Jamaica Hope: The dairy breed for the tropics

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Summary

Experimentation in breeding dairy cattle for the tropics began in Jamaica at Hope Farm in 1910 with local cattle, temperate dairy breeds and the infusion of the Sahiwal (Zebu) breed.

The research results, which also influenced farmers' operations, indicated the superiority of the grade Jersey for production and fertility, which was considered to be the result of adaptation. Thereafter, breeding inter se, a tropical dairy breed, the Jamaica Hope was established and was declared in 1952. The formation of the Jamaica Hope Cattle Breeders' Society immediately followed.

The breed has shown a high level of productivity under wide ranging husbandry conditions. The highest yields have been above 8 800 litres of milk in 305 days.

The MOET technique of reproduction will be employed in the expansion of the breed.

Resumen

La experimentación en mejora de bovinos de leche en la zona tropical comenzó en Jamaica en la Hope Farm en 1910 con una raza local, razas de leche de zonas templadas y con la raza Sahiwal (Zebu).

Los resultados de las investigaciones mostraron la superioridad de la raza Grade Jersey para la producción y la fertilidad; que se pensó era el resultado de una buena adaptación. Más adelante, con los cruzamientos *inter se*, se llegó a una raza lechera de zona tropical, la Jamaica Hope, que fue reconocida y declarada como tal en 1952.

A esto siguió el establecimiento de la Asociación de Ganaderos de la Raza Bovina Jamaica Hope.

La raza ha mostrado un alto nivel de productividad en condiciones intensivas. Los mayores rendimientos han sido de aproximadamente 8 000 litros de leche en 305 días.

La técnica MOET de reproducción será empleada para la expansión de esta raza.

Keywords*: Jamaica Hope, Tropical Dairy Breed, Production, Fertility, Adaptation.*

Origin

Cattle were introduced to Jamaica from the time of the Spanish occupation in 1494 to produce hides for leather manufacture with beef production being merely of secondary importance. This was followed by introductions by the British after 1655.

The growth of the sugar industry in the eighteenth century increased cattle rearing for the production of animals to work on the sugar estates. At the same time cattle from among the various breeds, both dairy and beef, which were then developed in the United Kingdom, were brought into Jamaica. The animals of Spanish and British origin were inter-bred in an attempt to increase productivity. The continued importations included Zebu or Indian cattle for their proven capacity as draft animals as well as their known resistance to tick borne diseases.

Dairying started on a limited scale and by the beginning of the twentieth century there was demand for supplies of fresh milk. This gave rise to a number of farms with animals from a mixture of breeds.

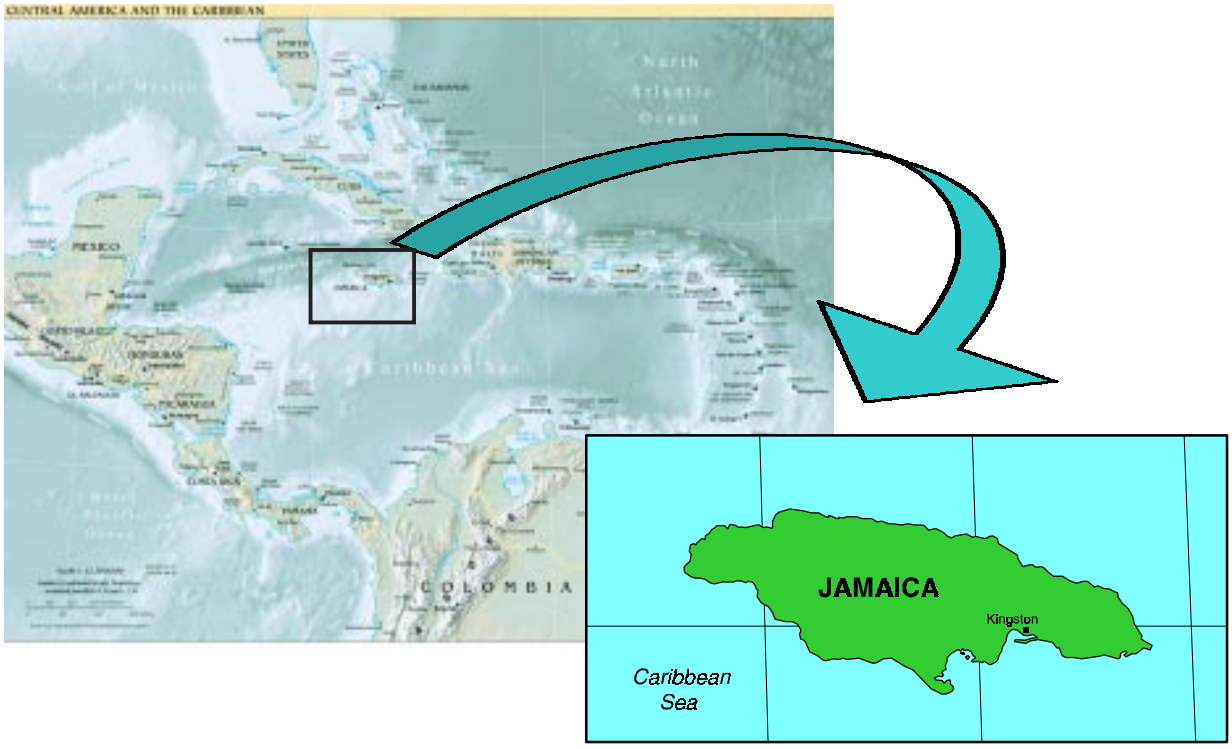

Figure 1. Jamaica in the geographic map.

Experimental work in the breeding of dairy cattle for the tropics began in Jamaica at the Government Hope Farm in 1910 when the need was recognized for a dairy breed capable of coping with the heat, humidity, diseases and low quality forages of the tropics.

A nucleus of local dairy cows purchased from farms and importations made up of dairy cattle from the Jersey, Guernsey, Ayrshire, Holstein, Brown Swiss and Red Poll breeds, as well as of two bulls of the Sahiwal breed from India, formed the basis for experimentation.

The Sahiwal has contributed hardiness, that is an ability to tolerate heat, low quality forage, parasite burdens, as well as strengthening feet and legs. The Jersey emerged the most heat tolerant of the Bos Taurus breeds and has enhanced fertility and udder characteristics, while at the same time ensuring a suitable body size for the tropics.

From the early experimental work Cousins (1933) indicated the possibility of developing a tropical dairy breed.

Jamaica, north of the equator in the Caribbean area, in the region of the 18th parallel, is in the tropics (Figure 1). Mountain ridges are mainly from east to west and grasslands are at different altitudes in hilly areas as well as on flat lands. Temperatures are moderated by the influences of day and night winds.

The average maximum temperature at Hope, the location of the start of dairy cattle research, was 24°C. Bodles, the new Research Station, slightly above sea level, to which the research herd was transferred in 1950–1951 to intensify development, has an average maximum temperature of 31.5°C.

Developmental Results

The experimental work, sustained within the Agricultural Station and influencing farmers island-wide, mainly by the provision of sires, resulted in the dominance of the grade Jersey as the most productive. On this observation

Table 1. Main characteristics of the Jamaica Hope.

Body size mature animals	630-730 kg for male and 385-455 kg for female
Appearance	Angular from fore to hindquarters showing a wedge-shaped form. Good width between forelegs; good barrel carrying through to hindquarters
Skin	Smooth appearance, not loose or coarse
Head in male	Masculine appearance, face, wide between eyes and moderately dished; medium-length, broad muzzle and wide nostrils
Head in female	Moderately dished, medium-length
Body in male	Neck, strong, with crest blending into shoulders, long body, with rump, slightly sloping, of good width and good length from hip to pins
Testicles	Evenly sized well-balanced and hanging at medium-length
Body in female	Neck, blending smoothly with withers, body firm and deep with well sprung ribs showing good barrel
Udder	Level floor, quarters evenly balanced and defined: teats well apart squarely placed; rear attachment high and with good width; fore attachment carried forward and well attached
Colour	Fawn, varying from light to dark fawn, solid colour predominates
Pigment	Dark (black) Nose – black Hooves – black Switch – dark
Other characteristics	• 12-months calving interval • Low maintenance requirements • High milk production • Tolerance to external parasites • Good milk let-down without calf • Easy calving • At foot • Strong feet and legs • High butter fat production • Calm dairy temperament • Good foraging ability

Lecky (1949) indicated and ceased further use of Jersey bulls on the grade Jersey as further use of the Jersey would lower adaptation.

A critical evaluation in 1950-51 of the data collected from the sustained research with the Hope herd revealed that to develop a new breed the greatest possibility was with the selection within the grade Jersey (Lecky, 1951).

The Jamaica Hope breed

The Jamaica Hope was declared a breed in 1952 with the Government's grade Jersey herd given pure-bred status. The genetic make-up is estimated to be 80 percent Jersey, 15 percent Sahiwal and five percent Holstein. The Jamaica Hope Cattle Breeders' Society was also founded in that year and involved farmers with grade Jersey Herds.

Breed Characteristics

Main characteristics of the breed are summarised in table 1.

Breed development

Breed development is controlled by the Jamaica Hope Cattle Breeders' Society. The Society operates an open Herd Book Policy whereby approved females are up-graded through three generations by the use of registered Jamaica Hope bulls.

Visual appraisals to ensure conformity with breed standards are carried out with females after calving and with bulls up to four years old. Strong emphasis is placed on udder characteristic, feet and legs.

Selection is against beef conformation and heavy fat deposition.

The Ministry of Agriculture continues research with the nucleus herd at Bodles Research Station, Old Harbour and operates the National Recording Programme enabling testing. Development programmes such as the Multiple Ovulation Embryo Transfer (MOET) are envisaged for the future.

The breed is productive, fertile, heat tolerant and has excellent dairy characteristics. This tropically adapted breed, resistant to tick borne diseases, Anaplasmosis and Piroplasmosis is fully established on several private- and Government-owned farms operating in the tropics.

Farmers' herds integrate the development of the breed thus enabling the use of bulls from their herds. **T**he second lactation pure-bred Jamaica Hope cow at Bodles, is sired by a bull introduced into the Bodles her (Figure 2).

Figure 2. Second lactation purebred jamaica Hope at Bodies Agricultural Research Station, Jamaica. First lactation production 3 700 litres in 305 days.

Figure 3. Jamaica Hope bull, named Bodles Brucome, age four (4) years, which is on national use through the Bodles Artificial Insemination Centre

Management of herds is through progressive husbandry from calf rearing onwards. Calf rearing is by different methods.

The Jamaica Hope development through the sire genealogy path across all sire lines, since declaration of the breed, ranges from seven to ten generations. Figure 3 is the Jamaica Hope bull, named Bodles Brucome, age four (4) years, which is on national use through the Bodles Artificial Insemination Centre.

Breed performance

Jamaica Hope cattle are used successfully over a wide spectrum of conditions ranging from subsistence farming to large commercial enterprises.

On low-input farming systems the Jamaica Hope is successful. Cows are milked once per day. Forage is often cut and carried with little supplementary feeding.

On the large dairy enterprises, cows are milked in the herds of several hundreds at stocking rates of five cows per hectare, to produce over 17 000 litres of milk per hectare with supplementary feed at 0.4 kg per litre of milk. Several herds have averages of over 4 800 litres per lactation while individual cows have produced over 8 800 litres of milk in 305 days, milking twice a day.

Longevity and reproductive performance are good even under intensive commercial systems. The average number of lactation is over five with calving intervals of less than 13 months.

Health status

Jamaica is free of rabies and foot-and-mouth disease. All herds are tested regularly for tuberculosis (TB) and brucellosis. The island's strict quarantine regulations ensure this status is maintained.

Population

The number of animals in the national herd is estimated at 20 000.

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Performance evaluation, conservation and improvement of Sahiwal cattle in India

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Summary

The Sahiwal cattle, one of the best dairy breeds of Zebu cattle in India and Pakistan, originate from the Montgomery district of Pakistan and is distributed on farmer herds in certain pockets of the bordering districts of Punjab and Rajsthan in India. The animals of this breed are also available in Kenya and are used for crossing with local East African Zebu types to improve milk production. Sahiwal cattle have deep body, loose skin, short legs, stumpy horns and a broad head with pale red to dark brown body colour. The average body weight in adult females and males is around 350 and 500 kg, respectively. The animals of this breed are maintained on various State and Central Government farms, privately owned farms, charitable trusts and a small proportion of animals are also available with the farmers. More than 1 200 breedable females are available at various farms in the country. The average lactation milk yield of Sahiwal cattle on organized farms ranges between 1 500 to 2 500 kg. However, in well-managed herds, the highest lactation milk production in certain cows is more than 4 500 kg. The overall weighted average milk yield, age at first calving, lactation length and calving interval based on the performance at various herds is around 1 900 kg, 36 months, 315 days and 420 days, respectively. The fat and Solid Non Fat (SNF) percent ranges from 4.6 to 5.2 percent and 8.9 to 9.3 percent, respectively. Quite a large proportion of pure-bred Sahiwal cattle maintained on organized breeding farms has been used for the production of cross-bred cattle. As a result, different cross-bred strains of dairy cattle *viz* Karan Swiss, Karan Fries and Frieswal have evolved at the National Dairy Research Institute, Karnal and Military Dairy Farms. The breed has also been utilized for the production of synthetic strains like Jamaica Hope (JH), Australian Milking Zebu (AMZ) and Australian Friesian Sahiwal (AFS) in other countries. Currently, efforts are being made to characterize, evaluate and conserve the breed in field conditions. More than 0.10 million doses of frozen semen of this breed are cryopreserved at various semen banks in the country. The frozen semen is being utilized for strengthening and genetically improving the existing herds of the breed through progeny testing programmes of sires associating various herds of Sahiwal in the country.

Resumen

La Sahiwal es una de las mejores razas zebú de leche en la India y Pakistan, originarias del distrito de Montgomery en Pakistan, se encuentran distribuidas por rebaños pequeños en algunas zonas limitadas de los distritos fronterizos de Punjab y Rajsthan en la India. Estos animales se encuentran también en Kenya y vienen utilizados para cruces con tipos locales de zebú del Africa del Este, con el fin de mejorar la producción de leche. La raza Sahiwal posee un cuerpo fuerte, poco pelo, patas cortas, cuernos cortos y una cabeza ancha y el color va del rojo claro al marrón oscuro. El peso medio corporal de las hembras y los machos adultos es de 350 y 500 kg, respectivamente. Los animales pertenecientes a esta raza se crian en centros

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estatales o regionales, en ganaderías privadas, centros de apoyo voluntario y también una pequeña cantidad de ellos se puede encontrar en pequeñas granjas privadas. Hay a disposición más de 1 200 hembras para cruces. La media del rendimiento por lactación de la raza Sahiwal en granjas organizadas es de 1 500 a 2 500 kg. Sin embargo, en rebaños muy bien conducidos, se alcanza con algunas hembras una producción lechera de más de 4 500 kg. Basándonos en los rendimientos de varios rebaños se puede decir que la media total de rendimiento por lactación es de 1 900 kg, la edad al primer parto de 36 meses, la duración de la lactación es de 315 días y el intervalo entre partos de 420 días. El porcentaje de grasa y SNF va de 4,6 a 5,2 y de 8,9 a 9,3, respectivamente. Una amplia proporción de pura raza Sahiwal conservada en granjas organizadas ha sido utilizada para producción de cruces. Como resultado de todo ello, distintas líneas de cruces especializadas en producción lechera, tales como Karan Swiss, Karan Fries y Frieswal, han sido mantenidas en el Instituto Nacional de Investigación Lechera, en Karnal y en Granjas Lecheras Militares. La raza ha sido también utilizada en otros países para la producción de líneas sintéticas tales como Jamaica Hope (JH), Austalian Milking Zebu (AMZ) y Australian Friesian Sahiwal (AFS). Recientemente, se han llevado a cabo esfuerzos para caracterizar, evaluar y conservar la raza en condiciones de campo. Más de 0,10 millones de dosis de semen congelado de esta raza han sido crioreservados en distintos bancos de semen en el país. El semen congelado se utilizará para reforzar y genéticamente mejorar los rebaños existentes a través de programas de test de progenie de machos de raza Sahiwal en distintos rebaños del país.

Key words*: Conservation, Sahiwal, Genetic gain, Breed improvement, Evaluation.*

Introduction

Sahiwal, one of the best dairy cattle breeds of India and Pakistan, originated from the Montgomery district of Pakistan. In India, the animals of the breed with good production potential are available at some of the organized farms in North, North-Western and Central India. In field conditions, animals of this breed are available in certain pockets of the bordering districts of Punjab and Rajasthan. The number of Sahiwal animals in Punjab has declined drastically due to cross-breeding of these animals with exotic breeds to enhance milk production. Though cross-breeding of Zebu cattle with exotic temperate dairy breeds has enhanced milk production, it is not presently feasible to introduce this system on a large scale due to several reasons like less heat tolerance capacity, more susceptibility to tropical diseases, low milk fat content, poor ability to use coarse fibres, deterioration of F_2 and further generations from intense mating and above all high cost of maintenance of cross-bred animals. On the contrary, Zebu cattle in particular have a remarkable power of endurance by adaptation to hot climate, resistance to tropical diseases, relatively higher percentages of milk fat and SNF and an ultimately low cost of maintenance compared to cross-breds. Due to these attributes, Sahiwal is one of the few indigenous breeds which has been imported by many tropical countries from India or Pakistan and has been used either for first crossing or later on for incorporating some Zebu genes, after the failure of the cross-breeding to make improvements by increasing the exotic inheritance for developing suitable dairy breeds (Nagarcenkar, 1982). The multi-faceted usage of this breed is clear from the fact that in Kenya, a National Sahiwal Stud has been established at Naivasha by importing Sahiwal cows from India and Pakistan. The animals of these breeds have also been utilized for the production of synthetic strains like Jamaica Hope (JH), Australian Milking Zebu (AMZ) and Australian Friesian Sahiwal (AFS) in other countries. In view of the multi purpose utility of this breed, it is of utmost importance to multiply, improve and conserve this valuable germplasm and to bring about

further improvement in the performance of this milk breed.

In India, more than 1 200 breedable females are maintained on various organized farms located in different areas of the country (Figure 1, 2 and 3). Breedwise, distribution of livestock population in the country is not available because the quinquiennium census on livestock are conducted species-wise. However, there are few farmers and breeders particularly belonging to tribal communities in the Pak bordering districts of Punjab and Rajasthan possessing a large number of Sahiwal cattle. The distribution of Sahiwal cattle in farmers' herds is scanty. At present there are 12 organized herds of this breed in India, namely:

1. Government Livestock Farm, Hisar (Haryana)
2. National Dairy Research Institute, Karnal (Haryana)
3. Cattle Breeding Farm, Beli Charana, Jammu Cantt (J & K)
4. Amritsar Pinjrapole Cow Stable (Regd.), Ghee Mandi, Amritsar (Punjab)
5. Cattle Breeding Farm, Nabha (Punjab)
6. Cattle Breeding Farm, Chak-Ganjaria, Lucknow (U.P.)
7. Cattle Breeding Farm, Bod, Amravati (Maharashtra)
8. Cattle Breeding Farm, Anjora, Distt. Durg (M.P.)
9. Military Dairy Farm, Meerut (U.P.)
10. Dairy Farm, Govind Ballabh Pant University of Agriculture and Technology, Pantnagar, Distt. Nainital (U.P.)
11. Shri Satguru Hari Singh Animal Breeding and Agricultural Farm, Sirsa (Haryana)
12. Satguru Sewa Sangh, Bheni Sahib (Khanna), Distt. Ludhiana (Punjab).

Sahiwal cattle on most of the central and State Government organized farms are pedigreed and performance recorded animals, however, very few farms have infrastructural facilities of rearing breeding bulls (Figure 4 and 5), collection and cryopreservation of semen and artificial insemination. More than 0.10 million frozen semen doses of 40 breeding bulls in breed improvement programmes are available with Germplasm Centres of NDRI, Karnal for distribution to associating organized and farmers' herds.

The objective of the present paper was to evaluate the performance of Sahiwal cattle with respect to growth, milk production and reproduction parameters. The heritability

Figure 1. In situ *conservation of Sahiwal cattle by tribal communities.*

Figure 2. A tribal cattle owner looking at his prised Sahiwal cattle.

estimates of different economic traits, genetic gain in milk production through selection, breed improvement programmes of Sahiwal in farm and field conditions and the use of Sahiwal in evolving new dairy breeds of cattle, will also be discussed.

Performance Parameters

Birth weight and growth rates

The average birth weight of male and female calves was 22.35 and 20.67 kg, respectively. The highest birth weights of male and female calves were reported during 4th parity at NDRI Farm, while Sivarajasingam *et al.* (1986) reported highest birth weight during 3rd parity in Sahiwal cattle in Malaysia. Mwandotto (1986) reported average birth weight of 22.9 ± 0.09 kg of Kenyan Sahiwal cattle, whereas Singh and Bhat (1987) reported lowest birth weight (20.4 kg) in Indian Sahiwal calves. Different factors like sex, dam, year, month / season and herd parity were reported to have significant effects on birth weight.

The growth rate serves as a check on feeding systems and management efficiency for rearing calves and it influences the maturity age and lifetime productivity of cows. Mudgal and Ray (1965) reported that daily growth rate (309 and 293 g in male and female calves) was slow from birth to 2½ months and later it exhibited an increasing trend (476 and 407g from 2.5 to 6 months). The growth rate was lower from seven months to one year of age. Mwandotto (1986) reported absolute daily growth rates in Kenyan Sahiwal animals as 339.5±2.9, 409.7±3.3, 329.0± 9.6 and 37.9±7.0g from birth to 55 kg, 55 kg-125 kg, 125 kg-27 months of age and from birth to 27 months of age, respectively. The average weight at first conception and at calving in Indian Sahiwal cows was 288.74±31.07 and 380.16±31.00 kg, while in Kenyan Sahiwal cattle weight at first calving was 410.9±1.8 kg (Mwandotto, 1986).

Mwandotto (1986) reported heritability estimates as 0.17±0.06 for birth weight, 0.25±0.06 for absolute growth rate to 27 months of age, 0.03±0.04 for relative growth rate to 27 months and 0.33±0.07 for 27 months body weight of Kenyan Sahiwal

cattle. Low and non-significant genetic and phenotypic correlations of growth traits with milk yield were reported.

Age at first calving

The overall average age at first calving was 1 080 days ranging from 879 days in Indian Sahiwal maintained at Karnal (Bhatnagar and Sharma, 1976) to 1 487 days at Hisar (Reddy, 1983). The heritability estimates of the trait reported by different workers ranged from zero (Reddy and Nagarcenkar, 1989) to 0.75±0.21 (Singh, 1977).

First lactation total milk yield

The overall weighted average first lactation milk yield of Sahiwal cows was 1 902 kg with a range of 1 519 kg (Singh *et al.*, 1980) to 2 499 kg (Sundersan *et al.* 1965). Heritability estimates ranging from zero to 0.92±0.40 have been reported. Positive and significant genetic and phenotypic correlations of milk yield with first lactation length and first calving interval have been reported. Moderate to high estimates of repeatability of lactation milk yield were reported by different workers (Gandhi and Gurnani, 1988; Khan *et al.* 1988).

First lactation length

The weighted average of first lactation length was 315 days. It ranged from 214±9 days (Kavitkar *et al.* 1968) to 345±4 days (Gandhi and Gurnani, 1988). Low to high estimates of heritability were reported by different workers ranging from close to zero (Reddy and Nagarcenkar, 1989) to 0.67±0.26 (Chopra *et al.*, 1973) in Sahiwal cattle. The genetic and phenotypic correlations of this trait with first calving interval were positive and significant (Rao, 1985). The repeatability estimates of lactation length were high (Khan *et al.*, 1988; Sharma and Khan, 1989; Reddy, 1983).

First calving interval

The average first calving interval reported by different workers was 440 days in Sahiwal cows and it ranged from 413 days (Reddy, 1983) to 498±124 days (Kushwaha and Misra, 1969). Most of the estimates of heritability reported in the literature were not significantly different from zero.

Life-time milk production

Life-time milk production ranged between 5 244 kg (Reddy, 1983) and 6 405 kg (Bhatia, 1980) up to three lactations and between 8 928 kg (Reddy, 1983) to 17 652 kg (Gopal and Bhatnagar, 1972) up to five lactations. Life-time milk production up to ten years of age was between 10 794 (Gandhi, 1986) and 24 406 kg (Gopal and Bhatnagar, 1972). The heritability of lifetime production up to ten years from adjusted and unadjusted data was not significantly different from zero as reported by Rao (1985) while Gandhi (1986) reported the heritability for the same trait as 0.43±0.06.

Breeding efficiency

The breeding efficiency is a function of the total number of parturitions, number of days from first to last calving and an ideal calving interval of 365 days and has been calculated after Wilcox *et al.* (1957). The average breeding efficiency in Sahiwal cattle ranged between 80.6 percent (Gandhi and Gurnani, 1990) and 89.2 percent (Singh *et al.*, 1980). Genetic correlations between breeding efficiency and weight and age at first calving, first lactation milk yield and milk yield per day of first calving interval were positive and significant. The phenotypic correlation of breeding efficiency with age at first calving and first lactation milk yield were, however, negative and significant (Singh *et al.*, 1980). Heritability estimates of breeding efficiency were 0.18±0.05 and 0.19±0.08 based on paternal halfsib and intrasire regression of offspring on dam methods, respectively (Singh *et al.*, 1980).

Figure 3. A thatched shed for housing Sahiwal cattle.

Figure 4. Sahiwal herd under field conditions.

Genetic gains in milk production through selection

Singh (1981) estimated the expected genetic progress in milk production through direct selection from the selection of dams of bulls, dams of cows, sires of bulls and sires of cows at Karnal and Chak-Ganjaria (Lucknow) herds in India. The overall genetic change per annum was 1.11 percent of herd average of 2 108 kg at Karnal herd and 0.20 percent of herd average of 1 614 kg at Chak Ganjaria farm. The average generation interval was 77.53 months at Karnal and 76.52 months at Chak-Ganjaria farm. The largest contribution of 69.6 percent in genetic change was found to be derived from dam to bull path followed by sire to bull (28.9 percent), dam to daughter (3 percent) and sire to daughter (-1.6 percent) paths in Karnal herd.

Sahiwal breed improvement programme

The main breeding policy has been the selective breeding for genetic improvement of this breed. To have an adequate number of superior breeding bulls for producing sufficient frozen semen doses in order to breed pure-bred Sahiwal cattle population in field and farm conditions, a progeny testing programme entitled "Associated herd progeny testing in Sahiwal" was started in 1979 associating five herds of Sahiwal maintained at Government Livestock Farms, Hisar, Lucknow, Durg; Cattle Breeding Farms, Nabha and NDRI, Karnal, to have the requisite number of progeny/sire and to evaluate sires more accurately. The NDRI herd of Sahiwal having fully established infrastructural facilities for bull rearing, semen collection, processing and cryopreservation was the coordinating centre and later on more Sahiwal herds were associated with the project. The association of different herds envisaged the effective testing and evaluation of a large number of bulls over a large population. Together these farms contributed about 700 breedable populations of Sahiwal cattle. Out of the first set of progeny testing six bulls, the highest predicted breeding value of 1 679 kg (+9.5 percent above herd average) based on 19 daughters in five herds was obtained. This bull was used for nominated matings with 20 percent elite females. Out of the second set of eight bulls, the highest breeding value of 1 824 kg (+12.9 percent above herd average) on 32 daughters followed by 1 743 kg (+7.9 percent above herd average) based on 14 daughters of second bulls was obtained. These bulls were also used for elite mating. For production of bull calves the performance of daughters of bulls of the third and fourth sets is being evaluated. Presently, the fifth set of six bulls with dam's best yield ranging from 3 031 to 3 559 kg (average superiority 3.6 to 12.3 percent) are being used in three herds (Figure 6).

The organized herds of Sahiwal cattle besides bringing out genetic improvement in the breed are also engaged in multiplication of germplasm in the form of breeding bulls and semen and their dissemination to the selected pockets of farmer herds, few cow stables and private breeders. The germplasm is also being used for up-grading of non-descript cattle.

The germplasm of Sahiwal has been used extensively for developing country's well known synthetic strains of the cross-bred cattle in organized herds. This has drastically reduced the number of Sahiwal cows on organized farms. No doubt, due to cross-breeding the milk production has increased significantly in field conditions. Research conducted under organized herds has shown that performance of cross-breds with 50-62.5 percent exotic inheritance is better than that of the indigenous cattle breeds. Sahiwal germplasm has been used to develop two cross-bred cattle strains *viz* Karan Swiss and Karan Fries at NDRI, Karnal by crossing Sahiwal/Tharparkar females with imported semen of Brown Swiss and Holstein Friesian bulls.

Frieswal is another cross-bred cattle strain being developed on military dairy farms by crossing Sahiwal females with Holstein Friesian males. The Sahiwal bulls are also

being used to backcross cross-bred progeny to maintain exotic inheritance at a level of 50-62.5 percent.

Furthermore, the Sahiwal breed has also been used for cross-breeding in different countries like Bangladesh, Australia, Tanzania and the West Indies and cross-bred cattle strains like Australian Friesian Sahiwal, Australian Milking Zebu, Jamaica Hope, Mpwapwa and Pabna crosses have evolved.

In India, the emphasis is currently being given to pure-breeding of Zebu milk breeds to strengthen their herd on organized farms to multiply, conserve and propagate superior germplasm of native breeds including Sahiwal. There is an urgent need to formulate breeding programmes and strategies to bring about genetic improvement in milk yield of Sahiwal cattle, which is one of the best indigenous cattle milk breeds.

Present status of Sahiwal cattle in field conditions

The fast changing socio-economic levels of farmers and cattle breeders, ecological profile and agricultural scenario and various factors such as shrinking pasture lands, over-emphasis on cross-breeding with exotic cattle inheritance as well as the increased emergence of buffalo as commercial dairy animals, have resulted in the further decline in the population of Sahiwal cattle which were sparsely distributed in the Pak-bordering districts of Punjab and Rajasthan. Now, very few pure-bred cattle of Sahiwal herds are maintained at selected cow stables, religious charitable trusts, State cattle breeding farms and the research and development organizations besides tribal cattle breeders who are still committed to rearing Sahiwal cattle on their own. These tribal families are now temporarily settled near the vicinity of various towns in the districts of Punjab and Rajasthan. The tribal cattle breeders in Rajasthan also introduced the inheritance of Sahiwal cattle in the indigenous cattle breeds and developed another milk breed of cattle named Rathi which carries the major proportion of Sahiwal cattle inheritance. These tribal cattle breeders possess large herds of Sahiwal cattle ranging from a few hundred to a thousand animals that can be seen camped at one place. To determine the socio-economic levels of Sahiwal cattle breeders / farmers, demographic and geographic distribution, morphological characteristics, performance traits as well as genetic characterization of the Sahiwal cattle breed, there is a need to conduct a breed survey in this area which could generate useful information for developing a breeding plan for conservation and further improvement.

Future Strategies for Improvement

The population of Sahiwal pure-bred herds on organized farms has declined drastically due to their extensive use for cross-breeding during the last two decades. No doubt, India has achieved a breakthrough to enhance milk production by cross-breeding native stock with exotic breeds to such an extent that it has emerged as the top producer of milk after surpassing the USA. In the process of over-emphasising the cross-breeding programme and its indiscriminate use, some of the well known Indian Zebu cattle breeds like Gir, Red Sindhi, Tharparkar and Sahiwal were subjected to genetic dilution and population decline. Realizing this, emphasis is given to further strengthen the already established pure-bred herds to increase the size of herds of our native milk and dual-purpose breeds on organized farms as well as in their respective breeding tracts. Hence, undertaking programmes on identification, selection and propagation of superior germplasm as well as re-establishing the herds of Sahiwal cattle, being one of the most important indigenous milk breeds, is of utmost importance. The comparable performance of Sahiwal with cross-bred cows in terms of per day milk yield (milking average of 8.8 kg in Sahiwal versus 12.5 kg in Karan Fries) at NDRI Farm, revealed that Sahiwal cows have the genetic potential to increase productivity and can withstand

Figure 5. Young Sahiwal calves under village conditions.

Figure 6. A progeny-tested Sahiwal bull.

tropical climatic stress and subsist on a crop residue based feed system. Thus, the cost of rearing and maintaining of Sahiwal cattle is comparatively lower in comparison to cross-breds.

A large scale progeny testing programme for evaluating the adequate number of Sahiwal bulls associating sizeable breeding herds of Sahiwal maintained at a number of Central / State Government livestock breeding farms and other organized herds possessed by the Charitable Trust, cow stables and even private farms, needs to be undertaken. This would also lead to the establishment of Sahiwal bull mother farms and germplasm collection centres which will further disseminate the superior germplasm in the form of semen and breeding bulls to Sahiwal herds on organized farms and farmer / breeder herds.

Multiple ovulation and embryo transfer (MOET), a new emerging tool of biotechnology may be used to enhance multiplication of superior germplasm from the nucleus herd of Sahiwal cows to produce a larger number of elite progeny from nominated matings per unit of time. It has been reported that by using this technology in the near future, 6-12 progenies from a donor can be produced in a year or 30-60 offsprings in her lifetime (Kurup, 1992). A conceptual model for production and evaluation of Sahiwal bulls in associated herd system integrating MOET with the conventional AI programme has been discussed by Gandhi and Singh (1997), using a nucleus herd of 500 breedable females. The expected genetic gain from the adult MOET scheme was 2.95 percent of the herd mean (1 788 kg), which was about two-fold expected from the progeny testing scheme in Indian conditions. It was concluded that wherever infrastructural facilities for cryopreservation of semen / embryos and transfer of embryos are available, MOET technology should be adopted on organized farms to raise progeny from elite mating for conservation, propagation and for bringing about faster genetic improvement in milk yield of Sahiwal cattle.

Furthermore, there is a need for inter-country collaboration among the countries maintaining the Sahiwal breed through the exchange of superior germplasm in order to broaden the genetic base and to make selection more effective. If possible, an associated herd progeny testing programme may be undertaken throughout these countries in order to improve the accuracy and intensity of selection of sire evaluation.

To summarize, the multiplication, evaluation, conservation and future propagation of the Sahiwal breed is of paramount importance in the prevailing situation in our country, where the number of animals of this breed has declined considerably due to their extensive use in cross-breeding with exotic breeds of temperate origin on organized farms as well as in field conditions. For conservation and improvement of this breed, concerted efforts have to be made to strengthen the breed improvement and development programmes by associating more farmers and organized herds in associated herd progeny testing programmes, producing superior germplasm on organized farms, establishing bull mother farms, producing a larger number of elite progeny by adoption of embryo transfer and ultimately creating awareness among farmers through the formation of the Sahiwal Cattle Breeders' Society and Breed Development Boards to the par excellence performance of this breed with cross-breds in terms of cost benefit ratio and feed conversion efficiency.

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Garole: The prolific sheep of India

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Summary

A survey on Garole sheep was carried out in the breeding tract for breed characterization. Garole sheep are distributed in the Sundarban region of West Bengal in India. It is a small-sized breed known for its prolificacy and adaptation to the saline marshy land of the Sundarban region. It is believed that these sheep contributed to the prolificacy gene in Booroola Merino sheep of Australia. The breeding tract of Garole sheep falls under the Coastal Saline Zone of West Bengal and the climate of this region is hot and humid. The population of Garole sheep was 206 720 in 1994-1995. This breed is maintained by marginal farmers and landless labourers. Flocks are stationary and average flock size ranges from three to five. They graze on rice fallow land and natural grass cover on the roadsides and water channels. Garole sheep have the ability to graze in knee deep conditions in marshy land. Their colour is generally white. Some animals of black or brown colour are also seen. The male is generally horned and females are polled. They have three distinct types of ears; small, medium and long. Average adult weights in male and females are 15 and 12 kg, respectively. Twin and triplet births are common. The Garole sheep are reared for mutton production. Farmers generally do not shear wool. Fleece is of a coarse quality and is used as bedding material.

Résumé

Une enquête sur la race ovine Garole a été réalisée sur place pour une étude de caractérisation de la race. La race Garole se trouve principalement dans la région de Sundarban dans l'Ouest Bengal aux Indes. Il s'agit d'une race de petite taille bien connue pour sa prolificité y grande adaptation aux terrains marécageux salins de la région de Sundarban. On pense que cette race a contribué a apporter le gène de la prolificacité dans la race Booroola Merino de l'Australie. Le milieu naturel de la race Garole se trouve sous la zone de la côte saline de l'Ouest Bengal et le climat de cette région est particulièrement chaud et humide. En 1994-1995 la population de race Garole était de 206 720 animaux. Cette race est élevée surtout par des petits fermiers et des paysans sans terre. Les troupeaux sont sédentaires et la taille moyenne de chacun est de trois à cinq animaux. Les animaux pâturent dans les jachères des risières et sur pâturages naturles des bords des chemins et des cours d'eau. Cette race possède l'habilité de pâturer même couverte jusqu'aux genoux dans les terrains marécageux. La couleur du manteau est généralement blanche, mais on voit aussi des animaux de couleur noir ou brun. En général les mâles possèdent des cornes et les femelles non. Il existe trois types différents d'oreilles: petites, moyennes, et longues. Le poids moyen à l'âge adulte chez le mâle et la femelle est de 15 et 12 kg, respectivement. Les naissances doubles et triples sont assez communes. La race Garole est élevée surtout pour la production de mouton. Les éleveurs en général n'utilisent pas la laine. La toison n'est pas de bonne qualité et n'est donc utilisée que comme matériel de litière.

Key words*: Garole sheep, Sheep genetic resources of India, Production system, Characteristics, Management.*

Introduction

Garole is a small sized sheep breed found in the Sundarban region of West Bengal. The Garole sheep are known for their survivability in marshy saline conditions and their prolificacy. Ghalsasi and Nimbkar (1993) reported that Garole sheep might be resistant to footroot. Garole sheep were imported into Australia from Bengal in 1792 and is assumed to have contributed prolificacy gene to the Booroola Merino sheep (Turner, 1982). There is much similarity in body and fleece characteristics of Garole sheep of the Sundarban region and that reported for early Bengal sheep of Australia (Singh and Bohra, 1996).

Garole sheep have not been characterized properly in their natural breeding tract. No mention of this unique sheep genetic resource is found in sheep and goat breeds of India (Acharya, 1982). Sharma *et al.* (1999) described the characteristics of Garole sheep maintained in farm conditions altogether different from its natural habitat. Information about this sheep from the breeding tract is meagre. This study was undertaken to document the Garole sheep by collecting information through a field survey in their home tract and documentation of the breed.

Materials and Methods

A pilot survey was undertaken in the Sundarban region of South 24-Paraganas of West Bengal to record information on Garole sheep. The physical characteristics were measured from 139 sheep of different age groups and reproductive performances were collected through interviews with the farmers.

Figure 1. Breeding tract of Garole sheep.

Table 1. The livestock population of the South 24-Paragans district of West Bengal.

Species	Male	Female	Total
Non-descript cattle	560 036	567 083	1 127 119
Cross-bred cattle	3 138	18 468	21 606
Buffalo	12 775	12 148	24 923
Sheep (Garole)	85 463	121 257	206 720
Sheep (cross-bred)	650	996	1 646
Goat	396 237	621 547	1 017 784
Pig (indigenous)	18 883	24 840	43 723
Pig (cross-bred)	1 907	1 895	3 802
Duck			1 333 534
Fowls			2 862 421

Results and Discussion

Distribution and breeding tract

The Garole sheep are found in the Sundarban region of South 24-Paragans district in West Bengal. Some animals are also found in parts of the North 24-Paraganas and Midnapore district adjoining the South 24-Paraganas district (Figure 1). The population of this breed is high in Joynagar-I, Joynagar-II, Kuttali, Mathurapur-I, Mathurapur-II, Mandir Bazar, Patharpratima, Namkhana and Kakdwip blocks of the 24-Parganas district.

The Sundarban region comes under the coastal Saline Zone of West Bengal. This zone is mostly comprised of the southern part of the state embracing the Alipore Sadar and Diamond Harbour sub-division of the South 24-Parganas district. The Sundarban is spread over an area of approximately 4 226 km² within 21-23º N latitude and 87-89º E longitudes. The human population of this region is about three million where 90 percent of the inhabitants are below the poverty line (Saha, 1996). Ninety five percent of the people depend only on agriculture of which 85 percent belong to small and marginal farmer families (Gangopadhyay, 1991).

Soil and climate

The breeding tract of Garole sheep is part of the Indo-Gangetic delta and traversed by numerous tidal rivers, cheeks and channels. The island areas are subjected to occasional inundation by the saline waters. Soils are of tidal origin and silty clay in nature. Soil pH ranges between 6.4 and 7.6 (Gangopadhyay, 1991). The mean annual rainfall of this region is 1 763 mm and ranges between 1 450 and 1 925 mm. Average minimum and maximum temperature range between 15.5 and 32.5°C. Relative humidity remains high, over 80 percent from June to September and minimum 65 percent in December.

Crops and cropping systems

Rice is cultivated in more than 80 percent of cultivable lands. Cropping intensity is 110 percent with the majority of lands remaining fallow for six to seven months due to non-availability of irrigation facilities, poor

Figure 2. Animals tied in the field during grazing.

Figure 3. Garole sheep grazing in the field.

drainage and saline soil. The main winter crops are wheat, barley, sunflower, cotton and chili.

Livestock population

The livestock population of the South 24-Paragans district of West Bengal as reported in the 15th Quinquennial Livestock Census Report in 1994-95 (Anonymous, 1996) is shown in the table 1.

It is evident from the Livestock Census figures that the population of cross-bred sheep was less than one percent of the total sheep population in that area. The same is true for cross-bred cattle also. The local agro-climatic condition like hot humid climate, lack of grazing land, saline soil and waterlogging during the rainy season may be a disadvantage to the cross-bred woolly sheep. The local livestock is well adapted to these conditions of the coastal area. The goat population of the 24-Paraganas district was 4.9 times the sheep population. The buffalo population was also very low in comparison to other livestock.

Management practices

Marginal farmers and landless labourers mostly from socially and economically less priviledged classes maintain Garole sheep. The flock size of Garole sheep ranges between two to 27 in the household surveyed. However, most of the farmers had small flocks ranging between three and five. No organized grazing land is available. The sheep are reared only on grazing on rice fallow land, bands and natural grass cover on the roadsides and water channels (Figures 2 and 3). The animals are tied with a small rope and allowed to graze the surrounding area. Mostly females and children are involved in the sheep rearing practices. In the rainy season, most of the fields become water-logged. Garole sheep have the ability to swim and graze in knee deep conditions in marshy land. During the monsoon, in addition to grazing, animals are fed treetops and chaffed paddy straw. Generally the sheep are not provided separate houses and are kept along with cattle. Some farmers believe that sheep and goats do not survive well together. Therefore, either they keep cattle and sheep or cattle and goats. However, some farmers

Table 1. Average body weights and body measurements and their standard errors in Garole sheep.

Traits												
Age (mo.)	Body weight (kg)		Body length (cm)		Height at wither (cm)		Height at ramp (cm)		Heart girth (cm)		Paunch girth (cm)	
	M	F	M	F	M	F	M	F	M	F	M	F
3	4.90±	5.80±	30.00±	36.30±	32.00±	35.20±	33.20±	36.00±	34.60±	41.90±	34.40±	44.5±
	0.86(5)	0.77(10)	2.12(5)	1.98(10)	2.17(5)	1.41(10)	2.48(5)	1.39(10)	3.01(5)	2.42(10)	3.61(5)	2.98(10)
6	8.55±	8.65±	40.81±	40.70±	39.64±	38.80±	41.36±	40.10±	49.00±	48.00±	53.09±	51.20±
	0.64(11)	0.56(10)	0.95(11)	1.09(10)	0.73(11)	0.87(10)	0.74(11)	0.97(10)	2.08(11)	1.02(10)	2.06(11)	1.91(10)
12	12.50±	11.89±	45.78±	45.62±	44.00±	43.69±	44.44±	44.69±	55.67±	55.69±	59.56±	59.23±
	0.83(9)	0.56(26)	0.70(9)	0.91(26)	0.75(9)	0.59(26)	0.80(9)	0.82(26)	1.05(9)	1.20(26)	2.39(9)	1.09(26)
18	15.08±	11.72±	50.00±	45.00±	50.00±	43.68±	50.67±	43.29±	59.67±	55.91±	66.17±	60.41±
	1.36(6)	0.78(22)	2.77(6)	0.82(22)	1.84(6)	0.76(22)	1.78(6)	2.06(22)	1.52(6)	1.19(22)	1.64(6)	1.11(22)
24	14.00±	14.33±	45.33±	47.50±	49.00±	46.75±	48.33±	48.17±	55.33±	59.63±	54.33±	64.79±
	0.58(3)	0.48(24)	0.33(3)	1.06(24)	0.58(3)	1.05(24)	0.33(3)	1.31(24)	1.33(3)	1.03(24)	2.33(3)	1.38(24)
>24	23.00±	15.82±	58.00±	48.64±	61.50±	47.09±	59.00±	47.27±	71.00±	61.64±	66.00±	65.91±
	1.00(2)	0.85(11)	0.0(2)	0.93(11)	0.50(2)	0.78(11)	0.0(2)	0.93(11)	1.00(2)	2.74(11)	1.00(2)	2.93(11)

M: Male, F: Female, Values in the parenthesis are number of observations.
Figures in the table are based on the sample surveyed. Age of lambs was taken as ' a word of mouth' from surveyed farmers, that of older sheep by dentition.

Table 2. Average body measurements and their standard errors in Garole sheep.

Traits / Age (mo.)	Ear length (cm)		Pole to pole length (cm)		Eye to eye length (cm)		Face length (cm)		Tail length (cm)	
	M	F	M	F	M	F	M	F	M	F
3	5.75± 0.48(4)	6.25± 0.84(8)	4.75± 0.25(4)	5.13± 0.61(8)	7.25± 0.85(4)	6.63± 0.42(8)	9.63± 0.75(4)	10.00± 0.66(8)	6.25± 0.25(4)	8.00± 0.27(8)
6	8.00± 0.66(8)	7.75± 0.84(8)	5.69± 0.37(8)	6.13± 0.35(8)	8.38± 0.38(8)	7.88± 0.35(8)	11.75± 0.16(8)	11.00± 0.27(8)	9.13± 0.44(8)	8.50± 0.27(8)
12	4.75± 1.44(4)	6.86± 0.51(14)	6.25± 01.32(4)	6.93± 0.37(14)	7.75± 1.60(4)	8.79± 0.21(14)	13.75± 0.48(4)	13.79± 0.32(14)	8.50± 0.50(4)	9.00± 1.18(14)
18	4.67± 1.66(3)	7.50± 1.15(8)	7.33± 0.33(3)	7.00± 1.15(8)	10.00± 0.0(3)	8.63± 0.49(8)	13.67± 0.88(3)	13.63± 0.46(8)	10.00± 1.00(3)	10.75± 0.53(8)
24	9.00± 1.00(3)	8.22± 0.57(9)	6.67± 0.33(3)	7.00± 0.33(9)	9.33± 0.67(3)	10.00± 0.24(9)	15.00± 0.58(3)	14.00± 0.33(9)	10.00± 1.00(3)	8.78± 0.36(9)
>24	9.00± 0.0(2)	6.63± 1.13(8)	8.00± 0.0(2)	7.50± 0.57(8)	12.00± 0.00(2)	10.00± 0.19(8)	17.00± 0.0(2)	14.88± 0.52(8)	10.00± 0.0(2)	9.75± 0.37(8)

M: Male, F: Female, Values in the parenthesis are number of observation.

Figures in the table are based on the sample surveyed. Age of lambs was taken as ' a word of mouth' from surveyed farmers, that of older sheep by dentition.

Figure 4. Housing of Garole sheep.

maintain both sheep and goats. Sheep are pegged in front of the house or on the roadside during daytime (Figure 4). The flocks are stationary.

Physical characteristics

Garole is a small sized sheep. More than 90 percent of sheep are white in colour and the remaining 10 percent are brownish black. Males are usually horned and females are polled. Garole sheep have rudimentary (1-3 cm), medium-sized (4-8 cm) or long (more than 8 cm) ears. Respective percentages reported by Bose (1996) was 12.7, 50.82 and 36.48 percent.

Birth weight of Garole sheep in the survey was about 1 kg. Similar birth weight (0.6-0.9 kg) was reported by Ghalsasi and Nimbkar (1993). Bose (1996) observed that the birth weight of Garole sheep was 1.116±0.021 kg. The body weights and body measurements of males and females at different ages are given in tables 2 and 3.

Reproductive performance

The Garole ewes breed round the year with two lambing peaks between December to February and August to September (Bose and Moitra, 1995). They lamb twice in 15-18 months and age at first lambing is 14-18 months. The lambing interval of 205±2.23 days was reported by Bose (1996). Multiple birth is common, mostly twins and triplets (Figure 5). Ewes also give birth to quadruplets. The percentages of single, twin, triplet and quadruplet births were 41.63, 43.35, 14.81 and 0.21, respectively (Bose 1996). He also reported the overall lambing rate as 173.6 per 100 ewes lambing. Singh and Bhora (1996) reported that twining was most common. They observed 25-30 percent single, 55-60 percent twins, 15-20 percent triplets and one-two percent quadruplets. They also reported 10-12 lambings in the lifetime of a ewe with longevity of seven-eight years.

Figure 5. Garole ewe and two lambs.

Disease prevalence

Parasitic infection and diarrhoea in the rainy season are the main health problems of Garole sheep. Singh and Bohra (1996) reported about 30 percent mortality in farmers' flocks due to various reasons. They also observed that mortality in lambs is higher during the winter season and in adults during the rainy season. Diarrhoea was mostly due to amphistomiosis infection. Bose (1996) observed that overall lamb and adult mortality was 33.2 and 12.2 percent, respectively and reported that death of lambs was highest in the rainy season (42 percent), followed by winter (39 percent) and summer (19 percent), whereas in adults it was highest in summer (40.3 percent) followed by winter (44.8 percent) and the rainy season (14.9 percent). He also reported that the mortality of lambs born as single, twin, triplet and quadruplet were 15.5, 36.1, 44 and 50 percent, respectively.

Utility of the breed

The Garole sheep are maintained only for meat production and the animals are not generally sheared. Surplus sheep and lambs are sold for slaughter prior to the rainy season to avoid risk of mortality. Some farmers do not sell ewes for slaughter. However, in some places, ewes are sold after six-seven lambings. The dressing percentage on a pre-slaughter liveweight basis of male animals slaughtered at the age of nine months was reported to be 48.26±0.31 (Bose, 1996).

In some cases wool is used as bedding material. Singh and Bohra (1996) reported that average annual wool production was about 150 g and the quality: staple length, 5.09 cm; fibre diameter, 67.82 µm and medullation percentage 75.17. Bose (1996) reported that the average annual greasy fleece yield of Garole sheep was 152±2.43 g.

The Garole sheep are self-sustainable in their breeding track due to their adaptability to the agro-climatic conditions, their survivability under low input system and their utility as meat animals. No organized cross-breeding is ongoing in the area because cross-bred may be less adaptable in that area. With a population of over 0.2 million Garole sheep and no organized sheep cross-breeding in this region, there is no immediate threat of decline in the breed's population. There is a need for a genetic improvement programme in Garole sheep in farmers' flocks in order to

make sheep rearing more profitable and for conservation of this unique sheep genetic resource of India.

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Beetal goats in their native tract

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Summary

Beetal is one of the largest Indian breeds of goats bred mainly for milk but equally important for meat as well. This breed is found in Punjab along the Indo-Pakistani border. The status of the Beetal breed in its native tract was studied through a detailed survey in the Gurdaspur and Amritsar districts of Punjab. In this part of the country, goats are mainly reared by '*Sansi*' tribals who are landless. Goat flocks are mainly stationery and browsing is the main source of feed and fodder for these goats. Long drooping ears and roman nose are the typical characteristics of this breed. The total population of this breed in its native tract in 1997 was found to be 20 772 and the average flock size was 5.27. Average test day milk yield and lactation length were 1.8±0.79 kg and 161 days, respectively. Average ages at first kidding and kidding interval were 17.2 and 11.14 months, respectively. Prolificacy was fairly high with an average of 1.76 kids per kidding.

Beetal goats are the mainstay for the landless poor families of this region and the breed needs to be conserved in its breeding tract. There is a need to popularize this breed through demonstration units to convince the farmers that this breed is sustainable under low input conditions. This will help in *in-situ* conservation of the Beetal breed.

Resumen

La raza caprina Beetal es una de las más importantes no sólo por su producción lechera sino también por la producción de carne. Esta raza se encuentra mayormente en Punjab, a lo largo de la frontera entre India y Pakistán. Se ha realizado un estudio de la raza Beetal en su entorno natural a través de una encuesta detallada llevada a cabo en los distritos de Gurdaspur y Amritsar pertenecientes a la región de Punjab. En este lugar del país las cabras pertenecen principalmente a los grupos tribales "Sansi" que no poseen tierras. Los rebaños de cabras son estacionarios y el pastoreo es la mayor fuente de alimentación disponible. Las características típicas de la raza son orejas largas y caídas y un perfil pronunciado. El total de esta población en su ambiente natural en 1997 era de 20 772 y la media del tamaño de los rebaños de 5,27. La media de producción de leche diaria comprobada en el campo y la duración de la lactación eran de 1,8±0,79 kg y 161 days, respectivamente. La media de la edad al primer parto y el intervalo entre partos eran de 17,2 y 11,14 meses, respectivamente. La prolificidad era relativamente alta con una media de 1,76 crías por parto. Las cabras Beetal representan una base sustancial para las familias sin tierras de esta región y por lo tanto se deberían conservar en su ambiente natural. Se debería también dar a conocer mejor esta raza a través de unidad de demonstraciones, con el objeto de convencer a los agricultores de la capacidad de esta raza de mantenerse en condiciones difíciles y con un aporte muy bajo. Todo esto ayudaría a la conservación *in situ* de la raza Beetal.

Key words: *Goat, Beetal, Population, Punjab, Gurdaspur, Amritsar, Characteristics.*

Introduction

Goats are considered the poor man's cow as they provide some milk with very little input. Goat rearing is an important occupation for

Figure 1. Breeding tract of Beetal.

the rural poor especially socially less privileged communities and it is a profitable venture for resource poor entrepreneurs as goats are able to sustain themselves on sparse vegetation, unsuitable for feeding to other livestock.

Beetal is one of the heaviest dairy type goat breeds of Northern India. The animals are characterized by a large size, long drooping ears and roman nose. The breed is found in the Gurdaspur and Amritsar districts of Punjab. It seems that the breed has been named after its place of origin i.e. Batala, a tehsil (sub-division) of the Gurdaspur district of Punjab. Pure animals are still found in and around Batala (Figure 1).

The breeding tract is characterized by extreme climatic conditions. Temperatures range from as low as 2ºC in winter to about 42ºC in summer. Annual rainfall is around 70 cm. Relative humidity ranges from 22 to 83 percent. Beetal goats are mainly reared for milk. The males are disposed of for meat at any age between three and 12 months whereas females are maintained for up to four to six lactations.

The Beetal breed has been used for cross-breeding with Saanen and Alpine breeds in the All India Coordinated Research Project on goats, both for milk and meat components. For the meat component, this breed was recommended to substitute Anglo-Nubian because the performance of both the breeds and their crosses is comparable (Rana *et al.*, 1981). However, the population of goats in Punjab is decreasing continuously and declined by about 23 percent during 1990 to 1997. Beetal being native to this area has suffered considerably. There is no information on its present status in its home tract. This study was therefore undertaken to evaluate Beetal breed in its native tract with respect to its population, characteristics, management practices and socio-economic status of the farmers raising this breed so that a proper strategy could be formulated for the improvement and conservation of this important breed.

Materials and Methods

A detailed study was carried out in 1997 covering the entire Gurdaspur district and Ajnala and Atari tehsils of the Amritsar district of Punjab to enumerate Beetal population in the breeding tract. All the villages of this area were surveyed and each household was contacted for this study. Enumeration was done separately for kids (zero-six months), yearlings, does in milk and dry and bucks.

After enumeration of the Beetal population, information on the socio-economic status of goat keepers, management practices, morphological, production and reproduction characteristics of Beetal goats was collected through a sample survey using a two way stratified sampling procedure. Questionnaires developed at the National Bureau of Animal Genetic Resources, Karnal for generating information through field surveys were translated into the local language (Punjabi) for easy communication with farmers.

Ten strata covering 76 villages were identified along the Indo-Pakistani border in Gurdaspur and Amritsar districts. Survey work was monitored through regular field visits and the data was cross-checked for ensuring accuracy. One enumerator was appointed in each stratum for conducting the survey. All enumerators were trained in the field for recording information on various parameters. A total of 8 932 households were contacted for this study.

Physical characteristics, body measurements and body weights were recorded on 1 029 goats. In addition to this, 1 190 females were recorded for daily milk yield at fortnightly intervals for complete lactation starting from the first week of kidding. Reproductive characters like age at first kidding, kidding interval and open period were noted by interviewing the farmers and the number of kids for each kidding was recorded for the lactating females. Frequency and average of various parameters were estimated.

Table 1. General statistics of the survey area in relation to goat rearing.

District	Villages	Houses	Goat keepers	Goats / village	Flock size
Gurdaspur	469	73 053	2 757	25.3	4.31
Amritsar	213	67 161	1 185	41.7	7.50
Overall	682	140 214	3 942	30.5	5.27

Table 2. Population of Beetal goats.

	Kids	Yearlings	Doe			
District	(0-6 months)	(6-12 months)	In milk	Dry	Buck	Total
Gurdaspur	3 927	2 545	3 029	2 417	975	11 883
Amritsar	1 676	1 833	3 002	1 746	632	8 889
Total	4 593	4 378	6 031	4 163	1 607	20 772

Figure 2. Beetal flock in the courtyard of farmer's house.

Results and discussion

Population

Goats are reared mainly by Sansi tribals who are landless. Goat keeping is considered a lower grade entrepreneurship and there is a social taboo among landlords in this area for keeping goats. A survey in the breeding tract revealed that there were a total of 3 942 families keeping goats in 682 villages. On average there were 156 and 315 households per village in Gurdaspur and Amritsar district, respectively. Only 2.8 percent of the households kept goats

Table 3. Frequency of farmers in various categories (%).

Districts	Total farmers contacted	Landless	Marginal 0-1 ha	Small 1-2 ha	Medium		Large>20 ha
					Lower 2-4 ha	Upper 4-8 ha	
Gurdaspur	3 372	48.2	20.3	19.2	8.6	3.0	0.7
Amritsar	5 560	34.7	14.1	26.0	18.3	5.9	0.9
Total	8 932	39.8	16.4	23.4	14.6	4.8	0.8
Goat Keepers							
Gurdaspur	205	71.2	10.2	13.7	3.9	0.5	0.5
Amritsar	148	70.9	8.1	12.0	6.8	0.7	0.7
Total	353	71.1	9.3	13.1	5.1	0.6	0.6

Table 4. Average family status in the survey area.

District	Family members	Literate members	Involved in animal rearing		Land holding (acres)
			Male	Female	
Gurdaspur	6.32	2.24	0.56	0.12	2.34
Amritsar	5.39	1.01	0.62	0.30	3.59

(Figure 2 and 3). Five percent of the villages had more than 100; 46 percent had 11 to 50; 12 percent had 51-100; and 37 percent had less than 10 Beetal goats. There were about 25.3 and 41.8 Beetal goats per village and the average flock size was 4.3 and 7.5 in the Gurdaspur and Amritsar districts, respectively, with an overall average of 5.27 (Table 1). Acharya (1982) reported a flock size of 21.06±1.92. This shows that there has been a marked decline in the flock size over the years. This is mainly due to reduction in the natural vegetation for browsing.

There were a total of 20 772 Beetal goats in the breeding tract (Table 2). The Gurdaspur district had 57 percent while the Amritsar district had 43 percent of these goats. Kids, yearlings and adult stock constituted 22, 21 and 56 percent, respectively. The adult male to female ratio was 1:6.3 which was lower than that reported by Acharya, 1982 (1:7.8). Among the adult females, 59 percent of does were in milk.

Socio-economic status

Analysis of landholding revealed that 48.2 and 34.7 percent of the respondents were landless; 20.3 and 14.1 percent marginal; 19.2 and 26 percent small; 8.6 and 18.3 percent lower medium; 3 and 5.9 percent upper medium; and only 0.7 and 0.9 percent were large farmers in the Gurdaspur and Amritsar districts, respectively (Table 3).

Most of the farmers kept both buffalo and cattle whereas very few had goats. Among the goat keepers, the majority of farmers (71 percent) were landless and only 0.6 percent were large farmers. Among the farmers contacted, 54 percent had cattle, 84 percent had buffaloes and only 4 percent had goats (Table 3).

The average family size was 6.32 and 5.39 in Gurdaspur and Amritsar districts, respectively. More male members of the family were engaged in animal rearing than female members (Table 4).

Figure 3. Housing for goat and sheep.

Table 5. Composition of livestock in survey area.

			Goat	
District	Cattle	Buffalo	Total	Beetal (%)
Gurdaspur	3 500	8 221	1 389	81.5
Amritsar	8 097	26 806	1 410	44.3
Total	11 597	35 027	2 799	62.8

Figure 4. Breeding buck.

Table 6. Characteristics of Beetal goat (frequency %).

Parameters		Kids		Young		Adult	
		Male	Female	Male	Female	Male	Female
Animals recorded		34	38	44	92	96	725
Hair	Long	38	23	5	12	52	37
	Medium	62	77	95	88	48	63
	Smooth	47	45	79	7	68	36
	Ugly	53	55	21	93	32	64
	Straight	100	100	90	97	86	99
	Curly	-	-	10	3	14	1
Colour	Body - Black	76	82	82	85	94	75
	Skin - Grey	72	79	67	78	76	86
	Lips - Black	92	83	63	94	93	82
	Eyes - Black	88	88	82	89	94	88
	Hooves –Black	88	91	95	93	95	86
	Tail Switch – Black	76	68	86	91	89	75
Horns	Present					85	93
	Colour –					35	44
	Brown					44	41
	- Grey						
	Shape –					49	42
	Straight					51	58
	Twisted						
	Orientation						
	- Backward					65	85
	- Inward					25	10
	- Upward					10	5
Ear	Length (cm)	14	15	17	26	23	19 (pruned)

Figure 5. Milking doe.

Figure 6. Beetal kid.

Livestock composition

In the area surveyed, buffaloes constituted about 71 percent, cattle 23.4 percent while goats constituted only 5.6 percent of the total livestock. Of the total goats enumerated, 81.5 and 44.3 percent were identified as Beetal goats in Gurdaspur and Amritsar districts, respectively (Table 5).

Management practices

Information on management practices for goat rearing was generated by interviewing 353 goat keepers in the breeding tract. Only one percent of the flocks were migratory and the rest were stationery. The goats were taken out for browsing by the owners themselves (96 percent). As there are no forest areas left, the goats were taken to roadside and canal embankments. The mortality was high due to worm infestations, as de-worming practices were not followed. The long ears were pruned to avoid injury. About 51 percent of breeders kept their own buck for service while others did it on a payment basis.

Almost all the Beetal females were reared on browsing whereas only 43 percent of adult males were taken out for browsing. Goats were fed mostly in groups and only 38 percent of adult males were fed alone. Fodder was generally purchased. Water was

sufficient and supplied through hand pumps. Eighty-nine percent of the respondents bathed their animals.

Morphological characteristics

Morphological characteristics and body measurements of Beetal goats are presented in table 6. Figures 4 to 6 show a breeding buck, a milking doe and a Beetal kid, respectively. The hair was of medium length and straight. The body colour was generally black but some animals with white spots were also available. Very few animals were brown in colour. The skin colour was predominantly grey. Lips, eyes, hooves and tail switch were black. Eighty-five percent adult males and 93 percent adult females were horned. The horns were either brown or grey in colour. The horns were twisted in 51 and 58 percent adult males and females, respectively. Sixty-five percent adult males and 85 percent adult females had horns turning backwards. The ears were long and hanging. The forehead was convex with a typical Roman nose. Wattles were present in only 15 percent males. Teats were either funnel (50 percent) or tube (44 percent) shaped. The teat tips were

Table 7. Average test day milk yield ± SE (kg) of Beetal does[a].

	Lactation number				
Test day	1	2	3	> =4	Pooled
1	1.7 ± 0.83 (232)	1.8 ± 0.84 (324)	1.9 ± 0.86 (221)	2.0 ± 0.95 (142)	1.9 ± 0.87 (919)
2	1.7 ± 0.75 (294)	1.8 ± 0.75 (394)	1.8 ± 0.79 (285)	2.0 ± 0.86 (164)	1.8 ± 0.78 (1137)
3	2.1 ± 0.73 (291)	2.2 ± 0.78 (388)	2.1 ± 0.74 (290)	2.2 ± 0.77 (169)	2.1 ± 0.76 (1138)
4	2.0 ± 0.63 (286)	2.1 ± 0.59 (386)	2.1 ± 0.57 (288)	2.1 ± 0.54 (162)	2.1 ± 0.59 (1122)
5	2.0 ± 0.63 (272)	2.1 ± 0.63 (380)	2.1 ± 0.61 (286)	2.0 ± 0.61 (158)	2.0 ± 0.63 (1096)
6	1.9 ± 0.76 (257)	2.1 ± 0.73 (354)	2.0 ± 0.80 (274)	1.8 ± 0.84 (148)	2.0 ± 0.78 (1033)
7	1.8 ± 0.83 (226)	1.9 ± 0.79 (332)	1.9 ± 0.81 (246)	1.8 ± 0.80 (125)	1.9 ± 0.81 (929)
8	1.6 ± 0.79 (202)	1.7 ± 0.74 (302)	1.6 ± 0.77 (216)	1.6 ± 0.78 (108)	1.6 ± 0.77 (828)
9	1.5 ± 0.71 (180)	1.5 ± 0.70 (275)	1.5 ± 0.68 (192)	1.3 ± 0.74 (97)	1.5 ± 0.71 (744)
10	1.3 ± 0.62 (155)	1.3 ± 0.67 (251)	1.3 ± 0.65 (172)	1.3 ± 0.75 (84)	1.3 ± 0.66 (662)
11	1.2 ± 0.54 (110)	1.2 ± 0.52 (199)	1.1 ± 0.52 (141)	1.1 ± 0.53 (59)	1.2 ± 0.53 (509)
12	0.9 ± 0.34 (63)	0.9 ± 0.38 (128)	0.9 ± 0.32 (97)	1.0 ± 0.29 (37)	0.9 ± 0.35 (325)
Average	1.8 ± 0.77 (2568)	1.8 ± 0.78 (3713)	1.8 ± 0.79 (2708)	1.8 ± 0.82 (1453)	1.8 ± 0.79 (10442)

[a]Numbers of record are in brackets

Table 8. Production characters of Beetal does.

Lactation no.	N	Lactation length±SE	Estimated milk yield
1	196	150.6 ± 52.56	264
2	282	168.2 ± 50.91	303
3	220	164.2 ± 51.09	294
>=4	133	154.6 ± 50.74	283
Pooled	831	160.8 ± 51.83	288

mostly pointed (72 percent) or rounded (26 percent). The milk vein was of medium size in 68 percent and small in 21 percent of the females. Most of the Beetal animals were docile.

The average body length, height and girth were 90, 81 and 83 cm, respectively in males and 64, 70 and 69 cm, respectively in females. Mishra (1979) reported body length, height and girth as 61.3, 63.9 and 59.8 cm, respectively, in females.

Production parameters

The average test-day milk yield was 1.8±0.79 kg (Table 7). Average daily milk yield recorded in this study in field conditions was much higher than 650–810 g reported by Gupta and Gill (1983) and 770 g by Rana and Dalal (1998) in farm conditions. This indicated that Beetal goats available in the breeding tract are superior. The average lactation length varied between 151 and 168 days with an overall average of 161 days (Table 8). Estimated milk yield per lactation was about 288 kg. Bhatnagar and Chawla (1984) reported a lactation milk yield and lactation length of 157 kg and 186 days, respectively in Beetal goats maintained at the National Dairy Research Institute, Karnal.

Reproduction parameters

The average age at first service and age at first kidding was 11.11 and 17.2±3.20 months, respectively. Mishra *et al*., (1979) also reported age at first kidding of 17.3 months while Singh and Acharya (1983), Kanaujia *et al*., (1987) and Rana and Dalal (1998) reported longer age at first kidding in Beetal goats (ranging from 21 to 25 months). Beetal goats kidded for the fifth time at about 5¼ years of age. Average service period was 5.2 months and average number of services per conception was 2.4±0.78. Average kidding interval, gestation period and number of kids per kidding were 11.1, 5.21 and 1.76 months, respectively. Mishra *et al*., (1979), Bhatnagar and Chawla (1984) Kanaujia *et al*. (1987) and Singh and Acharya, (1983) reported kidding interval in the range of 10.3 to 12.6 months. Rana *et al*. (1981) and Kanaujia *et al* (1987) recorded a slightly lower gestation period in Beetal goats (4.8-4.9 months). Similar litter size (1.7) was reported by Mishra *et al*. (1979) whereas Gupta and Gill (1983), reported lower kidding rate of 145 percent in Beetal goats as compared to that of this study.

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A review of conservation and management of the Pantaneiro horse in the Brazilian Pantanal

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Summary

The Pantaneiro horse is an important social and economic part of the infrastructure of cattle farms in the Brazilian Pantanal. It is of Iberian origin and closely related to other Brazilian breeds, specifically Mangalarga, Mangalarga Machador and Campolina. Physiological studies have shown this horse to be tolerant to long treks and capable of being maintained on natural pastures. The Brazilian Pantaneiro Horse Breeders' Association has registered, to date, approximately 1 600 mares and 300 stallions, the bulk of which are in the Poconé subregion. The horse is considered small and fast. Linear measurements taken at registration are shown to be, in general, highly heritable. The population has a vulnerable status. Characterization studies showed that a combination of genetic and physical characteristics of the Pantaneiro makes it a unique population that must be conserved. Recent trends in selection may threaten the rusticity and adaptability of this valuable genetic resource. In this paper, several research studies are reviewed and areas where research and technical training are needed are highlighted.

***Key words**: History, Characterization, Genetics, Physiology, Growth, Phenotype.*

Resumen

El caballo Pantaneiro es muy importante para la ganadería del Pantanal brasileño bajo el punto de vista social y económico. Estos animales son oriundos de la Peninsula Ibérica y están muy relacionados con otras razas caballares brasileñas, concretamente Mangalarga, Mangalarga Machador y Campolina. Estudios fisiológicos han mostrado que estos animales son resistentes a largas cabalgatas y capaces de mantenerse en pastizales naturales. La Asociación Brasileña de Ganaderos del Caballo Pantaneiro, ubicada en la subregión de Poconé, MT, posee hoy por hoy, cerca de 1600 yeguas y 300 sementales registrados. Estos caballos son considerados pequeños, veloces y con medidas morfométricas lineares de alta heredabilidad. La población se encuentra vulnerable y los estudios han mostrado que la combinación de genética y características físicas del caballo Pantaneiro apuntan para una población única y que debe ser conservada. Recientes tendencias en la selección apuntan amenazas en la rusticidad y adaptabilidad de este precioso recurso genético pantaneiro. En este artículo, varias investigaciones llevadas a cabo son revisadas y se apunta nuevas tendencias o inquietudes de investigaciones futuras.

Introduction

The Pantanal is a vast floodplain, situated in the central-west region of Brazil, characterized by distinct rainy and dry seasons (Figure 1 and 3). The intensity of flooding depends on rainfall, which presents multi-year cycles of greater or lesser intensity. In this region, beef cattle are the main economic source of income. The Pantaneiro horse is adapted to the bioclimatic conditions of this region, constituting an important economic and social factor, a must for the cattle industry and for regional transportation (Santos *et al*., 1992).

Historical and Actual Situation of the Pantaneiro Horse

The Pantaneiro horse has its probable origin from Iberian horses introduced by Spanish settlers, especially in the 16th and 17th centuries. Only in the 18th century, with the opening of a route from São Paulo to Cuiabá, through Goiás, were the horses introduced in the Pantanal. These came from the Brazilian coast, the main region of Portuguese colonization (Santos *et al*., 1992). The Guaicuru Indians were also important in the dissemination of horses in the Pantanal. As a consequence of natural selection for more than two centuries, with little or no human interference, an animal well adapted to the environment appeared.

At the end of the 19th century, the population of the breed was severely reduced mainly due to *Peste das cadeiras* (Trypanossomiasis). Later, other menaces to survival appeared, mainly indiscriminate cross-breeding and more recently Infectious Equine Anemia (AIE). Only in 1972, with the creation of the Brazilian Pantaneiro Horse Breeders' Association (ABCCP), was the breed standardized by uniting the different phenotypes. The ABCCP still has an open book for the registration of horses. In the Pantanal, there is an estimated population of 119 000 horses, mainly cross-bred. Of these,

Figure 1. Typical view of the Pantanal in the dry season (Source: Sandra Aparecida Santos).

there are about 1 600 mares and 300 stallions (Figure 4) registered in the ABCCP and the bulk of them are in the Poconé subregion, whose breeders collaborated in the creation of the ABCCP. Since the endangered status of animal breeds is determined by the size of breeding stock (Bodó, 1990), the Pantaneiro horse is classified as vulnerable and measures must be taken to prevent a further decrease in the population.

Genetic Characterization

Efforts to conserve rare breeds of domestic animals must take into account, conservation of genetic variability. Cothran *et al*. (1998) studied the genetics of the Pantaneiro horse. Individual genetic variation within the Pantaneiro (Ho) was slightly greater than mean Ho for 102 domestic horse populations (0.387 and 0.375, respectively). Thus, from a genetic conservation standpoint, there is no immediate concern about reduced genetic variation within the breed. Similarly, the population variation measures of the Pantaneiro were slightly greater than the means for domestic breeds with values of Hardy-Weinberg expected heterozygosity (He) at 0.369 compared to 0.365, effective number of alleles (Ae) of 2.68 compared to 2.397 and total number of variants found in each population (Na) of 72 compared to 64.99. Both individual and population estimates of genetic variation of the Pantaneiro indicate that variation levels are normal for horses and that there is no indication of inbreeding. There should be little concern for maintaining genetic variation within the breed as long as population size is maintained and there is no drastic change in breeding practices. For example, concentrated use of particular stallions would likely result in a loss of variation, especially if such a practice was continued for many years. The data show that the Pantaneiro horse has Iberian origin, as indicated by their known history and it was most closely related to other Brazilian breeds, specifically Mangalarga, Mangalarga Machador and Campolina.

Phenotypic Characterization

Conformation

Although concepts of perfect conformation vary among breeds, all breed registries agree that the overall quality and balance of a horse's build should be symmetrical and proportional to its size (Martin *et al*., 1978).

Fontes *et al*. (1987) established the norms for the Pantaneiro horse. For registration, the males must have a minimum shoulder height of 140 cm and females 135 cm. Morphologic aspects were analysed through genealogical registry charts, in collaboration with ABCCP (Santos *et al*., 1995, Miserani *et al*., submitted for publication). Pantaneiro horses usually stand between 134.7 and 143.4 cm high. Colours vary widely and include dapple-grey (35 percent), chestnut (27 percent), bay (21.8 percent), sorrel (6.4 percent), roan (4.2 percent) and grey (3.7 percent). According to Miserani *et al*. (submitted) the registered animals of the ABCCP from the Corumbá region were generally larger than animals from the other regions. Body index analysis indicates that these animals are considered as small and fast (McManus *et al*., 2001). Heritabilities for linear body measurements were medium to high (Miserani, 2001) and genetic correlations between most traits close to 1.00.

Today, the breeders are interested in selecting the Pantaneiro horse for expositions and auctions. Therefore, they place emphasis on desired conformation and have changed the natural environment, especially the diet, sometimes, without adequate criteria. The evaluation of genetic merit of the Pantaneiro horse population should include adaptability to the local environment, resistance against diseases and other traits balanced according to the intended use.

Growth curve

Growth curves reflect the lifetime interrelationships between an individual's inherent impulse to grow with the environment in which these impulses are

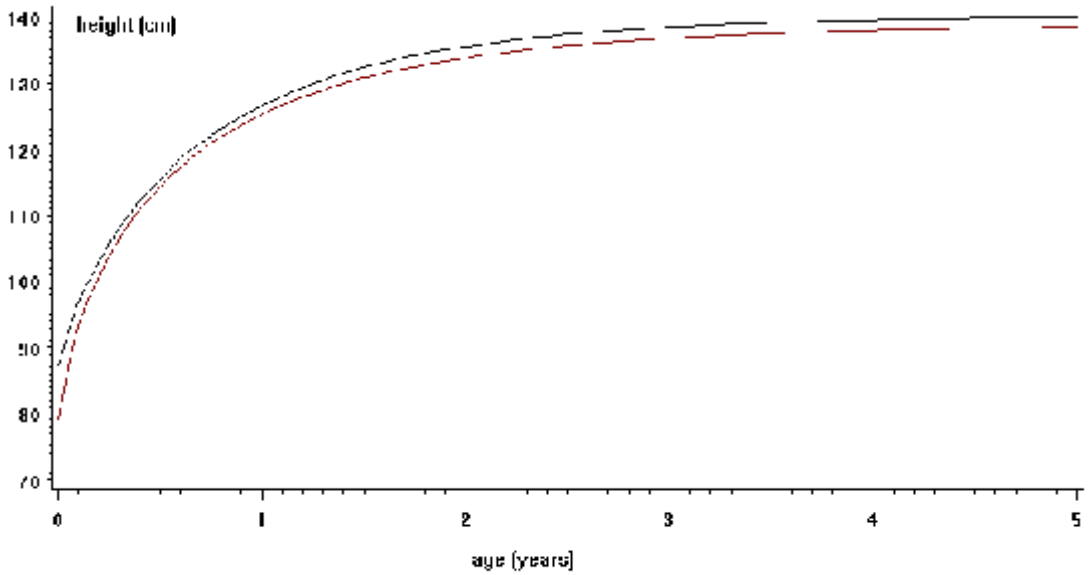

Figure 2. Height model functions for males (uppercurve): E(h) = 140.225 - 52.931 exp $(-1.360t^{.835})$ *and females:E(h) = 139.016 - 58.913 exp* $(-1.472t^{.732})$ *based on average values of parameters.*

expressed. The majority of the studies on the horse are based on weight, height, chest girth and cannon bone circumference (Santos, 1989). Of these measurements, height has more practical interest because it is required for the purpose of description and classification of horses, while weight is more a measure of the physical condition of the animal (Reed and Dunn, 1977).

Santos *et al*. (1999) used non-linear models to describe height growth curves in Pantaneiro horses from birth to 36 months age of 26 Pantaneiro horses raised on the Nhumirim farm. The animals were maintained in native pastures without supplementation. The Weibull model was chosen (Figure 2). Results showed that the mature height for males (140.2 cm) was below the mean for Pantaneiro males registered in the Association (ABCCP, C = 142 cm). For females the opposite was observed (study, X=139 cm and ABCCP, X=137 cm). There are two explanations for this. Firstly the males registered in the Association were selected animals and secondly the males in this study may not have reached maturity. Miserani *et al*. (submitted) note that the two and three year old horses were significantly smaller at registration than the other horses and if these data are used for selection, registration should be delayed until the horses have reached their mature size. Reed and Dunn (1977) studying Arabian horses observed that the mature height at withers for females was achieved by 48 months of age whereas males grew another 1 cm from 48-60 months of age.

Functional performance

In the Pantanal, the large distances between farms means that the horses have to walk for long distances in high environmental temperatures, over swampy and sandy terrain. Therefore, it is important to study the exercise physiology of the Pantaneiro horse as an adaptability criterion. Work endurance is one of the most important objectives for conservation. Athletic ability is determined by three main factors: genetics, environment and training. Studies of groups of identical twins has shown a strong genetic component for

Figure 3. Pantaneiro horse grazing in flooded field (Source: Revista Manchete Rural).

athletic performance, estimated to be between 40 and 60 percent for maximal oxygen consumption and endurance capacity, respectively (Derman and Noakes, 1994).

Training or conditioning implies creating progressively adaptive changes in response to correctly applied physical and mental stresses. Ability to withstand metabolic stress requires an increase in maximal oxygen intake, increase and enhancement of the oxidative capacity of muscle, increase in the efficiency of carbohydrate, fat and protein utilization and enhancement of the horse's thermoregulation abilities. Horses raised in a natural environment undergo early physical stress that helps to maximize genetic potential by tissue adaptation at an early age. This makes the conditioning progress more rapid while incurring less risk of injury (Ridgway, 1994).

Evaluation of performance potential requires an understanding of the physiological mechanisms involved in the energetics of exercise. As successful athletic performance is multifactorial, no single measurement will accurately predict exercise capacity. The most common measurements are: estimation of heart size and heart rate; hematology and plasma or serum biochemistry; muscle biopsy; conformation and score condition and treadmill testing.

Heart rate

Of all the measurements available to assess fitness and ability to continue an endurance ride, the heart rate is important because all other measurements used are reflected in the heart rate. Santos *et al*. (submitted) evaluated the heart rate of Pantaneiro horses during a 76 km ride in the Pantanal. The horses were divided into two groups (with and without work and supplementation) for one month before the ride: 1) four horses maintained on natural pastures, without work and supplementation for one month before the ride; and 2) four horses maintained on natural pastures with supplementation and working

for one month before the ride. The horses in groups one and two showed mean values of 60 and 56 beats per minute after 30 minutes of rest, respectively, indicating a good recovery response. Group 2 showed better adaptation to the level of exercise (applied stress) because they were working. Recovery heart rates can be used for determining the level of fitness and the ability to continue during exercise. Horses should be rested until the HR drops to 64 beats / minute or less. The 'true resting heart rate', when the animal is resting quietly in a pasture would fall between 24 and 36 beats / minute (Ridgway, 1994). In relaxed horses, resting heart rate is usually 25-40 beats / minute (Evans, 1994) and when saddled and ready to work 36 and 48 beats / minute, similar to mean values found with Pantaneiro horse (46 and 47 beats / minute, for groups 2 and 1, respectively).

Hematology and plasma or serum biochemistry

This provides access to the function of a range of body systems, which are crucial in the assessment of the athletic horse. During exercise, substantial sweat loss of electrolytes and the extent of fluid loss depends on the ambient temperature and humidity. The most extreme sweat losses are found during hot and humid conditions. Alterations in electrolyte concentrations could seriously affect work or athletic performance (Evans *et al*., 1995). The adaptive mechanisms to hypothermia and possible effects of acclimatization have not been studied intensively in horses, especially in the native (local) breeds that suffered adaptation due to environmental conditions such as the Pantaneiro horse.

Santos *et al* (1997; submitted) also evaluated biochemical parameters in the two groups of Pantaneiro horses submitted to an endurance ride of 76 km (described above). Serum concentration of total protein, albumin, sodium, potassium, chloride, calcium and phosphorus (Table 1), glucose and free fatty acids (FFA) were measured. Samples were taken before the ride (preride), during the mid point (midride), at the end of the ride (postride) and after a 30 minute recovery period (rest). In both groups, there was a significant decrease in calcium and potassium and an increase in sodium and phosphorus during the ride.

Table 1. Serum total protein (TP) and electrolyte means values (± SE) in two groups of Pantaneiro horses during a 76 km endurance ride.

	TP (g/l)	ALB. (g/l)	Na (mmol/l)	K (mmol/l)	Cl (mmol/l)	Ca (mmol/l)	P (mmol/l)
GROUP I							
Preride	57.2±7.1	27.2±1.9	119.2±6.3	6.3 ±2.3	83.3±15.5	3.3±0.3	0.81±0.2
Midride	63.0±1.5	31.8±3.2*	130.3±2.3*	4.6±1.0	74.5±3.8	2.1±0.4*	1.97±0.4 *+
Postride	62.0±6.1	29.6±2.1	134.3±8.6*	3.9±0.6*	74.7±12.8	1.6±0.3*	2.12±0.5*+
Rest	64.5±2.4	31.8±3.0	129.3±7.1*+	3.3±0.4*	68.6±4.8	1.8±0.4*	2.00±0.1*+
GROUP II							
Preride	66.0±4.6	24.8±1.0	115.6±4.5	4.8±0.2	71.1±4.6	3.5±0.6	0.68±0.2
Midride	64.7±2.9	28.2±0.6	128.3±4.4*	4.2±0.5	71.0±7.7	2.3±0.4*	2.64±0.4*+
Postride	64.6±2.2	28.1±4.5	133.0±8.5*	3.6±0.3	66.8±5.1	1.9±0.5*	3.06±0.3*+
Rest	67.5±2.1	29.5±4.6	139.5±3.5*+	4.4±2.3	67.5±4.2	2.2±0.5*	3.29±1.1*+

*Significantly different ($P<0.05$) from preride value.
+Significantly different ($P<0.05$) between groups.

With relation to glucose and FFA, the values increased during the exercise in the two groups. However, the values of serum glucose and FFA were significantly different between the groups, indicating that mobilization of the substrates depends probably on the physical condition, training and feed supplementation.

Blood or plasma lactate concentration is valuable information for evaluating exercise intensity and/or metabolic capacity of horses. Elevations in the rate of lactate production reflect an increased contribution of the anaerobic pathways to energy production. According to Evans *et al.* (1995) resting blood lactate concentrations in the horse is approximately 1-1.5 mmol/l, while Hodgson (1996) considers values normally bellow 1 mmol/l. Santos et al. (1996) determined changes in lactate (Table 2) during the course of a ride through the Pantanal.

Several major adaptations occur following physical training that influence lactate metabolism including improved circulatory function and metabolic efficiency of skeletal muscle (Hodgson, 1996). Trained horses show lower blood lactate concentrations at the same work speed (Evans *et al*., 1995), thus, Pantaneiro horses appeared to be better trained than other breeds during the ride. In general, a slight increase in lactate showed that anaerobic glycolysis was not an important factor and that the animals were working within their capacity for aerobic exercise.

Muscle biopsy

Hystochemical methods have shown that most mammalian muscles consist of a mosaic of muscle fibre types with varying metabolic and contractile properties. On the basis of myosin-ATPase activity at pH 9.4, two distinct fibre types exist. Those with low activity have been named type I fibres, and those with high activity are called type II fibres. The type II can be divided into the subtypes IIA, IIB and IIC.

Rosa (1997) determined the types of fibres of sixteen Pantaneiro horses. They were divided into four groups: mare, foal, castrated male and stallions. To classify the different types of muscle fibres, a biopsy was carried out with a Bergstrom needle (4.5 mm), to obtain samples from middle gluteal muscle. The results showed that Pantaneiro horses had greater proportion of the type I fibres (Table 3), so it can obtain better results over long distances or endurance events. In relation to the transversal section, the type I fibres were smaller (1 334 μm^2), followed by the type IIa (2 283 μm^2) and type IIb (3 743 μm^2). This pattern occurred in all groups.

Management and conservation

Seeking the conservation and encouragement of Pantaneiro horse-breeding, the EMBRAPA Pantanal Agricultural Research Center and Genetic Resources Research Center (CPAP

Table 2. Lactate concentration means (mmol/l) before (pre) and after (post) riding (340 km) in Pantaneiro, Criollo, cross-breed Criollo and mules.

	Pre	Post*
Pantaneiro	0.63±0.1	0.71±0.1
Crioulo	1.28±0.78	1.38±0.9
Cross-breed Crioulo	1.22±0.47	1.50±0.6
Mules	1.29±0.3	1.50±0.2

*Post riding blood samples were taken 30 minutes after the horses travelled the 340 km in 12 days.

and CENARGEN – EMBRAPA) established a conservation nucleus, *in situ*, at the Nhumirim Ranch, subregion of Nhecolândia, Pantanal. The base herd consisted of 30 mares and three stallions. The stallions were selected in accordance with the ABCCP norms and were substituted every three years. Sereno *et al*. (1997) established a breeding season from October to February. This allowed foaling to be concentrated, thus facilitating management. The percentage of pregnancy and parturition observed in 1990/1991 and 1991/1992 for the male:female proportions of 1:17 and 1:15 were 82.3, 100, 86.7 and 100 percent, respectively.

Horses in the nucleus share natural rangeland with cattle and wild herbivores. According to Bodó (1990), the maintenance of a local feeding system is obligatory because it is an important element of adaptation. He described that sometimes it is not easy to safeguard the traditional conditions because people do not want to live in such a way. This fact has been observed in several nuclei of Pantaneiro horses, described earlier.

For the conservation of the Pantaneiro horse, the conservation of the Pantanal region, considered that the patrimony of humanity, is also important. Farms in the Pantanal explore natural resources. The impact of the introduction of domesticated animals, such as horses and cattle, was so long ago that there is no record of the changes that occurred or the organisms that were lost. Today, the major challenge in rangeland management centres on how to manipulate grazing and browsing animals so as to maintain the ecological sustainability. Thus, ecological sustainability is a pre-requisite for social sustainability. A practice that is not ecologically sustainable will be neither economically sustainable nor socially acceptable in the long-term (Heitschmidt and Walker, 1997), therefore, the knowledge of key processes such as diet and habitat selection is fundamental. Santos *et al*. (1993, 1999) studied seasonal forages and habitat use of Pantaneiro horses in two subregions: Nhecolândia and Abobral (low Pantanal). In the Nhecolândia region, horses selected 'open grasslands' in the dry season (April/September) and the edge of 'permanent ponds' in the rainy season (October/March), with percentage of use of 64 and 47.5 percent, respectively. In the dry season, the most consumed forages were *Axonopus purpusii* (40 percent) and *Panicum repens* (13 percent). In the rainy season, the forages consumed included *Reimarochloa brasiliensis* (28.3 percent) and *Axonopus purpusii* (14.7 percent). In the Abobral subregion, horses selected lowlands, mainly 'temporary ponds' during the dry year (without inundation) and 'open grassland' and 'lowlands' during the wet year. The forage species most commonly consumed by horses were *Panicum laxum*, *Eleocharis minima*, *Reimarochloa brasiliensis and Axonopus purpusii*. The lowland areas are the habitat selected by Pantaneiro horses because they provide preferred forage species. Santos (1997) established recommendations on nutritional management for horses on native pastures in the Pantanal. However, more studies are necessary on adequate stocking rates compatible with environmental considerations.

Table 3. Muscle fibre types in Pantaneiro horse (%).

Group/Fibre	Type I	Type II	Type III
Mares	64.24±6.23	16.33±4.26	19.42±5.02
Foals	46.12±9.51	27.56±6.04	26.30±10.52
Stallions	60.28±6.11	27.16±5.08	12.55±2.04
Castrated males	65.62±2.61	17.91±2.97	16.45±4.97

Figure 4. Pantaneiro Stallion (Source: Sandra Aparecida Santos).

In the Pantanal, several diseases have caused high mortality in horses, such as Infectious Equine Anemia (AIE), Pitiose Equina, Encefalites and respiratory diseases. The most important of these is AIE, an infectious viral disease. It may occur as an acute, subacute or chronic illness, but has a marked tendency to assume a subclinical form. AIE was probably introduced in the middle of the 20th century and prophylaxis is suggested. Positively tested Pantaneiro horses are not registered by the ABCCP. However, due to the high prevalence of AIE (49 percent) in the Pantanal, it became impractical to sacrifice all positive horses and the control of AIE for Pantanal horses was proposed (Silva *et al*., 1997). Segregation, isolation and / or destruction of all infected horses; testing of all incoming horses to prevent the re-introduction of AIE carriers; and no re-use of needles and isolation of foals out of positive mares with a re-test after six months of age, were recommended. Bodó (1990) considered it dangerous to develop populations resistant to infectious diseases because the whole stock may be destroyed. In some cases there is the danger of infecting human population and other domestic and wild animals.

In the Nhumirim' nucleus, where the test is taken annually, all horses are negative for AIE. The horses are vaccinated against rabies and encephalitis. The herd (five percent) suffered from '*Pitiose equina*', which produces ulcerative granulomas and occurs mainly during the inundation period. The main etiologic agent is a fungus *Pythium insidiosum*. Studies are being carried out with the objective to develop a vaccine against '*Pitiose equina*' (Catto, personal information).

General considerations

Worldwide, there has been homogenization of the mean weight of horse populations and a disappearance of local breeds. This trend is mainly dictated by fashion, that is, the development of a modern sport horse. Today, the Pantaneiro horse is not an endangered

breed due to the creation of the ABCCP. However, the population has a vulnerable status. Characterization studies have shown that a combination of genetic and physical characteristics of the Pantaneiro indicted that it is a unique population that must be conserved.

Breeders of the Pantaneiro are interested in selection within the breed. This aims mainly at the improvement of the conformation and an increase in size. However, selection of the Pantaneiro should maintain its valuable characters acquired through natural selection.

For conservation purposes, the breed should be kept as much as possible in its natural habitat and its genetic diversity maintained. According to Cook (1992), most breeders of pedigree horses currently favour genetic uniformity (homozygosity), however, both genetic conservation and long-term breed development, depend on retaining genetic diversity. Audiot *et al*. (1992) considered that in conservation programmes, it is essential to take into account the variety of interests and tendencies of the breeders, attempting to adapt individual projects to a single common interest project. Only with cooperation among different institutions (regional, national and international), breeders and the ABCCP, will it be possible to define adequate conservation programmes which maximize effective population size. Thus, the establishment of a specific research entity (laboratory, place for physical tests, etc.) for the evaluation and study of the breed is necessary.

According to Alderson (1992), in medium-sized populations, plans would be based on a rotational mating system, which involves some line-breeding to maintain distinctive lines and cyclic crossing to restrict the increase in the level of inbreeding in the total population. Thus, studies are necessary on the genealogy of the Pantaneiro horse through registry data. Alternatively, DNA fingerprinting can be employed to study the genetic structure of the breed in which the pedigree record is absent or unreliable (Cook, 1992). In addition to conservation programmes, a system of breed evaluation needs to be established. For this, it is necessary to carry out more studies on characterization and evaluations of biological merit (e.g. adaptability and resistance to the local environment).

Pantaneiro horse conservation through DNA storage is carried out by Embrapa Recursos Genéticos e Biotecnologia (Cenargen).

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