ACHAI CATTLE BREED, ITS PRODUCTIVE AND REPRODUCTIVE PERFORMANCE UNDER TRADITIONAL MANAGEMENT SYSTEM IN DISTRICT LOWER DIR (N.W.F.P.) PAKISTAN

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BY

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CERTIFICATE

This thesis submitted by Muhammad Saleem is accepted in its present form by the Department of Animal Sciences as satisfying the thesis requirement for the degree of Doctor of Philosophy in Reproductive Physiology.

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____

Date:

IN THE NAME OF ALLAH, THE BENEFICENT, THE MERCIFUL

Dedicated

To

My parents, brother, sisters, wife, sons, Summaya

and

My uncle Gul Roz Khan

whose efforts, prayers, unconditional love,

wishes and affections are source of strength

in every step of my life

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Muhammad Saleem

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ABSTRACT

The present study on physical and morphometric characteristics and productive and reproductive performance was conducted on Achai cattle from Talash, Jandool and Maidan valleys of District Lower Dir, North West Frontier Province (NWFP now known as Khyber Pakhtunkhwa), Pakistan. Physical characteristics observed on Achai cows and bulls were colors of the coat, eyelashes, horns, hoof, muzzle and switch of the tail. Morphometric characteristics of Achai cows and bulls recorded were heart girth, body length, height at withers, height at hipbone, head region (face length, ear length and width), horn (length of the horn along the greater and smaller curvatures and the circumference of the horn at base, mid region and just below the tip), neck and dewlap (length and circumference of the neck, length and width of the dewlap), height and circumference of the hump, back and rump (chine length, loin length, rump length and width), length of the leg below knee joint, circumference of the hoof, length of the tail and length of the switch of the tail. Productive performance studies included standard 305-day milk yield and birth weight of male and female calves. Studies on reproductive performance included pubertal age, postpartum anoestrus interval, conception efficiency, calving interval and dry period.

The present study revealed that majority of the Achai cows have spotted reddish brown coat color; reddish brown color of eyelashes, light brown color of hooves, and reddish brown color of tail switch in all the three valleys. The dominant color of the horn of cows was light brown at the base, grayish in the middle and black in the upper part upto the tip in Jandool and Maidan valley and light brown at base with blackish tinge in the upper part of the horn in Talash valley. The most prevalent color of the muzzle of the cows was light brown with black pigments in Jandool and Maidan valley, whereas, it was light brown in Talash valley. The highest percentage of Achai bulls have spotted reddish brown coat color; light brown color horns at base with blackish tinge in the upper part of the horn; reddish brown color of eyelashes, light brown color of muzzle with black pigments, black color of hooves and white color of tail switch. There was no significant difference in the distribution of the physical characteristics of cows and bulls among the three valleys except colors of the horns of the bulls where significant difference (P=0.04) was observed among the three valleys. There was also no significant difference in the prevalence of the physical characteristics between Achai cattle genders in these three valleys.

Morphometric characteristics of Achai cows with significant differences among the three valleys included ear length, horn mid region circumference, chine length, loin length and switch length. In bulls' significant difference was observed in height at withers, face length, ear length, ear width, neck length, loin length, rump length, length of the leg below knee joint and switch length among the three valleys. Based on combined data of all three valleys, Achai cows have significantly longer and wider ears, long neck, long loin and wider rump than Achai bulls. On the other hand, Achai bulls have significantly higher values for heart girth, body length, height at withers, height at hip bone, length and circumference of the horns, neck circumference, dewlap length and width, chine length, rump length, length of the leg below knee joint, hoof circumference, tail length and switch length than Achai cows.

Based on combined data of all the three valleys, the overall mean 305-day milk yield was 1426.31±30.23 liters. It was significantly higher in Jandool (1560.14±36.88 liters; P<0.0001) and Maidan valley (1501.76±47.76 liters; P=0.0002) as compared to Talash valley (1217.04±53.05 liters). Regression analysis of variance revealed no significant difference in mean 305-day milk yield among first, second and third parity in Talash, Jandool and Maidan valley. Similarly no significant difference was observed in mean 305-day milk of cows calved in spring, summer, autumn and winter season in all the three valleys. The overall mean birth weight of male Achai calves based on combined data of all the three valleys was 16.88±0.27 kg. There was no significant difference in birth weight of male calves among Talash (17.50±0.43 kg), Jandool (16.40±0.50 kg) and Maidan valley (16.74±0.48 kg). The birth weight of male calves increased significantly with advancing parity number from first to third parity in Talash (b=0.28±0.003; $F_{(1, 1)}$ = 9747; P=0.006) and Jandool valley (b=0.16±0.006; $F_{(1, 1)}$ = 768; P=0.02), whereas, there was no significant difference among the three parities in Maidan valley. The overall mean birth weight of female Achai calves based on combined data of all the three valleys was 14.46±0.24 kg. There was no significant difference in birth weight of female calves among Talash (14.30±0.46 kg), Jandool (14.46±0.45 kg) and Maidan valley (14.62±0.37 kg). Parity also has no significant effect on birth weight of female calves in all the three valleys. Combined data of all the three valleys revealed that male calves (16.88±0.27 kg) were significantly (P<0.001) heavier than female calves (14.54±0.26 kg) at birth.

The overall mean pubertal age of cow based on data of all the three valleys was 1147.73±18.26 days. There was no significant difference in pubertal age among Talash (1144.29±45.18 days), Jandool (1161.00±22.45 days) and Maidan valley (1125.00±39.04 days). The overall mean postpartum anoestrus interval based on combined data of all the three valleys was 97.33±3.42 days. There was no significant difference in postpartum anoestrus interval among Talash (100.00±6.33 days), Jandool (96.31±5.35 days) and Maidan valley (92.50±5.67 days). Parity significantly affected postpartum anoestrus interval in Talash valley and a significant (b= -10.06±1.49; $F_{(1, 2)}$ =45.11; P=0.02) decrease was observed from first to fourth parity. However, parity did not significantly affect postpartum anoestrus interval in Jandool and Maidan valley. Season also had no significant effect on postpartum anoestrus interval in Talash and Jandool valley. In Maidan valley significantly (P=0.02) longer postpartum anoestrus interval was observed in cows calved in winter as compared to spring season. The highest percentage of cows conceived at first natural service was observed in Jandool (72.32%) followed by Maidan (71.58%) and Talash valley (68.12%). The overall mean calving interval based on combined data of all the three valleys was 476.37±5.17 days. There was no significant difference in calving interval among Talash (462.10±9.18 days), Jandool (483.36±8.01 days) and Maidan valley (480.65±9.70 days). Parity and season did not affect calving interval significantly in all the three valleys. The overall mean dry period based on combined data of all the three valleys was 91.55±2.71 days. Cows in Talash valley had significantly shorter dry period than cows in Jandool (P<0.001) and Maidan valley P=0.005). Regression analysis of variance revealed no significant effect of parity and season on dry period in all the three valleys. The present study indicated that Achai cows and bulls had no significant difference in physical characteristics except the colors of horns in bulls among all the three valleys. Bulls were larger in size than cows. Standard 305-day milk yield was significantly higher in Jandool and Maidan valley than Talash valley. Male as well as female calf birth weight did not differ significantly among the three valleys. However, male calves were significantly heavier than female calves at birth. There was no significant difference in reproductive performance like pubertal age, postpartum anoestrus interval, conception efficiency and calving interval among the three valleys except dry period which was significantly short in Talash compared to Jandool and Maidan valley. Parity significantly affected male calf birth weight and postpartum anoestrus interval in Talash valley, whereas, the effect of parity on other productive and reproductive parameters was not significant. Similarly, the significant effect of season was observed on postpartum anoestrus interval in Maidan valley and season did not significantly affect other productive and reproductive parameters.

The present investigation was conducted for the first time for Achai cattle with the objectives to study the physical and morphometric characteristics and productive and reproductive performance under traditional management system. The findings obtained can be used as baseline data to improve productive and reproductive performance of Achai cattle with the potential approaches discussed for improving these parameters. No doubt this study was carried out for a particular breed. It can be suggested that on the same pattern improvement in productive and reproductive performance in other cattle breed in the country can be carried out. It is expected that improvement in productive and reproductive performance shall lead to the improvement of economy of farmers as well.

INTRODUCTION

Livestock as a sub-sector of agriculture accounts for 51.80% of agricultural value added and contributes 11.30% to Gross Domestic Products. Livestock play a vital role in rural economy, which is evident from the fact that about 35 million people are engaged in livestock rearing in rural areas deriving 30 to 40% of the household income from this sector. Livestock provides principal sources for essential items of human diet in the form of milk, meat, egg, provides wool, hair, hides, skin, and farmyard manure and is an important source of motive power for cultivation and rural transport. It is also a source of regular cash income and provides employment for more than half of the population of Pakistan (Panhwer and Khan, 2002; Pakistan Economic Survey, 2007-2008 and 2008-2009).

Pakistan is endowed with a rich livestock genetic resources, well adapted to the local conditions. There are 15 breeds of cattle, 5 breeds of buffaloes, 25 breeds of sheep and 25 breeds of goat (Khan et al., 2007 a; Khan et al., 2007 b; Khan et al., 2008 a; Khan et al., 2008 b). The population of cattle in Pakistan is 29.6 million, buffalo 27.7 million, sheep 26.5 million and goat 53.8 million (Government of Pakistan, 2006). Among cattle breeds, Sahiwal, Red Sindhi and Cholistani are milch breeds, Bhagnari and Dajal are heavy draught breeds, Dhanni, Lohani and Rojhan are medium-draught breeds. Kankrej, Tharparker, Achai and Gabrali are considered as dual purposes breeds of cattle (Khan et al., 2005; Khan et al., 2008 a).

Punjab province is the home tract of indigenous cattle breeds like Sahiwal, Cholistani, Dajal, Dhanni and Rojhan whereas Sindh is the habitat of Tharparker and Kankrej cattle breeds. Red Sindhi and Bhagnari are found in Sindh and Baluchistan provinces. In North West Frontier Province, cattle breeds found in the southern districts are Rojhan and Lohani and in the northwest region are Achai and Gabrali (Khan et al., 2005; Khan et al., 2008a).

Indigenous breeds are multipurpose, adapted to the prevailing environmental conditions, perform well on poor quality roughages, resistant to diseases and can move in rugged terrain for grazing. Exotic breeds on the other hand require quality fodder and concentrates for economically viable performance, susceptible to prevailing diseases, vulnerable to weather extremes, unadapted to move in rugged terrain for grazing, demands labor intensive stall feeding and rely on high inputs to be purchased from outside the system (Carvalho et al., 1995; Hammond and Leitch, 1996; Alderson, 2001; Orskov, 2008; Hoffmann, 2008; Kohler-Rollefson et al., 2009).

Indigenous livestock breeds face many challenges and tend to disappear as a result of development interventions where high-input, high out-put breeds are preferred, specialization with emphasis on single productive trait, genetic introgression through crossbreeding, technical change in which machinery replaces work animals, economic change where subsidized imports or synthetics affects markets for typical outputs of indigenous breeds, environmental change rendered a breed unviable in a particular habitat and political instability which perish the local breeds owned by vulnerable populations (Hammond and Leitch, 1996; Blench, 2005). There is a terrible risk that most breeds may perish before they have been exclusively recognized and exploited (FAO, 2000). Recognizing the imperative value of animal genetic resources to food security, rural development and environment, the international community agreed on concerted efforts to use, develop and conserve the livestock biodiversity and halt its further depletion (FAO/UNDP, 2000; FAO, 2007; Pilling et al., 2008). To materialize conservation and development of livestock breeds, proper characterization of the breed is essential to identify breed attributes for immediate use by farming communities and design appropriate breeding strategies for their sustainable use and development (Hassen et al., 2007; FAO, 2007; Zulu, 2008; Kohler-Rollefson et al., 2009). The commonly used phenotypic characteristics are physical characteristics, morphometric measurements, productive and reproductive performance.

Data on physical, morphometric, productive and reproductive characteristics in various combinations have been used in the conservation and development of cattle breeds. In Kenya, breeding plan has been designed for the genetic improvement of milk yield and growth rate in Sahiwal cattle. The process involved selection of cows on the basis of individual milk yield as bull dams and the young bulls thus produced were subjected to progeny testing. The proven bulls were then used for breeding elite cows to produce more bulls for dissemination to the farmers (Muhuyi et al., 1999). For evaluation of Sahiwal and Ongole cattle in India, bulls have been put to progeny testing and are ranked on the basis of first lactation milk yield of their daughters and the top ranked bulls are used for elite mating for further production of proven bulls which are then used for the improvement in milk yield (Joshi et al., 2005). In China, Southern Yellow cattle has been improved from exclusively a draught animal to a dual-purpose cattle breed through selective breeding on the basis of recording performance traits like milk yield and birth weight (Huai et al., 1993). N'Dama cattle in Gambia has also been genetically improved where the cows were selected according to an index containing information on daily weight gain (between 15 and 36 months) and 0-100 day milk yield of all lactation. Resultantly an increase of 0.40 kg per year for the weight at 36 months was obtained during the 10 years period (Bosso et al., 2007). In other species like sheep, information about physical and productive characteristics have been used in the improvement of Djalkonke sheep in Cote d, Ivoire and resultantly the progeny of the selected population weight 28-30 kg at 12 months of age compared to 15-17 kg for unselected population at farm level (Blackburn et al., 1998; Yapi-Gnaone et al., 2001). Conservation and improvement programs using performance data are under way for Nguni cattle in South Africa (Bester et al., 2001), Hariana cattle in India (Joshi et al., 2005) and Sahiwal cattle in Pakistan (Iqbal, 2006).

The physical characteristics (color of the coat, horns, eyelashes, muzzle, hoof, tail switch) and morphometric measurements (heart girth, body length, height at withers and hipbone, head region, horns, neck and dewlap, hump, back and rump, legs and tail) have their significance in breed identification. The productive (standard 305-day milk yield, birth weight), and reproductive performance (pubertal age, postpartum aoestrus interval, conception efficiency, calving interval, dry period) shall provide broad based information that shall assist that how improvement in different characteristics can be made in Achai cows.

Physical characteristics.

Phenotypic characterization of the livestock breeds is usually based on common physical characteristics such as color of the body coat, horn, muzzle, hoof, tail switch, eyelids and eyelashes to identify a breed and differentiate it from others (Pundir et al., 2007; Singh et al., 2007; Singh et al., 2011).

Among the physical characteristics, coat color is one of the most important qualitative traits used to distinguish cattle breeds. Coat color, color pattern, size and shape of the horns are so important distinctive phenotypic traits that are applicable as trademark of the breed (Adalsteinsson et al., 1995; Schmutz et al., 1995; Klungland and Vage, 2003; Okeyo et al., 2005). Breeders in the past evaluate breeds on the basis of coat color as they have no scientific knowledge for measuring the economic traits (Seo et al., 2007). Information on these phenotypic traits and genes controlling them are of great importance in describing different breeds of livestock and are helpful in breed conservation (Klungland et al., 2000; Klungland and Vage, 2003).

Coat color in cattle can be broadly described as basic coat colors, modifications of the basic coat color and color pattern. There are three basic coat colors in cattle; black, reddish-brown to brownish black and red and are determined by Extension (E) and Agouti (A) loci (Olson, 1999; Kuhn and Weikard, 2007). Modified basic colors in cattle are represented as dilution (D), roan (R), brown (B) and albino (C) which involve lightening or removal of pigmentation from basic coat colors (Olson, 1999; Barsh, 2001; Seo et al., 2007). Color patterns observed in cattle breeds like blaze (Bl), brockling (Bc), color sided (Cs) or brindle (Br) is mainly due to their interaction with spotted (S) or other genes (Olson, 1999; Barsh, 2001; Seo et al., 2007).

Information about the effect of coat color of cattle on productive and reproductive performance is vary scanty and the available reports indicate no significant effect of coat color on productive and reproductive performance (Peters et al., 1982; Becerril et al., 1996; Okeyo et al., 2005). On the other hand, no information are available in the literature showing the association of eyelash color with productive or reproductive performance of the cattle. However, such physical characteristics are used to characterize cattle breeds and distinguished one breed from others (Singh et al., 2007; Singh et al., 2011).

Morphometric measurements.

Morphological characterization of the livestock breeds can help in proper management, conservation and genetic improvement of the local livestock breeds and morphometric measurements could aid field assessment, management and conservation of the cattle population where the goal is to obtain phenotypically pure local genetic resources for future selection and breed improvement strategies (Yakubu et al., 2010).

Morphometric measurements have been used to evaluate the characteristics of the animal that may vary due to the influence of breed evolution, environment and nutrition (Riva et al., 2004). Morphometric measurements can be easily measured under field condition and are biologically related to cost traits (Gallo et al., 2001). Morphometric measurements have been suggested as more objective measures of body conformation of animal (Janssens and Vandepitte, 2004; Janssens et al., 2004). Morphometric measurements are used for prediction of body conformation, which is an important component of breeding and selection decision both in dairy (Schneider et al., 2003) and beef cattle (Doren et al., 1989; Gilbert et al., 1993) and are also useful as selection criteria for performance traits with small scale farmers where weight measurements might not be feasible as they do not have access to weighbridge (Maiwashe et al., 2002).

In dairy cattle morphometric measurements with other performance traits have been investigated in many studies. In Holstein cows, it has been reported that cows with smaller heart girth and larger paunch girth had significantly higher yield. Taller cows produced more milk than shorter cows and cows lighter in weight yield greater fat corrected milk as first-calf heifer and through all lactations (Siber et al., 1988). A positive relationship between linear type traits and longevity has also been observed and therefore, linear type traits (body depth, chest width, rump length, rump width, foot angle, udder and teat traits), can be used as indicators of longevity in dairy cows (Neuenschwander et al., 2005; Bouska et al., 2006). Bayram et al (2006) study the correlation between body measurements and production traits and reported positive significant correlation between body length, heart girth, height at wither, chest depth, pelvic length and body weight with 305-days milk yield.

In beef cattle linear type traits like hip width or rump length or a combination of both can be used to predict breed type (Alderson, 1999). Longevity, an increasingly important trait can also be predicted from linear type traits (height at withers, rump length, hip width etc) in beef cattle (Forabosco et al., 2004). Information about the association of the linear body measurements and reproductive performance is scarce and are limited to rump/ pelvic width, length and angle. Royal et al. (2002) reported a negative correlation between rump width and commencement of luteal activity, whereas, Pryce et al (2000) observed very little or no relationship between rump traits and fertility in terms of cyclicity in cattle.

Productive performance.

The productive performances studied were Standard 305-day milk yield and birth weight.

Standard 305-day milk yield.

Milk is the trait of major economic importance in dairy cattle and estimation of milk yield is useful for dairy producers in making management and breeding decision and is essential for genetic evaluation (Kalsi and Dhillon, 1982; Ahmad and Sivarajasingam, 1998; Rehman et al., 2006; Quist et al., 2007). Among the traits, 305-day milk yield has the greatest influence on the dairy economy and should therefore be considered as the most important trait (Dahlin et al., 1998).

Milk production is influenced by both genetic and environmental factors including parity, year and season of calving, breed, age at first calving, lactation length and herd (Javed et al., 2000; Aslam et al., 2002; Bajwa et al., 2004; Rehamn et al., 2006; Lee and Kim, 2006; Cilek and Tekin, 2007; Lateef et al., 2008). Regarding the effect of parity on milk yield, both significant (Lee and Kim, 2006) and non-significant (Rehman et al., 2006) effects have been reported in literature. Similarly calving season has also been reported as a significant (Rehman et al., 2006; Gader et al., 2007) and non significant (Shafiq et al., 1995; Chagunda et al., 2004) source of variation in 305-day milk yield in cows.

Birth Weight.

Birth weight in cattle is one of the most important factors from the economic point of view particularly in terms of meat production as it is directly correlated with weight at maturity and can be used as a measure for effective selection for further breeding. A well grown bull shall be useful to have better generation. It is a measure of growth in a relatively homogenous environment and is the first component of growth rate, which can be easily evaluated (Ahmad and Kumbhar, 1975; Yadav et al., 2001).

Birth weight of calf is significantly influenced by various factors like breed of the cow (Syed et al., 1994; Mondal et al., 2005), sex of the calf (Ahmad and Kumbhar, 1975; Tawonezvi, 1989), parity of the cow (Nagaracenkar et al., 1981; Eriksson et al., 2004) and year and season of birth of calf (Ahmad and Kumbhar, 1975; Nagaracenkar et al., 1981; Tawonezvi, 1989). However, several reports in the literature revealed that parity (Yadav et al. 2001; Nogalski, 2003), calving season (Tuah and Danso, 1985; Yadav et al., 2001) and calf sex (Yadav et al., 2001; Ebangi et al., 2002) have no significant effect on calf birth weight in cattle.

Reproductive performance.

Successful reproductive performance is a critical component of profitable dairy enterprise (Garcia-Ispierto et al., 2007a; Palomares-Naveda et al., 2008) as it affects the amount of milk produced per cow per day of herd life, which is an important factor influencing the profitability of dairy herd (Evans et al., 2006; de Vries, 2006; Bishop and Pfeiffer, 2008). Reproductive success is also associated with increased herd longevity (Stevenson and Call, 1988), availability of replacement stock (Britt, 1985; Esslemont, 1992), opportunities for more selective culling and rate of genetic improvement for the traits of economic importance (Evans et al., 2006; Chang et al., 2006).

Traditional measures of fertility used for the assessment of reproductive performance are the interval measures and fertility scores (Weigel, 2004). Interval measures include days from calving to first service or heat (postpartum estrus interval), days from calving to conception (days open) and interval between successive calving (calving interval) (Royal et al., 2000). Fertility scores are non-return to first service, determined by weather another service follows within a pre-determined number of days such as 56 or 90 days and conception at first service, determined either through pregnancy diagnosis or subsequent calving.

As no single parameter can adequately summarize reproductive performance (Kanuya et al., 2000), therefore, a panel of parameters like first service conception rate and calving interval can be used to evaluate reproductive efficiency/fertility in cattle (Upham, 1991; Barth, 1993; Gonzalez, 2001; Sarder, 2006; Swai et al., 2007). Reproductive traits of significant importance are pubertal age, postpartum estrus interval, conception rate, calving interval and dry period.

Pubertal age.

Pubertal age in female cattle has been defined as the age at which estrus first occurs with ovulation (Rawlings et al., 2003; Ball and Peters, 2004). In male cattle pubertal age may be defined as the age in which production of the first ejaculate with at least 50 x 10^6 sperms with 10% progressive motility occurs (Nogueira, 2004).

Pubertal age is an important determinant of reproductive efficiency and early attainment of pubertal age is necessary for optimum reproductive performance in cattle (Ali and Farooque, 1989; Tegegne et al., 1992). Pubertal age is determined by several factors, which are endogenous as well as exogenous. Endogenous factors include genotype (Mukasa-Mugerwa, 1989; Abeygunwardena et al., 1994), growth and body weight (Ali and Farooque, 1989; Moore et al., 1990; Tegegne et al., 1992) whereas, exogenous factors are nutrition (Mustafa et al., 2003; Rekwot, 2004), year or season of birth (Grass et al., 1982; Azam et al., 2001; Mustafa et al., 2003) and bull biostimulation (Rekwot et al., 2000)

Bos indicus (zebu cattle) cattle reached pubertal age when they attain 60% of adult body weight whereas Bos tarus cattle attain pubertal age at 30-55% of adult body weight (Mukasa-Mugerwa, 1989; Abeygunawardena et al., 1994). It has been observed that Bos indicus heifers reached pubertal age about 12 months later than Bos taurus heifers (Tegegne et al., 1992). Late attainment of pubertal age in zebu cattle is a problem that affects their productivity by causing them to calve first at late age. Genetic improvement for this characteristic is possible because age at puberty has high heritability in zebu cattle. Genetic selection and improved nutrition can be used to reduce the age at puberty and first calving in zebu heifers (Nogueira, 2004; Rekwot, 2004).

Postpartum anoestrous interval.

Postpartum anoestrous interval is the interval from calving to first behavioral oestrus (Short et al., 1990; Mukasa-Mugerwa et al., 1991; Mialon et al., 2000; Abdalla and Elsheikh, 2008). Postpartum anoestrous interval plays a pivotal role in cattle reproduction and its duration greatly influences reproductive performance of the cattle (Lucy, 2007; Peter et al., 2009). The early resumption of normal ovarian activity accompanied by visible oestrus symptoms after calving is essential for high reproductive efficiency in cows and delay in the commencement of ovulation and expression of oestrus are associated with reduced conception rate and increased interval from calving to conception and such cows are more likely to be culled compared to cows with a short postpartum anoestrus interval (Opsomer et al., 2000; Rhodes et al., 2003; Tanaka et al., 2008).

The main factors affecting the duration of postpartum anoestrus interval in cattle are nutritional status (Jolly et al., 1995; Butler, 2000; Mureda and Zeleke, 2007) and suckling (Mukasa-Mugerwa et al., 1991; Das et al., 1999; Lobago et al., 2007). However, breed, parity, and calving season have also been identified as factors affecting postpartum anoestrus interval in cattle (Berka et al., 2004; Abdalla and Elsheikh, 2008; Matiko et al., 2008).

Abdalla and Elsheikh (2008) reported significantly short postpartum anoestrus interval in crossbred cows as compared to local Kenana and Fellata cattle breeds in Sudan.

The effect of parity on the resumption of ovarian cycle postpartum is complicated. A positive ($P<0.001$) relationship between parity and number of days from calving to the resumption of ovarian cyclicity was found in British Friesian and North American Holstein dairy cows (Fonseca et al., 1983; Darwash et al., 1997). However, postpartum anoestrus interval has been demonstrated to be significantly longer in primiparous and biparous cows as compared to multiparous cows (Boonbrahm et al., 2004; Matiko et al., 2008). On the other hand, Berka et al. (2004) and Lobago et al. (2007) reported no significant effect of parity on postpartum anoestrus interval in Czech Pied and Holstein cows in Czech Republic and crossbred dairy cows in central Ethiopia respectively.

The influence of calving season on the postpartum anoestrus interval is well documented in cattle and it has been observed in many studies that calving season significantly affect the trait. Obese et al. (1999) reported significantly short postpartum anoestrus interval in Sanga cows calving in dry season as compared to rainy season in Ghana. Similarly, Matiko et al. (2008) also reported significantly short postpartum anoestrus interval in zebu cows calving in dry season as compared to rainy season in Tanzania. However, Abdalla and Elsheikh, (2008) observed significantly short postpartum anoestrus interval in crossbred cows (Kenana x Friesian) calving in summer as compared to autumn and winter season in Sudan. On the other hand, Lobago et al. (2007) reported no significant effect of calving season on postpartum anoestrus interval in crossbred dairy cows in central Ethiopia.

Conception efficiency.

Conception efficiency which is also known as fertility scores is a traditional measure of fertility (Fetrow et al., 1990; Royal et al., 2000; Weigel, 2004). Fertility is one of the most important determinants of production as it affects the most vital reproductive indicators like days open and calving interval and increased feeding, insemination, veterinary costs and delayed the subsequent lactation (Biochard, 1990; Bousquet et al., 2004; Chang et al., 2006). A decline in cow fertility has been reported in the literature over the last 20 years (Lucy, 2001; Royal et al., 2002; Washburn et al., 2002; de Vries and Risco, 2005) thus alarming an immediate attention towards this problem. Keeping in view the importance of fertility in reproductive success of a herd, its evaluation and inclusion in the genetic selection indices in order to attenuate the rate of decline in fertility has been widely recommended (Washburn et al., 2002; Gonzalez-Recio et al., 2004; Gonzalez-Recio et al., 2006; Evans et al., 2006). Fertility is generally measured by conception rate to first service and number of services per conception (Fetrow et al., 1990; Gonzalez-Recio et al., 2006; Melendez and Pinedo, 2007; Soydan et al., 2009). However, the percentage of service-specific conception can also be used which provides a measure of the conception efficiency broken down by the number of services a cow has received (Chaudhry et al., 1989; Fetrow et al., 1990). The most widely used measure of fertility is the first service conception rate, an index that measures the ability of the cow to become pregnant after first service. Conception rate to first service provides a useful estimate of the conception rate of a herd and is the combined consequence of fertilization; early embryonic, late embryonic and fetal development (Nebel, 1998; Grimard et al., 2006). The number of services per conception measures female fertility directly and indicates the probability of conception when a cow is given the opportunity to get pregnant (Gonzalez-Recio et al., 2006).Various factors influencing conception rate are parity and season (Perea-Ganchou et al., 2005; Garcia-Ispierto et al., 2007b; Soydan et al., 2009), cyclicity and breeding time post-calving (Lamming and Darwash, 1998; Gustafsson and Emanueleson, 2002; Shreshta et al., 2004; Perea-Ganchou et al., 2005), milk production (Royal et al., 2000; Huang et al., 2008), breed and breeding system (Howlader et al., 1997; Kanuya et al., 2000; Perea-Ganchou et al., 2005).

Calving interval.

Calving interval in cattle is defined as the interval between the two most recent consecutive calvings (Sarder, 2006; Swai et al., 2007). It is a vital index to estimate reproductive performance of the herd and is the best economic index of any dairy enterprises (Sackey et al., 1999; Sarder, 2006; Swai et al., 2007).

Calving interval is the sum of service period (the interval from last calving date to the date of conception) and gestation period. Service period is the main determinant of calving interval because gestation period is almost similar in cattle (Salah and Mogawer, 1990; Masama et al., 2003; Sarder, 2006). Service period is influenced by postpartum estrus interval and conception rate or a combination of both (Slama et al., 1976; Obese et al., 1999; Azam et al., 2001; Masama et al., 2003; Swai et al., 2007).

The desirable calving interval for efficient milk production is 365 to 405 days or 12 to 13.5 months in dairy cows (McDowell, 1985; Esslemont, 1993; Hafez, 1993; Radostits, 2001; Sarder, 2006). To achieve this goal, the cows must conceive before 100 days postpartum (Munro, 1987). However, it should be mentioned that optimum calving interval might not be 365 days (12 months) under all managements and milk production levels. Average calving interval recommended for U.S dairies is 405 days or 13.5 months (Britt, 1981), for Texas dairies is 420 days or 14 months (Tomaszewski et al., 1981) and for dairy production under tropical condition is 430 days or 14.33 months (Mujuni, 1991; Kanuya, 1992). Long calving interval adversely affects productivity because cows spend a greater portion of their lactation at low production level and the calf crop is also reduced (Kanuya et al., 2000; Swai et al., 2007).

Various factors that significantly affect calving interval are parity (Goshu et al., 2007; Mureda and Zeleke, 2007), calving season (Parra-Bracamonte et al., 2005; Sattar et al., 2005), year of calving (Mustafa et al., 2003; Parra-Bracamonte et al., 2005) and breed of the cattle (Swai et al., 2005; Medina et al., 2009). On the other hand, several studies have reported no significant effect of parity (Lobago et al., 2007; Ansari-Lari and Abbasi, 2008) and calving season (Goshu et al., 2007; Lobago et al., 2007) on calving interval in cattle.

Dry Period.

Dry period is a nonlactating period incorporated between successive lactation that allows the mammary epithelial component to regress, proliferate and differentiate which in turn allows maximal milk production to occur during the subsequent lactation (Capuco et al., 1997; Annen et al., 2004). Dry period is one of the important factors that influences lifetime milk production and has been established as a necessary management practice to maintain profitable milk production in dairy cows (Bachman and Schairer, 2003; Grummer and Rastani, 2004).

Substantial amount of research has supported 60 days dry period for optimum milk production and reported 20 to 25% loss of milk in subsequent lactation when the cows are milked continuously (Bachman and Schairer, 2003; Grummer and Rastani, 2004; Andersen et al., 2005; Rastani et al., 2005). Many of the recent studies also recommended a dry period of 40 to 60 days for optimum milk production in subsequent lactation (Kuhn et al., 2005; Kuhn et al., 2006; Gallo et al., 2008).

Traditionally, 60 days dry period was applied to the whole herd, however, the optimal dry period length may vary depending upon parity, days open, and level of milk production etc (Schaeffer and Henderson, 1972; Funck et al., 1987; Makuza and McDaniel, 1996; Annen et al., 2003; Kuhn et al., 2006).

Variable results have been reported regarding the effect of parity on dry period. Aslam et al. (2002) observed significantly longer postpartum anoestrus interval while Gallo et al. (2008) reported significantly shorter dry period after first parity in Italian Friesian and various indigenous cattle breeds of Pakistan respectively.

Kuhn et al. (2007) reported that Jersey cows with longer days open have longer dry period that resulted in substantial loss of production across the lifetime of a cow.

Considerable increase has occurred in milk production per cow as a result of progressive changes in the genetics and management of the dairy animal population (Bachman and Schairer, 2003). Thus optimum length of dry period has been a subject of great debate and there is an emerging interest to reevaluate the traditional dry period length, which could increase income from milk production and simplify dry cow management (Grummer and Rastani, 2004). In some recent studies, it has been observed that reduction in dry period length from 60 days to 30-34 days has not significantly affect milk production, dry matter intake and body condition score (Gulay et al., 2003; Bachman, 2002; Annen et al., 2004). Resultantly a dry period length of 41 to 50 days is recommended to maximize yield across adjacent lactation after first lactation and 31 to 40 days after second and later lactations (Kuhn et al., 2006).

Achai is considered to be the finest and oldest cattle breed of NWFP, essentially a dairy and light draught breed and has the highest population (684000 number of cattle) among the recognized cattle breeds of NWFP (Mohammad and Shah, 1986; Livestock Census Report, 2006; Khan et al., 2008a).

The per capita consumption of milk is 68 kg and meat is 14.5 kg per annum in Pakistan that are far below the recommended level for individual in most of the advanced countries. The situation is worst in northern areas of this province where the per capita milk consumption is only 40 liters per annum (Afridi et al., 2009). The demand for livestock products is expected to increase at quite higher rates induced by various factors like population growth, demand for animal based products, increased per capita income and change in consumption pattern (Sharif and Farooq, 2004). Total milk production by various livestock species in NWFP is 3.02 million tones and meat is 0.36 million tones and cattle contribute 55% to total milk and 41% to total meat produced in NWFP (Sharif and Farooq, 2004). Cattle population of district Dir share for almost 10% of the total cattle population of NWFP and more than half (55%) of the cattle population of this region is Achai cattle. Therefore, Achai cattle share for 10% of the total milk and 10 % of the total meat produced in NWFP and 55% of the milk and 55% of the meat produced in district Dir (Khan, 2004a; Livestock Census Report, 2006).

Agriculture is the main stay of the people of district Dir and more than 85% of the population is directly dependent on agriculture. The total cropped area of district Dir is 85000 hectares, where wheat is cropped on 52% and maize on 36% of the cropped area in a wheat-maize rotation system (Khan, 2004a; Ali et al., 2008). Most of the area is hilly, the agriculture is practiced on the hill slopes and in the narrow valley (District Census Report Dir Lower, 1999). Achai bulls are used for ploughing these narrow terraces and threshing of harvested crops (Mohammad and Shah, 1986) as heavy draught bulls and crossbred bulls cannot perform in these narrow terraces. On the other hand mechanized agriculture is very low and limited to plain areas in the valleys. Continuous use of inorganic fertilizers and new crop varieties are deteriorating the physical condition of the soil and reducing soil fertility of the eroded marginal land in this part of NWFP that can be restored through the use of farm yard manure in proper combination with inorganic fertilizers (Ali et al., 2008; Khanum et al., 2010; Shah et al., 2010). Farm yard manure has been considered as the third main reason for keeping cattle after milk production for home consumption and offspring for replacement and sale in this region of NWFP (Mohammad, 2004).

Achai cattle is therefore, of paramount importance to the livelihoods of the farming communities of this region particularly in the rain-fed areas as it provides milk for subsistence, meat, draught power for agricultural activities, farm yard manure for soil fertility, and hides for the leather industry of Pakistan and need to be conserved and improved (Mohammad and Shah, 1986; Jadoon, 1987). The concentrated efforts to increase milk production through crossbreeding with exotic breeds, indiscriminate breeding with non-descript bulls and lack of institutional support to conserve and improve the breed are the major threats to the erosion of the pure Achai breed that will result into the loss of an adapted animal genetic resource (Khan, 2004b). To prevent the erosion of indigenous breeds and materialize their conservation (Mwacharo and Rege, 2002; Hassen et al., 2007), scientific documentation of the important characteristics of the indigenous breeds is the crucial pre requisite (FAO, 2007; Kohler-Rollefson et al., 2009). No scientific information on physical and morphometric characteristics and performance traits like productive and reproductive performance of Achai cattle breed is available and therefore, study to assess these characteristics is urgently needed. The information thus obtained on physical and morphometric characteristics will provide basis for identification of the Achai cattle, productive performance will help in improving milk yield and reproductive performance will be beneficial in improving the overall reproduction and fertility of Achai cows. Furthermore, these information could be used as baseline data for the conservation and development of Achai cattle breed.

The prevailing environmental conditions in the valleys of the study area are quite different particularly in terms of availability of water and fodder. Vegetation, cropping and even breeding practices also vary considerably among these valleys.

The present investigation is thus designed to elucidate Achai cattle breed in the three valleys with the following objectives.

To determine the physical and morphometric characteristics of Achai cattle

To study productive traits of Achai cattle under traditional management system

To explore the reproductive performance of Achai cattle under traditional management system.

MATERIAL AND METHODS

Study area.

District Lower Dir was selected as the study area for research on Achai cattle due to its central location in the home tract of Achai cattle and three valleys namely Talash, Jandool and Maidan were selected as representative territories of the study area (Fig 1). District Dir Lower is situated in north-western part of North West Frontier Province (NWFP), Pakistan. It is located from 34º 37' to 35º 07' north latitude and from 71º 31' to 72º 14' east longitudes. It is bounded on the north by Upper Dir District, on the east by Upper Dir and Swat districts, on the south by Malakand protected area, and on the west by Bajaur agency and Afghanistan. Total area of the district is 1583 square kilometer. The topography of the district is dominated by the mountains and hills which are part of the ranges/branch of southern Hindu Kush. The mountain ranges run from north to the south with the highest peaks in the upper northern part of the district where they reach more than 3000 meters in height. In the central part, the height varies between 1800 and 2000 meters. In the south, at the junction of Panjkora River and Swat River, the height shows a rapid decrease where it is around 600 meters. The ranges have been cut by Punjkora River and its tributaries. It is these narrow valleys that most of the people live and practice agriculture. Main valleys are Talash, Jandool and Maidan. The climate can be described as mild temperate with cold winter season where temperature generally falls below freezing point in December, January and February (temperature ranges from –2.39ºC to11.2ºC). Summer season is mild hot and June and July are hot months. Maximum and minimum temperature recorded during summer is 32.52ºC and 15.67ºC respectively. Average annual rainfall varies from 700mm to 1000mm. The north is generally cooler and receives more rainfall (average annual rainfall is about 1000mm) whereas; the south is hotter and receives annual rainfall of 600mm on the average. Average rainfall is more in winter season than summer. Maximum rainfall has been recorded in March (242 mm) and minimum in November (51mm). Relative humidity is quite high throughout the year and maximum value was recorded during the month of January (70%) and minimum during June (42%). Cultivatable area of District Lower Dir is 44432 hectares whereas forest area is 91482 hectares (District Census Report, Lower Dir, 1999).

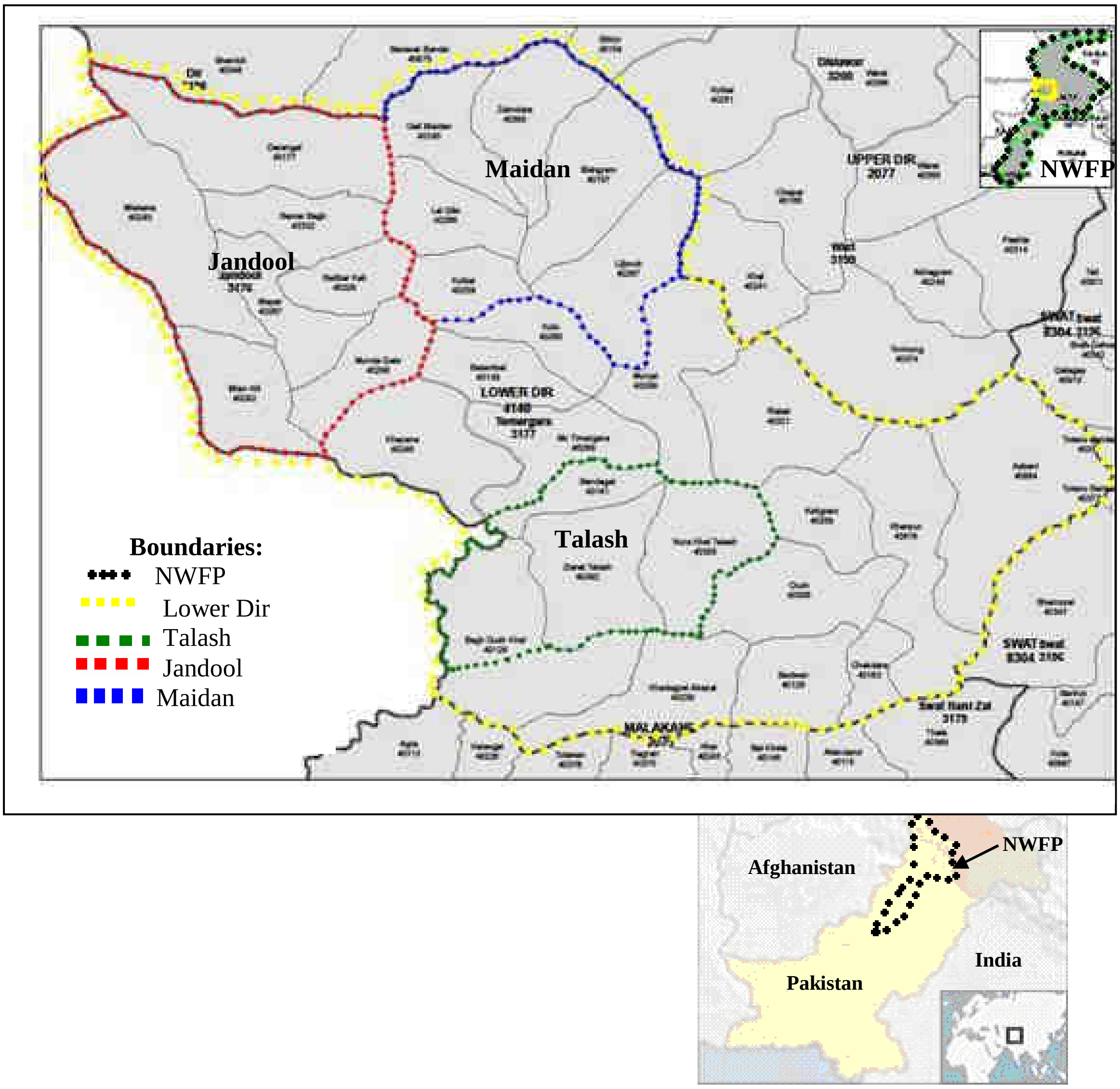


Figure 1: Map of the study area showing Talash, Jandool and Maidan valleys of District Lower Dir, NWFP, Pakistan.

Identification of Achai cattle breed.

Farmers who rear Achai cattle since long and are well aware of the breed were identified through the officials of the Department of Livestock and Dairy Development District Lower Dir. Meetings with these farmers were conducted for identification of Achai cattle breed. Physical characteristics of Achai cattle known in the farmer's communities were reddish brown coat color either solid or spotted, red eyelashes, red or white tail switch and small body size which differentiate Achai from other cattle breeds in Pakistan. Based on these physical characteristics, a total of 495 Achai cattle from 378 farm families were randomly selected from Talash, Jandool and Maidan valley of District Lower Dir, NWFP for the study of physical and morphometric characteristics and productive and reproductive performance.

Out of these 495 Achai cattle, 108 adult Achai cows and 108 adult Achai bulls were investigated for physical and morphometric characteristics. In addition to physical and morphometric characteristics, these 108 Achai cows were also used to obtained data on productive performance (Standard 305-day milk yield). Data on reproductive performance of 279 Achai cows was collected from 270 farm families on a pre-designed questionnaire (Annexure-1). The reproductive performance include pubertal age (n= 97), postpartum anoestrus interval (n=161), conception efficiency based on the percentage of cows conceived after availing first, second, third, fourth and more than fourth (fifth and sixth) natural services (n=276), calving interval (n=279) and dry period (n=174).

Data collection on physical and morphometric characteristics.

Data on physical and morphometric characteristics of both Achai cows and Achai bulls was collected as per standard procedure of FAO (1986). The selection of Achai cows and Achai bulls and the description of physical and morphometric characteristics are as follows.

Achai cows.

A total of 108 adult Achai cows were randomly selected for data collection on physical and morphometric characteristics with 36 Achai cows each from Talash, Jandool and Maidan valley. These selected cows were maintained with their owners and were also used for data collection on productive performance (305-day milk yield). Selected lactating cows were stall-fed and offered water two times daily.

Feeding components include wheat straw, wheat brans and weed thinning in spring, wheat straw, wheat brans and tree leaves in summer, wheat straw, wheat brans, maize stover and weed thinning in autumn and wheat straw, wheat brans, maize stover and hay in winter season. Calves were fed two quarters of the udder during first month, one quarter during second and half quarter during third month of life. After third month, calf is only allowed to suckle the dam for milk let down. Calves are maintained in the vicinity of cows. Routine vaccination and deworming is not practiced. However, sick animals are treated on need basis.

Achai bulls.

A total of 108 adult Achai bulls (castrated and intact bulls were taken together for study just to score them for morphometric characteristics that for what morphometric characteristics males and females differ) were also randomly selected with 36 each from Talash, Jandool and Maidan valley.

Physical characteristics.

Physical characteristics recorded for both Achai cows and Achai bulls were color of the coat, eyelashes, horn, hoof, muzzle and tail switch. Physical characteristics of both Achai cows and Achai bulls were studied according to the valleys (Talash, Jandool, Maidan). Sex differences in the prevalence of physical characteristics in these three valleys were also investigated.

Morphometric characteristics.

The following morphometric measurements (Fig 2) were taken using measuring tap with animals standing on flat surface in normal position. In case of cows, measurements were taken within two to three months after parturition. In bulls measurements were taken in off-season when they were not used for plough to avoid stress condition. All the measurements were taken by one person (author) to avoid between-individual variations.

1. Heart girth (body circumference immediately posterior to the front leg), body length (horizontal distance from the point of shoulder to the end of the pin bones), height at wither (the distance from the ground to the highest point of the withers) and height at hipbone (the distance from ground to the hip bone).

2. Head region: Measurements taken were face length (the distance from poll to upper edge of the muzzle), ear length (distance from tip of the ear to the base of the ear) and ear width (the distance between the two sides of the ear at its middle).

3. Horns: The length of horn was taken as the distance from the tip of the horn to the base of the horn both along the greater and smaller curvatures and the circumference of the horn was measured at base, mid region and just below the tip.

4. Neck and dewlap: Measurements taken were length of the neck (taken from withers to poll), circumference of the neck (taken at the mid point of neck length while pressing the dewlap to one side of the neck), length of the dewlap (from intermandibular region to the brisket or behind the brisket) and width of the dewlap (widest part of the hanging portion)

5. Hump: Height of the hump (from base to apex) and circumference of the hump (measured at the central point from base to apex) were measured in Achai bulls only because in Achai cows the hump was very small and no measurements were taken.

6. Back and rump: Measurements of the back region taken were chine length (length from withers to last rib) and loin length (length from last rib to hip bone). The rump length was taken as the length from tuber coxae to tuber ischii and the rump width was measured as the distance between the lateral surfaces of the left and right tuber coxae.

7. Legs: Length of the leg below knee joint and circumference of the hoof were measured.

8. Tail and switch of the tail: Length of the tail was measured as the length from the tail head to the end of the tail and length of the switch of the tail was taken as the length of the tuft of the hair only.

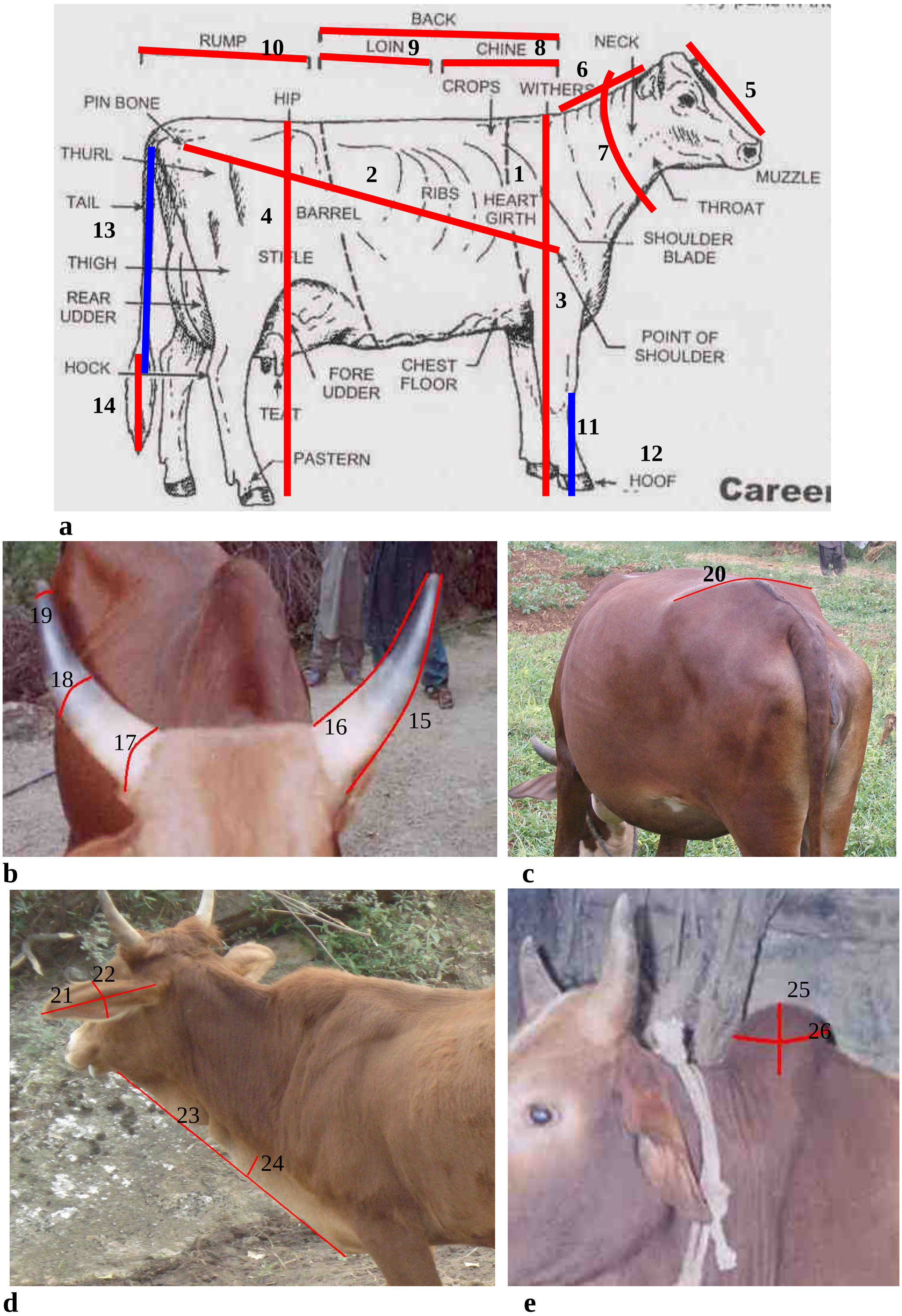


Fig 2: Labeled diagram showing various body parts of cattle (cow/bull) measured for this study (a) (1) heart girth (2) body length (3) height at withers (4) height at hip bone (5) face length (6**)** neck length (7) neck circumference (8) chine length (9) loin length (10) rump length (11) length of the front leg below knee joint (12) circumference of hoof (13) tail length (14) switch length. (b) (15) horn length along the greater curvature (16) horn length along the smaller curvature (17) circumference of the horn at the base (18) circumference of the horn at mid region (19) circumference of the horn just below the tip (c) (20) rump width (21) ear length (22) ear width (d) (23) dewlap length (24) dewlap width (e) (25) hump height (26) hump circumference.

Source (Fig. 2 a): www.utextension.utk.edu/4h/projects/activities/Dairy-W059.pdf

Data collection on productive performance.

Productive performance studied were standard 305-day milk yield of Achai cows and birth weight of both male and female calves.

Standard 305-day milk yield.

Achai cows selected for physical and morphometric characteristics as described above were also used for obtaining information on 305-day milk yield. The selected Achai cows from Talash (n=36), Jandool (n=36), and Maidan valley (n=36) were grouped according to parity (first, second and third) and calving season (spring, summer, autumn and winter) to study the effect of these factors on 305-day milk yield. Milk recording was carried out according to International Committee for Animal Recording (ICAR, 2004) A 4/2 method in which milk is recorded at morning and evening on the same day at an interval of 4 weeks. Milk was recorded from parturition till 300 day of lactation with first record within first two weeks of parturition. To obtain a standard 305-day milk yield, the method used by Khan (1997) and Bajwa et al. (2004) for projecting lactation records by estimating milk yield for the unknown part of the lactation from last test day milk yield was used. The formula for 305-day milk yield estimation thus used was: Lactation milk yield = known milk yield + estimated milk yield. Lactation milk yield is the estimated 305-day milk yield, known milk yield is the milk yield recorded for the known lactation period and estimated milk yield is milk yield estimated for the unknown part of lactation length. The estimation of milk yield for the unknown part of lactation length is done from the information (milk yield) at the last recording i.e. the last test day and the equation developed for this purpose is given below.

$\hat{Y}_{305} = Y_t + [\alpha + \beta X_i] (305\text{-DIM})$.

$\hat{Y}_{305}$ = Predicted 305-day lactation milk yield.

Y_t = Known milk yield or milk yield available to-date (up to the last test day).

α = Intercept for any lactation stage.

β = Regression coefficient for any lactation stage.

X_i = Milk yield (liters) on last test day.

DIM = days in milk.

Birth weight of male and female calves.

Calves (male and female) born to cows selected for productive performance (Standard 305-day milk yield) were weighed within 24 hours of birth with a portable balance. Birth weight of both male and female calves was recorded according to valley (Talash, Jandool, Maidan), parity (first, second, third) and calving season (spring, summer, autumn, winter).

Data collection on reproductive performance.

Data on reproductive performance of 279 Achai cows was obtained from a total of 270 farm families randomly selected from Talash, Jandool and Maidan valleys on a pre-designed questionnaire (Annexure 1). Reproductive performance of Achai cows included pubertal age, postpartum anoestrus interval, conception efficiency based on the percentage of cows conceived after availing first, second, third, fourth and more than fourth (fifth and sixth) natural services, calving interval and dry period.

Pubertal age.

Pubertal age of Achai cow was taken as the age at first behavioral estrus based on bellowing, vaginal mucus discharge and decrease in milk production and data on pubertal age of 97 Achai cows (Talash, n=21; Jandool, n= 50; Maidan, n=26) was obtained.

Postpartum anoestrus interval.

It was considered as the interval from calving to first observed estrus. Postpartum anoestrus interval was studied according to valley (Talash, n=48; Jandool, n=65; Maidan, n=48). The data was also grouped according to parity (first, second, third, fourth) and calving season (spring, summer, autumn, winter) in Talash, Jandool and Maidan valley to study the effect of parity and season on postpartum anoestrus interval in these valleys.

Conception efficiency.

Conception efficiency of Achai cows was calculated as the number of Achai cows conceived to any number of service (first, second, third, fourth and more than fourth) divided by total number of cows provided with natural service x 100 (Chaudhry et al., 1989; Fetrow at al., 1990) and was expressed as the percentage of Achai cows conceived after availing first, second, third, fourth and more than fourth (fifth and sixth) natural services. Data for 276 Achai cows (Talash, n= 69; Jandool, n=112; Maidan, n= 95) was obtained for the study of this reproductive performance.

Calving interval.

The calving interval was taken as the interval between the last two successive calving and data on calving interval of 279 Achai cows was obtained for this study. The calving interval was studied according to valley (Talash, n= 80; Jandool, n=107; Maidan, n=92). The data was also grouped according to parity (first, second, third, fourth) and calving season (spring, summer, autumn, winter) in Talash, Jandool and Maidan valley to study the effect of parity and season on calving interval in these three valleys.

Dry period.

The dry period was taken as the nonlactating period between the last two successive calving. Data on dry period of 174 Achai cows was collected for this investigation. The dry period was studied according to valley (Talash, n=49; Jandool, n=72; Maidan, n=53). The data on dry period was also grouped according to parity (first, second, third, fourth) and calving season (spring, summer, autumn, winter) in Talash, Jandool and Maidan valley to study the effect of parity and season on dry period in these three valleys.

Statistical analysis.

Mean, standard error, Student's t-test, Chai-square test, Analysis of variance and regression analysis of variance were calculated for various comparisons using GraphPad Prism-5 (GraphPad Software, San Diego, CA).

RESULTS

This study was conducted on Achai cows and Achai bulls in Talash, Jandool and Maidan valleys of District Lower Dir, NWFP, Pakistan. Physical characteristic observed on both Achai cows and Achai bulls were color of the coat, horns, eyelashes, muzzle, hooves and tail switch. Morphometric measurements carried out on Achai cows and Achai bulls were heart girth, body length, height at withers, height at hip bone, head region (face length, ear length and width), neck (circumference and length) and dewlap (length and width), hump (height and circumference in bulls only), back region (loin length, chine length, and rump length and width), leg (length below knee and hoof circumference) and length of the tail and switch. Productive performance recorded was standard 305-day milk yield of cows and birth weight of male and female calves. Reproductive performance of the Achai cows included pubertal age, postpartum anoestrus interval, conception efficiency based on the percentage of cows conceived after availing first, second, third, fourth and more than fourth (fifth and sixth) natural services, calving interval and dry period.

Physical characteristics of Achai cows and bulls.

The physical characteristics observed were color of the coat, horns, eyelashes, muzzle, hoof and tail switch.

Coat.

The coat color of both Achai cows and bulls was reddish brown either solid or spotted (Fig. 3 a, b; Fig. 4 a, b). Among Achai bulls, some were slightly darker at neck, shoulders, and hindquarters (Fig. 5 a, b).

Cow.

The distribution of coat color of Achai cows in Talash, Jandool and Maidan valleys is shown in Table 1. The study of coat color of Achai cows in these three valleys indicated that the highest percentage of Achai cows (64%) was with spotted reddish brown coat color in Maidan valley. The lowest percentage (36%) of Achai cows with solid reddish brown coat color was also noted in Maidan valley. There was no significant (χ^2 = 0.53, df = 2, P=0.76) difference in the distribution of spotted reddish brown and solid reddish brown coat color of cows among these three valleys.

Bull.

The percentage of bulls with different coat color in Talash, Jandool and Maidan valley is given in Table 1. The highest percentage (72.22%) of bulls were found to have spotted reddish brown coat color in Talash valley and the lowest percentage (27.78%) of bulls with solid reddish brown coat color also in Talash valley. In some Achai bulls, darkening of the coat color can also be seen but it is restricted to neck, shoulder and hindquarters. Bulls have no significant difference (χ^2=1.75, df = 2, P=0.42) in the distribution of spotted reddish brown and solid reddish brown coat color among Talash, Jandool and Maidan valleys.

Sex differences in color pattern of the coat.

Cows and bulls have no significant difference in the prevalence of spotted reddish brown (χ^2 =0.71; df =2, P=0.70) and solid reddish brown (χ^2 =1.282, df = 2, P=0.53) coat color in these three valleys.

Table 1: Coat color of Achai cows and Achai bulls in Talash, Jandool and Maidan valleys of District Lower Dir, NWFP.

		Valleys					
		Talash		Jandool		Maidan	
Achai cattle	Coat color	No	%	No.	%	No.	%
Achai cows	Solid reddish brown	15	41.66	16	44.00	13	36.00
	Spotted reddish brown	21	58.33	20	56.00	23	64.00
Achai bulls	Solid reddish brown	10	27.78	11	30.56	15	41.67
	Spotted reddish brown	26	72.22	25	69.44	21	58.33

a

b

Fig. 3: Coat color of Achai cow (a) solid reddish brown (b) spotted reddish brown.

a

b

Fig. 4: Coat color of Achai bull (a) solid reddish brown (b) spotted reddish brown.

a

b

Fig. 5: Achai bull with (a) darker neck and shoulder region (b) darker neck, shoulder and hind quarter.

Horns.

In Achai cows and bulls, three different colors of the horns observed were light brown at base, grayish in the middle and black in the upper part of the horn upto the tip, light brown at base with blackish tinge in the upper part of the horn; and light brown. In addition to these three colors, black color horns were also recorded in bulls (Fig. 6 a, b, c, d).

Cows.

The percentage of cows with different colors of the horns in Talash, Jandool and Maidan is shown in Table 2. The highest percentage (52.78%) of cows have horns of light brown color at base, grayish in the middle and black in the upper part of the horn upto the tip in Jandool and the lowest percentage (22.22%) of cows have light brown color horns at base with blackish tinge in the upper part of the horn in Jandool valley. There was no significant difference (χ^2=3.69, df =4, P= 0.45) in the prevalence of these three colors of the horns of cows (light brown color at base with grayish in the middle and black in the upper part of the horn upto the tip, light brown at base with blackish tinge in the upper part of the horn, light brown) among these three valleys.

Bulls.

The percentage of bulls with different colors of the horns in Talash, Jandool and Maidan valley is given in Table 2. The highest percentage (58.33%) of bulls have horns of light brown color at base with blackish tinge in the upper part of the horn in Talash and the lowest percentage (2.78%) of bulls have black color horns in Jandool. Significant difference (χ^2=12.63, df=6, P=0.04) was observed in the occurrence of these four colors of horns of bulls (light brown at base with grayish in the middle and black in the upper part of the horn upto the tip, light brown at base with blackish tinge in the upper part of the horn, light brown, and black) among these three valleys.

Sex differences in color pattern of horns.

Sex of the Achai cattle has no significant effect on the distribution of the colors of horns like light brown at base with grayish in the middle and black in the upper part of the horn upto the tip (χ^2= 2.22, df =2; P=0.33), light brown at base with blackish tinge in the upper part of the horn (χ^2= 0.25, df =2, P=0.88) and light brown (χ^2= 2.17, df =2; P=0.34) in these three valleys.

Fig. 6: Colors of the horns of Achai cattle (a) light brownish at base with grayish in the middle and black in the upper part of the horn upto the tip (b) light brown at the base with blackish tinge in the upper part of the horn (c) light brown (d) black.

Table 2: Colors of the horns of Achai cows and bulls in Talash, Jandool and Maidan valleys of District Lower Dir, NWFP.

		Valleys					
		Talash		Jandool		Maidan	
Achai cattle	Horn color	No.	%	No.	%	No.	%
Achai cows	Light brown at base with grayish in the middle and black in the upper part of the horn upto the tip	12	33.33	19	52.78	17	47.22
	Light brown at base with blackish tinge in the upper part of the horn	14	38.89	8	22.22	9	25.00
	Light brown	10	27.78	9	25.00	10	27.78
	Black	-	-	-	-	-	-
Achai bulls	Light brown at base with grayish in the middle and black in the upper part of the horn upto the tip	4	11.11	16	44.44	14	38.89
	Light brown at base with blackish tinge in the upper part of the horn	21	58.33	15	41.67	17	47.22
	Light brown	9	25.00	4	11.11	3	8.33
	Black	2	5.56	1	2.78	2	5.56

Eyelashes.

Three different colors of eyelashes like reddish brown, black; and white were observed in both Achai cows and bulls (Fig 7 a, b, c).

Cows.

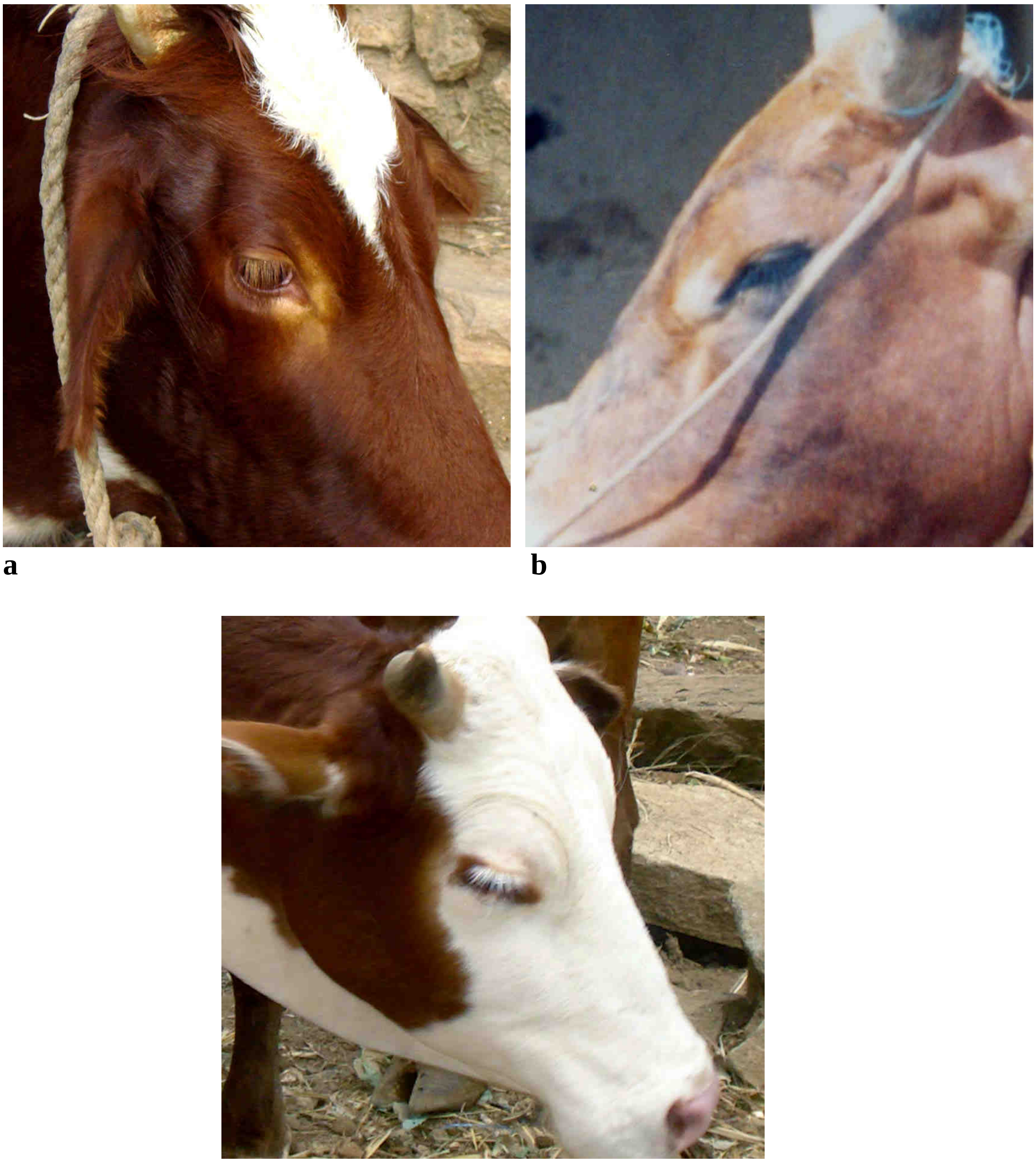
The percentage of Achai cows with different colors of eyelashes in Talash, Jandool and Maidan valley is shown in Table 3. The highest percentage (88.89%) of Achai cows was observed with reddish brown color eyelashes in Maidan valley and the lowest percentage (2.78%) with white color both in Talash and Maidan valley. In Jandool valley no cow with white color eyelashes was noted. Distribution of reddish brown, black, and white color of eyelashes has no significant (χ^2 = 6.56, df = 4, P=0.16) difference among these three valleys.

Bulls.

The distribution of color of eyelashes in Achai bull in Talash, Jandool and Maidan valley is given in Table 3. The highest percentage (83.33%) of Achai bulls was recorded with reddish brown color eyelashes in Jandool valley and the lowest percentage (2.78%) of bulls with white color eyelashes in Maidan valley. The prevalence of reddish brown, black, and white color eyelashes has no significant (χ^2 = 2.05, df =4, P=0.73) difference among these three valleys.

Sex differences in color pattern of eyelashes.

Sex differences for reddish brown (χ^2 =0.71, df =2, P=0.69), black (χ^2 =4.59, df =2, P=0.10) and white (χ^2 = 1.28, df =2, P=0.53) color eyelashes were statistically not-significant in these three valleys.



a b

c

Fig. 7: Colors of the eyelashes of Achai cattle (a) reddish brown (b) black (c) white

Table 3: Colors of the eyelashes of Achai cows and Achai bulls in Talash, Jandool and Maidan valleys of District Lower Dir, NWFP.

		Valleys					
		Talash		Jandool		Maidan	
Achai cattle	Colors of eyelashes	No.	%	No.	%	No.	%
Achai cows	Reddish brown	26	72.22	25	69.44	32	88.89
	Black	9	25.00	11	30.56	3	8.33
	White	1	2.78	-	-	1	2.78
Achai bulls	Reddish brown	26	72.22	30	83.33	28	77.77
	Black	8	22.22	4	11.11	7	19.44
	White	2	5.56	2	5.56	1	2.78

Muzzle.

The colors of muzzle observed in Achai cows and Achai bulls were light brown, light brow with black pigments and black (Fig 8 a, b, c).

Cows.

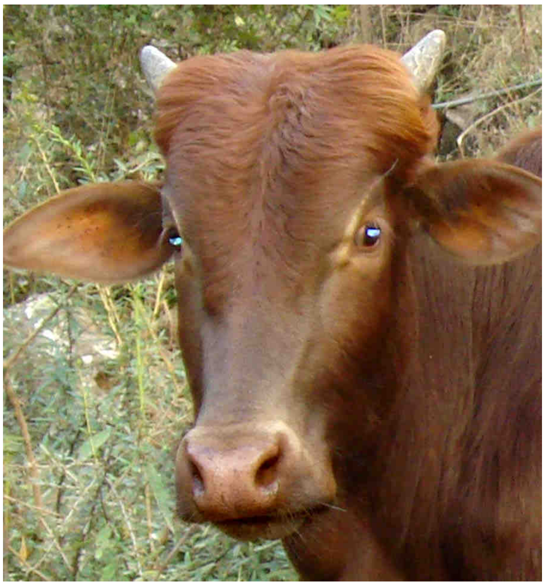
The percentage of cows with different colors of the muzzle in Talash, Jandool and Maidan valleys is shown in Table 4. The highest percentage (58.33%) of Achai cows was observed with light brown color muzzle with black pigments in Jandool valley and lowest percentage (5.56%) of cows with black color muzzle in Maidan valley. The distribution of light brown, light brown with black pigments and black color of muzzle has no significant (χ^2 =5.35, df = 4, P=0.25) difference among these three valleys.

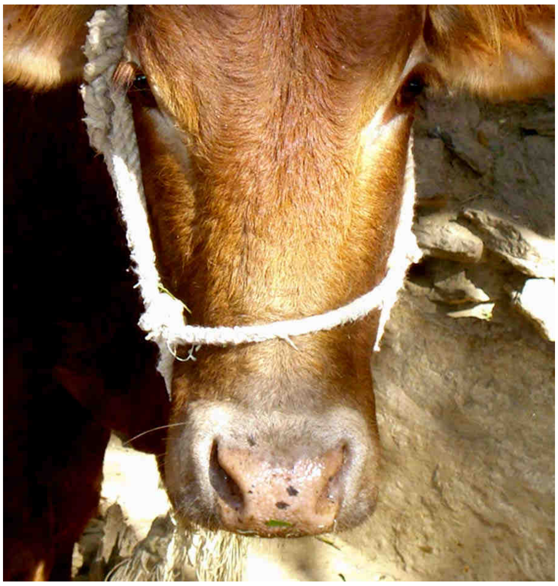
Bulls.

Distribution of colors of muzzle in Achai bulls in Talash, Jandool and Maidan valleys is presented in Table 4. The highest percentage (55.56%) of bulls has light brown color muzzle with black pigments in both Jandool and Maidan valleys and the lowest percentage (8.33%) of bulls has light brown color muzzle in Maidan valley. There was no significant (χ^2 =6.19, df = 4, P=0.18) difference in the occurrence of light brown, light brown with black pigments and black color of muzzle in bulls among these three valleys.

Sex differences in color pattern of muzzle.

Sex differences for light brown (χ^2 =3.55, df = 2, P=0.17), light brown with black pigments (χ^2 =0.06, df =2, P=0.97) and black (χ^2 =3.11, df =2, P=0.22) color of muzzle was statistically non significant in these three valleys.





a **b**

c

Fig. 8: Colors of the muzzle of Achai cattle (a) light brown (b) light brown with black pigments (c) black

Table 4: Colors of the muzzle of Achai cows and bulls in Talash, Jandool and Maidan valleys of District Lower Dir, NWFP.

		Valleys					
		Talash		Jandool		Maidan	
Achai cattle	Colors of the muzzle	No.	%	No.	%	No.	%
Achai cows	Light brown	15	41.67	10	27.28	14	38.89
	Light brown with black pigments	14	38.89	21	58.33	20	55.55
	Black	7	19.44	5	13.89	2	5.56
Achai bulls	Light brown	8	22.22	9	25.00	3	8.33
	Light brown with black pigments	15	41.67	20	55.56	20	55.56
	Black	13	36.11	7	19.44	13	36.11

Hoof.

Three different colors; light brown, black and light brown with black striation were recorded in both Achai cows and Achai bulls (Fig 9 a, b, c).

Cows.

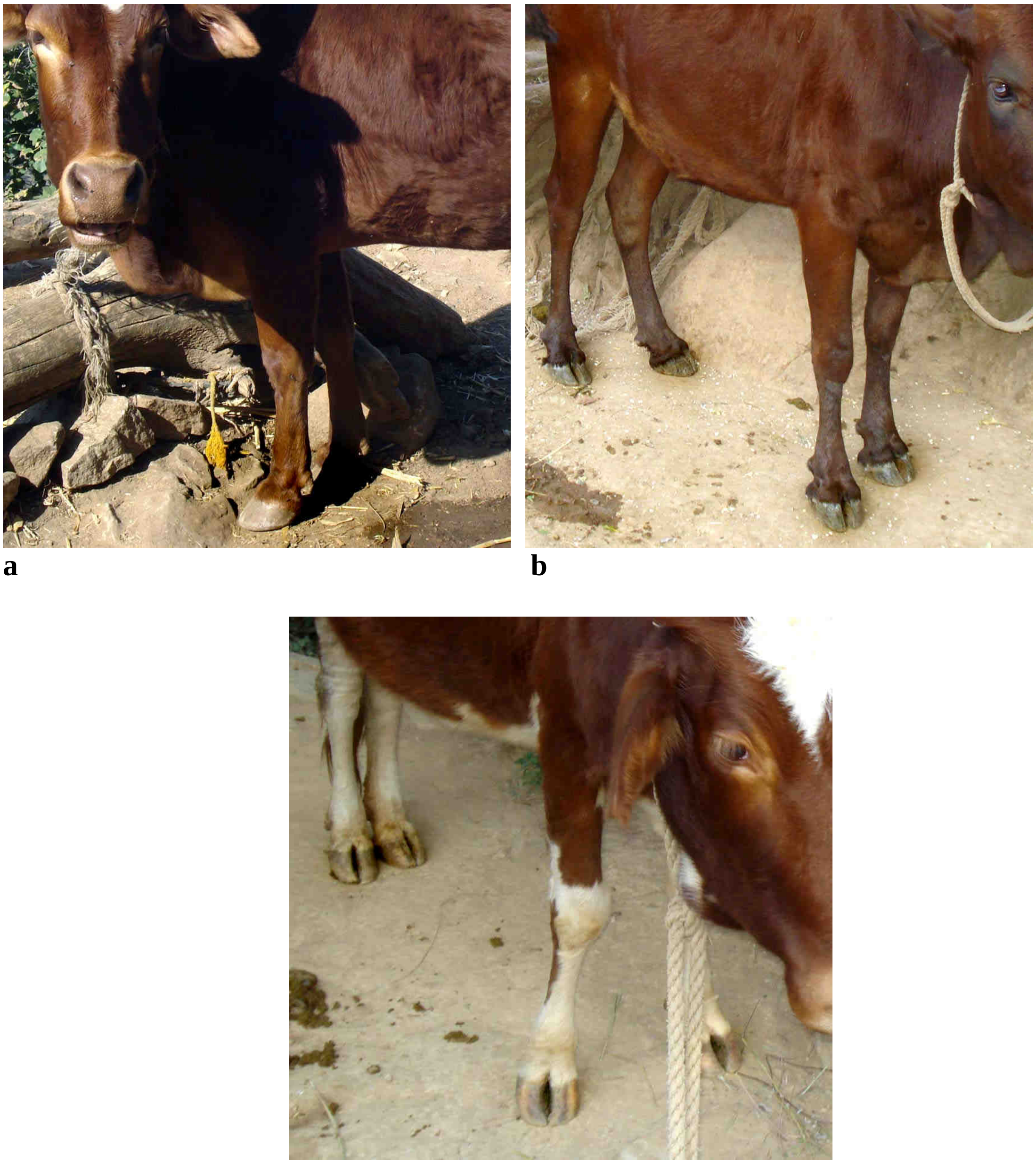
The distribution of colors of hoof of Achai cows in Talash, Jandool and Maidan valley is given in Table 5. The highest percentage (63.89%) of Achai cows was observed with light brown color hoof in Maidan valley and lowest percentage (8.33%) of cows was observed having light brown color hoof with black striations in Talash valley. There was no significant (χ^2 =2.76, df =4, P=0.59) difference in the distribution of light brown, black, and light brown with black striation color of hoof among Talash, Jandool and Maidan valley.

Bulls.

The distribution of hoof color of Achai bulls in Talash, Jandool and Maidan valley is presented in Table 5. The highest percentage (58.33%) of Achai bulls was recorded with black color hoof in Talash valley and lowest percentage (11.11%) of bulls having light brown color hoof with black striations also in Talash valley. No significant (χ^2 = 5.19, df = 4, P=0.27) difference was observed in the prevalence of light brown, black and light brown with black striation color of hoof in bulls among these three valleys.

Sex differences in color pattern of hooves.

Sex of the Achai cattle has no significant effect on the prevalence of light brown (χ^2 =3.08, df =2, P=0.21), black (χ^2 =1.28, df =2, P=0.53) and light brown with black striations (χ^2 = 0.97, df =2, P=0.61) color of hoof in these three valleys.



a b c

Fig. 9: Colors of the hooves of Achai cattle (a) light brown (b) black (c) light brown with black striations.

Table 5: Colors of the hoof of Achai cows and bulls in Talash, Jandool and Maidan valleys of District Lower Dir, NWFP.

		Valleys					
		Talash		Jandool		Maidan	
Achai cattle	Colors of the hoof	No.	%	No.	%	No.	%
Achai cows	Light brown	21	58.33	17	47.22	23	63.89
	Black	12	33.33	13	36.11	9	25.00
	Light brown with black striation	3	8.33	6	16.67	4	11.11
Achai bulls	Light brown	11	30.55	15	41.67	8	22.22
	Black	21	58.33	15	41.67	19	52.78
	Light brown with black striation	4	11.11	6	16.67	9	25.00

Tail switch.

The colors of tail switch recorded in both Achai cows and Achai bulls were reddish brown, white and black (Fig 10 a, b, c). Tail switch is smooth and symmetrical in both Achai cows and bulls and hangs at hock joint or below hock joint and in some cases even touch the ground.

Cows.

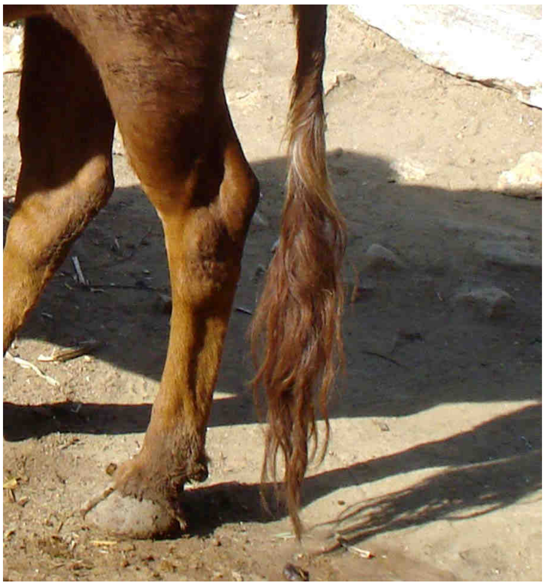
The distribution of the colors of the tail switch of Achai cows in Talash, Jandool and Maidan valley is shown in Table 6. The highest percentage (61.11%) of Achai cows was recorded with reddish brown color tail switch in Jandool and the lowest percentage of cows (2.78%) with black color tail switch in Maidan valley. Distribution of the reddish brown, white; and black color of tail switch of cows has no significant (χ^2 =7.11, df =4, P=0.13) difference among these three valleys.

Bulls.

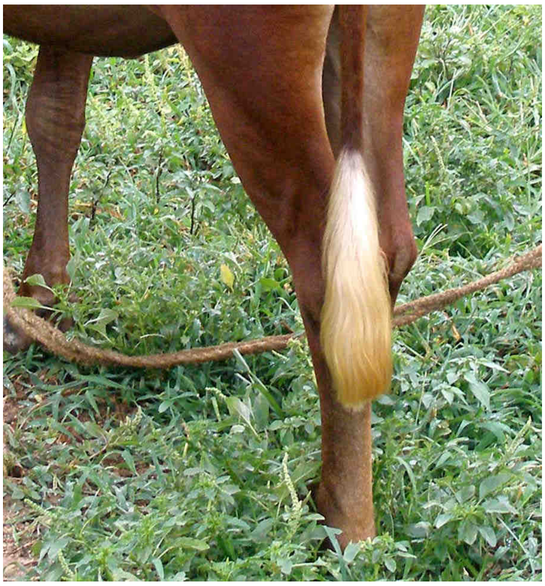
The colors of tail switch of Achai bulls in Talash, Jandool and Maidan valley is shown in Table 6. The highest percentage (50%) of bulls was observed with white tail switch color in Jandool valley and the lowest percentage (13.89%) of bulls with black tail switch color also in Jandool valley. The prevalence of reddish brown, white; and black color of tail switch in bulls has no significant (χ^2 = 2.26, df = 4, P=0.69) difference among Talash, Jandool and Maidan valley.

Sex differences in color pattern of tail switch.

There was no significant difference in the prevalence of reddish brown (χ^2 = 0.16, df = 2, P= 0.92), white (χ^2 = 0.28, df = 2, P=0.87) and black (χ^2 = 2.95, df =2, P= 0.23) color of tail switch between cows and bulls in these three valleys.



a



b

c

Fig 10: Colors of the switch of Achai cattle (a) reddish brown (b) white (c) black

Table 6: Colors of the tail switch of Achai cows and Achai bulls in Talash, Jandool and Maidan valleys of District Lower Dir, NWFP.

		Valleys					
		Talash		Jandool		Maidan	
Achai cattle	Colors of the switch	No.	%	No.	%	No.	%
Achai cows	Reddish brown	17	47.22	22	61.11	21	58.33
	White	12	33.33	12	33.33	14	38.89
	Black	7	19.44	2	5.56	1	2.78
Achai bulls	Reddish brown	11	30.55	13	36.11	11	30.56
	White	15	41.67	18	50.00	16	44.44
	Black	10	27.78	5	13.89	9	25.00

Morphometric characteristics of Achai cows and Achai bulls.

Morphometric characteristics of both Achai cows and Achai bulls were studied according to valleys (Talash, Jandool, Maidan). The overall mean of each morphometric characteristic both for Achai cows and Achai bulls mentioned in the results are based on the combined data of all the three valleys. Similarly sex differences (difference between Achai cow and Achai bull) for each morphometric characteristic described in the results also based on the combined data of all the three valleys.

1. Heart girth, body length, height at withers and height at hipbone.

Achai cows.

The overall mean heart girth, body length, height at withers and height at hipbone of Achai cow was 134.33±0.60 cm, 112.20±0.77 cm, 101.80±0.42 cm and 100.79±0.30 cm respectively (Table 7).

Mean heart girth, body length, height at withers and height at hipbone of Achai cows in Talash, Jandool and Maidan valley is given in Table 7. One-way analysis of variance (Table 8) revealed no significant difference in mean heart girth ($F_{(2, 105)}$ = 0.22; P=0.80), body length ($F_{(2, 105)}$ = 0.04; P=0.96), height at withers ($F_{(2, 105)}$ = 0.30; P=0.74) and height at hipbone ($F_{(2, 105)}$ = 0.22; P=0.81) of Achai cows among these three valleys.

Achai bulls.

The overall mean heart girth, body length, height at withers and height at hipbone was 140.50±1.12 cm, 116.26±1.02 cm, 107.62±0.68 cm and 106.38±0.42 cm respectively (Table 7).

Mean heart girth, body length, height at withers and height at hipbone of Achai bulls in Talash, Jandool and Maidan valley is given in Table 7. One-way analysis of variance (Table 9) showed no significant difference in mean heart girth ($F_{(2, 105)}$ =1.46; P=0.24), body length ($F_{(2, 105)}$ = 1.65; P=0.19) and height at hipbone ($F_{(2, 105)}$ = 1.57; P=0.21) of Achai bulls among these three valleys. However, significant ($F_{(2, 105)}$ = 6.07; P=0.003) difference was observed in mean height at withers of Achai bulls in these three valleys. Achai bulls in Talash ($t_{(70)}$ = 3.45; P<0.001; Table 7) and Jandool valley ($t_{(70)}$ = 2.20; P=0.03; Table 7) were significantly taller at withers than Achai bulls in Maidan valley. The difference in height at withers of Achai bulls in Talash and Jandool valley was statistically not significant ($t_{(70)}$ = 1.24; P=0.22).

Sex differences in heart girth, body length, height at withers and at hipbone.

The combined data of all the three valleys (Table 7) revealed significantly higher values of heart girth ($t_{(214)}$ =4.82; P<0.001), body length ($t_{(214)}$ =3.12; P<0.01), height at withers ($t_{(214)}$ =7.37; P<0.001) and height at hipbone ($t_{(214)}$ =10.33; P<0.001) of Achai bulls as compared to Achai cows.

Table 7: Mean heart girth, body length, height at withers and height at hipbone (cm) of Achai cows and bulls in Talash, Jandool and Maidan valleys of District Lower Dir, NWFP.

Achai cattle	Variables	Talash (n=36)	Jandool (n=36)	Maidan (n=36)	Overall ♦ (n=108)
Achai cows	Heart girth	133.75±1.00	134.50±1.14	134.75±1.14	134.33±0.60
	Body length	112.04±1.10	112.52±1.60	112.05±1.33	112.20±0.77
	Height at withers	101.55±0.69	102.26±0.80	101.60±0.67	101.80±0.42
	Height at hipbone	100.53±0.55	101.08±0.68	100.79±0.55	100.79±0.30
Achai bulls	Heart girth	140.86±2.00	142.63±2.00	138.01±1.78	140.50±1.12 ^{c***}
	Body length	118.39±1.84	116.49±1.81	113.91±1.59	116.26±1.02 ^{c**}
	Height at withers	110.10±1.13	108.13±1.13	104.63±1.11 $^{a***\ b*}$	107.62±0.68 ^{c***}
	Height at hip bone	107.27±0.78	106.44±0.80	105.44±0.60	106.38±0.42 ^{c***}

Mean±SE
n= Number of Achai cows or Achai bulls
a= Talash vs Jandool and Maidan,
b= Jandool vs Maidan.
♦ c = The overall mean heart girth, body length, height at withers and height at hipbone of Achai cows vs bulls (based on combined data of all the three valleys)
$P \leq 0.05^{*}$, $P \leq 0.01^{**}$, $P \leq 0.001^{***}$

Table 8: One-way analysis of variance showing differences in mean values of heart girth, body length, height at withers and height at hipbone of Achai cows among Talash, Jandool and Maidan valleys of District Lower Dir, NWFP.

Variables	Source of variation	df	SS	MS	F	P
Heart girth	Between valleys	2	19.27	9.26	0.22	0.80
	Within valleys	105	4551.00	43.35		
	Total	107	4571.00			
Body length	Between valleys	2	5.48	2.74	0.04	0.96
	Within valleys	105	7001.00	66.67		
	Total	107	7006.00			
Height at wither	Between valleys	2	11.35	5.68	0.30	0.74
	Within valleys	105	1968.00	18.75		
	Total	107	1980.00			
Height at hip	Between valleys	2	5.55	2.77	0.22	0.81
	Within valleys	105	1346.00	12.82		
	Total	107	1351.00			

Table 9: One-way analysis of variance showing differences in mean values of heart girth, body length, height at withers and height at hipbone of Achai bulls among Talash, Jandool and Maidan valleys of District Lower Dir, NWFP.

Variables	Source of variation	df	SS	MS	F	P
Heart girth	Between valleys	2	391.5	195.7	1.46	0.24
	Within valleys	105	14080.0	134.1		
	Total	107	14480.0			
Body length	Between valleys	2	364.1	182.0	1.65	0.19
	Within valleys	105	11580.0	110.3		
	Total	107	11950.0			
Height at wither	Between valleys	2	552.0	276.00	6.07	0.003
	Within valleys	105	4775.0	45.48		
	Total	107	5327.0			
Height at hipbone	Between valleys	2	60.7	30.37	1.57	0.21
	Within valleys	105	2026.0	19.30		
	Total	107	2087.0			

The ratio of heart girth to height at withers (HG: HW), body length to height at withers (BL: HW) and rump width to height at withers (RW: HW).

Achai cows.

The overall mean ratio of heart girth to height at withers, body length to height at withers and rump width to height at withers of cows was 1.32±0.004, 1.10±0.01 and 0.29±0.002 respectively (Table 10). The mean ratio of heart girth to height at withers, body length to height at withers and rump width to height at withers of cow in Talash, Jandool and Maidan valley is shown in Table 10. One-way analysis of variance (Table 11) revealed no significant difference in the ratio of heart girth to height at withers ($F_{(2,105)}$ =0.48; P=0.62), body length to height at withers ($F_{(2,105)}$ =0.02; P=0.98) and rump width to height at withers ($F_{(2,105)}$ =0.42; P=0.66) among these three valleys.

Achai bulls.

The overall mean ratio of heart girth to height at withers, body length to height at withers and rump width to height at withers of bulls was 1.31±0.01, 1.08±0.01 and 0.26±0.002 respectively (Table 10). The mean ratio of heart girth to height at withers, body length to height at withers and rump width to height at withers of bull in the three valleys is given in Table 10. One-way analysis of variance (Table 12) revealed significant ($F_{(2, 105)}$ = 4.18; P=0.01) difference in the ratio of heart girth to height at withers of bulls among these three valleys. Bulls in Talash have significantly lower ratio of heart girth to height at withers than bulls in Jandool ($t_{(70)}$ =2.34; P=0.02; Table 10) and Maidan valley ($t_{(70)}$ =2.34; P=0.02; Table10). No significant (Table 12) difference in the ratio of body length to height at withers ($F_{(2, 105)}$ =0.45; P=0.64) and rump width to height at withers ($F_{(2, 105)}$=0.03; P=0.97) was found among the three valleys.

Sex differences in the ratio of heart girth to height at withers, body length to height at withers and rump width to height at withers.

Combined data of all the three valleys revealed no significant difference ($t_{(214)}$ =1.77; P=0.07) in the ratio of heart girth to height at withers between cows and bulls. However, cows have significantly higher ratio of body length to height at withers ($t_{(214)}$ =2.37: P=0.01) and rump width to height at withers ($t_{(214)}$ =13.14; P<0.001) than bulls.

Table 10: The ratio of heart girth to height at withers (HG: HW), body length to height at withers (BL: HW) and rump width to height at withers (RW: HW) of Achai cows and Achai bulls in Talash, Jandool and Maidan valleys of District Lower Dir, NWFP.

Ratio	Achai cattle	Talash (n=36)	Jandool (n=36)	Maidan (n=36)	Overall ♦ (n=108)
HG: HW	Cows	1.32± 0.01	1.31± 0.01	1.33± 0.01	1.32±0.004
	Bulls	1.27± 0.01	1.32± 0.01 ^{a*}	1.32± 0.01 ^{a*}	1.31± 0.01
BL:HW	Cows	1.10± 0.01	1.10± 0.01	1.10± 0.01	1.10± 0.01
	Bulls	1.07± 0.01	1.08± 0.01	1.09± 0.01	1.08± 0.01^{c**}
RW: HW	Cows	0.30±0.003	0.30±0.004	0.30±0.003	0.30±0.002
	Bulls	0.26±0.005	0.26±0.004	0.26±0.003	0.26±0.002 ^{c***}

Mean±SE
n= Number of Achai cows or Achai bulls.
a = Talash vs Jandool and Maidan.
b = Jandool vs Maidan.
♦c = The overall mean ratio of HG: HW, BL: HW and RW: HW of Achai cows vs bulls (based on combined data of all the three valleys).
$P<0.05^{*}$, $P<0.01^{**}$, $P<0.001^{***}$

Table 11: One-way analysis of variance showing differences in the ratio of heart girth to height at wither (HG:HW), body length to height at wither (BL:HW) and rump width to height at withers (RW: HW) of Achai cows among Talash, Jandool and Maidan valleys of District Lower Dir, NWFP.

Variables	Source of variation	df	SS	MS	F	P
HG:HW	Between valleys	2	0.002	0.001	0.48	0.62
	Within valleys	105	0.235	0.002		
	Total	107	0.238			
BL:HW	Between valleys	2	0.0002	0.0001	0.02	0.98
	Within valleys	105	0.5460	0.0052		
	Total	107	0.5462			
RW: HW	Between valleys	2	0.0004	0.0002	0.42	0.66
	Within valleys	105	0.0491	0.0005		
	Total	107	0.0500			

Table 12: One-way analysis of variance showing differences in the ratio of heart girth to height at wither (HG:HW) and body length to height at wither (BL:HW) of Achai bulls among Talash, Jandool and Maidan valleys of District Lower Dir, NWFP.

Variables	Source of variation	df	SS	MS	F	P
HG:HW	Between valleys	2	0.0378	0.0189	4.18	0.01
	Within valleys	105	0.4748	0.0045		
	Total	107	0.5126			
BL:HW	Between valleys	2	0.004	0.002	0.45	0.64
	Within valleys	105	0.472	0.004		
	Total	107	0.475			
RW: HW	Between valleys	2	0.00003	0.00002	0.03	0.97
	Within valleys	105	0.06898	0.0007		
	Total	107	0.06901			

2. Head region.

Measurements taken were face length, ear length and ear width.

Achai cows.

The overall mean face length of Achai cows was 41.27±0.27 cm whereas the overall mean ear length and ear width was 17.99±0.21 cm and 11.59±0.15 cm respectively (Table 13).

The mean face length, ear length and ear width of Achai cows in Talash, Jandool and Maidan valley is presented in Table 13. One-way analysis of variance (Table 14) showed no significant difference in mean face length ($F_{(2, 105)}$ = 2.41; P=0.09) and ear width ($F_{(2, 105)}$ = 1.11; P=0.33) of Achai cows among these three valleys. However, significant ($F_{(2, 105)}$ = 3.87; P=0.02) difference was noted in mean ear length of Achai cows among these three valleys. Cows in Jandool valley have significantly longer ears than cows in Talash valley ($t_{(70)}$ =2.56; P=0.01; Table 13) and Maidan valley ($t_{(70)}$ =2.29; P=0.02; Table 13). The difference in ear length of cows between Talash and Maidan valley was statistically not significant ($t_{(70)}$ =0.63; P=0.53)

Achai bulls.

The overall mean face length of Achai bull was 41.93±0.25 cm whereas the overall mean ear length was 16.14±0.15 cm and ear width was 10.79±0.11 cm (Table 13).

Mean face length; ear length and ear width of Achai bull in Talash, Jandool and Maidan valley is given in Table 13. One-way analysis of variance showed significant difference in mean face length ($F_{(2, 105)}$ = 10.42; P=0.0001; Table 15), ear length ($F_{(2, 105)}$ = 5.79; P=0.004; Table 15) and ear width ($F_{(2, 105)}$ = 7.88; P=0.0006; Table 15) of Achai bulls among these three valleys. Bulls in Talash valley have significantly longer face than bulls in Jandool valley ($t_{(70)}$ =2.03; P=0.04; Table 13) and Maidan valley ($t_{(70)}$ =4.63; P<0.001; Table 13). Bulls in Jandool valley also have significantly ($t_{(70)}$ =2.46; P=0.02; Table 13) longer face than bulls in Maidan valley. Significantly ($t_{(70)}$ =3.31; P=0.001; Table 13) longer ears were observed in bulls in Talash valley compared to bulls in Maidan valley. However, ear length of bulls in Jandool valley did not differ significantly from bulls in Talash valley ($t_{(70)}$ =1.61; P=0.11) and Maidan valley ($t_{(70)}$ =1.89; P=0.62). Bulls in Maidan valley have significantly narrow ears than bulls in Talash valley ($t_{(70)}$ =3.49; P=0.0008; Table 13) and Jandool valley ($t_{(70)}$ =3.53; P=0.0007; Table 13). The difference in ear width of bulls in Talash valley and Jandool valley was statistically not significant ($t_{(70)}$ =0.005; P=0.99).

Sex differences in face length, ear length and ear width.

Combined data of all the three valleys revealed a non-significant ($t_{(214)}$ = 1.83; P>0.05) difference in mean face length between Achai cows and bulls. However, Achai cows have significantly longer ($t_{(214)}$ = 7.4; P<0.001; Table 13) and wider ears ($t_{(214)}$ = 4.70; P< 0.001; Table 13) than bulls.

Table 13: Face length, ear length and ear width (cm) of Achai cows and bulls in Talash, Jandool and Maidan valleys of District Lower Dir, NWFP.

Achai cattle	Variables	Talash (n=36)	Jandool (n=36)	Maidan (n=36)	Overall ♦ (n=108)
Cows	Face length	41.14±0.39	42.04±0.46	40.64±0.52	41.27±0.27
	Ear length	17.44±0.42	18.76±0.29 ^{a**}	17.78±0.31 ^{b*}	17.99±0.21
	Ear width	11.87±0.39	11.58±0.15	11.33±0.26	11.59±0.15
Bulls	Face length	43.18±0.36	42.05±0.42 ^{a*}	40.57±0.43 $^{a***\ b*}$	41.93±0.25
	Ear length	16.74±0.30	16.13±0.23	15.56±0.19 ^{a***}	16.14±0.15 ^{c***}
	Ear width	11.09±0.20	11.09±0.23	10.18±0.17 $^{a***\ b***}$	10.79±0.11 ^{c***}

Mean±SE
n= Number of Achai cows or Achai bulls.
a = Talash vs Jandool and Maidan
b = Jandool vs Maidan.
♦c =The overall mean face length, ear length and ear width of Achai cows vs bulls (based on combined data of all the three valleys).
$P \leq 0.05^{*}$, $P \leq 0.01^{**}$, $P \leq 0.001^{***}$

Table 14: One-way analysis of variance showing differences in mean face length, ear length and ear width of Achai cows among Talash, Jandool and Maidan valleys of District Lower Dir, NWFP.

Variables	Source of variation	df	SS	MS	F	P
Face length	Between valleys	2	36.24	18.12	2.41	0.09
	Within valleys	105	1968	18.75		
	Total	107	1980			
Ear length	Between valleys	2	33.86	19.93	3.87	0.02
	Within valleys	105	459.8	4.38		
	Total	107	493.7			
Ear width	Between valleys	2	5.255	2.63	1.11	0.33
	Within valleys	105	247.6	2.36		
	Total	107	252.8			

Table 15: One-way analysis of variance showing differences in mean face length, ear length and width of Achai bulls among Talash, Jandool and Maidan valleys of District Lower Dir, NWFP.

Variables	Source of variation	df	SS	MS	F	P
Face length	Between valleys	2	123.4	61.68	10.42	0.0001
	Within valleys	105	621.7	5.92		
	Total	107	745.1			
Ear length	Between valleys	2	25.4	12.70	5.79	0.004
	Within valleys	105	230.1	2.19		
	Total	107	255.5			
Ear width	Between valleys	2	19.9	9.98	7.88	0.0006
	Within valleys	105	132.9	1.26		
	Total	107	152.8			

3. Horns.

The measurements of horn taken were length along the greater curvature and smaller curvature and circumference at the base, mid region and just below the tip in both Achai cows and bulls.

Achai cows.

The overall mean length of the horn along the greater and smaller curvature was 17.37±0.42 cm and 12.92±0.34 cm respectively. The overall mean circumference of the horn at base was 11.86±0.15 cm, at mid region was 9.66±0.19 cm and just below the tip was 5.22±0.14 cm (Table 16).

The mean length of the horn along the greater curvature and smaller curvature and the mean circumference of the horn at base, mid region and just below the tip in Talash, Jandool and Maidan valley is given Table 16. One-way analysis of variance (Table 17) showed no significant difference in mean length of the horn along the greater curvature ($F_{(2, 105)}$ =0.69; P=0.50), mean length along the smaller curvature ($F_{(2, 105)}$ =0.75; P=0.47), circumference of the horn at the base ($F_{(2, 105)}$ = 2.70; P=0.07) and circumference just below the tip of the horn ($F_{(2, 105)}$ =0.47; P=0.63). However, circumference of the horn at mid region showed significant difference ($F_{(2, 105)}$ =3.10; P=0.04; Table 17) among these three valleys. Achai cows in Maidan valley have significantly thicker horns at mid region than cows in Talash valley ($t_{(70)}$ =2.62; P=0.01; Table 16) whereas this difference between cows in Talash and Jandool valley ($t_{(70)}$ =0.78; P=0.43) and Jandool and Maidan valley ($t_{(70)}$ =1.64; P=0.10) was statistically not significant.

Achai bulls.

The overall mean length of the horn along the greater and smaller curvature was 19.73±0.55 cm and 16.75±0.20 cm respectively. The overall mean circumference of the horn at base was 16.75±0.20 cm, at mid region was 14.66±0.25 cm and just below the tip was 6.25±0.16 cm (Table16).

The mean length of the horn along the greater curvature and smaller curvature and the circumference of the horn at base, mid region and just below the tip in the three valleys (Talash, Jandool, Maidan) are shown in Table 16. One-way analysis of variance (Table 18) revealed no significant difference in mean length of the horn along the grater curvature ($F_{(2,\ 105)}$ =0.67; P= 0.51) and smaller curvature ($F_{(2,105)}$ =0.36; P= 0.69) among these three valleys. Similarly the difference in mean circumference of the horn at base ($F_{(2,105)}$ =1.94; P= 0.15), mid region ($F_{(2,105)}$ =0.42 P= 0.66) and just below the tip ($F_{(2,105)}$ =0.13; P= 0.88) was also statistically not significant among these three valleys.

Sex differences in horn length and circumference.

Combined data of all the three valleys revealed that Achai bulls have significantly longer horns with respect to greater curvature ($t_{(214)}$ = 3.42; P<0.001; Table 16) and smaller curvature ($t_{(214)}$ =5.87; P<0.001; Table 16) than cows. Horns of bulls were also significantly thicker at base ($t_{(214)}$ =19.56; P<0.001; Table 16), mid region ($t_{(214)}$ = 16.13; P<0.001; Table 16) and just below the tip ($t_{(214)}$ = 5.15; P<0.001; Table 16) than cows.

Table 16: Mean length (cm) of the horn along the greater and smaller curvature and mean circumference (cm) of horn at base, mid region and just below the tip in Achai cows and bulls in Talash, Jandool and Maidan valleys of District Lower Dir, NWFP

Achai cattle	Variables	Talash (n=36)	Jandool (n=36)	Maidan (n=36)	Overall (n=108)
Cow	Length of the horn along the greater curvature	17.23±0.74	16.86±0.71	18.03±0.72	17.37±0.42
	Length of the horn along the smaller curvature	12.66±0.53	12.59±0.62	13.50±0.59	12.92±0.34
	Circumference at the base of the horn	11.48±0.33	11.76±0.24	12.33±0.21	11.86±0.15
	Circumference at the mid region of the horn	9.16±0.33	9.54±0.36	10.27±0.26 ^{a**}	9.66±0.19
	Circumference just below the tip of the horn	5.40±0.30	5.10±0.20	5.16±0.20	5.22±0.14
Bull	Length of the horn along the greater curvature	20.06±1.07	20.30±0.90	18.84±0.89	19.73±0.55 ^{c***}
	Length of the horn along the smaller curvature	16.03±0.85	16.56±0.68	15.67±0.66	16.75±0.20 ^{c***}
	Circumference at the base of horn	17.09±0.35	16.94±0.34	16.21±0.32	16.75±0.20 ^{c***}
	Circumference at the mid region of the horn	14.46±0.40	14.98±0.49	14.56±0.39	14.66±0.25 ^{c***}
	Circumference just below the tip of the horn	6.27±0.30	6.34±0.27	6.15±0.24	6.25±0.16 ^{c***}

Mean±SE
n= Number of Achai cows or Achai bulls.
a = Talash vs Jandool and Maidan
b = Jandool vs Maidan.
♦c =The overall mean length of the horn along the greater curvature, smaller curvature and circumference of the horn at base, mid region and just below the tip of Achai cows vs bulls (based on combined data of all the three valleys).
$P \leq 0.05^{*}$, $P \leq 0.01^{**}$, $P \leq 0.001^{***}$

Table 17: One-way analysis of variance showing differences in mean length (along the greater and smaller curvature) and circumference (at base, mid region and tip) of the horn of Achai cows among Talash, Jandool and Maidan valleys of District Lower Dir, NWFP.

Variables	Source of variation	df	SS	MS	F	P
Length of the horn along the greater curvature	Between valleys	2	25.68	12.84	0.69	0.50
	Within valleys	105	1961	18.68		
	Total	107	1987			
Length of the horn along the smaller curvature	Between valleys	2	18.67	9.33	0.75	0.47
	Within valleys	105	1299	12.37		
	Total	107	1317			
Circumference at the base of the horn	Between valleys	2	13.34	6.67	2.70	0.07
	Within valleys	105	259.1	2.47		
	Total	107	272.5			
Circumference at the mid region of the horn	Between valleys	2	22.74	11.37	3.10	0.04
	Within valleys	105	384.5	3.66		
	Total	107	407.2			
Circumference just below the tip of the horn	Between valleys	2	1.91	0.95	0.47	0.63
	Within valleys	105	215	2.05		
	Total	107	216.9			

Table 18: One-way analysis of variance showing differences in mean length (along greater and smaller curvature) and circumference (at base, mid region and tip) of the horn of Achai bulls among Talash, Jandool and Maidan valleys of District Lower Dir, NWFP.

Variables	Source of variation	df	SS	MS	F	P
Length of the horn along the greater curvature	Between valleys	2	44.19	22.10	0.67	0.51
	Within valleys	105	3469	33.03		
	Total	107	3513			
Length of the horn along the smaller curvature	Between valleys	2	14.36	7.18	0.36	0.69
	Within valleys	105	2064	19.66		
	Total	107	2079			
Circumference at the base of the horn	Between valleys	2	15.87	7.93	1.94	0.15
	Within valleys	105	429.3	4.09		
	Total	107	445.2			
Circumference at the mid region of the horn	Between valleys	2	5.557	2.78	0.42	0.66
	Within valleys	105	697.0	6.64		
	Total	107	702.5			
Circumference just below the tip of the horn	Between valleys	2	0.695	0.35	0.13	0.88
	Within valleys	105	281.4	2.68		
	Total	107	282.1			

4. Neck and Dewlap.

Measurements of the neck taken were length and circumference, and that of the dewlap were length and width of both Achai cows and Achai bulls. In Achai cows, dewlap extends from intermandibular region just in front of the angle of the jaw and tapers at or slightly behind the brisket. The skin of the dewlap has very small folds in Achai cows. In Achai bulls, the dewlap extends from more anterior region of the intermandibular area than Achai cows but tapered at or slightly behind the brisket like Achai cows. Skin folding of the dewlap of Achai bulls is more prominent as compared to cows.

Achai cows.

The overall mean length and circumference of the neck of Achai cows was 34.92±0.52 cm and 63.41±0.54 cm respectively (Table 19). Similarly the overall mean length of the dewlap was 67.11±1.02 cm and mean width of the dewlap was 8.03±0.17 cm in Achai cows (Table 19).

The mean length and circumference of the neck and the mean length and width of the dewlap of Achai cows in Talash, Jandool and Maidan valley is given in Table 19. One-way analysis of variance (Table 20) revealed no significant difference in mean length ($F_{(2, 105)} = 0.98$; P=0.38) and mean circumference ($F_{(2, 105)} = 0.69$; P=0.49) of the neck of Achai cows among these three valleys. Similarly, no significant difference was observed in mean length ($F_{(2, 105)} = 0.25$; P=0.78) and mean width ($F_{(2, 105)} = 1.42$; P=0.25) of the dewlap of Achai cows among these three valleys.

Achai bulls.

The overall mean length and circumference of the neck of Achai bulls was 33.22±0.57 cm and 71.64±0.78 cm respectively. The overall mean length of the dewlap of Achai bulls was 76.37±0.93 cm and the overall mean width of the dewlap was 13.17±0.27 cm (Table 19).

The mean length and circumference of the neck and the mean length and width of the dewlap of Achai bulls in Talash, Jandool and Maidan valley is given in Table 19. One-way analysis of variance (Table 21) showed significant difference ($F_{(2, 105)}$ =

4.79; P=0.01) in mean neck length of Achai bulls among these three valleys. Bulls in Talash valley have significantly longer neck than bulls in Jandool valley ($t_{(70)}$ =1.99; P=0.04; Table 19) and Maidan valley ($t_{(70)}$ =2.89; P=0.005; Table 19). The difference in neck length of bulls between Jandool and Maidan valley did not differ significantly ($t_{(70)}$ =1.02; P=0.31). The difference in mean neck circumference of Achai bulls among Talash, Jandool and Maidan valley was statistically not significant ($F_{(2, 105)}$ = 1.69; P=0.19; Table 21). In case of the length and width of the dewlap, one-way analysis of variance (Table 21) revealed no significant difference in mean dewlap length ($F_{(2, 105)}$ = 1.88; P=0.16) and dewlap width ($F_{(2, 105)}$ = 1.65; P=0.19) of Achai bulls among these three valleys.

Sex differences in mean length and circumference of the neck and mean length and width of the dewlap.

Combined data of these three valleys showed that Achai cows have significantly longer ($t_{(214)}$ = 2.16; P=0.02; Table 19) but thinner ($t_{(214)}$ = 8.69; P< 0.001; Table 19) neck than Achai bulls. Significantly longer ($t_{(214)}$ = 6.68; P< 0.001; Table 19) and wider ($t_{(214)}$ = 15.57; P< 0.001; Table 19) dewlap was noted in Achai bulls as compared to Achai cows in these three valleys.

Table 19: Length and circumference of the neck, and length and width of the dewlap (cm) of Achai cows and Achai bulls in Talash, Jandool and Maidan valleys of District Lower Dir, NWFP.

Achai cattle	Variables	Talash (n=36)	Jandool (n=36)	Maidan (n=36)	Overall ♦ (n=108)
Cow	Neck length	35.56±0.93	35.33±1.01	33.87±0.84	34.92±0.52
	Neck circumference	62.80±0.99	62.80±0.99	64.30±0.94	63.41±0.54
	Dewlap length	66.39±1.68	66.84±1.76	68.11±1.93	67.11±1.02
	Dewlap width	7.67±0.31	7.99±0.40	8.42±0.19	8.03±0.17
Bull	Neck length	35.55±1.14	32.68±0.87 ^{a*}	31.44±0.84 ^{a**}	33.22±0.57 ^{c*}
	Neck circumference	72.78±1.27	72.51±1.55	69.64±1.15	71.64±0.78 ^{c***}
	Dewlap length	77.50±1.90	77.77±1.55	73.85±1.29	76.37±0.93 ^{c***}
	Dewlap width	13.56±0.52	13.47±0.54	12.46±0.33	13.17±0.27 ^{c***}

Mean±SE
n= Number of Achai cows or Achai bulls.
a= Talash vs Jandool and Maidan
b= Jandool valley vs Maidan valley.
♦c =The overall mean length and circumference of the neck and length and width of the dewlap of Achai cows vs bulls (based on combined data of all the three valleys).
$P \leq 0.05^{*}$, $P \leq 0.01^{**}$, $P \leq 0.001^{***}$

Table 20: One-way analysis of variance showing differences in mean length and circumference of neck and mean length and width of dewlap of Achai cows among Talash, Jandool and Maidan valleys of District Lower Dir, NWFP.

Variables	Source of variation	df	SS	MS	F	P
Neck length	Between valleys	2	60.57	30.29	0.98	0.38
	Within valleys	105	3247	30.92		
	Total	107	3307			
Neck circumference	Between valleys	2	44.59	22.29	0.69	0.49
	Within valleys	105	3348	31.89		
	Total	107	3393			
Dewlap length	Between valleys	2	57.57	28.79	0.25	0.78
	Within valleys	105	12160	115.80		
	Total	107	12220			
Dewlap width	Between valleys	2	10.08	5.04	1.42	0.25
	Within valleys	105	372.2	3.54		
	Total	107	382.3			

Table 21: One-way analysis of variance showing differences in mean length and circumference of neck and length and width of dewlap of Achai bulls among Talash, Jandool and Maidan valleys of District Lower Dir, NWFP.

Variables	Source of variation	df	SS	MS	F	P
Neck length	Between valleys	2	319.8	159.90	4.79	0.01
	Within valleys	105	3499	33.32		
	Total	107	3818			
Neck circumference	Between valleys	2	218.3	109.10	1.69	0.19
	Within valleys	105	6748	64.27		
	Total	107	6966			
Dewlap length	Between valleys	2	345	172.50	1.88	0.16
	Within valleys	105	9639	91.80		
	Total	107	9984			
Dewlap width	Between valleys	2	26.67	13.34	1.65	0.19
	Within valleys	105	849.40	8.09		
	Total	107	876.00			

5. Hump.

Measurements (height and circumference) of the hump were taken only in Achai bulls because in Achai cows the hump was very small and no measurements were taken.

Achai bulls.

Hump was cervico-thoracic in position. The overall mean height (from base to apex) and circumference (measured at the central point from base to apex) of the hump was 11.38±0.20 cm and 57.44±0.85 cm respectively (Table 22).

The mean height and circumference of the hump of Achai bulls in Talash, Jandool and Maidan valley is shown in Table 22. One-way analysis of variance (Table 23) revealed no significant ($F_{(2,105)}$ =1.44; P=0.24) difference in mean height and circumference ($F_{(2,105)}$ =1.01; P=0.37) of the hump of bulls among these three valleys.

Table 22: Mean height and circumference (cm) of the hump of Achai bull in Talash, Jandool and Maidan valleys of District Lower Dir, NWFP.

Variables	Talash (n=36)	Jandool (n=36)	Maidan (n=36)	Overall (n=108)
Hump height	11.08±0.34	11.20±0.34	11.85±0.34	11.38±0.20
Hump circumference	56.48±1.32	58.86±1.29	56.99±1.78	57.44±0.85

Mean±SE
n= Number of Achai bulls.

Table 23: One-way analysis of variance showing differences in mean height and circumference of the hump of Achai bulls among Talash, Jandool and Maidan valleys of District Lower Dir, NWFP.

Variables	Source of variation	df	SS	MS	F	P
Hump height	Between valleys	2	12.17	6.08	1.44	0.24
	Within valleys	105	442.1	4.21		
	Total	107	454.2			
Hump circumference	Between valleys	2	113.9	56.97	1.01	0.37
	Within valleys	105	5931	56.49		
	Total	107	6045			

6. Back and rump.

The measurements of the back region taken were chine length and loin length, whereas, that of the rump were rump length and rump width in both Achai cows and bulls. Rump is slightly concave and sloped caudally in both Achai cows and Achai bulls. Rump of the Achai bulls is fleshier than that of the cow. However, pin bones are always lower than hipbones in both Achai cows and Achai bulls.

Achai cows.

The overall mean chine length and loin length of Achai cows was 36.81±0.37 and 33.28±0.45 cm respectively whereas, the overall mean rump length of Achai cows was 30.92±0.38 cm and rump width was 30.55±0.27 cm (Table 24).

The mean chine length, loin length, rump length and rump width of Achai cows in Talash, Jandool and Maidan valley is given in Table 24. One-way analysis of variance revealed (Table 25) significant difference in mean chine length ($F_{(2, 105)} = 3.78$; P=0.03) and loin length ($F_{(2, 105)} = 3.75$; P=0.03) of Achai cows among these three valleys. Cows in Jandool valley have significantly longer chine than cows in Talash valley ($t_{(70)} = 2.60$; P=0.01; Table 24) and Maidan valley ($t_{(70)} = 2.02$; P=0.04; Table 24). However, the difference in mean chine length of Achai cows between Talash and Maidan valley was not significant ($t_{(70)} = 0.53$; P=0.59). Regarding the loin length, Achai cows in Maidan valley have significantly ($t_{(70)} = 2.80$; P=0.006; Table 24) longer loin than cows in Talash valley, whereas, the difference in loin length of cows between Talash and Jandool valley ($t_{(70)} = 1.60$; P=0.11) and Jandool and Maidan valley ($t_{(70)} = 1.08$; P=0.28) was statistically not significant.

On the other hand, no significant difference was observed in mean rump length ($F_{(2,105)} = 0.13$; P=0.88; Table 25) and rump width ($F_{(2,105)} = 0.25$; P=0.78; Table 25) of Achai cows among these three valleys.

Achai bulls.

The overall mean chine length and loin length of Achai bulls was 39.66±0.48 cm and 29.44±0.27 cm respectively (Table 24). The overall mean rump length of Achai bulls was 33.45±0.32 cm and rump width was 27.72±0.29 cm (Table 24).

The mean chine length, loin length, rump length and rump width of Achai bull in Talash, Jandool and Maidan valley is given in Table 24. One-way analysis of variance (Table 26) showed no significant difference in mean chine length ($F_{(2,\ 105)}$ = 0.31; P=0.73) of Achai bulls between these three valleys. However, mean loin length of Achai bulls differed significantly ($F_{(2,\ 105)}$ = 5.20; P=0.007; Table 26) among these three valleys. Bulls in Talash valley have significantly ($t_{(70)}$ =3.23; P=0.001; Table 24) longer loin than bulls in Maidan valley. However, the difference in mean loin length of Achai bulls between Talash and Jandool valley ($t_{(70)}$ =1.81; P=0.07; Table 24) and Jandool and Maidan valley ($t_{(70)}$ =1.36; P=0.18; Table 24) was statistically not significant.

Mean rump length of Achai bulls vary significantly ($F_{(2,105)}$ = 4.99; P=0.008; Table 26) among these three valleys. Bulls in Maidan valley have significantly short rump than bulls in Talash valley ($t_{(70)}$ =2.93; P=0.004; Table 24) and Jandool valley ($t_{(70)}$ =2.41; P=0.02; Table 24), whereas the difference in rump length of bulls between Talash and Jandool valley was statistically not significant ($t_{(70)}$ =0.45; P=0.65). Rump width of Achai bulls also showed no significant ($F_{(2,105)}$ =1.85; P=0.16; Table 26) among these three valleys.

Sex differences in chine length, loin length, rump length and rump width.

Based on combined data of all the three valleys, it was observed that Achai bulls have significantly longer chine ($t_{(214)}$ =4.69; P<0.001) but shorter loin ($t_{(214)}$ =7.38; P<0.001) than Achai cows in these three valleys. Similarly Achai bulls also have significantly longer ($t_{(214)}$ =5.06; P<0.001) but narrow rump ($t_{(214)}$ =7.07; P<0.001) than Achai cows.

Table 24: Measurements (cm) of back region (chine and loin length) and rump (length and width) of Achai cows and bulls in Talash, Jandool and Maidan valleys of District Lower Dir, NWFP.

Achai cattle	Variables	Talash (n=36)	Jandool (n=36)	Maidan (n=36)	Overall ♦ (n=108)
Cow	Chine length	35.86±0.60	38.23±0.68 ^{a**}	36.33±0.65 ^{b*}	36.81±0.37
	Loin length	31.73±0.73	33.47±0.80	34.65±0.74 ^{a**}	33.28±0.45
	Rump length	30.75±0.65	31.19±0.66	30.80±0.71	30.92±0.38
	Rump width	30.30±0.43	30.57±0.50	30.77±0.46	30.55±0.27
Bull	Chine length	40.20±0.91	39.38±0.93	39.41±0.64	39.66±0.48 ^{c***}
	Loin length	30.51±0.49	29.30±0.45	28.50±0.38 ^{a***}	29.44±0.27 ^{c***}
	Rump length	34.31±0.50	33.97±0.54	32.08±0.57 $^{a**\ b*}$	33.45±0.32 ^{c***}
	Rump width	28.32±0.62	27.87±0.47	26.97±0.40	27.72±0.29 ^{c***}

Mean±SE
n= Number of Achai cows or Achai bulls.
a= Talash vs Jandool and Maidan.
b= Jandool vs Maidan.
♦c =The overall mean chine length, loin length, rump length and rump width of Achai cows vs bulls (based on combined data of all the three valleys).
$P \leq 0.05^{*}$, $P \leq 0.01^{**}$, $P \leq 0.001^{***}$

Table 25: One-way analysis of variance showing differences in mean loin length, loin width, rump length and rump width of Achai cows among Talash, Jandool and Maidan valleys of District Lower Dir, NWFP.

Variables	Source of variation	df	SS	MS	F	P
Chine	Between valleys	2	113.4	56.70	3.78	0.03
	Within valleys	105	1575	15.00		
	Total	107	1688			
Loin length	Between valleys	77.84	155.7	3.75	3.75	0.03
	Within valleys	105	2177	20.74		
	Total	107	2333			
Rump length	Between valleys	2	4.14	2.071	0.13	0.88
	Within valleys	105	1707	16.25		
	Total	107	1711			
Rump width	Between valleys	2	3.915	1.957	0.25	0.78
	Within valleys	105	821.4	7.822		
	Total	107	825.3			

Table 26: One-way analysis of variance showing differences in mean chine length, loin length, rump length and rump width of Achai bulls among Talash, Jandool and Maidan valleys of District Lower Dir, NWFP.

Variables	Source of variation	df	SS	MS	F	P
Chine	Between valleys	2	15.62	7.81	0.31	0.73
	Within valleys	105	2657	25.30		
	Total	107	2673			
Loin length	Between valleys	2	73.94	36.97	5.20	0.007
	Within valleys	105	746.1	7.11		
	Total	107	820.0			
Rump length	Between valleys	2	104.1	52.04	4.99	0.008
	Within valleys	105	1095	10.43		
	Total	107	1199			
Rump width	Between valleys	2	34.19	17.10	1.85	0.16
	Within valleys	105	967.5	9.21		
	Total	107	1002			

7. Legs.

The legs of Achai cows and Achai bulls are short, slim but strongly built. Front legs are straight whereas hind legs have medium angularity. The measurements taken for this study were length of the front leg below knee joint and circumference of the hoof of both Achai cow and Achai bulls.

Achai cows.

The overall mean length of the front leg below knee joint was 26.93±0.31 cm and the overall mean circumference of the hoof was 27.94±0.36 cm (Table 27). The mean length of the front leg below knee joint and mean circumference of the hoof of Achai cows in Talash, Jandool and Maidan valley is shown in Table 27. One-way analysis of variance (Table 28) showed no significant difference in mean length of the front leg below knee joint ($F_{(2, 105)} = 0.49$; P=0.62) and mean circumference of the hoof ($F_{(2, 105)} = 0.13$; P=0.88) of Achai cows among these three valleys.

Achai bulls.

In Achai bulls, the overall mean length of the front leg below knee joint was 27.94±0.15 cm and mean circumference of the hoof was 33.49±0.17 cm (Table 27). The mean length of the front leg below knee joint and mean circumference of the hoof of Achai bulls in Talash, Jandool and Maidan valley is presented in Table 27. One-way analysis of variance (Table 29) revealed significant ($F_{(2, 105)} = 4.06$; P=0.02) difference in mean length of the front leg below knee joint among these three valleys. Bulls in Talash valley have significantly ($t_{(70)} = 2.67$; P=0.009; Table 27) higher values for length of the front leg below knee joint than bulls in Maidan valley. However, the difference in mean length of the front leg below knee joint of bulls of Talash and Jandool valley ($t_{(70)} = 1.19$; P=0.23) and Jandool and Maidan valley ($t_{(70)} = 1.70$; P=0.09) was statistically non-significant. Statistical analysis also revealed non-significant ($F_{(2, 105)} = 2.03$; P=0.14; Table 29) difference in mean circumference of the hoof of Achai bulls among these three valleys.

Sex differences in length below knee joint and hoof circumference.

Combined data of all the three valleys showed that Achai bulls have significantly higher values for length of the front leg below knee joint ($t_{(214)} = 5.32$; P<0.001; Table 27) and hoof circumference ($t_{(214)} = 13.87$; P<0.001; Table 27) than Achai cows.

Table 27: Mean length of the front leg below knee joint (cm) and mean circumference of the hoof (cm) of Achai cows and Achai bulls in Talash, Jandool and Maidan valleys of District Lower Dir, NWFP.

Achai cattle	Variables	Talash (n=36)	Jandool (n=36)	Maidan (n=36)	Overall ♦ (n=108)
Cow	Length of the front leg below knee joint	27.06±0.26	26.97±0.24	26.75±0.17	26.93±0.31
	Hoof circumference	28.19±0.62	27.88±0.58	27.75±0.71	27.94±0.36
Bull	Length of the front leg below knee joint	28.39±0.24	28.01±0.21	27.41±0.28 [a**]	27.94±0.15 [c***]
	Hoof circumference	33.56±0.36	33.04±0.18	33.86±0.31	33.49±0.17 [c***]

Mean±SE
n= Number of Achai cows or Achai bulls
a= Talash vs Jandool and Maidan
b= Jandool vs Maidan.
♦c=The overall mean length of the leg below knee joint and circumference of the hoof of Achai cows vs bulls (based on combined data of all the three valleys).
$P \leq 0.05$*, $P \leq 0.01$**, $P \leq 0.001$***

Table 28: One-way analysis of variance showing differences in mean length of the front leg below knee joint and hoof circumference of Achai cows among Talash, Jandool and Maidan valleys of District Lower Dir, NWFP.

Variables	Source of variation	df	SS	MS	F	P
Length of the front leg below knee joint	Between valleys	2	1.795	0.90	0.49	0.62
	Within valleys	105	193.8	1.85		
	Total	107	195.6			
Hoof circumference	Between valleys	2	3.69	1.85	0.13	0.88
	Within valleys	105	1541	14.68		
	Total	107	1545			

Table 29: One-way analysis of variance showing differences in mean length of the front leg below knee joint and hoof circumference of Achai bulls among Talash, Jandool and Maidan valleys of District Lower Dir, NWFP.

Variables	Source of variation	df	SS	MS	F	P
Length of the front leg below knee joint	Between valleys	2	17.83	8.916	4.06	0.02
	Within valleys	105	230.60	2.196		
	Total	107	248.40			
Hoof circumference	Between valleys	2	12.62	6.312	2.03	0.14
	Within valleys	105	326.60	3.110		
	Total	107	339.20			

8. Tail and switch of the tail.

Measurements taken were length of the tail and length of the switch of the tail in both Achai cows and Achai bulls.

Achai cows.

The overall mean length of the tail was 78.81±1.03 cm and the overall mean length of the switch of the tail was 21.65±0.89 cm in Achai cows (Table 30).

The mean length of the tail and mean length of the switch of the tail of Achai cows in Talash, Jandool and Maidan valley is given in Table 30. One-way analysis of variance (Table 31) showed no significant ($F_{(2,105)}$ = 1.08; P=0.34) difference in mean length of the tail but length of the switch vary significantly ($F_{(2,105)}$ = 4.44; P=0.01) among these three valleys. Cows in Maidan valley have significantly short length of the switch than cows in Jandool valley ($t_{(70)}$ =2.20; P=0.03; Table 30) and Talash valley ($t_{(70)}$ =2.94; P=0.004; Table 30). The difference in switch length of cows between Talash and Jandool valley was statistically not significant ($t_{(70)}$ =0.51; P=0.61).

Achai bulls.

The overall mean length of the tail and overall mean length of the switch of the tail of Achai bulls was 95.06±0.60 cm and 32.44±0.44 cm respectively (Table 30).

The mean length of the tail and mean length of the switch of the tail of Achai bulls in Talash, Jandool and Maidan valley is presented in Table 30. One-way analysis of variance (Table 32) revealed no significant difference ($F_{(2, 105)}$ = 0.43; P=0.65) in mean length of the tail of Achai bulls among these three valleys. However, the mean length of the switch vary significantly $F_{(2,105)}$ = 4.50; P=0.01; Table 32) among these three valleys. Bulls in Talash valley have longer switch than bulls in Maidan valley ($t_{(70)}$ =2.69; P=0.009; Table 30). The difference in mean switch length of Achai bulls between Talash and Jandool valley ($t_{(70)}$ =1.07; P=0.29) and Jandool and Maidan valley ($t_{(70)}$ =1.65; P=0.10) was statistically not significant.

Sex differences in tail length and switch length.

Achai bulls have significantly longer tail ($t_{(214)}$ =13.32; P<0.001; Table 30) and longer switch ($t_{(214)}$ =10.78; P<0.001; Table 30) than Achai cows in these three valleys.

Table 30: Length of the tail and length of the switch of the tail of Achai cows and Achai bulls in Talash, Jandool and Maidan valleys of District Lower Dir, NWFP.

Achai cattle	Variables	Talash (n=36)	Jandool (n=36)	Maidan (n=36)	Overall ♦ (n=108)
Cow	Length of the tail	76.76±1.61	79.16±1.67	80.52±2.16	78.81±1.03
	Length of the switch of the tail	24.01±1.39	22.91±1.64	18.04±1.48 [a**b*]	21.65±0.89
Bull	Length of the tail	95.69±1.26	95.16±0.99	94.33±0.84	95.06±0.60 [c***]
	Length of the switch of the tail	33.87±0.95	32.69±0.55	30.76±0.65 [a**]	32.44±0.44 [c***]

Mean±SE
n= Number of Achai cows or Achai bulls.
a= Talash vs Jandool and Maidan
b= Jandool vs Maidan.
♦c=The overall mean length of the tail and length of the switch of the tail of Achai cows vs bulls (based on combined data of all the three valleys).
$P \leq 0.05$*, $P \leq 0.01$**, $P \leq 0.001$***

Table 31: One-way analysis of variance showing differences in mean tail and switch length of Achai cows among Talash, Jandool and Maidan valleys of District Lower Dir, NWFP.

Variables	Source of variation	df	SS	MS	F	P
Tail length	Between valleys	2	261.5	130.7	1.08	0.34
	Within valleys	105	12670	120.7		
	Total	107	12930			
Switch length	Between valleys	2	725.7	362.8	4.44	0.01
	Within valleys	105	8586	81.78		
	Total	107	9312			

Table 32: One-way analysis of variance showing differences in mean tail and switch length of Achai bulls among Talash, Jandool and Maidan valleys of District Lower Dir, NWFP.

Variables	Source of variation	df	SS	MS	F	P
Tail length	Between valleys	2	33.95	16.98	0.43	0.65
	Within valleys	105	4142	39.45		
	Total	107	4176			
Switch length	Between valleys	2	177.2	88.61	4.50	0.01
	Within valleys	105	2066	19.67		
	Total	107	2243			

Productive performance.

Productive performance studies included standard 305-day milk yield of Achai cows and birth weight of male and female calves.

Standard 305-day milk yield.

The overall mean standard 305-day milk yield of Achai cow was 1426.31±30.23 liters ranging from 627.09 to 2017.19 liters. Standard 305-day milk yield of Achai cow was studied according to valley (Talash, Jandool, Maidan), parity (first, second, third) and season (spring, summer, autumn, winter).

Valley: Milk yield of Achai cows on the basis of standard 305-day lactation period was calculated from first to third parity in Talash, Jandool and Maidan valley and is presented in Table 33. Mean milk yield in all the parities combined together showed lowest milk yield in Talash valley and highest milk yield in Jandool valley. Mean milk yield in all the parities in Talash valley was significantly less than in Jandool ($t_{(70)}$ = 5.31; P<0.0001; Table 33) and Maidan valley ($t_{(70)}$ =3.98; P=0.0002; Table 33). However, there was no significant difference in mean milk yield of Achai cows between Jandool and Maidan valleys ($t_{(70)}$ = 0.97; P=0.34).

Parity: Standard 305-day milk yield in relation to parity in Talash, Jandool and Maidan valley is given in Table 33. In the first parity the lowest mean milk yield was in Talash valley and the highest was in Jandool valley. In first parity compared to Talash valley significantly higher milk yield was in Jandool valley ($t_{(22)}$ =3.78; P=0.001; Table 33) and Maidan valley ($t_{(22)}$ = 3.10; P=0.005; Table 33). There was no significant difference in milk yield in comparison of Jandool valley with Maidan valley ($t_{(22)}$ = 0.27; P=0.78). In second parity the highest mean milk yield was in Jandool valley and the lowest in Talash valley. In second parity milk yield in Jandool valley was significantly higher than in Talash valley ($t_{(22)}$ = 2.66; P=0.01; Table 33). Milk yield in second parity in Maidan valley was not significantly different from Talash ($t_{(22)}$ = 1.92; P=0.07) and Jandool valley ($t_{(22)}$ = 0.65; P= 0.52). In third parity, the lowest milk yield was in Talash valley and highest in Jandool valley. Compared to Talash valley significantly higher milk yield was in Jandool ($t_{(22)}$ = 2.76; P= 0.01; Table 33). There was no significant difference in mean milk yield in Maidan compared to Talash ($t_{(22)}$ =1.88; P= 0.07) and Jandool valley ($t_{(22)}$ = 0.73; P= 0.47).

Regression analysis of variance (Table 34) revealed no significant difference in mean 305-day milk yield of Achai cows among the three parities in Talash (b= 65.19±27.63; $F_{(1, 1)}$ = 5.57; P=0.25), Jandool (b= 20.60±25.72; $F_{(1, 1)}$ = 0.64; P=0.57) and Maidan valley (b= - 3.25±19.18; $F_{(1, 1)}$ = 0.03; P=0.89).

Season: Mean milk yield of Achai cows calved during different seasons and calving percentage in these seasons in the three valleys is given in Table 35. The highest mean milk yield in Talash (1260.04±142.91 liters), Jandool (1719.15±45.28 liters) and Maidan valley (1659.55±99.00 liters) was seen in cows calved in spring season and the lowest milk yield in Talash (1009.77 liters), Jandool (1459.91 liters) and Maidan valley (1387.59±171.49 liters) was observed in cows calved in autumn season. Regression analysis of variance (Table 36) showed no significant difference in mean 305-day milk yield of Achai cows in different seasons of the year in Talash (b= - 59.34±47.34; $F_{(1, 2)}$ =1.57; P=0.34), Jandool (b= - 43.26±56.36; $F_{(1, 2)}$ =0.59; P=0.52) and Maidan valley (b= - 76.84±35.51; $F_{(1, 2)}$ = 4.68; P=0.16).

The highest percentage of calving was observed in all the three valleys in summer season and the lowest calving percentage was in autumn season. No correlation was observed between the percentage of calving and milk yield in Talash (b=3.36±2.64; $F_{(1, 2)}$ = 1.62; P= 0.33; Table 37), Jandool (b= - 0.22±4.10; $F_{(1, 2)}$ = 0.003; P=0.96; Table 37) and Maidan valley (b=0.85±4.31; $F_{(1, 2)}$ =0.04; P=0.86; Table 37).

Table 33: Standard 305-day milk yield (liters) of Achai cows in first, second and third parity in Talash, Jandool and Maidan valleys of District Lower Dir, NWFP

	Valleys		
Parity	Talash	Jandool	Maidan
First	1135.90± 75.48 (12)	1524.69±69.98 [a * * *] (12)	1493.93±87.34 [a * *] (12)
Second	1248.95±115.21 (12)	1589.83±55.75 [a * *] (12)	1523.91±85.40 (12)
Third	1266.28± 83.55 (12)	1565.89±69.17 [a * *] (12)	1487.43±82.36 (12)
Mean	1217.04± 53.05 (36)	1560.14±36.88 [a * * *] (36)	1501.76±47.76 [a * * *] (36)

Mean±SE
( ) = Number of cows
a= Talash vs Jandool and Maidan
b= Jandool vs Maidan
$P \leq 0.05$*, $P \leq 0.01$**, $P \leq 0.001$***

Table 34: Regression analysis of variance of 305-day milk yield of Achai cows on parity in Talash, Jandool and Maidan valleys of District Lower Dir, NWFP.

Valley			df	SS	MS	F	P
Talash	b = 65.19±27.63	Regression	1	8499.47	8499.47	5.57	0.25
		Residual	1	1526.41	1526.41		
		Total	2	10025.89			
Jandool	b= 20.60±25.72	Regression	1	848.72	848.72	0.64	0.57
		Residual	1	1322.54	1322.54		
		Total	2	2171.26			
Maidan	b= - 3.25±19.18	Regression	1	21.09	21.09	0.03	0.89
		Residual	1	736.32	736.32		
		Total	2	757.41			

Table 35: Standard 305-day milk yield (liters) of Achai cows calved in spring, summer, autumn and winter season in Talash, Jandool and Maidan valleys of District Dir Lower, NWFP.

	Valleys								
	Talash			Jandool			Maidan		
Season	305-day milk	C P	n	305-day milk	C P	n	305-day milk	C P	n
Spring	1260.04±142.91	19.44	7	1719.15±45.28	25.00	9	1659.55± 99.00	19.44	7
Summer	1244.35± 61.33	58.33	21	1487.76±45.28	52.78	19	1485.82± 58.32	52.78	19
Autumn	1009.77	5.56	2	1459.91	05.56	2	1387.59±171.49	8.33	3
Winter	1140.41±148.99	16.67	6	1584.24±96.05	16.67	6	1436.16±144.27	19.44	7

C P= Calving percentage,

n= Number of cows

Table 36: Regression analysis of variance of 305-day milk yield of Achai cows on season in Talash, Jandool and Maidan valleys of District Dir Lower, NWFP.

Valleys			df	SS	MS	F	P
Talash	b= - 59.35±47.34	Regression	1	17610.33	17610.33	1.57	0.34
		Residual	2	22412.34	11206.17		
		Total	3	40022.67			
Jandool	b= - 43.26±56.36	Regression	1	9356.27	9356.27	0.59	0.52
		Residual	2	31766.07	15883.04		
		Total	3	41122.34			
Maidan	b= - 76.84±35.51	Regression	1	29521.93	29521.93	4.68	0.16
		Residual	2	12608.51	6304.25		
		Total	3	42130.44			

Table 37: Regression analysis of variance of 305-day milk yield on percentage calving of Achai cows in Talash, Jandool and Maidan valley of District Lower Dir, NWFP.

Valleys			df	SS	MS	F	P
Talash	b= 3.36±2.64	Regression	1	17936.50	17936.50	1.62	0.33
		Residual	2	22086.17	11043.08		
		Total	3	40022.67			
Jandool	b = - 0.22±4.10	Regression	1	56.75	56.75	0.003	0.96
		Residual	2	41065.59	20532.80		
		Total	3	41122.34			
Maidan	b= 0.85±4.31	Regression	1	808.13	808.13	0.04	0.86
		Residual	2	41322.31	20661.15		
		Total	3	42130.44			

Birth weight.

Male Achai calves.

The overall mean birth weight of male Achai calves was 16.88±0.27 kg ranging from 12.50 to 21.00 kg. Birth weight of male Achai calves was studied according to valley (Talash, Jandool, Maidan), parity (first, second, third) and season (spring, summer, autumn, winter).

Valley: Mean birth weight of male Achai calves in Talash, Jandool and Maidan valley is presented in Table 38. Mean birth weight of male Achai calves was 17.50±0.43 kg in Talash valley, 16.40±0.50 kg in Jandool valley and 16.74±0.48 kg in Maidan valley and there was no significant ($F_{(2, 56)}$ = 1.46; P=0.24; Table 39) difference in mean birth weight of male Achai calves among these three valleys.

Parity: Mean birth weight of male Achai calves born in first, second and third parity in Talash, Jandool and Maidan valley is shown in Table 38.

In Talash valley the highest mean birth weight of male calves was in third parity and the lowest was in first parity. A significant increase (b=0.28±0.003; $F_{(1, 1)}$ = 9747; P=0.006; Table 40) in mean birth weight of male calves was observed with ascending parity in Talash valley.

In Jandool valley a similar pattern like Talash valley was seen with the highest mean birth weight in third parity and lowest in first parity. Mean birth weight showed significant (b=0.16±0.006; $F_{(1, 1)}$ = 768; P=0.02; Table 40) increase with increase in parity number in this valley.

In Maidan valley the highest mean birth weight of male calves was in second parity and the lowest mean birth weight was in third parity. Regression analysis of variance revealed no significant (b= - 0.245±0.286; $F_{(1, 1)}$ = 0.73; P= 0.55; Table 40) difference in mean birth weight of male calves among these three parities.

Season: Mean birth weight of male Achai calves born in spring, summer, autumn and winter seasons in Talash, Jandool and Maidan valley is shown in Table 41. No statistical analysis was applied to the data on birth weight of male Achai calves due to insufficient number of records of birth weight in autumn season.

Table 38: Birth weight (kg) of male Achai calves born in first, second and third parity in Talash, Jandool and Maidan valleys of District Lower Dir, NWFP.

	Valleys					
Parity	Talash		Jandool		Maidan	
First	17.21±0.70	(07)	16.25±0.86	(08)	16.33±1.30	(06)
Second	17.50±1.07	(06)	16.40±1.33	(05)	17.10±0.40	(05)
Third	17.78±0.56	(07)	16.57±0.68	(07)	16.36±0.49	(07)
Mean	17.50±0.43	(20)	16.40±0.50	(20)	16.74±0.48	(19)

Mean±SE
( ) =Number of calves.

Table 39: One-way analysis of variance showing differences in mean birth weight of male Achai calves between Talash, Jandool and Maidan valleys of District Lower Dir, NWFP.

Source of variation	df	SS	MS	F	P
Between valleys	2	12.6853	6.3426	1.46	0.24
Within valleys	56	243.9842	4.3568		
Total	58	256.6695			

Table 40: Regression analysis of variance of birth weight of male Achai calves on parity in Talash, Jandool and Maidan valleys of District Lower Dir, NWFP.

Valley			df	SS	MS	F	P
Talash	b= 0.28±0.003	Regression	1	0.162450	0.162450	9747	0.006
		Residual	1	0.000016	0.000016		
		Total	2	0.162467			
Jandool	b= 0.16±0.006	Regression	1	0.051200	0.051200	768	0.02
		Residual	1	0.000067	0.000067		
		Total	2	0.051267			
Maidan	b= - 0.25±0.286	Regression	1	0.12005	0.12005	0.73	0.55
		Residual	1	0.16335	0.16335		
		Total	2	0.28340			

Table 41: Birth weight (kg) of male Achai calves born in spring, summer, autumn and winter season in Talash, Jandool and Maidan valleys of District Lower Dir, NWFP.

	Valleys					
Seasons	Talash		Jandool		Maidan	
Spring	17.83±1.09	(03)	16.62±1.49	(04)	17.25±0.85	(04)
Summer	17.14±0.70	(11)	16.50±0.79	(09)	15.94±0.98	(08)
Autumn	19.00	(01)	14.50	(02)	17.50	(02)
Winter	17.90±0.43	(05)	16.80±0.83	(05)	17.30±0.46	(05)

Mean±SE
( ) = number of calves.

Female Achai calves.

The overall mean birth weight of female Achai calves was 14.46±0.24 kg ranging from 12.00 to 17.50 kg. Birth weight of female Achai calves was studied according to valley (Talash, Jandool, Maidan), parity (first, second, third) and season (spring, summer, autumn, winter).

Valley: Mean birth weight of female Achai calves in Talash, Jandool and Maidan valley is shown in Table 42. Mean birth weight of female Achai calves was 14.30±0.46 kg in Talash, 14.46±0.45 kg in Jandool and 14.62±0.37 kg in Maidan valley. One-way analysis of variance revealed no significant ($F_{(2, 42)}$ = 0.15; P=0.86; Table 43) difference in birth weight of female Achai calves among these three valleys.

Parity: Birth weight of female Achai calves born in first, second and third parity in Talash, Jandool and Maidan valley is given in Table 42. Regression analysis of variance (Table 44) showed no significant difference in mean birth weight of female Achai calves among these three parities in Talash (b= - 0.04±0.19; $F_{(1, 1)}$ = 0.04; P=0.87), Jandool (b= 0.73±0.67; $F_{(1, 1)}$ = 1.16; P=0.47) and Maidan valley (b= 0.10±1.19; $F_{(1, 1)}$ = 0.007; P=0.95).

Season: Birth weight of female Achai calves born in different seasons of the year in Talash, Jandool and Maidan valley is given in Table 45. No statistical analysis was applied to the data on birth weight of female Achai calves due to insufficient number of records of birth weight in autumn and winter seasons.

Table 42: Birth weight (kg) of female Achai calves born in first, second and third parity in Talash, Jandool and Maidan valleys of District Lower Dir, NWFP.

	Valleys					
Parity	Talash		Jandool		Maidan	
First	14.20±0.97	(05)	14.37±1.05	(04)	15.30±0.73	(05)
Second	14.50±0.56	(06)	13.93±0.54	(07)	13.33±0.25	(06)
Third	14.12±1.18	(04)	15.83±0.88	(03)	15.50±0.45	(05)
Mean	14.30±0.46	(15)	14.46±0.45	(14)	14.62±0.37	(16)

Mean±SE
( ) = number of calves

Table 43: One-way analysis of variance showing differences in mean birth weight of female Achai calves among Talash, Jandool and Maidan valley of Lower Dir.

Source of variation	df	SS	MS	F	P
Between valleys	2	0.8178	0.4089	0.15	0.86
Within valleys	42	115.8821	2.7590		
Total	44	116.7000			

Table 44: Regression analysis of variance of birth weight of female Achai calves on parity in Talash, Jandool and Maidan valleys of District Lower Dir, NWFP.

Valley			df	SS	MS	F	P
Talash	b= - 0.04±0.19	Regression	1	0.0032	0.0032	0.04	0.87
		Residual	1	0.0770	0.0770		
		Total	2	0.0802			
Jandool	b= 0.73±0.67	Regression	1	1.06	1.06	1.16	0.47
		Residual	1	0.92	0.91		
		Total	2	1.97			
Maidan	b= 0.10±1.19	Regression	1	0.02	0.02	0.007	0.95
		Residual	1	2.56	1.99		
		Total	2	2.87			

Table 45: Birth weight (kg) of female Achai calves born in spring, summer, autumn and winter season in Talash, Jandool and Maidan valleys, Lower Dir.

	Valleys					
Season	Talash		Jandool		Maidan	
Spring	14.50±0.91	(04)	13.75±0.95	(04)	14.83±0.83	(03)
Summer	14.72±0.92	(09)	14.44±0.47	(09)	14.55±0.50	(10)
Autumn	14.00	(01)	-	-	13.00	(01)
Winter	14.00	(01)	18.00	(01)	15.50	(02)

Mean±SE, ( ) =number of calves

Effect of calf sex on birth weight.

Based on combined data of all the three valleys, the overall mean birth weight of male Achai calves was 16.88±0.27 kg and female Achai calves was 14.54±0.26 kg (Table 46). Male Achai calves were highly significantly ($t_{(102)}$ =6.11; P<0.001) heavier than female Achai calves at birth.

Comparison of mean birth weight of male and female Achai calves was carried out according to valley (Talash, Jandool, Maidan) and parity (first, second and third).

Valley: Mean birth weight of male and female Achai calves based on combined data of all the three parities in Talash, Jandool and Maidan valley is given in Table 46. Male Achai calves were highly significantly heavier than female Achai calves at birth in Talash ($t_{(33)}$ =5.01; P<0.001), Jandool ($t_{(32)}$ =2.71; P=.01) and Maidan valley ($t_{(33)}$ =3.40; P=.002).

Parity: Mean birth weight of male and female Achai calves born in first, second and third parity in Talsh, Jandool and Maidan valley is shown in Table 47. Comparison of mean birth weight of male and female calves revealed significantly heavier birth weight of male as compared to female calves in first parity ($t_{(10)}$ =2.58; P=0.02), second ($t_{(10)}$ =2.48; P=0.03) and third parity ($t_{(9)}$ =3.19; P=0.01) in Talsah valley. In Jandool valley there was no significant difference in mean birth weight of male and female Achai calves born in first ($t_{(10)}$ =1.31; P=0.22), second ($t_{(10)}$ =1.94; P=0.08) and third parity ($t_{(8)}$ =0.61; P=0.56). In Maidan valley the situation was similar to Janddol valley for first parity ($t_{(10)}$ =0.98; P=0.35) and third parity ($t_{(10)}$ =1.22; P=0.25) except second parity where male calves were significantly ($t_{(9)}$ =8.32; P<0.001) heavier than female calves at birth.

Table 46: Mean birth weight (kg) of male and female Achai calves in Talash, Jandool and Maidan valley of District Lower Dir, NWFP.

Calf sex	Valleys							
	Talash		Jandool		Maidan		Overall	
Male	17.50±0.43	(20)	16.40±0.50	(20)	16.74±0.48	(19)	16.88±0.27	(59)
Female	$14.30 \pm 0.46^{a***}$	(15)	$14.46 \pm 0.45^{a**}$	(14)	$14.62 \pm 0.37^{a**}$	(16)	$14.54 \pm 0.26^{a***}$	(45)

Mean±SE
( ) = Number of calves
a = Male vs female calves.
P≤0.05*, P≤0.01**, P≤0.001***

Table 47: Mean birth weight (kg) of male and female Achai calves born in first, second and third parity in Talash, Jandool and Maidan valleys of District Lower Dir, NWFP.

	Valleys					
	Talash		Jandool		Maidan	
Parity	Male calf	Female calf	Male calf	Female calf	Male calf	Female calf
First	17.21±0.70 (07)	14.20±0.97 ^{a*} (05)	16.25±0.86 (08)	14.37±1.05 (04)	16.33±1.30 (06)	15.30±0.73 (05)
Second	17.50±1.07 (06)	14.50±0.56 ^{b*} (06)	16.40±1.33 (05)	13.93±0.54 (07)	17.10±0.40 (05)	13.33±0.25 ^{b***}(06)
Third	17.78±0.56 (07)	14.12±1.18 ^{c**}(04)	16.57±0.68 (07)	15.83±0.88 (03)	16.36±0.49 (07)	15.50±0.45 (05)

Mean±SE
( ) = Number of calves
a = Male vs female calves, first parity.
b = Male vs female calves, second parity.
c = Male vs female calves, third parity.
P≤0.05*, P≤0.01**, P≤0.001***

Reproductive performance.

Reproductive performance of Achai cows investigated in the present study included pubertal age, postpartum anoestrus interval, conception efficiency based on percentage of Achai cows conceived after availing first, second, third, fourth and more than fourth (fifth and sixth) natural services, calving interval and dry period.

Pubertal age.

The overall mean pubertal age of Achai cows was 1147.73±18.26 days ranging from 720 to 1440 days. Mean pubertal age of cows in Talash, Jandool and Maidan valley is presented in Table 48. Analysis of variance showed no significant ($F_{(2, 94)}$ = 0.34; P= 0.71; Table 49) difference in mean pubertal age of cows among these three valleys.

Pubertal age of Achai cow was divided into four groups with an interval of 180 days (Table 50). In Talash valley the highest percentage (42.86%) of Achai cows reached puberty at the age ranging from 901-1080 days, whereas, in Jandool (48%) and Maidan valley (38.46%), the maximum percentage of Achai cows attain puberty at the age ranging from 1081-1260 days.

Table 48: Pubertal age and range (days) of Achai cows in Talash, Jandool and Maidan valleys of District Lower Dir, NWFP.

Valley	Mean	Range	No. of cows
Talash	1144.29±45.18	735-1440	21
Jandool	1161.00±22.45	720-1440	50
Maidan	1125.00±39.04	720-1440	26

±SE

Table 49: One- way analysis of variance showing difference in mean pubertal age of Achai cows among Talash, Jandool and Maidan valleys of District Lower Dir, NWFP.

Source of variation	df	SS	MS	F	P
Between valleys	2	22486.75	11243.37	0.34	0.71
Within valleys	94	3083014.00	32798.02		
Total	96	3105501.00			

Table 50: Pubertal age of Achai cows (days) in Talash, Jandool and Maidan valleys of District Lower Dir, NWFP.

	Valleys								
	Talash			Jandool			Maidan		
Interval (days)	Mean	No.	%	Mean	No.	%	Mean	No.	%
720- 900	820.00±52.91	3	14.28	740.00±20.00	3	6.00	765.00±28.72	4	15.38
901- 1080	1066.67±13.33	9	42.86	1076.25±03.75	16	32.00	1080.00± 0.00	8	30.77
1081-1260	1192.50±30.92	4	19.05	1192.50±10.09	24	48.00	1179.00±14.87	10	38.46
1261-1440	1440.00± 0.00	5	23.81	1427.14±12.86	7	14.00	1440.00±00.00	4	15.38

Postpartum anoestrus interval.

The overall mean postpartum anoestrus interval of Achai cows was 97.33±3.42 days ranging from 40 to 210 days. Postpartum anoestrus interval was studied according to valley (Talash, Jandool and Maidan), parity (parity first, second, third and fourth) and season (spring, summer, autumn and winter).

Valley: Mean postpartum anoestrus interval of Achai cows in Talash, Jandool and Maidan valley is shown in Table 51. Mean postpartum anoestrus interval was 100.00±6.33 days in Talash valley, 96.31±5.35 days in Jandool valley and 92.50±5.67 days in Maidan valley and there was no significant ($F_{(2,158)}$ =0.37; P=0.69; Table 52) difference in mean postpartum anoestrus interval among these three valleys.

Parity: Parity wise postpartum anoestrus interval in Talash, Jandool and Maidan valley is given in Table 51. In Talash valley Achai cows in first parity showed the longest mean postpartum anoestrus interval compared to cows in second, third and fourth parity. The lowest mean postpartum anoestrus interval was observed in fourth parity. Regression analysis of variance revealed significant (b= -10.06±1.49; $F_{(1, 2)}$ =45.11; P=0.02; Table 53) decrease in mean postpartum anoestrus interval from first parity to fourth parity. In Jandool valley more or less consistency in mean postpartum anoestrus interval was observed with no significant (b= 2.41±1.03; $F_{(1, 2)}$ =5.41; P=0.15; Table 53) difference in mean postpartum anoestrus interval from first to fourth parity. In Maidan valley mirror image of Talash valley was observed. Regression analysis of variance showed a non-significant (b=8.02±3.06; $F_{(1, 2)}$ =6.88; P=0.12; Table 53) increase in mean postpartum estrus interval with ascending parity.

Season: Mean postpartum anoestrus interval in relation to different seasons in Talash, Jandool and Maidan valley is shown in Table 54. Regression analysis of variance revealed no significant difference in mean postpartum anoestrus interval of Achai cows among different seasons in Talash (b= 8.92±2.95; $F_{(1, 2)}$ =9.16; P=0.09; Table 55) and Jandool valley (b= 4.25±1.23; $F_{(1, 2)}$ = 11.87; P=0.07; Table 55). However, in Maidan valley, Achai cows calved in winter season have significantly ($t_{(22)}$ = 2.50; P=0.02; Table 54) longer postpartum anoestrus interval than Achai cows calved in spring season.

Table 51: Postpartum anoestrus interval (days) of Achai cows in first, second, third and fourth parity in Talash, Jandool and Maidan valley of District Lower Dir, NWFP.

	Valleys		
Parity	Talash	Jandool	Maidan
First	118.33±33.21 (03)	90.77±10.41 (13)	75.71±11.31 (07)
Second	106.24± 9.66 (21)	97.04±10.59 (27)	95.69±10.18 (16)
Third	93.05± 9.74 (19)	98.42± 8.63 (19)	91.83± 9.15 (18)
Fourth	89.20±21.83[a*] (05)	98.33±13.76 (06)	103.71±18.03 (07)
Mean	100.00± 6.33 (48)	96.31± 5.35 (65)	92.50± 5.67 (48)

Mean±SE
( ) = number of cows
a=First parity vs second, third and fourth parity
b= Second parity vs third and fourth parity
c= Third parity vs fourth parity
P≤0.05*

Table 52: One-way analysis of variance showing differences in mean postpartum anoestrus interval of Achai cows among Talash, Jandool and Maidan valley of District Lower Dir, NWFP.

Source of variation	df	SS	MS	F	P
Between valleys	2	1350.13	675.06	0.37	0.69
Within valleys	158	290955.85	1841.49		
Total	160	292305.97			

Table 53: Regression analysis of variance of postpartum anoestrus interval on parity in Talash, Jandool and Maidan valleys of District Lower Dir, NWFP.

Valley			df	SS	MS	F	P
Talash	b= - 10.06±1.49	Regression	1	505.82	505.82	45.11	0.02
		Residual	2	22.42	11.21		
		Total	3	528.24			
Jandool	b= 2.41±1.03	Regression	1	28.94	28.94	5.41	0.15
		Residual	2	10.69	5.35		
		Total	3	39.64			
Maidan	b= 8.02±3.06	Regression	1	321.76	321.76	6.88	0.12
		Residual	2	93.46	46.73		
		Total	3	415.22			

Table 54: Postpartum anoestrus interval (days) of Achai cows calved in spring, summer, autumn and winter seasons in Talash, Jandool and Maidan valleys.

	Valley					
Season	Talash		Jandool		Maidan	
Spring	85.46±10.99	(13)	94.80± 8.87	(25)	77.28± 7.43	(18)
Summer	96.87±12.85	(08)	96.15±16.39	(13)	98.89±16.11	(09)
Autumn	95.00±27.58	(04)	99.09± 8.47	(11)	97.50±14.36	(04)
Winter	115.82±13.69	(11)	108.00± 24.37	(05)	115.50±14.36 [a *]	(06)

Mean±SE
( ) =number of cows.
a = Spring vs summer, autumn, winter
b = Summer vs autumn, winter
c = Autumn vs winter
P≤0.05*

Table 55: Regression analysis of variance of postpartum anoestrus interval on season in Talash and Jandool valleys of District Lower Dir, NWFP.

Valley			df	SS	MS	F	P
Talash	b= 8.92±2.95	Regression	1	397.92	397.92	9.16	0.09
		Residual	2	86.83	43.41		
		Total	3	484.75			
Jandool	b= 4.25±1.23	Regression	1	90.48	90.48	11.87	0.07
		Residual	2	15.25	7.62		
		Total	3	105.73			

Conception efficiency.

Data for the study of this reproductive performance was obtained for a total 276 Achai cows including 69 cows in Talash valley, 112 cows in Jandool valley and 95 cows in Maidan valley. One cow each in Talash and Jandool valley and two cows in Maidan valley were recorded that conceived on 5th service and only one cow was observed that conceived on 6th service in Jandool valley.

The percentage of Achai cows conceived after availing first, second, third fourth and more than fourth (fifth and sixth) natural service in Talash, Jandool and Maidan valley is shown in Table 56. In all the three valleys, majority of the cows conceived after first natural service and the highest percentage was observed in Jandool valley followed by Maidan and Talash valley. The percentage of cows conceived after second, third, fourth and more than fourth natural services were lesser in all the three valleys.

Table 56: Number and percentage of Achai cows conceived after availing first, second, third, fourth and more than fourth (fifth and sixth) natural services in Talash, Jandool and Maidan valleys of District Lower Dir, NWFP.

	Valleys					
	Talash		Jandool		Maidan	
Number of service provided	No.	%	No.	%	No.	%
1st service	47	68.12	81	72.32	68	71.58
2nd service	14	20.29	18	16.07	13	13.68
3rd service	5	7.24	10	8.93	9	9.48
4th and more than 4th (5th and 6th)	3	4.35	3	2.68	5	5.26
Total	69	100.00	112	100.00	95	100.00

Calving interval.

The overall mean calving interval of Achai cows was 476.37±5.17 days ranging from 360 to 720 days. Calving interval was studied according to valley (Talash, Jandool and Maidan), parity (parity first, second, third and fourth) and seasons (spring, summer, autumn and winter).

Valley: Mean calving interval of Achai cows in Talash, Jandool and Maidan valley is given in Table 57. Mean calving interval of Achai cows was 462.10±09.18 days in Talash valley, 483.36±08.01 days in Jandool valley and 480.65±09.70 days in Maidan valley and there was no significant ($F_{(2, 276)}$ = 1.56; P=0.21; Table 58) difference in mean calving interval among these three valleys.

Parity: Calving interval in relation to parity in Talash, Jandool and Maidan valley is shown in Table 57. Regression analysis of variance (Table 59) revealed no significant difference in mean calving interval of Achai cows among the four parities in Talash (b= - 2.387±7.53; $F_{(1, 2)}$ =0.10; P=0.78), Jandool (b= 11.89±14.61; $F_{(1, 2)}$ =0.66; P=0.50) and Maidan valley (b= 5.32±5.72; $F_{(1, 2)}$ =0.86; P=0.45).

Parity-wise comparison of mean calving interval between Talash, Jandool and Maidan valley revealed significantly ($t_{(75)}$ =3.03; P=0.003; Table 57) long mean calving interval of Achai cows in second parity in Talash valley as compared to Jandool valley. All other parity-wise comparisons of mean calving interval among the three valleys were statistically non-significant.

Season: Mean calving interval in relation to seasons in Talash, Jandool and Maidan valley is given in Table 60. Regression analysis of variance (Table 61) revealed no significant difference in mean calving interval of Achai cows among different seasons in Talash (b= 3.85±10.49; $F_{(1, 2)}$ = 0.13; P=0.75), Jandool (b= -8.51±4.06; $F_{(1, 2)}$ = 4.40; P=0.17) and Maidan valley (b= - 2.78±5.99; $F_{(1, 2)}$ = 0.21; P=0.69). Season-wise comparison of calving interval between Talash, Jandool and Maidan valleys showed significantly ($t_{(51)}$ = 2.30; P=0.02) long calving interval of Achai cows in spring season in Jandool valley as compared to Talash valley. All other season-wise comparison of calving interval among Talash, Jandool and Maidan valley were statistically not significant.

Table 57: Calving interval (days) of Achai cows in first, second, third and fourth parity in Talash, Jandool and Maidan valleys of District Lower Dir, NWFP.

	Valleys					
Parity	Talash		Jandool		Maidan	
First	458.33±20.78	(09)	442.50±14.87	(16)	457.50±26.44	(08)
Second	452.44±11.23	(32)	509.33±13.63 [a**]	(45)	482.90±16.06	(31)
Third	476.06±17.96	(33)	463.23±12.49	(34)	485.00±16.26	(42)
Fourth	442.50±28.13	(06)	497.50±21.04	(12)	474.54±20.95	(11)
Mean	462.10±09.18	(80)	483.36±08.01	(107)	480.65±09.70	(92)

Mean±SE
( ) =number of cows.
a= Talash vs Jandool and Maidan
b= Jandool vs Maidan
P≤0.05*, P≤0.01**, P≤0.001***

Table 58: One- way analysis of variance showing difference in mean calving interval of Achai cows among Talash, Jandool and Maidan valleys of District Lower Dir, NWFP.

Source of variation	df	SS	MS	F	P
Between valleys	2	23212.38	11606	1.56	0.21
Within valleys	276	2048740.85	7423		
Total	278	2071953.23			

Table 59: Regression analysis of variance of calving interval on parity in Talash, Jandool and Maidan valleys of District Lower Dir, NWFP.

Valley			df	SS	MS	F	P
Talash	b= - 2.387±7.53	Regression	1	28.49	28.49	0.10	0.78
		Residual	2	567.16	283.58		
		Total	3	595.65			
Jandool	b= 11.89±14.61	Regression	1	706.86	706.86	0.66	0.50
		Residual	2	2133.28	1066.64		
		Total	3	2840.14			
Maidan	b=5.32±5.72	Regression	1	141.62	141.62	0.86	0.45
		Residual	2	327.25	163.63		
		Total	3	468.87			

Table 60: Calving interval of Achai cows calved in spring, summer, autumn and winter season in Talash, Jandool and Maidan valleys, District Lower Dir, NWFP

Season	Valley					
	Talash		Jandool		Maidan	
Spring	428.75±15.51	(16)	489.73±15.68 [a *]	(37)	475.71±22.23	(21)
Summer	476.54±28.22	(13)	467.37±14.20	(19)	450.00±18.09	(12)
Autumn	456.33±25.63	(06)	475.71±10.83	(14)	454.29±22.13	(07)
Winter	448.33±16.60	(12)	458.57±26.73	(07)	465.00±20.12	(10)

Mean±SE
( ) =number of cows
a= Talash vs Jandool and Maidan
b= Jandool vs Maidan
P≤0.05*

Table 61: Regression analysis of variance of calving interval on season in Talash, Jandool and Maidan valleys of District Lower Dir, NWFP.

Valley			df	SS	MS	F	P
Talash	b= 3.85±10.49	Regression	1	74.23	74.23	0.13	0.75
		Residual	2	1099.81	549.91		
		Total	3	1174.04			
Jandool	b= - 8.51±4.06	Regression	1	362.44	362.44	4.40	0.17
		Residual	2	164.62	82.31		
		Total	3	527.06			
Maidan	b= - 2.78±5.99	Regression	1	38.75	38.75	0.21	0.69
		Residual	2	359.40	179.70		
		Total	3	398.16			

Dry period.

The overall mean dry period of Achai cows was 91.55±2.71 days ranging from 20 to180 days. Dry period was studied according to valley (Talash, Jandool and Maidan), parity (parity first, second, third and fourth) and seasons (spring, summer, autumn and winter).

Valley: Mean dry period of Achai cows in Talash, Jandool and Maidan valley is presented in Table 62. Mean dry period was 74.08± 4.57 days in Talash valley, 103.33± 4.41 days in Jandool valley and 91.69± 4.16 days in Maidan valley. One-way analysis of variance showed highly significant ($F_{(2,171)}$ =10.86; P=0.00004; Table 63) difference in mean dry period of Achai cows among Talash, Jandool and Maidan valleys. Achai cows in Talash valley have significantly shorter dry period than Achai cows in Jandool valley ($t_{(119)}$ = 4.47; P<0.001; Table 62) and Maidan valley ($t_{(100)}$ =2.85; P=0.005; Table 62). However, the difference in mean dry period of Achai cows between Jandool and Maidan valley was statistically not significant ($t_{(123)}$ =1.86; P=0.06).

Parity: According to parity, mean dry period of Achai cow in Talash, Jandool and Maidan valley is shown in Table 62. Regression analysis of variance (Table 64) revealed a non-significant decrease in mean dry period from first parity to fourth parity in Talash (b= - 4.70±2.77; $F_{(1, 2)}$ =2.89; P= 0.23), Jandool (b= - 5.42±2.49; $F_{(1, 2)}$ =4.75; P= 0.16) and Maidan valley (b= - 3.42±1.64; $F_{(1, 2)}$ = 4.36; P=0.17).

In first parity, the shortest mean dry period was in Talash valley and the longest mean dry period was in Jandool valley but the difference between the two was not significant ($t_{(13)}$ = 1.24; P=0.24). In the second parity, in Jandool valley there was significantly longer mean dry period compared to Talash valley ($t_{(53)}$ = 3.24; P=0.002; Table 62). In the third parity the picture is the same as with the second parity i.e. mean dry period in Jandool was significantly longer than in Talash valley ($t_{(35)}$= 2.08; P=0.04; Table 62). All other parity-wise comparisons for mean dry period between the three valleys were statistically not significant.

Season: Mean dry period of Achai cows in relation to different seasons of the year in Talash, Jandool and Maidan valley is given in Table 65. Regression analysis of variance (Table 66) revealed no significant difference in mean dry period of Achai cows among different seasons in Talash (b= 6.17±2.75; $F_{(1, 2)}$ = 5.03; P=0.15), Jandool (b= - 8.3±2.06; $F_{(1, 2)}$ = 16.29; P=0.06) and Maidan valley (b= -1.73±4.75; $F_{(1, 2)}$ =0.13; P= 0.75).

In Jandool valley, cows calved in spring season have significantly longer mean dry period compared to Talash valley ($t_{(37)}$ = 2.59; P=0.01; Table 65) and Maidan valley ($t_{(43)}$ = 2.62; P=0.01; Table 65). All other season-wise comparisons among the three valleys were not significant. In general Achai cows vary in mean length of dry period in the three valleys.

Table 62: Dry period of Achai cows in first, second, third and fourth parity in Talash, Jandool and Maidan valleys of District Lower Dir, NWFP.

	Valleys					
Parity	Talash		Jandool		Maidan	
First	75.00±19.36	(04)	104.54±12.53	(11)	98.57± 8.57	(07)
Second	77.04± 6.42	(22)	107.88± 4.67 ^{a**}	(33)	95.00± 7.09	(20)
Third	75.00± 8.72	(17)	101.00± 8.78 ^{a*}	(20)	86.50± 7.08	(20)
Fourth	60.00±10.95	(06)	88.75±10.43	(08)	90.00±13.42	(06)
Mean	74.08± 4.57	(49)	103.33± 4.41 ^{a***}	(72)	91.69± 4.16 ^{a**}	(53)

Mean±SE
( ) = Number of Achai cows.
a= Talash vs Jandool and Maidan
b= Jandool vs Maidan
P≤0.05*, P≤0.01**, P≤0.001***

Table 63: One- way analysis of variance showing difference in mean dry period of Achai cows among Talash, Jandool and Maidan valleys of District Lower Dir, NWFP.

Source of variation	df	SS	MS	F	P
Between valleys	2	24950.19	12475.1	10.86	0.00004
Within valleys	171	196330.8	1148.13		
Total	173	221281			

Table 64: Regression analysis of variance of dry period on parity in Talash, Jandool and Maidan valleys of District Lower Dir, NWFP.

Valley			df	SS	MS	F	P
Talash	b= - 4.70 ±2.77	Regression	1	110.64	110.64	2.89	0.23
		Residual	2	76.53	38.27		
		Total	3	187.17			
Jandool	b= - 5.42±2.49	Regression	1	147.15	147.15	4.75	0.16
		Residual	2	61.94	30.97		
		Total	3	209.09			
Maidan	b= -3.42 ±1.64	Regression	1	58.52	58.52	4.36	0.17
		Residual	2	26.83	13.41		
		Total	3	85.34			

Table 65: Dry period of Achai cows calved in spring, summer, autumn and winter season in Talash, Jandool and Maidan valleys of District Lower Dir, NWFP.

	Valleys		
Season	Talash	Jandool	Maidan
Spring	78.75± 9.62 (12)	110.00± 6.79 [a**] (27)	83.33± 7.14 [b**] (18)
Summer	73.33±15.09 (09)	108.23±11.58 (17)	93.33±11.67 (09)
Autumn	86.25±12.81 (04)	100.00±10.52 (07)	96.00±14.70 (05)
Winter	95.00± 5.00 (06)	85.00± 9.22 (06)	76.67± 7.26 (09)

Mean±SE
( ) =number of cows.
a= Talash vs Jandool and Maidan
b= Jandool vs Maidan
P≤0.05*, P≤0.01**, P≤0.001***

Table 66: Regression analysis of variance of dry period of Achai cows on season in Talash, Jandool and Maidan valleys of District Lower Dir, NWFP.

Valley			df	SS	MS	F	P
Talash	b= 6.17±2.75	Regression	1	190.16	190.16	5.03	0.15
		Residual	2	75.53	37.77		
		Total	3	265.69			
Jandool	b= - 8.3±2.06	Regression	1	344.45	344.45	16.29	0.06
		Residual	2	42.30	21.15		
		Total	3	386.75			
Maidan	b= - 1.73±4.75	Regression	1	14.98	14.98	0.13	0.75
		Residual	2	225.82	112.91		
		Total	3	240.80			

DISCUSSION

Physical characteristics

Most domestic animal species display a wide variety of coat colors which is determined by the ratio of eumelanin and pheomelanin in hair and skin (Olson, 1999; Barsh, 2001; Klungland and Vage, 2003). Higher concentration of eumelanin imparts a black coat color while increase in pheomelanin is responsible for a yellowish or reddish coat color in cattle (Seo et al., 2007).

In the present study on Achai cows and bulls in Talash, Jandool and Maidan valleys of District Lower Dir, NWFP, the dominant coat color observed was spotted reddish brown. There was no significant variation in coat color of the cows and bulls among these three valleys. Also no gender differences were observed. The reason could be the similar geographic conditions of these valleys. According to Finch and Western (1977) and Seo et al. (2007), it is the prevailing natural selective forces rather than social preferences that determine coat color of cattle. In Bhutanese yak, black coat color is considered as an adaptation to the natural environment in which it survives (Dorji and Tshering, 2006). Coat color variation in Ethiopian indigenous sheep population has been found to be highly associated with ecological variation (Gizwa et al., 2007). Achai cattle is different from Lohani cattle (Khan et al., 2005) found in Dera Ismail Khan and Bannu Districts (southern region of North West Frontier Province of Pakistan) in that the body color of Lohani cattle is red splashed with white spots. The coat color of Achai cow is reddish brown either solid or spotted but the spots are large compared to Lohani cattle and did not splash the basic coat color. Rojhan is another cattle breed found in parts of Dera Ismail Khan and Bannu Districts of North West Frontier Province of Pakistan and has red coat with white spots (Khan et al., 2005). White spots in Rojhan cattle breed are of large size as compared to Achai cows and bulls. Majority of the Achai bulls from Talash and Maidan valley have horns of light brown color at base with blackish tinge in the upper part of the horn, whereas those from Jandool valley have horns of light brown color at base with grayish in the middle and black in the upper part of the horn upto the tip. A significant (P=0.04) difference in the distribution of colors of the horns was observed in these three valleys. Nakimbugwe and Muchunguzi (2003) and Wurzinger et al. (2006) are of the view that color, size and shape of horns are among the most important phenotypic features used as selection criteria in bulls compared to cows. This is just possible that in the present study in these three valleys the farmers may have exercised their own preference in the case of horns. No significant difference was observed in the distribution of colors of the eyelashes, muzzle, hooves and switch in these three valleys both in Achai cows and Achai bulls. Sarkar et al (2007) also reported no significant variation in color pattern of coat, muzzle, eyelids, hooves and switch in Deshi cattle studied from three different agro-climatic zones of West Bengal, India.

Morphometric characteristics.

Phenotypic as well as genetic characterization of breeds of domestic animals are essential for designing appropriate breeding, management and conservation strategies particularly in developing countries (Zulu, 2008; Berthouly, 2008). Phenotypic characteristics are important in breed identification, evaluation of breeding goals, assessment of type and function of the animals and estimation of the animal value as potential breeding stock (Mwacharo and Druker, 2005; Mwacharo et al., 2006). Evaluation of morphometric characteristics periodically have also been used to identify population experiencing inbreeding depression (Zulu, 2008).

In the present study no significant difference was observed in face length, ear width, horn length (along the greater and smaller curvature), horn circumference (at the base and just below the tip of the horn), neck length and circumference, dewlap length and width, rump length and width, length below knee joint, hoof circumference and tail length of Achai cows between these three valleys. Morphometric traits of Achai cows with significant difference among the three valleys were ear length (P=0.02), circumference of horn at mid region (P=0.04), chine length (P=0.03), loin length (P=0.03) and switch length (P=0.01). In Achai bulls, no significant difference was recorded in horn length (along the greater and smaller curvature), horn circumference (at the base, mid region and just below the tip of the horn), dewlap width, chine length, rump width, hoof circumference and switch length between Talash, Jandool and Maidan valleys. Significant difference was recorded in height at wither (P=0.003), face length (P=0.0001), ear length (P=0.004), ear width (P=0.0006), neck length (P=0.01), loin length (P=.007), rump length (P=0.008), length below knee joint (P=0.02) and switch length (P=0.01) of Achai bulls between these three valleys. Significant differences in morphometric traits were also observed by other workers.

Pundir et al. (2007) reported significantly higher values for heart girth, body length, height at withers, ear length and tail length in Kenkatha cattle breed (an indigenous cattle breed of Utter Pradesh and Madhya Pradesh states of India) from district Banda compared to those from district Lalitpur of Uttar Pradesh state of India. Berthouly (2008) studied height at wither, body length, heart girth, ear length and thorax depth in H'mong cattle (an indigenous breed) in 8 different districts of Ha Giang province of Vietnam and reported significant difference in height at wither among these districts. However, Bostime (2005) reported no significant effect of four different agro-ecological zones (represented by veld type) on heart girth, body length and shoulder height (height at withers) in Nguni cattle in South Africa. Sarkar et al (2007) also reported no significant difference in chest girth (heart girth), body length and height at withers in Deshi cattle between three different agro-climatic zones of West Bengal, India. Differences in these morphometric traits particularly of the length (chine, loin, rump) and height measurements (height at wither, length below knee joint) of Achai cows and bulls indicate genetic differences in size of both Achai cows as well as bulls as the skeletal measurements such as body height and length, ulna length and chest depth are less affected by nutrition and more by genetics thus indicate inherent size better than measures related to muscles and fat deposition such as width (hip width, shoulder width) and girth measurements (chest girth) and body weight (Searle et al., 1989; Kamalzadeh et al., 1998). Although in this study castrated and intact bulls were taken combined for morphometric measurements, Chenyambuga et al. (2008) reported significantly higher values for heart girth, height at withers, body length and rump width of the castrated bulls than intact bulls of Tarime zebu cattle breed in Tanzania and attributed this difference to the fact that castration imposes accretion of subcutaneous fats, which in turn affect body measurements. Morphometric measurements of castrated and intact Achai bulls should therefore be studied to find out the effect of castration on morphometric measurements in this breed.

Mwacharo et al. (2006) reported that the linear body dimensions (heart girth, body length, height at withers, height at rump, face length, ear length, tail length) of Maasai zebu cattle were significantly greater than those of Kamba zebu cattle due to harsher environment in terms of nutrition and disease under which the Kamba zebu is reared. Achai cows also face harsher conditions related to nutrition in valleys under study. The reason may valid for their shorter stature than that of other cattle breeds found in

Pakistan as Achai cows and bulls are the smallest of all the currently known cattle breeds of Pakistan (Table 67).

Combined data of all the three valleys revealed that sex of the Achai cattle significantly affects all the studied morphometric traits except face length. Achai cows have highly significantly longer ($P<0.001$) and wider ears ($P<0.001$), long neck ($P=0.02$), long loin ($P<0.001$) and wider rump ($P<0.001$) than Achai bulls. On the other hand, Achai bulls have significantly higher values for heart girth ($P<0.001$), body length ($P<0.01$), height at withers ($P<0.001$), height at hip bone ($P<0.001$) and also have long ($P<0.001$) and thick horns ($P<0.001$), thicker neck ($P<0.001$), long ($P<0.001$) and wider dewlap ($P<0.001$), long chine ($P<0.001$), long rump ($P<0.001$), longer leg below knee joint ($P<0.001$), large hoof circumference ($P<0.001$) and long tail ($P<0.001$) and switch ($P<0.001$) than Achai cows. Mwacharo et al. (2006) also reported significant ($P<0.001$) effect of sex on heart girth, body length, height at withers, height at hipbone, face length and tail length with higher values for bulls than cows of Massai zebu and Kamba zebu in East Africa. Pundir et al. (2007) also reported significantly higher values of heart girth, body length, height at withers, face length, ear length, horn length and tail length for bulls than cows of the Kenkatha cattle breed in India. Bulls of the Baila and Angoni cattle of Zambia have been reported to be significantly taller and longer than cows (Zulu, 2008). Sex differences in morphometric measurements of Achai cattle breed with the male having relatively greater values for majority of the traits studied revealed sexual dimorphism in this breed. Sex-related differences resulted from sex differential hormonal effects on growth (Zulu, 2008). However, Raji et al. (2007) reported no significant effect of sex of Bunaji cattle breed on height at withers, heart girth, body length, tail length, horn and ear length in Oyo State of Nigeria. Chenyambuga et al. (2008) also reported no significant effect of sex of Tarime zebu cattle breed on height at withers, body length and heart girth in Tanzania.

The overall mean (based on combined data of all the three valleys) ratio of heart girth to height at withers (HG: HW) of Achai cows (1.32 ± 0.004) observed in the present study was comparable to that reported in Kuri cows (1.32) in Africa (Tawah et al., 1997), Massai zebu cows (1.31) and Kamba zebu cows (1.31) in Kenya (Mwacharo et al., 2006). However, the overall mean ratio of heart girth to height at withers (HG:

HW) of Achai bull (1.31±0.01) observed in this study was higher than the HG: HW ratio of bulls (1.29) of Kuri cattle breed (Tawah et al., 1997) but less than Massai zebu bulls (1.33) and Kamba zebu bulls (1.37) of Kenya (Mwacharo et al., 2006).

Combined data for the three valleys showed significantly lower ratio of body length to height at withers ($t_{(214)}$ = 2.37; P=0.02) and rump width to height at withers ($t_{(214)}$ = 13.14; P<0.001) for Achai bulls compared to cows indicating that bulls are shorter with respect to height at withers and narrow bodied at rump with respect to height at withers than Achai cows. According to Mwacharo et al. (2006), short, smaller and compact animals are better at pulling plough for longer hours than larger and taller animals. The same reason may be valid for short and compact body of Achai bulls as they are used for pulling plough in the hilly terrain of the valleys under study. In contrast to the present study, Mwacharo et al. (2006) reported low values for the ratio of body length to height at withers for Massai zebu cows (1.05) and Kamba zebu cows (1.08) in Kenya as compared to Achai cows (1.10). However, the ratio of body length to height at withers reported by Mwacharo et al. (2006) for Massai (1.09) and Kamba zebu bulls (1.12) were higher than Achai bulls (1.08) observed in the present study. The ratio of rump width to height at withers reported in the present study for Achai cows (0.30±0.002) and Achai bulls (0.26±0.002) was lower than reported for Nigerian cattle like Skoto Gudali (0.34), White Fulani (0.33) and N,Dama (0.32) and also for Aryshire (0.45) and Friesian cattle (0.40) (Hall, 1999).

The present study provide breed descriptor (physical and morphometric) as laid down by FAO (1986) for the first time for Achai cattle that can subsequently be used as selection criteria for the conservation and development of Achai cattle breed (Yakubu et al., 2010)

Productive performance.

Standard 305-day milk yield.

The overall mean 305-day milk yield of Achai cow recorded during this study was 1426.31±30.23 liters. It was 1217.04±53.05 liters in Talash valley, 1560.14±36.88 liters in Jandool valley and 1501.76±47.76 liters in Maidan valley. Variable results regarding milk yield have been reported for dairy cattle breeds (Sahiwal, Red Sindhi, Cholistani) of Pakistan in literature. Javed et al. (2000) reported 1862.42±42.08 kg milk yield in Sahiwal cows kept at Livestock Experiment Station Jahangirabad, Khanewal, Pakistan. On the other hand, Bhatti et al. (2007) reported 1440.80 kg milk yield in Sahiwal cows while analyzing data from five different Government farms in Punjab province of Pakistan. In Red Sindhi cows, Mustafa et al. (2002) reported 1531±34.80 kg milk yield at Government Red Sindhi cattle farm Baluchistan whereas Aslam et al. (2002) reported 1780.40±68.64 liters of milk at Barani Livestock Production Research Institute, Kherimurat, Punjab, Pakistan. In Cholistani cows, Chaudhry et al. (1983) reported 1470.93±595 kg (±SD) milk yield whereas Ashfaq (2000) reported 1219.24±44.84 kg milk yield under farm condition in Punjab province of Pakistan. The present study revealed that Achai cows produces more milk than the draft breeds of Pakistan like Bhagnari (1300.92±27.02 kg; Wahid, 1975 a), Dhanni (763.86±12.87 kg; Joshi and Phillips, 1953; 770-1317 liters, Wahid, 1975 b), Lohani (907.2kg; Joshi and Phillips, 1953; 800-1000 liters; Khan et al., 2005) and local cows (breed not mentioned) of North West Frontier Province (1269.7 kg; Syed et al., 1994).

In Talash valley mean 305-day milk yield was significantly lower than in Jandool ($P<0.0001$) and Maidan ($P=0.0002$) valleys. This may be due to comparatively less availability of fodder in Talash valley than the other two valleys. The significantly higher 305-day milk yield in Jandool and Maidan than Talash valley provide a scope for the improvement of milk yield of Achai cattle that could be achieved through proper selection for higher milk yield, better management and feeding (Musa et al., 2005; Cilek and Tekin, 2005; Pundir and Singh, 2007).

No significant effect of parity on 305-day milk yield was observed in the present study in Talash ($P=0.56$), Jandool ($P=0.77$) and Maidan valley ($P=0.95$). Rehman et al. (2006) also reported non-significant effect of parity (considering first three parities) on milk yield in Sahiwal cows in Pakistan. However, Lee and Kim (2006) and Gader et al. (2007) reported significant effect of parity on 305-day milk yield in Holstein cows in Korea and Friesian cows in Sudan respectively.

Seasonal variation in milk production has been extensively studied with variable results in different breeds of dairy cattle in different countries like Malawi (Chagunda et al., 2004), Mexico (Parra-Bracamonte et al., 2005), Thailand (Konig et al., 2005), Pakistan (Rehman et al., 2006; Ahmad et al., 2007; Lateef et al., 2008), Sudan (Gader et al., 2007) and Czech Republic (Frelich et al., 2008). Milk production in cows is affected by environmental stress like ambient temperature, humidity, thermal radiation, air speed and rainfall directly or indirectly through the availability and quality of feed (Keown and Grant, 1991; Johnson, 1994; Bouraoui et al., 2002; Chagunda et al., 2004; Parra-Bracamonte et al., 2005). Both heat and cold stress affect milk production in dairy cattle. The optimum milk production was at temperature ranging from 5ºC to 15ºC. At temperature ranges between 5ºC to 0ºC and 15ºC to 25ºC, loss in milk production was nominal (WMO, 1989). Keown and Grant (1991) reported 37.78 ºC (100 ºF) ambient temperatures and 80% humidity as lethal ranges for milk production in cattle. In the present study no significant effect of season on 305-day milk yield was observed in Achai cows. However, 305-day milk yield was the highest in Achai cows calving during spring season in the three valleys (Talash, Jandool and Maidan). This season may be favorable for milk production because of availability of green fodder during spring. Ambient temperature ranges from 16.23 ºC to 22.41 ºC and relative humidity ranges from 57 to 70% in Talash, Jandool and Maidan valleys of District Lower Dir (District Census Report Lower Dir, 1999) and these factors are also favorable for milk production. Syed et al. (1994) also reported a non-significant effect of calving season on 305-day milk yield in local and crossbred cows in the central valley of Peshawar, North West Frontier Province, Pakistan. In Sahiwal cows, Shafiq et al. (1995) reported that combined first three lactation milk production was not significantly different in different seasons. Chagunda et al. (2004) also reported non-significant effect of calving season on 305-day milk yield of the first three lactations in Holstein Friesian cows in Malawi. In Holstein upgraded cows in Northern Thailand, Konig et al. (2005) also found no significant effect of calving season on 305-day milk yield. On the other hand, calving season had been reported as a significant source of variation in milk production both in indigenous cattle breed (Sahiwal cattle breed; Tahir et al., 1989; Rehman et al., 2006) and exotic cattle breed like Jersey and Holstein Friesian (Ahmad et al., 2007; Lateef et al., 2008) in Pakistan. Parra-Bracamonte et al. (2005), Gader et al., (2007) and Frelich et al. (2008) also reported significant difference in milk production during different seasons in dual purpose breed in southern Mexico, Friesian breed in Sudan and crossbred cows (Czech pied x Holstein) in Czech Republic respectively.

Birth weight.

Male Achai calves.

The overall mean birth weight of male Achai calves recorded in the present study was 16.88±0.27 kg. It was 17.50±0.43 kg in Talash valley, 16.40±0.50 kg in Jandool valley and 16.74±0.48 kg in Maidan valley. This was comparable to the birth weight of male calves (16.00±1.52 kg) reported in Red Chittagong calves in Bangladesh under rural management system (Khan et al., 2000). Higher birth weight than the Achai calves observed in the present study were reported in N'Dama calves in Ghana (18.49 kg; Tuah and Danso, 1985), Bhagnari calves in Pakistan (26.36 kg; Wahid, 1975 a), Tharparker calves in India (21.27±0.27 kg; Bhattacharya et al., 1999), calves of the local cattle in Peshawar, North West Frontier Province, Pakistan (21.97±0.4 kg; Syed et al., 1994) and Gaolao calves in India (18.92±0.44 kg; Yadav et al., 2001). Calves with light birth weight than male Achai calves were Namchi (13.27±0.44 kg) and Kapsiki (13.19±0.42 kg) in Cameroon (Ebangi et al., 2002) and Khariar calves in India (10.55±0.21 kg; Dhal et al., 2007). This variation in birth weight may be due to breed differences (Syed et al., 1994; Ebangi et al., 2002; Mondal et al., 2005).

Parity number significantly affect male birth weight in Achai calves and a significantly increasing trend in birth weight with advancing parity number from parity first to third was seen in Talash (b=0.28±0.003; $F_{(1, 1)}$ =9747; P=0.006) and Jandool valley (b=0.16±0.006; $F_{(1, 1)}$ =768; P=0.02). Nagaracenkar et al. (1981) also reported significant effect of parity number on birth weight of Tharparker calves with an increasing trend from parity first to fifth. Parity was also found as a significant source of variation in birth weight of Charolias and Hereford calves with lower birth weight of calves born to first parity cows compared to calves from higher parity cows (Eriksson et al., 2004). The higher birth weight of calves with advancing parity number indicates high influence of intra uterine environment of dams on the birth weight of calves (Nagaracenkar et al., 1981). This increase in birth weight with increasing parity number might be due to increased vascularization of the uterus during first pregnancy (Khong et al., 2003) and greater blood volume expansion during second pregnancy (Campbell and MacGillivray, 1984) thus facilitating relatively greater foetal growth in subsequent pregnancies. Furthermore, the cows during early lactations were not fully grown and thus continued to grow till attaining an adult size. This appeared to influence the birth weight of calves in later parities

(Shehzad et al., 2010). Therefore, proper feeding of first parity Achai cows during gestation particularly second and third trimester can improve birth weight of the calves (Spitzer et al., 1995; Zhang et al., 2002). In Maidan valley, no significant (P=0.55) effect of parity was observed on birth weight of male Achai calves in the present study. Non-significant effect of parity number on calf birth weight has also been reported in Gaolao calves in India (Yadav et al. 2001), Holstein calves (Nogalski, 2003) and Gascon calves in Czech Republic (Bures et al., 2008).

Female Achai calves.

The overall mean birth weight of female Achai claves observed in the present study was 14.54±0.26 kg. Mean birth weight of female Achai calves was 14.30±0.46 kg in Talash valley, 14.46±0.45 kg in Jandool valley and 14.62±0.37 kg in Maidan valley. Higher birth weight than the present study have been reported in Bhagnari calves in Pakistan (23.18 kg; Wahid, 1975 a), N'Dama calves in Ghana (17.69 kg; Tuah and Danso, 1985), Tharparker calves in India (20.88±0.25 kg; Bhattacharya et al., 1999), Gaolao calves in India (17.48±0.02 kg; Yadav et al., 2001) and Kapsiki calves in Cameroon (15.76±0.40 kg; Ebangi et al., 2002). However, lower birth weight than Achai calves has been reported in Namchi calves in Cameroon (12.16±0.50 kg; Ebangi et al., 2002) and Kharair calves in India (9.44±0.22 kg; Dhal et al., 2007).

No significant effect of parity on mean birth weight of female Achai calves was observed in the present study in Talash (b= - 0.04±0.19; $F_{(1, 1)}$ = 0.04; P=0.87), Jandoo (b= 0.73±0.67; $F_{(1, 1)}$ = 1.16; P=0.47) and Maidan valley (b= 0.10±1.19; $F_{(1, 1)}$ = 0.007; P=0.95). Yadav et al. (2001) also reported non-significant effect of parity on birth weight in Gaolao calves in India.

Effect of calf sex on birth weight.

Combined data of all the three valleys revealed that male Achai calves were highly significantly ($t_{(102)}$ = 6.11; P<0.001) heavier than female Achai calves at birth. Valley wise comparison of mean birth weight of male and female Achai calves showed significantly heavier birth weight for male Achai calves than female Achai calves in Talash (P<0.001), Jandool (P=.01) and Maidan valley (P=.002). Significantly higher birth weight of male calves compared to female calves have also been reported in Tharparker calves in India (Nagaracenkar et al., 1981), N'Dama calves in Ghana (Tuah and Danso, 1985), Belgian Blue calves (Coopman et al., 2004) and Gascon calves in Cameroon (Bures et al., 2008). However, a non-significant effect of calf sex on birth weight was reported in West African Shorthorn calves in Ghana (Tuah and Danso, 1985), Gaolao calves in India (Yadav et al., 2001) and Namchi and Kapsiki calves in Cameroon (Ebangi et al., 2002). Higher male birth weight might be due to the effect of breed, sex, hormonal influence and maternal effect as male calves grow faster than female calves in uterus (de Zegher et al., 1999; Bhattacharaya et al., 1999; Loos et al., 2001). Calves born with heavier birth weight tend to grow faster (Yadav et al., 2001), show better performance in the pre-weaning growth period (Khan and Khan, 1999) which tended to be leaner (Moloney and Drennan, 2006). Therefore, selection of Achai calves on the basis of higher birth weight will result an increase in this trait (Ahmad and Kumbhar, 1975) and will also reduce the cost of maintenance of animals (Yadav et al., 2001).

Reproductive performance.

Pubertal age.

The overall mean pubertal age of Achai cows observed in the present study was 1147.73±18.26 days. In Talash valley mean pubertal age of Achai cow was 1144.29±45.18 days whereas it was 1161.00±22.45 days in Jandool valley and 1125.00±39.04 days in Maidan valley. There was no significant ($F_{(2, 94)}$ = 0.343; P= 0.71) difference in mean pubertal age of Achai cows between these three valleys. Achai cows have late pubertal age than other cattle breeds of Pakistan like Sahiwal cows (1041±16 days; Ali and Farooque, 1989), Red Sindhi cows (1024.86±27.54 days; Mustafa et al., 2003), Cholistani cows (609.67±31.90 days; Chaudhry et al., 1983), Bhagnari cows (987.22±14.73 days; Azam et al., 2001), Tharparker cows, Lohani cows and Dhanni cows (891 days, 900 days and 910 days respectively; Afzal and Naqvi, 2004). Achai cows also attain puberty at later age than crossbred cows in Bangladesh (837±189 days; Sarder, 2006), crossbred cows in eastern lowland of Ethiopia (786 days; Mureda and Zeleke, 2007), Rawandan cows (831±312 days; Bishop and Pfeiffer, 2008) and crossbred cows in eastern Himalaya, India (858±30 days; Kumaresan et al., 2009). Late pubertal age than Achai cow was reported in local cows in Peshawar, North West Frontier Province, Pakistan (1372±169.3 days; Syed et al., 1994), Fogera cows and their crossbred in north eastern Ethiopia (1218±24 days; Gebeyehu et al., 2005), Khariar cows in India (1224.29±3.61 days; Dhal et al., 2007) and crossbred cows in Bangladesh (1205.02±313.80 days; Azizunnesa et al., 2008). Late onset of puberty in cattle have been attributed to genetic factor (Mukasa-Mugerwa, 1989; Abeygunawardena et al., 1994; Nogueira et al., 2004; Asseged and Birhanu, 2004), poor nutrition (Shiferaw et al., 2003; Rekwot, 2004; Mureda and Zeleke, 2007) and poor management (Mustafa et al., 2003; Sarder, 2006; Kumaresan et al., 2009).

Late onset of puberty in Achai cows could be reduced through genetic selection and improved nutrition and this can in turn reduce the generation interval and thus increase the rate of genetic gain and optimize reproductive performance (Rekwot, 2004; Nogueira, 2004).

Postpartum anoestrus interval.

The overall mean postpartum anoestrus interval observed in this study was 97.33±3.40 days whereas it was 100.00±6.33 days in Talash valley, 96.31±5.35 days in Jandool valley and 92.50±5.67 days in Maidan valley. Postpartum anoestrus interval varies for cows from different countries. In countries like Ethiopia this was 98 days for indigenous zebu and crossbred cows reared in smallholder system (Kassa, 1990). In Sanga cattle breed (Zebu x West African Shorthorn) postpartum anoestrus interval reported was 101.0±7.0 days (Obese et al., 1999). Similarly, Friesian, Red Dane, Mashona and crossbred cows maintained under small scale commercial production system in Zimbabwe had postpartum anoestrus interval of 104.0±10.6 days (Masama et al., 2003). Shorter postpartum anoestrus interval than the present study has been reported in Small East African Zebu cows (81±11 days) in Ethiopia (Mukasa-Mugerwa et al., 1991), Charolais cows (72±27 (±SD) days), in France (Mialon et al., 2000) and Thai x Holstein-Friesian crossbred cows (63.43±1.81) in Thailand (Boonbrahm et al., 2004). However, compared to the present investigation, longer postpartum anoestrus interval has been reported in Sahiwal cows (130.40±2.88 days) in Pakistan (Tahir et al., 1992) and crossbred dairy cows (141 days) in central Ethiopia (Lobago et al., 2007).

Postpartum anoestrus interval of 97.33±3.4 days in Achai cows observed in this study crosses the recommended value for postpartum anoestrus interval in dairy cows which is less than 60 days (Farin and Slenning, 2001; Zdunczyk et al., 2002). In literature there are very few studies which found postpartum anoestrus interval less than 60 days in cows (Berka et al., 2004; Boonbrahm et al., 2004).

As nutrition and suckling are the major factors affecting postpartum anoestrus interval (Montiel and Ahuja, 2005) along with poor heat detection (Kuthu et al., 2007). Therefore, improvement in the management regarding nutrition, both during pre- and post calving period, minimal suckling and better oestrus detection can reduce the postpartum anoestrus interval in Achai cows (Mukas-Mugerwa et al., 1991; Kuthu et al., 2007).

In Talash valley a significant (P=0.02) reduction in mean postpartum anoestrus interval was observed from first to fourth parity with the longest postpartum anoestrus interval in first parity Achai cows and shortest in fourth parity. This longer postpartum anoestrus interval in first parity in Talash valleys may be due to nutritional stress as Rhodes et al. (2003) and Mureda and Zeleke, (2007) are of the view that greater nutritional stress for growth and lactation in first parity cows prolonged postpartum anoestrus interval. Matiko et al. (2008) also reported significantly longer postpartum anoestrus interval in younger zebu cows (first and second parity) in Morogoro, Tanzania.

In the present study, no significant effect of calving season was observed on postpartum anoestrus interval of Achai cows in Talash and Jandool valley. In Maidan valley, a significant effect of calving season was observed on postpartum anoestrus interval of Achai cows with significantly (P=0.02) longer postpartum anoestrus interval in winter calvers compared to spring calvers. This variation in postpartum anoestrus interval observed in this study may be due to seasonal fluctuation in quality and quantity of feed as one of the factors. Rhodes et al. (2003), Lyimo et al. (2004) and Montiel and Ahuja (2005) are also of the same opinion regarding short and long postpartum anoestrus interval of cows calving in different seasons. Significant effect of calving season was reported in Sahiwal cows in Pakistan with the shortest postpartum anoestrus interval in cows calved in spring season compared to other seasons of the year (Ahmad et al., 1989). Obese et al. (1999) reported significantly short postpartum anoestrus interval in Sanga cows calving in dry season (November to March) than rainy season (April to October) in Ghana. Significantly short postpartum anoestrus interval was also reported in crossbred cows calving during summer season (March to June) compared to autumn season (July to October) in Sudan (Abdalla and Elsheikh, 2008).

Conception efficiency.

The percentage of Achai cows conceived at first natural service was 72.32% in Jandool valley, 71.58% in Maidan valley and 68.12% in Talash valley. Soydan et al. (2009) reported 71.6% conception rate to first service in multiparous Jersey cows in Turkey. Lower percentage of first service conception rate than the present study has been reported in crossbred dual-purpose suckling cows in Venezuela (58.20%; Perea-Ganchou et al. 2005), Zebu and their crossbred cows in Ethiopia (55.5%; Lobago et al., 2006), Holstein Friesian and crossbred cows in Iran (45%; Ansari-Lari and Abbasi, 2008) and crossbred cows in eastern Himalaya, India (44.4%; Kumaresan et al., 2009). However, higher percentage of conception at first service was reported by Kanuya et al. (2000) in Friesian, Aryshire and Jersey cows (85%) in Tanzania.

The percentage of Achai cows conceived at first service observed in the present study is better than the recommended value for this trait (~60%, Radostites, 2001). This could be due to breeding system as cows under natural breeding system (49%) has significantly ($P<0.05$) higher conception at first service than Artificial Insemination (32%) (Kanuya et al., 2000) and breeding time post-calving as cows bred during the period of 60-120 days post-calving have conception rate at first service of 60.6% compared to 54% for the cows bred ≤ 60 days post-calving (Perea-Ganchou et al., 2005). It was observed in the present study that Achai cows are bred beyond 60 days.

In the present study, Achai cows conceived after second service were 20.29% in Talash, 16.07% in Jandool and 13.68 % in Maidan valley. Chaudhry et al. (1989) reported 20.19 % Holstein Friesian x Sahiwal crossbred cows conceived after availing second service whereas this percentage was 27.78 % for Jersey x Sahiwal crossbred cows in Pakistan. Indetie et al. (2007) reported 13% of the cows (Friesian, Ayrshire, Guernsey and Jersey) that required two inseminations for conception in smallholder dairy farms of Nakuru district of Kenya. Achai cows conceived after third service were 7.24 % in Talash valley, 8.93 % in Jandool valley and 9.47 % in Maidan valley. Chaudhry et al. (1989) reported higher percentage of Holstein Friesian x Sahiwal (12.99 %) and Jersey x Sahiwal crossbred cows (13.89 %) conceived after availing three services. Indetie et al. (2007) also reported higher percentage (19%) of cows (Friesian, Ayrshire, Guernsey Jersey) in smallholder dairy farms of Nakuru district of Kenya that required more than 3 inseminations for conception. The percentage of Achai cows conceived at fourth and more than fourth services in Talash (4.35 %), Jandool (1.79 %) and Maidan valley (5.26%) was lower than Friesian x Sahiwal

(18.31 %) and Jersey x Sahiwal crossbred cows (13.89%) reported by Chaudhry et al. (1989) and Sahiwal cows (14.89%) reported by Khan et al. (1992) in Pakistan. The percentage of Achai cows that require more than two services for conception (Talash valley, 11.59%; Jandool valley, 11.61%; Maidan, 14.74%) indicates subfertility in the herd. Therefore, hormonal (short term), nutritional (medium term) and genetic (long term) approaches should be exploited to treat subfertility in Achai cows to optimize reproductive performance (Royal et al., 2000).

Calving interval.

The overall mean calving interval of Achai cows observed in the present study was 476.37±5.17 days and it was 462.10±09.18 days in Talash valley, 483.36±08.01 days in Jandool valley and 480.65±09.70 days in Maidan valley with no significant (P=0.21) difference in the trait between these three valleys.

The overall mean calving interval observed in Achai cows is comparable to that reported in crossbred cows in eastern Umbra mountain region of Tanzania (476±14 days: Swai et al., 2007), Friesian and Aryshire cattle in rural highland area of northern Tanzania (477 days; Kanuya et al., 2000) and Zebu cows in Tanzania reared under traditional agro-pastoral system (478±13.7 days; Matiko et al., 2008). Calving interval less than that of Achai cows were observed in crossbred cows in Greater Rajshahi district of Bangladesh (438±49 days; Sarder, 2006), Sahiwal cows in Pakistan (Zafar et al., 2008), Holstein Friesian and crossbred cows in Fars province of Iran (388 days; Ansari-Lari and Abbasi, 2008) and Boran cows in Tanzania (463.6±1.93 days; Mwatawala and Kifaro, 2009). However, long calving interval than the present study were reported in Zebu cows in Tanzania (500±13.6 days; Kanuya et al., 2006), crossbred cows in eastern lowland of Ethiopia (534 days; Mureda and Zeleke, 2007), Rawandan cows (504±156; Bishop and Pfeiffer, 2008) and crossbred cows in eastern Himalaya, India (538±25.3 days; Kumaresan et al., 2009).

For a profitable dairy enterprise, a calving interval of 365 days is usually regarded as ideal (Hafez, 1993), which can only be achieved if the calving to conception interval (service period) is less than 90 days (Masama et al., 2003). But this ideal calving interval is not feasible for all types of production systems. The recommended calving interval in US dairies is 405 days (Britt, 1981) and in Texas dairies is 420 days (Tomaszewski et al., 1981). Under tropical conditions, the recommended calving interval for dairy production is 430 days (Mujuni, 1991; Kanuya, 1992). The overall mean calving interval of Achai cows (476.37±5.17 days) observed in this study is longer than the recommended calving interval (430 days) for cows in tropical countries. Long calving interval adversely affects the profitability of dairy enterprises because cows spend a greater portion of their lactation at low production level, reduced the number of calves born, extra veterinary costs, more services, enforced culling and higher replacement costs (Kanuya et al., 2000; Esslemont et al., 2001; Swai et al., 2007; Medina et al., 2009).

Calving interval depends upon early return to oestrus and conception efficiency (Malau-Aduli et al., 1996). Therefore, efficient management that reduces the postpartum anoestrus interval and improve conception efficiency like proper nutrition, proper heat detection and timely breeding can reduce calving interval and improve reproductive performance in Achai cow (Obese et al., 1999; Mustafa et al., 2003; Rehman et al., 2008; Zafar et al., 2008).

No significant effect of parity on calving interval was observed in Talash, Jandool and Maidan valleys. Similarly, non-significant effect of parity on calving interval has been reported in Friesian cows in Pakistan (Sattar et al., 2005), crossbred cows in central Ethiopia (Lobago et al., 2007) and Holstein Friesian and crossbred cows in Iran (Ansari-Lari and Abbasi, 2008). Contrary to this, significant effect of parity has been reported in Sanga cows in Ghana (Obese et al., 1999), crossbred cows in Ethiopia (Mureda nad Zeleke, 2007) and Sahiwal cows in Pakistan (Zafar et al., 2008).

In the present study, no significant effect of season on calving interval was observed. Non-significant effect of season on calving interval was also observed by Turkyilmaz (2005) in Friesian cows in Ayden. However, significant effect of season on calving interval was reported in Bhagnari cows (Azam et al., 2001), Red Sindhi cows (Mustafa et al., 2003) and Friesian cows (Sattar et al., 2005) in Pakistan.

Dry period.

The overall mean dry period observed in the present study was 91.55±2.7 days whereas it was 74.08± 4.57 days in Talash valley, 103.33± 4.41 days in Jandool valley and 91.69± 4.16 days in Maidan valley.

In dairy cows the recommended length for dry period is 50 to 60 days for optimum milk production (Bachman and Schairer, 2003; Grummer and Rastani, 2004; Annen et al., 2004; Kuhn et al., 2005; Gallo et al., 2008). Mean dry period of Achai cows observed in this investigation is longer than the recommended range for dry period. It has been reported that dry period above 70 days had detrimental effect on lifetime milk production in dairy cows (Kuhn et al., 2005; Kuhn et al., 2006; Kuhn et al., 2007). It has been observed that days open and eventually calving interval had the greatest impact on dry period and cows with longer calving interval had longer days dry (Cilek and Tekin, 2005; Kuhn et al., 2005; Kuhn et al., 2006). Therefore, reducing calving interval in Achai cows will enhance the feasibility of shortened dry period and thus improved lifetime productivity (Ahmad and Ahmad, 1981; Kuhn et al., 2005; Kuhn et al., 2007).

Shorter dry period than the present study was reported in Italian Friesian cows (67±27 days; Gallo et al., 2008) and Holstein Friesian and crossbred cows in Iran (68 days; Ansari-Lari and Abbasi, 2008). Longer dry period than that of Achai cow has been reported in Red Sindhi, Dhanni, Dajal, Lohani, Rojhan and crossbred cows (198.9±17.17 days; Aslam et al., 2002), Friesian cows (224.99±10 days; Sattar et al., 2005) and Sahiwal cows (172±1.44 days; Zafar et al., 2008) under farm conditions in Pakistan.

In the present study no significant effect of parity on dry period was observed in the three valleys. Sattar et al. (2005) also reported no significant effect of parity on dry period in Friesian cows in Pakistan. However, Gallo et al. (2008) reported significantly shorter dry period after first parity compared to later parities in Italian Friesian cows. Contrary to Gallo et al. (2008), Aslam et al (2002) reported significantly longer dry period during first parity compared to later parities in various indigenous cattle breeds of Pakistan like Red Sindhi, Dajal, Lohani, Rojhan, Dhanni and crossbred (crosses of Red Sindhi and Dhanni with Friesian and Jersey cows).

No significant effect of season was observed on dry period in Achai cows in the present study. Similar to the present investigation, no significant effect of calving season on dry period has been reported in Holstein Friesian, Jersey and their crossbred with Red Fulani, White Fulani and Gudali cows in Cameroon (Djoko et al., 2003), Simmental cows at the Kazova state farm (Cilek and Tekin., 2005) and Sahiwal cows in Pakistan (Zafar et al., 2008).

The prevailing environmental conditions in the three valleys are quite different particularly in terms of availability of water and fodder. Talash valley is worst affected because of scarcity of water and crop cultivation which directly affects fodder availability. The other thing about Talash valley is that breeding of Achai cows in this valley is restricted to within valley. The cows are not exposed to cows from Jandool and Maidan valleys. In other words inbreeding is practiced to a large extent, because of which productive and reproductive aspects are affected in downward direction. Migration of cows from other two valleys is almost negligible, which also affects the productive and reproductive performance because there is no gene flow from other valleys.

On the other hand, Jandool valley has the best water resources and crop production and the cows have better access to fodder. There is migration of cows between Jandool and Maidan valley which has positive effects on productive and reproductive performance because of mixing of two gene pools. Maidan valley also has better water resources and crop production. In the case of Talash valley, people are following their old custom to not to mix up their cows with cows from other valleys. This is what was revealed by residents when they were asked in this regard. Traditions are fixed part of life and normally this is difficult to change them. However, people from Talash valley can be educated and strategies can be given to improve productive and reproductive performance.

Table 67: Comparison of some morphometric measurements (cm) of Achai cattle with other cattle breeds of Pakistan.

Breed	Sex	Heart girth	Body length	Height at wither	Source
Achai	Cow	134.33±0.60	112.20±0.77	101.80±0.42	Present study
	Bull	140.50±1.12	116.26±1.02	107.62±0.68	Present study
Lohani	Cow	139.78±1.58	114.96±0.79	111.84±1.07	Joshi and Phillips (1953) *
	Bull	160.02±2.06	129.11±3.05	121.92±1.65	
Rojhan	Cow	152.40	124.46	106	Shah (1953) *
	Bull	163.83	134.62	120.65	
Dhanni	Cow	160.02	129.54	114.30	Singh and Singh (1936) * ♦
	Bull	190.50	152.40	134.62	
Dhanni	Cow	142	137	119	Khan et al.(1982)
	Bull	182	162	132	
Sahiwal	Cow	174.75	137.67	127.97	Shah (1953)
	Bull	209.55	164.34	139.70	
Sahiwal	Cow	168.91	134.62	121.92	Joshi and Phillips (1953)
	Bull	182.88	147.32	137.16	
Red Sindhi	Cow	158.37±0.91	128.88±1.04	120.73±0.68	Joshi and Phillips (1953)
	Bull	175.56±1.90	139.70±0.18	130.81±1.22	
Red Sindhi	Cow	155	127	115	Khan et al.(1982)
	Bull	185	145	132	
Tharparker	Cow	165.66±1.35	133.25±0.84	126.24±1.04	Joshi and Phillips (1953)
	Bull	184.66±1.60	139.95±1.24	130.81±0.99	
Bhagnari	Cow	169.15±2.34	134.11±1.02	129.54±064	Wahid (1975 a) *
	Bull	189.74±1.80	156.03±0.94	145.64±0.68	
Dajal	Cow	205	145	136	Khan et al. (1982)
	Bull	167	137	126	

* The measurements taken in inches by Singh and Singh (1936), Joshi and Phillips (1953), Shah (1953) and Wahid (1975) were converted into centimeters (inch x 2.54).

♦ Singh and Singh (1936) studied Dhanni cattle before the partition of India and Pakistan in District Rawalpindi, Jhelum and Attock which are now included in Pakistan.

CONCLUSION

1. The physical characteristics of both Achai cows and Achai bulls did not differ significantly among Talash, Jandool and Maidan valleys.

2. Achai bulls are significantly larger than the cows. Gender differences were also observed in other morphometric traits indicating sexual dimorphism in the two sexes. Males are distinct compared to females due to bulls being significantly different from the cows: obviously there must be genetic variability in the two sexes.

3. Achai cattle are the smallest in heart girth, body length and height at withers of all the cattle breeds of Pakistan.

4. Achai cows have low milk yield (1426.31±30.23 liters) than the dairy cattle breeds of Pakistan like Sahiwal (1862.42±42.08 kg) and Red Sindhi (1531±34.80 kg). They are better in milk production than Bhagnari (1300.92±27.02 kg), Dhanni (770-1317 liters) and Lohani (800-1000 liters) cattle breeds of Pakistan.

5. Male calves are significantly heavier than female calves at birth.

6. Achai cows have late onset of puberty and have long postpartum anoestrus interval, long calving interval and long dry period than the recommended values.

7. Achai cows in Talash valley have significantly low standard 305-day milk yield and short dry period than cows in Jandool and Maidan valleys. However, birth weight, pubertal age, postpartum anoestrus interval, conception efficiency and calving interval did not differ significantly among the three valleys.

8. Parity did not significantly affect 305-day milk yield, birth weight of female calves, calving interval and dry period in all the three valleys except birth weight of male calves in Talash and Jandool and postpartum anoestrus interval in Talash valley.

9. Seasonal differences in 305-day milk yield, postpartum anoestrus interval, calving interval and dry period were also non-significant in all the three valleys except postpartum anoestrus interval in Maidan valley.

10. Achai cows have significant variation in morphometric measurements, productive performance and the effect of parity and calving season on birth weight and postpartum anoestrus interval among the three valleys. It indicates that valleys should

be given due consideration while designing conservation and improvement plan for Achai cattle

11. The present study was conducted for the first time for Achai cattle and the findings obtained can be used as baseline data to identify pure Achai cattle on the basis of physical and morphometric characteristics and improve its productive and reproductive performance with the potential approaches discussed for improving these parameters.

SUGGESTIONS FOR FUTURE STUDIES

1. In the current study, traditional measures of fertility like postpartum anoestrus interval, conception efficiency and calving interval have been investigated. Physiological parameters of fertility such as the commencement of luteal activity postpartum, ovulation time, lifespan of corpus luteum, pattern of estrus cyclicity and maintenance of pregnancy, assessed by milk progesterone levels, are necessary to be investigated to obtain information on the inherent capability of Achai cows to resume ovarian cyclicity postpartum which are useful for selecting cattle for improved fertility.

2. There is need to investigate the causes of late pubertal age, long postpartum anoestrus interval, long calving interval and long dry period and to devise strategies to optimize these reproductive performances.

3. Studies should be conducted on the existing management; feeding and breeding system to find out the weaknesses and to introduce a systematic management system to optimize the productivity of Achai cattle.

4. The high milk producing Achai cows should be bred with Achai bulls from high milk producing dams to find out the transmitting capabilities of milk yield traits in the next generations.

5. Comparative evaluation of productive and reproductive performance of Achai cows and crossbred cows should be conducted with more emphasis on the cost of production so that the breed/breeds of choice can be ranked and promoted in specific environment.

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ANNEXURE

Annexure 1

Questionnaire:

No________________________ Name of the respondent____________________

Village______________________________ Date_________________________

Valley (Tick)

Talash	Jandool	Maidan

Herd composition of Achai cattle

Type	Number
Achai cows	
Heifers	
Female calves	
Male calves	
Bulls	

Pubertal age of Achai cows/heifers

Type	No. of Cow/heifer	Pubertal age (months)
Achai cows	Cow No.1	
	Cow No.2	
	Cow No.3	
	Cow No.4	
	Cow No. 5	
Heifers	Heifer No. 1	
	Heifer No. 2	
	Heifer No. 3	
	Heifer No. 4	

Parity number, calving season and calf sex of Achai cows

Cow No.	Parity No.	Calving season	Sex of the calf
Cow No.1			
Cow No.2			
Cow No.3			
Cow No.4			
Cow No. 5			

Postpartum anoestrus interval of Achai cows (months)

Cow No.	Postpartum anoestrus interval (months)
Cow No.1	
Cow No.2	
Cow No.3	
Cow No.4	
Cow No. 5	

Conception efficiency of Achai cows

	Number of natural services provided							
Achai cows	1st	2nd	3rd	4th	5th	6th	7th	8th
Cow No.1								
Cow No.2								
Cow No.3								
Cow No.4								
Cow No. 5								

Calving interval of Achai cows (months)

	First parity	Second parity	Third parity	Fourth parity
Achai cows				
Cow No.1				
Cow No.2				
Cow No.3				
Cow No.4				
Cow No. 5				

Dry period of Achai cows (months)

	First parity	Second parity	Third parity	Fourth parity
Achai cows				
Cow No.1				
Cow No.2				
Cow No.3				
Cow No.4				
Cow No. 5				