name of 'Kali Kotri'. Body is compact with long legs. One of the distinct features of the breed is long pendulous leaf like



Fig.3 : A lactating Jakhirana goat

while browsing and dipping in water while drinking. The nose is slightly roman type and face line is straight with bulging forehead. Both the male and female sexes have thick stumpy,



Fig.5 : A typical white patch around nostril and the jaws



Fig.2 : Jakhirana Buck

white coloured ears. The average size of the ears measures 16.72 ± 2.39 cms in males and 14.02 ± 0.44 cms in females. As a common practice, the ears of animals are cut short so as to avoid their entangling in the bushes



Fig.4 : A Jakhirana Kid

small, grayish black and slightly curved horns. Udder is large and well developed with long and conical shaped teats (Fig. 6). Males are heavier in body weight. The various body parameters viz. body length,

height at withers, chest girth, tail length, and face length in adult males and females are 82.07 ± 1.91 and 73.66 ± 0.65 , 87.85 ± 1.65 and 77.42 ± 0.46 , 86.01 ± 1.86 and 76.58 ± 0.53 , 12.79 ± 0.00 and 20.64 ± 0.46 , and 21.50 ± 0.86 and 18.85 ± 0.33 cm, respectively (Tables 1 and 2).



Fig.6 : A well developed udder and teats of jakhrana goat

Table 1. Body measurements of young kids of Jakhrana goat

S. No.	Body Parameters	1 month (17)	2 months (7)	3 months		6 months	
				Male (13)	Female (15)	Male (3)	Female (18)
1.	Body Weight	9.76 ± 0.60	12.86 ± 0.31	17.83 ± 1.41	16.53 ± 0.60	26.33 ± 2.96	21.83 ± 0.62
2.	Body Length	45.36 ± 0.81	49.25 ± 0.89	57.92 ± 1.62	56.36 ± 1.63	65.51 ± 1.04	63.33 ± 1.12
3.	Height at wither	46.35 ± 0.93	50.54 ± 0.84	60.71 ± 1.49	59.18 ± 1.17	72.08 ± 0.96	63.92 ± 1.12
4.	Chest girth	44.37 ± 0.96	47.63 ± 0.68	57.15 ± 1.38	55.27 ± 0.99	65.33 ± 1.83	57.58 ± 0.17
5.	Tail length	12.70 ± 0.0	13.21 ± 0.01	16.47 ± 1.57	15.24 ± 1.47	21.84 ± 1.02	19.34 ± 0.65
6.	Face length	12.35 ± 0.19	12.96 ± 0.22	15.16 ± 0.47	14.96 ± 0.23	17.01 ± 0.53	14.33 ± 1.58
7.	Horn length	-	-	4.023 ± 0.54	2.34 ± 0.14	6.06 ± 0.29	4.50 ± 0.42
8.	Ear length	17.88 ± 0.42	18.66 ± 0.74	18.95 ± 0.33	17.36 ± 1.63	20.96 ± 0.63	12.41 ± 1.04

Figures in parenthesis indicate number of animals

Table 2. Body measurements of Jakhrana Adult animals

S.N.	Body parameter	Number	Male	Number	Female
1.	Body Weight	8	55.00 ± 2.84	83	36.98 ± 0.68
2.	Body Length	8	82.07 ± 1.91	82	73.66 ± 0.65
3.	Height	8	87.85 ± 1.65	83	77.42 ± 0.46
4.	Chest Girth	8	86.01 ± 1.86	83	76.58 ± 0.53
5.	Tail length	2	12.79 ± 0.0	38	20.64 ± 0.46
6.	Face length	4	21.50 ± 0.86	56	18.85 ± 0.33
7.	Horn Length	5	12.85 ± 1.50	54	9.41 ± 0.34
8.	Ear Length	6	16.72 ± 2.39	36	14.02 ± 0.44

3. Management practices

3.1 Feeding

It is generally believed that goats can eat anything and everything, which sometimes may not be true. The goat has very sensitive lips and is in the habit of smelling for food that is clean and tasty. Goats avoid eating soiled food unless they are pushed to the extent of starvation. Jakhrana goats



Fig.8 : Jakhrana goats on browsing

are supplemented with the concentrate consisting of Loom, Guar, Moth, Moong, Bajra, Jowar etc. Apart from this animals seem to relish the buttermilk and Raabri, a local preparation consisting of buttermilk and flour (Fig. 10). The pregnant animals are given special feed allowance in the form of concentrate.



Fig.7 : A flock of the breed in the pasture

can graze on natural pasture and browse on shrubs and trees (Fig. 7 & 8). Fodder resources consist primarily leaves of Pala (*Zizyphus Jujube*), Khejri (*Prosopis cineraria*), Ber (*Zizyphus rotundifolia*), Neem (*Azadirachta indica*), Babool (*Acacia arabica*), Kikkar (*Acacia nioltica*). The animals can be managed on stall feeding also (Fig. 9). Animals



Fig.9 : Jakhrana goat on stall feeding

Kids are generally kept on dam's milk and are allowed to suckle their mother ad-lib. This practice continues till the time they start browsing. These goats can consume 4 -5 liters of water in a day where some other goat breeds like Marwari belonging to similar region can consume only 1.5-2.0 liters of water a day.



Fig.10 : Feeding of Raabri to Lakshmana goats

3.2 Flock size

The animals are seen in the flock of size varying from 5-100 animals, which consisted of kids and adults of both sexes. The flocks are generally stationary. Animals go for pasture grazing in the nearby jungles. The flock of three-four farmers are pooled and are taken for community grazing.

3.3 Housing

Animals are kept separately in open (Fig. 11) during the day time and in closed housing (Fig. 12) during night. Animals' houses (locally called as 'Baara') are katcha with thatched roof with no proper drainage and electricity supply. The open housings are fenced with 5-6 feet long wooden logs and bushes to avoid the entry of predators. The size of the houses depends upon the number of animals kept. The gates of houses are also temporarily made of wooden logs or bamboo sticks (Fig. 11). Kids upto



Fig.11 : Open housing system for Lakshmana goats



Fig.12 : Close housing system for Jaktrana goats



Fig.13 : A cage housing system for the kids

one month of age are sometimes kept separately in the bara in a cage like structure (Fig. 13). In case of very small flock (2-5) the animals share the residence of the farmers.

3.4 Health

Goats are not too different from cattle and sheep of the same region while considering diseases of Goats, who tend to have more internal parasites than dairy cows but less tuberculosis, milk fever, brucellosis. Among reproductive problems abortions, still births and post gestational mortalities are more commonly reported which are 1-2% under village conditions. Foot and mouth disease, goat pox, jaundice, diarrhoea and respiratory problems have also been reported. Kids suffer generally from diarrhoea and pneumonia. A study conducted at CIRG Makhdoom indicated 1.6 per cent per annum kid mortalities and the major causes were pneumonia, colibacillosis, toxæmia, pneumoenteritis and coccidiosis. Though the animals are well adapted to the semi arid conditions of the region, yet mortalities are reported in the kids and the rate depends upon the birth weight of the kid, kidding season and mothering ability (Goel *et al.* 1997) . The reported mortalities in kids are also due to the still birth and other prenatal diseases.

4. Performance

4.1 Production performance

Body Weights : The average body weight of adult and 6 month old male and female animals is 55.00 and 36.98 kg, and 26.33 and 21.83 kg, respectively. The males are heavier and bigger in size than the females. Males having good growth rate are sold for meat.

Milk production: Jakhrana breed is well known for its milk potential (Fig.14,15). The daily milk yield varies from 2.0 to 5.0 liter (average 3.31 litre, table 3). Milk yield more than 5.0 litres per day has also been reported by the farmers. Jakhrana goat producing 5-6 kgs of milk was demonstrated before the President of Egypt (Rai *et al.* 2000). Milk of Jakhrana goats is also richer in fat (5.06%), SNF (8.60%) and protein (3.70%) as reported by Verma *et al.* (2004) and is given in table 3. The milk composition of Jakhrana goat is well comparable to that of cow's milk . The lactating capabilities of Jakhrana goats can be harvested fully by further improving the feeding conditions and other management practices. The sale of a milch goat with the milk yield of 3-4 liter per day fetches a handsome sale price up to Rs. 6000. To most of the people, the term milk is synonymous with cow milk as if cows alone possess the ability to produce the mammary secretions. But this is not true under



Figs. 14 & 15 : Milking of Jakhrana goat

rural conditions where people use goat milk for all-purpose. If we compare the economics involved in the production of cow milk vis-a-vis goat milk particularly of Jakhrana goats, the goat dairying will come as more profitable enterprise. A goat will eat very little, occupy a small area and produce enough milk for an average family. Further, goat's milk is superior to that of a cow in its basic composition. The milk of Jakhrana goat showed superiority over the cow's milk in its fat, protein and solid not fat contents. The studies have shown that average size of goat milk fat globule is about $2\mu\text{m}$ as compared to $2.5 - 3.0 \mu\text{m}$ that of cow milk fat globules. These smaller sized fat globules provide better dispersion and a more homogenous mixture of fat in the goat

Table 3. Milk composition of Jakhrana goats

Parameter	Sample size	Mean and S.E
Test day Yield	70	3.310 ± 0.10
Fat%	37	5.06 ± 0.24
Solid -Not- Fat	35	8.60 ± 0.10
Total Solids	35	13.55 ± 0.26
Protein%	18	3.70 ± 0.02

milk, which leads to its easy digestion when consumed. Apart from this goat milk has greater amount of vitamin A, immunoglobulins and minerals (Calcium, Potassium, Magnesium, Phosphorus, Chlorine and Manganese) as observed by Haenlein *et al.* (1992). All these provide the goat milk medicinal value and make it as an alternative food not only for children and sick people but the value of milk also extended to the feeding animals including calves. The reports indicate that calves consuming a large amount of goat milk feel more comfortable while the same amount of cow milk results in calf diarrhoea.

4.2 Reproduction performance

Goats generally have a life span of 10-12 years. Animals show puberty (sexual maturity) at the age less than one year. Does come into estrus in 21 days cycles normally lasting 1-2 days. Ovulation rate (number of ova liberated from the ovary during the given oestrus period) reflects the potential kidding rate in terms of kids born. Jakhrana is a moderately ovulating breed. Ovulation, as observed by Goel and Aggarwal (2003), occurred 28h post on set of oestrus in Jakhrana goats and reached upto 36h of post oestrus. Mean ovulation rate observed was 1.33 ± 0.10 (range 1-2). The ovulation rate ranging 1.07 to 4.00 have been reported in indian goats breeds (Basu *et al*, 1961; Shukla *et al*, 1971; Prasad *et al*, 1980; Rao and Bhattacharya, 1980; Chakraborty *et al*, 1993). Kidding takes place generally twice in a year and is in the months of June-July (rainy season) and Oct. – Nov. (winter season). A doe can conceive again after 3-5 months of the kidding specially when kids are weaned early. Kidding percentage is about 90%. These goats show good prolificacy. The high prolificacy gives an additional profit to the farmers. The goat keepers in the home tract have reported twinning up to 80-90 % with a smaller percentage of triplets (Fig.16). Higher litter size is possible with improved feeding and management. There is ample scope to increase multiple births and productivity in Jakhrana goats by use of reproductive tools like superovulation, embryo transfer, artificial insemination etc. (Goel and Aggarwal, 2003). Natural service is preferred over the AI by the farmers. The farmers having bigger flocks keep their



Fig.16 : Jakhrana kids (Triplets)

own buck. One or two breeding males are seen in a flock of 25 to 60 animals of all ages and sex. A panchayati buck is also available in villages, which is used for breeding purpose by small flock owners who can not afford to keep their own buck. Leaving the buck on attaining the maturity for community service is assumed to be a sacred practice and hence this buck is known by the name of 'Mata Ka Bakra' or 'Amar Bakra'. The breeding buck roams freely and is allowed to feed in any house of the village. This buck is protected from all sufferings including the slaughtering. Many times the breeding buck of one village is shared by the neighbouring village also.

5. Genetic studies

5.1 Molecular genetic variations

The polyacrylamide gel electrophoresis (PAGE) of the amplified DNA was used to generate the data in terms of number of alleles / effective number of alleles per locus, observed / expected heterozygosity, Nei's expected heterozygosity and polymorphic information content (PIC) of loci. The results are presented in table 4. The gels exhibiting polymorphism at locus ILSTS005 and OarFCB304 have been shown in Figs. 17 and 18. The observed number of alleles across the loci studied varied from 2 (OarJMP29, ILSTS065) to



Fig.17 : Gel showing the genetic polymorphism at locus ILSTS005



Fig.18 : Microsatellite allelic profile of OarFCB304 locus in Jakhana goat population, standard marker- Phi X 174-Hinf-I digest

11 (OarFCB304) with an overall mean of 5.2. The observed number of alleles across the loci is more than effective number of alleles as per expectations. The genetic diversity as observed across the loci ranged from 0.03-0.80 with an overall mean of 0.39. All the 23 loci exhibited polymorphism.

Table 4. Number of alleles, effective number of alleles, observed and expected heterozygosity, Nei's expected heterozygosity in Jakhrana goat population.

Locus	Sample size	Observed No. of alleles	Effective No. of alleles	Observed heterozygosity	Expected heterozygosity	Nei's Expected heterozygosity
ILSTS008	92	4	1.91	0.39	0.48	0.47
RM 085	92	4	2.41	0.35	0.59	0.58
ILSTS087	68	6	4.79	0.76	0.80	0.79
ILSTS005	84	4	2.30	0.57	0.57	0.57
ILSTS019	88	5	3.10	0.29	0.69	0.68
ILSTS058	78	7	3.54	0.41	0.73	0.72
OarFCB304	92	11	6.70	0.80	0.86	0.85
OarJMP29	90	2	1.04	0.04	0.04	0.04
Oar FCB48	94	8	4.99	0.68	0.81	0.80
ILSTS30	82	7	5.00	0.58	0.81	0.80
OarHH64	90	8	6.07	0.82	0.84	0.83
ILSTS033	56	6	2.06	0.50	0.52	0.51
ILSTS049	86	6	2.79	0.44	0.64	0.64
ILSTS059	86	3	1.82	0.09	0.45	0.45
ILSTS034	94	5	1.43	0.29	0.30	0.30
ILSTS065	70	2	1.72	0.08	0.42	0.42
OarAE129	50	6	3.02	0.44	0.68	0.67
RM4	90	3	1.33	0.28	0.25	0.25
ILSTS029	80	3	1.19	0.05	0.16	0.16
ILSTS087	60	7	3.60	0.56	0.73	0.72
ILSTS044	66	4	1.28	0.12	0.22	0.22
ILSTS002	64	6	3.77	0.53	0.74	0.73
ETH225	72	3	1.36	0.03	0.27	0.27
Mean	79	5.2	2.92	0.39	0.55	0.54
St. Dev	2.2	1.64	0.24	0.24	0.24	

The observed gene diversity was less than the expected gene diversity and Nei's expected heterozygosity.

All measures of genetic variation showed almost similar pattern of polymorphism across the loci in Jakhrana goat population. The population heterozygosity had positive deviation from Hardy-Weinberg equilibrium due to heterozygote deficiency across most of loci studied. Heterozygote deficiencies have also been reported in some studies (Luikart *et al.*, 1999; Barker *et al.*, 2001). The observed heterozygote deficiency found in Jakhrana goat population may be due to segregation of non amplifying (null) alleles, Wahlund effects, and/or selection against heterozygotes or inbreeding. To know the contribution and distinguishing among these factors is generally difficult. However, nulls are most unlikely to be segregating at all loci studied. Wahlund effects (localities with known sub population) may not account for Jakhrana population as it is distributed in a cluster of few villages. Therefore, it seems that there is inbreeding in the population resulting from uncontrolled and indiscriminate mating leading to small population sizes, breeding between relatives and consequent genetic drift.

5.2 Cytogenetic characteristics

5.2.1 Karyotypic features

Little information is available on the karyotypic characteristics of Indian goats in general and Jakhrana goats in particular. The normal diploid count of 60 is composed of 29 pairs of acrocentric autosomes and a pair of sex chromosomes. The study reporting the karyotypic features of Jakhrana goats showed that karyotypic features of Jakhrana breed of goat are similar to the features of other Indian breeds (Prakash and Balain 1992) and exotic breeds (Ford *et al* 1980). All the 29 pairs of autosomes are acrocentric in their morphology and formed a gradually decreasing series with respect to

their lengths. The karyotypic features of the breeds have been established based on a study involving 4 male and 9 female Jakhrana goats. Sex chromosome dimorphism was typical mammalian type, XX females and XY males. The male component in goats contained a small biarmed Y chromosome which varied from sub metacentric to metacentric in its morphology. However, polymorphism has been observed in the morphology of Y chromosome of some Indian goats (Bhatia and Vijay Shankar, 1992).

There has been ambiguity in the identification of the goat X chromosome by different workers. Some workers described it as the largest chromosome in the karyotype (Prakash 1978, Prakash and Balain 1992), others described it as second or third largest or one of the largest chromosome in the karyotype. While carefully screening the goat karyotypes Prakash (2003) observed that the Goat X chromosome is not the largest chromosome rather it possessed

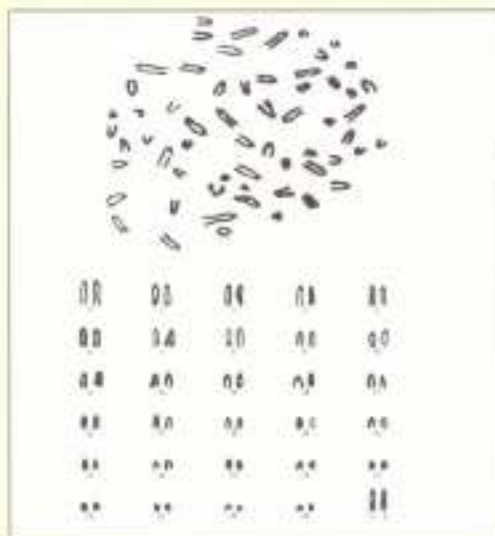


Fig.18 : Metaphase spread and normal Karyotype of a Female Jakhrana Goat

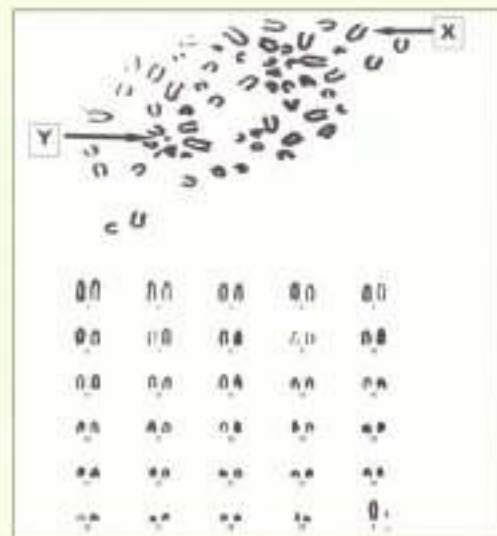


Fig.19 : Metaphase spread and normal Karyotype of a Male Jakhrana Goat

morphological distinguishing features. It has been observed that a pair of large acrocentric chromosome in females and a single chromosome in males possessed distinct but very short small arms. This chromosome is identified as the X chromosome. Confirmation by C banding verified that the same chromosome possessed the X chromosome specific C-band. The Y chromosome in both the breeds is a minute chromosome and is the only metacentric chromosome in the karyotype. Typical metaphase spreads and karyotypes of a female and male Jakhrana goat are shown in Figures 18 and 19.

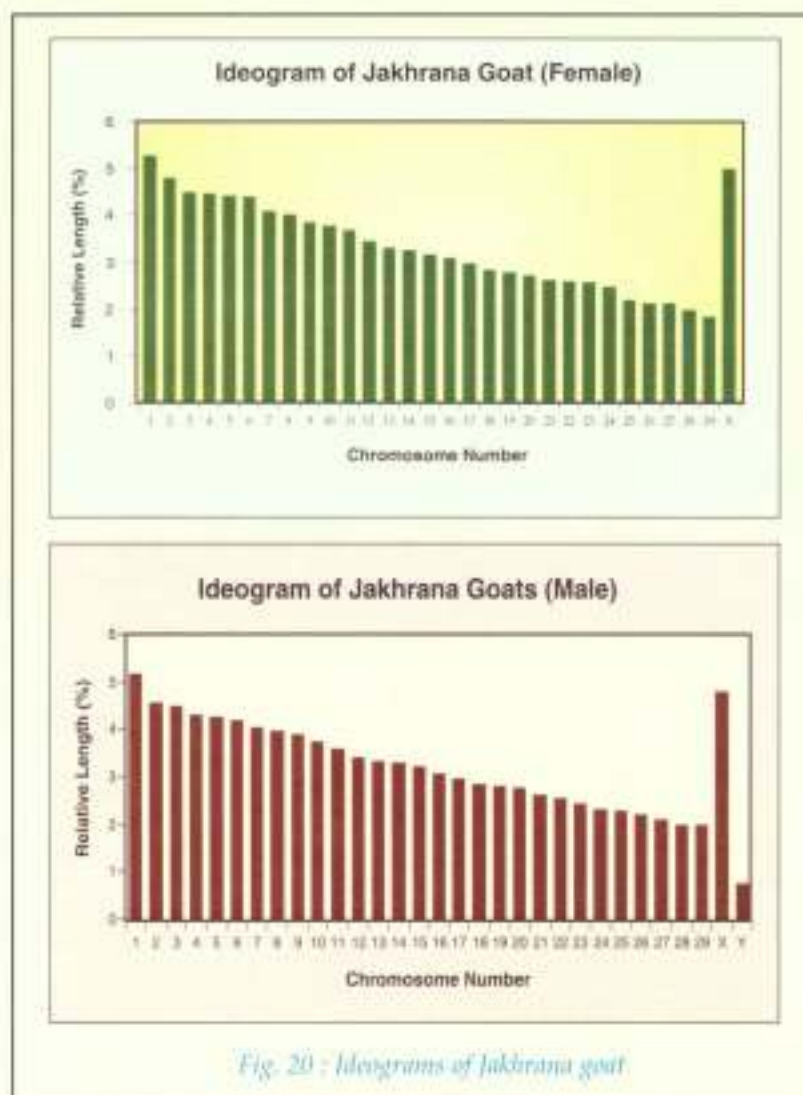
5.2.2 Relative length and ideograms

The relative length measurements computed for each sex are given in Table 5 and the ideograms prepared from the relative length computations

Table 5. Relative length measurements of chromosomes of Jakhrana Goats

Chromosome No	Relative lengths of chromosomes (%)				
	Male	Female	Chromosome No	Male	Female
1	5.16	5.26	17	2.98	2.96
2	4.59	4.78	18	2.86	2.83
3	4.50	4.49	19	2.81	2.78
4	4.32	4.47	20	2.76	2.71
5	4.27	4.41	21	2.64	2.61
6	4.19	4.38	22	2.56	2.58
7	4.06	4.08	23	2.42	2.56
8	3.98	4.00	24	2.33	2.47
9	3.91	3.85	25	2.30	2.19
10	3.75	3.77	26	2.22	2.11
11	3.61	3.67	27	2.09	2.10
12	3.43	3.45	28	2.00	1.98
13	3.34	3.30	29	1.98	1.82
14	3.31	3.25	X	4.79	4.98
15	3.24	3.15	Y	0.75	—
16	3.06	3.08	Source		

are provided in Fig. 20. The values of chromosomal lengths indicate that the X chromosome of the sex chromosomes is second largest in the whole chromosomal complement whereas the Y chromosome is the smallest. The Y-axis bars represent the proportionate contribution of each chromosome pair towards the total genome.



5.2.3 C-banding

C-banding helped in the unambiguous identification/verification of the sex chromosomes. All the 29 pairs of autosomes possessed a strong C-band at their centromeric ends (Fig. 21). The X chromosome was completely devoid of a distinct C-band and definitely was not the longest chromosome in the karyotype. The X chromosome was also characterized by the presence of an intercalary heterochromatic band almost midway in the long arm. The Y chromosome, though devoid of a distinct centromeric band was wholly darkly stained.



Fig. 21 : C-banded metaphase spread of a male (above) and female (below) Jhakrana Goat

6. Conclusion and recommendations

Jakhrana goat is a large sized animal reared for dual purpose in a limited pocket of Behror tehsil of Alwar district of Rajasthan State. Though the Jakhrana goats are having a good milking potential and good prolificacy, no concerted improvement programme has been made to harvest the full potential for milk and meat of these goats. Since the animals are confined to a limited pocket of Rajasthan and are small in numbers, a more concerted effort is required for conservation and improvement of this breed. The animals showed a drop in their performance whenever shifted to new environment. Hence, more in depth study is required on environmental factors affecting growth, reproduction, survival and milk and meat

production. The State Government and SAUs in the region where breed is predominant, can play a vital role in conservation and further improvement of this unique genetic resource. With the increase in interest in dairy goat farming and their products many myths and misconceptions about the goat milk will fade. The goat probably may not replace the cow for commercial production of milk but for domestic purpose goat farming is definitely a profitable enterprise than the cattle farming. With a little serious effort and planned breeding we can see the Jakhrana goat developing into a mini cow. It is worthwhile to compare the milk of goats with that of cows and make the public aware of its superior nutritional value. Simultaneously, encouraging the marketing of goat milk and its products like cheese by private and public enterprises may increase the interests in goat rearing among the small and marginal farmers and landless labourers. Organising these farmers in self help groups and providing support in training these groups in management, feeding, prophylactic health cover especially external and internal parasites, will help improving production, processing and marketing of the products from goat milk.

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