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Morphological characterization of Achai cattle in sedentary and transhumant systems in Pakistan

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Summary
Achai is an as yet undocumented but well-adapted cattle breed of the Hindu Kush Mountains of northern Pakistan, which is reared under sedentary farming system (SFS) and transhumant farming system (TFS). This paper compares the morphological (physical and morphometric) characteristics of this cattle breed under both farming systems to know the effect of these styles of management. Data were collected from 108 adult females and 108 males in SFS and 108 females and 36 males in TFS on physical characteristics (colour of the coat, horns, eyelashes, muzzle, hoof, switch) and morphometric measurements – i.e. heart girth, body length, height at withers, height at hipbone, face length, horn length, horn circumference, ear (length and width), neck length, dewlap length, chine length, loin length, rump (length and width), length below knee, hoof circumference, tail and switch length. Results showed that farming systems significantly affect most of the morphological characteristics of both sexes, particularly the morphometric measurements with tall and leggy conformation for TFS cows and bulls. This indicates an adaptation to long distance transhumance and mountain terrain grazing. It can be concluded that the Achai has the potential to adapt to the requirements of specific farming systems. There is hence a need for the conservation of its adaptive traits in both farming systems.

Keywords: *Achai cattle, morphological characterization, sedentary farming system, transhumant farming system*

Resumen
Pese a ser una raza bovina muy bien adaptada a las condiciones montañosas del macizo Hindu Kush en el norte de Pakistán, el ganado Achai sigue siendo un gran desconocido a día de hoy. La raza Achai es criada bajo un sistema ganadero estante (SGE) y un sistema ganadero trashumante (SGT). Este artículo compara las características morfológicas (físicas y morfométricas) de esta raza bovina bajo ambos sistemas ganaderos para conocer el efecto de estos tipos de manejo. Los datos fueron recogidos en 108 hembras adultas y 108 machos del SGE y en 108 hembras y 36 machos del SGT. Se tomaron datos de características físicas (color de la capa, de los cuernos, de las pestañas, del hocico, de las pezuñas y de la punta de la cola) y medidas morfométricas (perímetro torácico, longitud corporal, altura a la cruz, altura a la grupa, longitud de la cara, longitud y circunferencia de los cuernos, longitud y anchura de las orejas, longitud del cuello, longitud de la papada, longitud del tronco, longitud de los lomos, longitud y anchura de la grupa, longitud bajo las rodillas, circunferencia de las pezuñas, longitud de la cola y del mechón de pelo final). Los resultados mostraron que el sistema ganadero afecta significativamente a la mayoría de las características morfológicas de ambos sexos, en especial a las medidas morfométricas. Así, vacas y toros del SGT son animales altos con patas largas. Esta conformación refleja una adaptación a trashumancias de larga distancia y a un pastoreo en terrenos montañosos. Se puede concluir que el ganado Achai tiene potencial de adaptación a las necesidades de sistemas ganaderos específicos. Existe por tanto la necesidad de conservar los rasgos adaptativos de ambos sistemas de explotación.

Palabras clave: *ganado bovino Achai, caracterización morfológica, sistema ganadero estante, sistema ganadero trashumante*

Résumé
Bien qu'elle soit une race bovine bien adaptée aux conditions montagneuses de la chaîne Hindu Kush du nord du Pakistan, la race Achai demeure encore de nos jours assez inconnue. Ces animaux sont élevés selon un système d'élevage sédentaire (SES) et un système d'élevage transhumant (SET). Cet article compare les caractéristiques morphologiques (physiques et morphométriques) de cette race bovine élevée selon les deux systèmes d'exploitation pour connaître l'effet de ces pratiques d'élevage. Les données ont été prélevées sur 108 femelles adultes et 108 mâles en SES et 108 femelles et 36 mâles en SET. Les suivantes caractéristiques physiques ont été évaluées: couleur de la robe, des cornes, des cils, du museau, des sabots et de la mèche de la queue, et les suivantes mesures morphométriques ont été prises: périmètre thoracique, longueur du corps, hauteur au garrot, hauteur à la croupe, longueur de la tête, longueur et circonférence des cornes, longueur et largeur des oreilles, longueur du cou, longueur du fanon, longueur du tronc, longueur de l'échine, longueur et largeur de la croupe, longueur sous le genou, circonférence des sabots, longueur de la

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queue et de la mèche finale. Les résultats ont montré que les systèmes d'élevage affectent de façon significative la plupart des caractéristiques morphologiques aussi bien des mâles que des femelles, l'effet étant particulièrement significatif pour les mesures morphométriques. Ainsi, il a été noté que les vaches et les taureaux du SET sont de grands animaux à longues pattes. Ceci reflète une adaptation à des transhumances sur de longues distances et au pâturage en terrain montagneux. Il peut être conclu que les bovins Achai ont du potentiel pour s'adapter aux besoins de systèmes d'élevage spécifiques. La conservation de ses traits adaptatifs s'avère donc nécessaire dans les deux systèmes d'élevage.

Mots-clés: *bovins Achai, caractérisation morphologique, système d'élevage sédentaire, système d'élevage transhumant*

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Introduction

It is increasingly recognized that the use, development and conservation of livestock biodiversity are of great importance to food security, rural development and the environment (Pilling *et al.*, 2008). Phenotypic characterization of the indigenous livestock breeds is critical in breed improvement and conservation (Jing *et al.*, 2010; Kugonza *et al.*, 2011). The Achai is an as yet undocumented but well-adapted indigenous cattle breed of the Hindu Kush Mountains in northern Pakistan (Saleem *et al.*, 2012). It is a dairy and light draught breed that can thrive under scarce fodder availability, and it can produce adequately under a hilly and sub-hilly subsistence production setup (Khan *et al.*, 2008). The Achai grazes freely, is resistant to diseases and is better adapted to high altitude areas, and has a better efficiency index than all other cattle breeds of Pakistan, except Jersey crosses and Sahiwal (Kenyanjui and Sheikh-Ali, 2009). Achai cows also have a better reproductive performance than other cattle breeds in Pakistan (Saleem *et al.*, 2012).

Though the official livestock census (Anonymous, 2006) has reported the total population to be 0.59 million with 55 percent concentration in Hindu Kush Mountains, however, these figures include all the non-descript crosses having some resemblance to Achai breed. We estimate the population of phenotypically true Achai breed to be no more than 0.15 millions. This population is limited to the less accessible Hindu Kush Mountain valleys, where the agro-pastoralists still depends on Achai bulls to plough the narrow mountain terraces and hence can afford keeping Achai bull for plough as well as breeding. In these areas the average herd size of Achai cattle is four and seven animals in sedentary farming system (SFS) and transhumant farming system (TFS), respectively (Saleem *et al.*, 2012).

Owing to its important role in the future, the public sector in Khyber Pakhtunkhwa has recently initiated an Achai cattle conservation programme (Khan *et al.*, 2008). However, such conservation programmes remain ineffective because of the lack of scientific information on phenotypically pure Achai cows and bulls (Yakubu *et al.*, 2010). The current investigation shall thus fill this gap while providing the crucial information needed to establish efficient conservation efforts. The generated information will also help breeders to select better animals to keep the breed in its best condition for subsisting in remote mountains. This will insure food security for the poorest segments of Pakistani society living in the Hindu Kush Mountain region.

Material and methods

Study area

The broader home tract of the Achai cattle is spread over the northwestern Hindu Kush Mountains of the Khyber Pukhtunkhwa province in Pakistan. SFS are distributed over the mountain and rain-fed areas of the province. For the current study, the district of Lower Dir was taken as the study area for SFS (34°37′ to 35°07′N and 71°31′ to 72°14′E), with a mild, temperate climate, 700–1000 mm annual rainfall and 42 to 70 percent relative humidity (Anonymous, 1999). The SFS study area includes the mountainous Talash, Jandool and Maidan valleys (Figure 1). Under TFS, Achai herders spend summers in the uplands of Swat, Dir and Indus Kohistan, and winters in the major sugarcane growing lowlands of the Peshawar valley. The TFS involving transhumance between the Gabral uplands of Swat and the Mardan lowlands was taken as a representative area for the study (Figure 1). The Gabral valley lies between 35°20′ and 35°48′N and 72°12′ and 72°32′E, with a typical dry temperate zone climate (Hamayun, Afzal and Khan, 2006). The Mardan lowlands lay between 34°12′0N and 72°1′60E, and has a temperature range from 2.1 to 41.5°C, an average rainfall of 524.40 mm and humidity of 73 percent.

Attributes of the farming systems

The seasonal feeding in SFS is known as a cut-and-carry system, which provides wheat straw, weed thinning and hay in spring; wheat straw, tree leaves and hay in summer; wheat straw, maize stalks and weed thinning in fall; and wheat straw, maize stalks and hay in winter. Farmers also graze their cows on stubble fields (Saleem *et al.*, 2012). For TFS at Gabral (upland), the herders take dry cows, heifers and bulls to the high pastures for grazing, and keep milking cows at the settlements in the valley bottoms for homestead use. Milking cows are taken for grazing daily

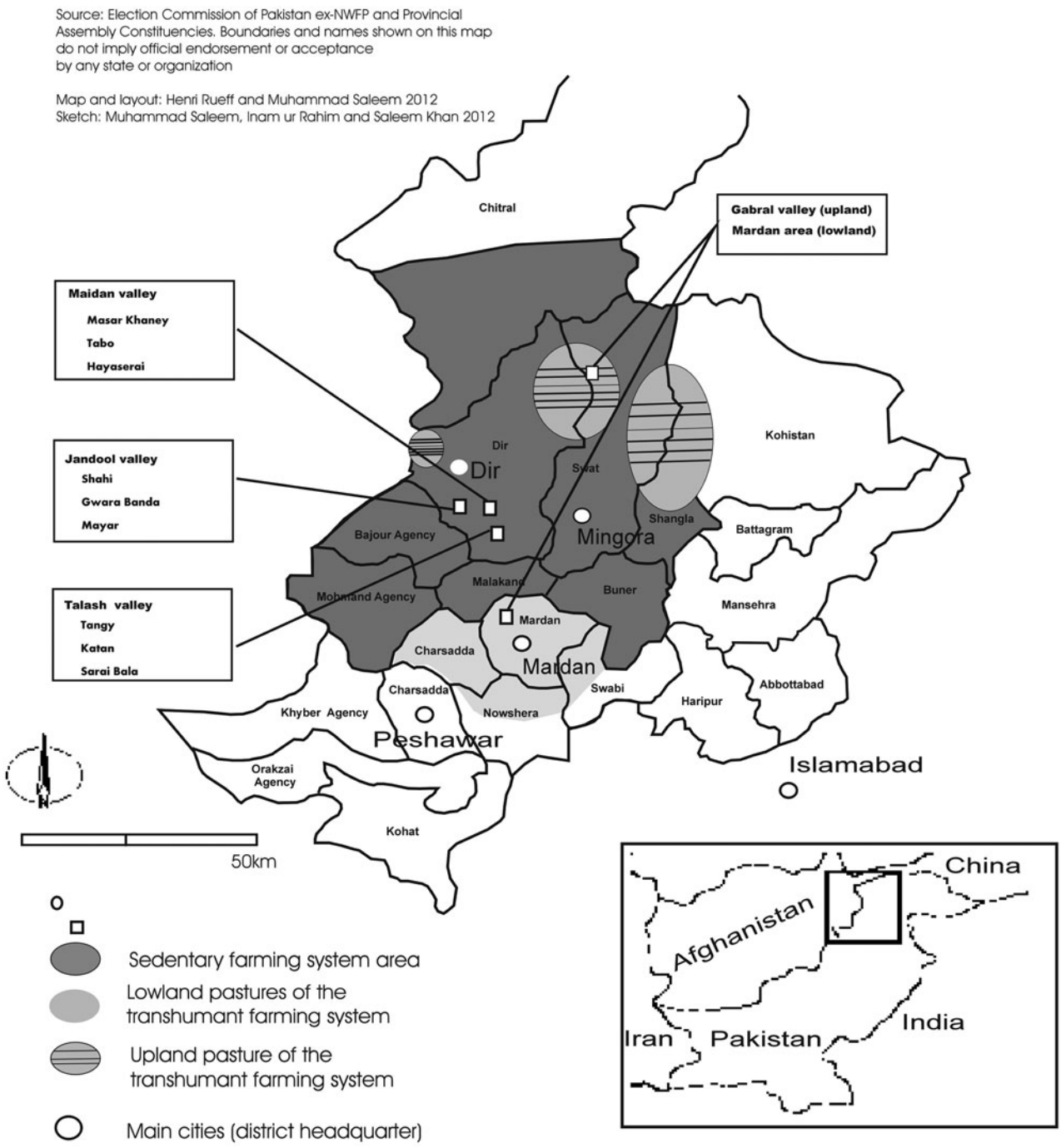

Figure 1. Map of the study area and locations of the villages where adult Achai cows and bulls were sampled.

to the hillsides near the settlements. In the lowlands, sugarcane tops and maize stover are given during winter, and are complemented with grazing along the canal sides and on stubble fields. The breeding season spreads over the entire year. However, the majority of cows come into heat during summer. In uplands and lowlands, cows are served with the available Achai bulls (Saleem *et al.*, 2012).

Sampling pattern

The sampling pattern for the study in SFS and TFS is presented in Table 1.

Sedentary farming system

Three villages each from the Talash, Jandool and Maidan valleys in the Lower Dir district were randomly selected. From each village, 12 adult Achai cows and 12 adult Achai bulls were then randomly sampled.

Transhumant farming system

Three settlements were randomly selected in the Gabral valley where 36 adult Achai cows and 12 adult Achai bulls were observed at each settlement for physical and morphometric characteristics.

Table 1. Sampling pattern of adult Achai cows and bulls in SFS and TFS.

Management	Valley	Village/ settlement	Number of cows	Number of bulls
SFS	Talash	Tangey	12	12
		Katan	12	12
		Sarai Bala	12	12
	Jandool	Shahi	12	12
		Gwarabanda	12	12
		Mayar	12	12
	Maidan	Masar Khaney	12	12
		Tabo	12	12
		Haya serai	12	12
	Total		108	108
TFS	Gabral	Ghwai Bela	36	12
		Gul Abad	36	12
		Karin	36	12
	Total		108	36

Physical characteristics like colour of the coat, horns, eyelashes, muzzle, hooves and switch were recorded for each animal, and morphometric measurements including heart girth, body length, height at withers, height at hipbone, face length, horn length (along the greater and smaller curvature), horn circumference (at base, mid and tip), ear (length and width), neck (length and circumference), dewlap (length and circumference), chine length, loin length, rump (length and width), length below knee, hoof circumference, tail length and switch length were carried out with the help of measuring tape according to the Food and Agriculture Organization's (FAO) standard procedure (FAO, 1986). Body weight was estimated according to Shaffer's method as described by Al-Amin *et al.* (2007).

Statistical analysis

Chi-square test and Student's *t*-test was used to study the effect of a farming system (SFS, TFS) on physical and morphometric characteristics respectively performed in GraphPad Prism-5 software (GraphPad Software, San Diego, CA, USA).

Results

Physical characteristics

Physical characteristics of Achai cows and bulls in SFS and TFS are presented in Table 2.

The dominant coat colour of the cows and bulls in both farming systems is spotted reddish-brown (Figures 2 and 3). However, the farming system significantly ($P < 0.05$) affects the coat colour of Achai cows, with a higher percentage of spotted reddish-brown colour Achai cows in TFS as compared with SFS. Significant variations in the distribution of the colour of eyelashes ($P < 0.05$), muzzle ($P < 0.01$) and switch ($P < 0.01$) of the Achai cow were also observed between SFS and TFS. In the case of bulls, significant variations were observed only in the prevalence of the colour of the horn ($P < 0.01$) and the switch ($P < 0.05$) of the tail between the two systems.

Morphometric measurements and adult body weight

Morphometric measurements and body weight of Achai cows and bulls in SFS and TFS are shown in Table 3.

Table 2. Physical characteristics of Achai cows and bulls in SFS and TFS.

Colour	Description (%)	Cow			Bull		
		SFS *n*=108	TFS *n* = 108	Significance	SFS *n* = 108	TFS *n* = 36	Significance
Coat	Spotted reddish brown	59.26	72.22	*	66.67	68.57	NS
	Solid reddish brown	40.74	27.78		33.33	31.43	
Horn	Light brown with greyish black tip	44.44	25.93	NS	31.48	8.57	**
	Light brown with blackish tinge in the upper part	28.70	36.11		49.07	14.29	
	Light brown	26.85	20.37		14.81	62.86	
	Black	–	17.59		4.63	14.29	
Eyelashes	Red	76.85	62.04	*	77.78	80	NS
	Black	21.30	27.78		17.59	8.57	
	White	1.85	10.19		4.63	11.43	
Muzzle	Light brown	36.11	17.59	**	18.52	25.71	NS
	Light brown with black pigments	50.93	53.70		50.92	45.71	
	Black	12.96	28.70		30.56	28.57	
Hoof	Light brown	56.48	40.74	NS	31.48	48.57	NS
	Black	31.48	39.81		50.92	31.43	
	Light brown with black striations	12.04	19.44		17.59	20.00	
Switch	Reddish brown	55.56	22.22	**	32.41	45.71	*
	White	35.18	66.67		45.37	51.43	
	Black	9.26	11.11		22.22	2.86	

NS = not significant.
*$P < 0.05$; **$P < 0.01$.

Figure 2. Spotted reddish brown Achai (left) with Friesian cow (right) in SFS.

Achai cows in TFS have significantly higher values for most of the morphometric measurements and adult body weight than do Achai cows in SFS, except chine and loin length, which were significantly longer in SFS cows. There was no significant difference in horn length, ear length and width and height below the knee joint between Achai cows in SFS and TFS.

Achai bulls in SFS have significantly larger heart girth size, longer bodies, longer and thicker horns, long neck,

Figure 3. Spotted reddish brown Achai cows in a transhumant cattle herd in TFS.

Table 3. Mean values (±SEM) of morphometric measurements (cm) and adult body weight (kg) of Achai cows and bulls in SFS and TFS.

Variables	Cows		Bulls	
	SFS	TFS	SFS	TFS
Heart girth	134.33 ± 0.6	138.60 ± 0.64^{a**}	140.50 ± 1.1	134.12 ± 1.9^{b**}
Body length	112.20 ± 0.7	116.11 ± 0.71^{a**}	116.26 ± 1.0	112.12 ± 1.85^{b*}
Height at withers	101.80 ± 0.4	103.69 ± 0.53^{a**}	107.62 ± 0.6	106.88 ± 1.1^{NS}
Height at hipbone	100.79 ± 0.3	102.48 ± 0.52^{a**}	106.38 ± 0.4	106.09 ± 0.7^{NS}
Face length	41.27 ± 0.27	42.57 ± 0.20^{a**}	41.93 ± 0.26	42.48 ± 0.46^{NS}
Horn greater curvature length	17.37 ± 0.42	17.72 ± 0.46^{NS}	19.73 ± 0.57	16.45 ± 0.99^{b**}
Horn small curvature length	12.92 ± 0.34	13.81 ± 0.36^{NS}	16.09 ± 0.44	13.04 ± 0.77^{b**}
Horn base circumference	11.86 ± 0.15	12.82 ± 0.22^{a**}	16.75 ± 0.20	15.94 ± 0.54^{b*}
Horn mid circumference	9.66 ± 0.19	10.56 ± 0.16^{a**}	14.66 ± 0.24	12.6 ± 0.41^{b**}
Horn tip circumference	5.22 ± 0.14	5.22 ± 0.08^{NS}	6.25 ± 0.15	5.88 ± 0.26^{NS}
Ear length	17.99 ± 0.21	16.56 ± 0.15^{NS}	16.14 ± 0.15	16.59 ± 0.26^{NS}
Ear width	11.59 ± 0.15	12.09 ± 0.11^{NS}	10.79 ± 0.11	11.34 ± 0.19^{NS}
Neck length	34.92 ± 0.52	30.95 ± 0.37 ^{a**}	33.22 ± 0.55	30.26 ± 0.97^{b**}
Dewlap length	67.11 ± 1.02	72.21 ± 0.95^{a**}	76.38 ± 0.97	71.15 ± 1.7^{b**}
Chine length	36.81 ± 0.37	33.08 ± 0.26^{a**}	39.66 ± 0.46	34.96 ± 0.8^{b**}
Loin length	33.28 ± 0.45	31.37 ± 0.26 ^{a**}	29.44 ± 0.26	28.74 ± 0.45^{NS}
Rump length	30.92 ± 0.38	36.04 ± 0.19^{a**}	33.45 ± 0.29	33.2 ± 0.52^{NS}
Rump width	30.55 ± 0.27	32.00 ± 0.18^{a**}	27.72 ± 0.28	28.72 ± 0.49^{NS}
Length below knee	26.93 ± 0.31	26.95 ± 0.14^{NS}	27.94 ± 0.15	28.67 ± 0.26^{b*}
Hoof circumference	27.94 ± 0.36	33.49 ± 0.22^{a**}	33.49 ± 0.19	32.91 ± 0.33^{NS}
Tail length	78.81 ± 1.03	91.04 ± 0.79^{a**}	95.06 ± 0.66	89.39 ± 1.16^{b**}
Switch length	21.65 ± 0.89	30.99 ± 0.61^{a**}	32.44 ± 0.5	30.30 ± 0.88^{b*}
Body weight	188.23 ± 2.6	207.13 ± 2.59^{a*}	215.83 ± 4.9	190.32 ± 8.20^{b*}

^{a,b}Means with different superscript letters in the same row for the same sex differ significantly between SFS and TFS.
NS = not significant.
*$P < 0.05$; **$P < 0.01$.

dewlap, chine, tail and switch and adult body weight than TFS Achai bulls. Achai bulls in TFS only have a significantly higher value for height below knee joint. There were no significant differences for the rest of the body measurements.

Discussion

Variation in coat colour in cattle depends upon geographical and climatic features and is reinforced by herder's preferences (Seo *et al.*, 2007; Desta, Ayalew and Hedge, 2011). The spotted reddish-brown coat colour of Achai cows and bulls in SFS and TFS may be due to the similar environmental condition in both farming system. However, the significantly ($P < 0.05$) higher percentage of spotted reddish-brown coat coloured cows in TFS could be due to the preference of the transhumant herders for this type of cows owing to better productivity. Such preference for spotting colour pattern has not been observed in SFS. Kugonza *et al.* (2012) also reported coat colour as the most important selection criteria among physical characteristics by the pastoralists rearing Ankole cattle in Uganda. In the case of bulls, the significant ($P < 0.01$) variations in the prevalence of horn colour between SFS and TFS may also be due to the herders' preference for light brown colour in TFS. In SFS, the herders give more attention to body frame followed by horn colour and orientation. Wurzinger *et al.* (2006) and Kugonza *et al.* (2012) also considered horn colour and shape as the most important phenotypic features among the physical characteristics, followed by coat colour, all of which are used as selection criteria in bulls as compared with cows.

Various morphometric measurements have been identified as the most appropriate variables to discriminate between and within cattle breeds (Mwacharo *et al.*, 2006; Yakubu *et al.*, 2010). Within the breed variation in morphometric measurements reflect adaptation to the specific production system (Hall, 1998; Kugonza *et al.*, 2011).

The significantly higher values (Table 2) for most of the morphometric measurements of Achai cows in TFS than Achai cows in SFS seem to be an adaptation to TFS, where tall (height at withers) and large body size (heart girt and body length) are suitable for trekking long distances to water and grazing points (Hall, 1998; Mwacharo *et al.*, 2006). Kugonza *et al.* (2011) also recorded significantly larger body dimensions for Ankole cattle in a pastoral system as compared with a crop-livestock production system.

Achai bulls in TFS have significantly lower values for most of the body measurements than Achai bulls in SFS, except for length below the knee joint, which was significantly higher for TFS bulls (Table 2). This could be an adaptation to mountain terrain grazing as the taller and

Table 4. Comparison of morphometric measurements (cm) of Achai cattle in SFS and TFS with other cattle breeds of Pakistan.

Breed		Sex	Heart girth	Body length	Height at wither	Source
Achai	SFS	Cow	134.33 ± 0.60	112.20 ± 0.77	101.80 ± 0.42	Present study
Achai	TFS	Bull	140.50 ± 1.12	116.26 ± 1.02	107.62 ± 0.68	
		Cow	138.60 ± 0.64	116.11 ± 0.71	103.69 ± 0.53	
		Bull	134.12 ± 1.97	112.12 ± 1.85	106.88 ± 1.16	
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	142	137	119	Khan, Younas & Hanjra (1982)
		Bull	182	162	132	
Sahiwal		Cow	167	135	120	Khan, Younas & Hanjra (1982)
		Bull	200	160	136	
Red Sindhi		Cow	155	127	115	Khan, Younas & Hanjra (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)
		Bull	189.74 ± 1.80	156.03 ± 0.94	145.64 ± 0.68	
Dajal		Cow	205	145	136	Khan, Younas & Hanjra (1982)
		Bull	167	137	126	

leggier animals are more suitable for grazing in steep and rugged terrains than short-legged animals (Mwacharo *et al.*, 2006). The Achai bulls in TFS also have significantly ($t_{(141)} = 2.55$; $P < 0.01$) shorter body length to height at withers ratio than bulls in SFS (1.05 ± 0.01 and 1.08 ± 0.01, respectively), which indicates that TFS bulls are taller with respect to body length than SFS bulls. This sort of morphological feature is best suited to draught power in rocky mountains (Berthouly *et al.*, 2010).

The smaller body size of Achai cattle among all the cattle breeds of Pakistan, as indicated by the smaller heart girth, body length and height at wither (Table 4), seems to be an adaptive trait for survival during seasonal fodder fluctuation. This is because smaller animals are reported to be less susceptible to fodder shortages (Hall, 1998), and they can move more easily and quickly (Ouma *et al.*, 2004) on mountain slopes for grazing.

Conclusion

Because of the diversity of the Achai cattle production system, it has developed diverse morphological characteristics that suit mobility and draughtability in rugged mountain terrain, as well as better reproductive and productive performance under scarce fodder availability. These characteristics make it an ideal breed that can insure food security, particularly in relation to the changing climate that is predicted in the Hindu Kush and Himalayan regions (Hussain *et al.*, 2005). Our findings contribute to the basic information that characterizes this breed, and is relevant as a source of essential information to support the selection and conservation programmes of the Achai cattle breed under both SFS and TFS. However, comprehensive research is needed to find out the breeding goals of the relevant farming systems through which an *in situ* conservation can be made.

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