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Morphological diversity of principal horse (*Equus caballus*) populations of Bhutan

JIGME DORJI*, TSHEWANG, TSHERING DORJI, SONAM TAMANG, AND TASHI Y DORJI

National Biodiversity Centre, Ministry of Agriculture and Forests, Serbithang, Thimphu, Bhutan
*Author for correspondence: email-jigmedorjik@gmail.com; ph: +975 2351218

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ABSTRACT

The objective of the study was to understand the horse population types and to document the morphometric characteristics of predominant horse types in Bhutan. The study indicated the presence of about seven horse types including the imported breeds. The three predominant types were Yuta, Boeta and Sharta. A total of 11 biometric measurements were recorded on 324 unrelated adult horses (162 stallions and 162 mares) comprising of Yuta (272), Boeta (30) and Sharta (20). Overall, the multivariate analysis of biometric measurements revealed a significant ($p \leq 0.01$) difference among the horse types. The parameters such as ear length, back height, barrel length, height at withers, and heart girth of the Yuta horses were significantly lower than Boeta type but similar to Sharta horses. The difference in the parameters between the sexes were not significant. The cluster analysis based on squared Euclidean distance derived from mean values of aggregated gender grouped horses into two types. The findings suggest the morphometric similarity of Yuta and Sharta, and their variation from Boeta horses. Further, the molecular studies to determine their phylogeny and genetic diversity is recommended.

INTRODUCTION

The transportation of goods in mountainous terrains and rugged environment in Bhutan in the past has always demanded highly enduring and intelligent horses to negotiate with the difficult terrains. The Bhutanese horses were one of its kind and were described as sturdy, hardy, and surefooted for both pack and riding (Pemberton 1839; Ashley Eden's Political Mission to Bhootan 1865). For this reason, Bhutanese horses were in demand in neighboring plains of India. The horses as a commodity consistently topped the Bhutan's export by value to the Indian state of Assam during 1920s (Ray and Sarkar 2012).

The horses are also associated with Bhutanese culture and traditions. Often horses were offered as gift and tribute by Bhutanese to representatives to British India (Luethi 1999). The horses continue to be used in various religious ceremonies, particularly as riding horse for deity (Gurung 2008). The use of horses in sports and entertainment is limited to a case of *Am Jhomo Soelkha* (annual ritual offering to a local deity) by the yak herding communities of Merak and Sakten. The event includes horses racing and honoring of the best horses and their horsemen.

The traditional Bhutanese horse populations are categorized based on source as Yuta (born in locality), Boeta (horse from Tibet), Jata (horse from India), and Merak Saktenpata (Horse in Merak and Sakten) (Gurung 2008). In fact, the origin of Yuta horses remains unclear. It is believed to have brought in from Tibet during the ancient trade, probably along the old silk route (Leuthi 1999). Studies by Nawaza et al. (2007) traced the phylogenetic relation of the native horses of Bhutan with those of the Mongolian horses with genetic introgression from Tibetan horses. Further, the knowledge on the distribution, population, morphological characters, and diversity of the traditional Bhutanese horse types are limited. On the other hand, the horse population in the country is declining rapidly. It declined by 40 % over six years from 25,384 in 2007 (DoL 2007) to 15,991 heads in 2013 (DoL 2013)). This is mainly attributed to the rapid socio-economic development in the country and specifically the improved road connectivity and fast diminishing utility of the horse species. The rapid rate of decline in the population poses risk of losing the important genetic resource. A good understanding on horse genetic diversity is important for decisions on their conservation and sustainable utilization. Breed characterization and documentation is recognized as an essential step to planning the animal genetic resources management (FAO 2012). Therefore, a study was conducted to understand the principal traditional horse and their characteristics. The knowledge shall aid in effective management of their genetic resources in the future.

MATERIALS AND METHOD

A nationwide purposive sampling was carried out at 26 different locations based on horse population and the relative economic importance of the species (Figure 1). Accordingly, the agro-ecological zonation was developed for the study. For the morphometric measurements, the horses were made to stand on a levelled ground and measurements (Table 1) were taken according to the methods suggested by Gutpa et al (2012) and Kefena et al. (2012). Qualitative traits such as coat colors and markings (Figure 2) on the face and leg were also noted. Although about seven horse types (Boeta, Yuta, Sharta, Jata,

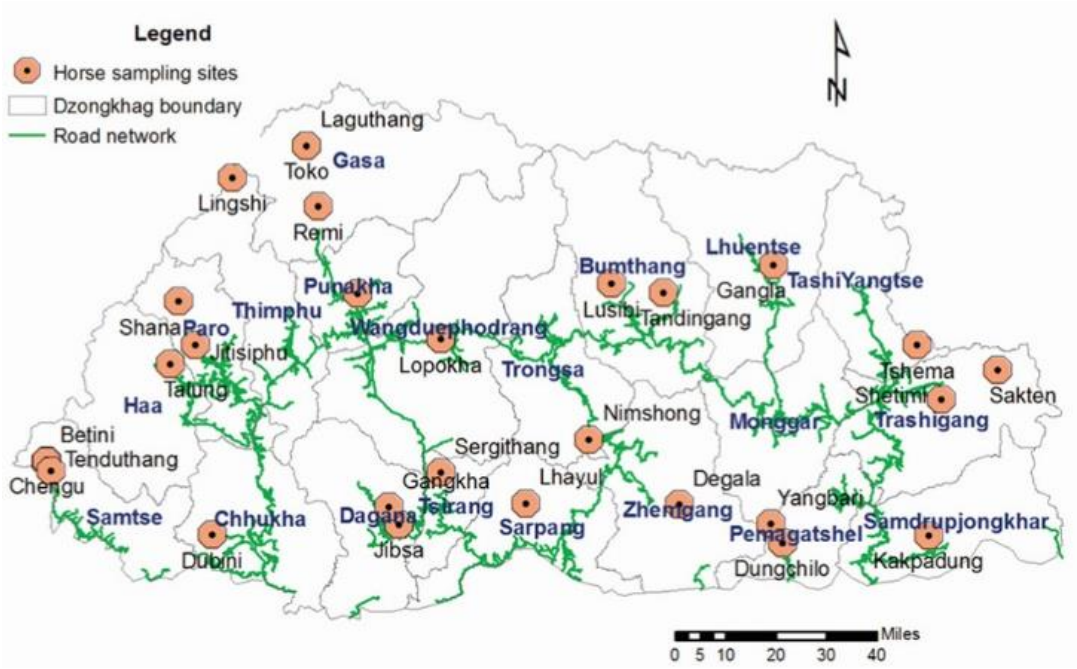

Figure 1 Study locations

Table 1 Description of morphological traits.

Sl. No.	Definition
1	Ear Length (EL): Distance from the base of the ear on the dorsal side to the tip of the ear
2	Face length (FL): Distance from the intersection of dorsal most point of eyes to the tip of the nasal bone
3	Height at withers (WH): distance from the highest point of processes spinalis of the vertebrae thoracic to the ground
4	Back height (BkH): Distance from the deepest point of back to the ground
5	Body length (BL): Distance from the most cranial point of the shoulder joint to the caudal most point of pin bone
6	Barrel length (BrL): Distance from the most caudal point of the scapula to the most cranial and dorsal point of the hip
7	Length of cannon bone (CL_f): Distance from the lateral tuberculum of the os metacarpale IV to the fetlock joint
8	Canon bone circumference (CC_f): The smallest circumference of the canon bone of the forelimb
9	Depth of shoulder (SD): Distance from withers to shoulder joint
10	Heart Girth (HG): Measure in place of saddle girth
11	Hoof length (HL): Length of hoof from the cranial part to the caudal most point of the hoof
12	Hoof width (HW): The maximum length of hoof from side to side

Haflinger crosses, Spiti, and Lhota) were encountered during the survey, only 324 adults (162 stallions and 162 mares) of unrelated horses belonging to three horse types; ((Yuta (N,274), Boeta (N, 30), and Sharta (N,20)) were included in the

Figure 2 Qualitative traits (color and markings on face and leg) of horses.

study. The number of cases in other types were too small for a meaningful inference and thus omitted.

Data analysis

The data were analyzed using SPSS version 23 (IBM Corp 2015). Coat colors, face and leg marks of the study population were analyzed as frequency and Chi square test was conducted. Biometric measurements were analyzed using the multivariate GLM procedures with Duncun Multiple Range Test for comparison of main effects. The body measurements were fitted as dependent variable. Breed and sex were fitted as fixed independent variables and age as covariate. The values were considered significant at $p \leq 0.05$. The mean values of the parameters of each population were used to derive squared Euclidean distances and agglomerative hierarchical cluster analysis was employed to develop dendrograms.

RESULTS

Morphological traits

The coat colors varied across the horse types and had no clear association either for the breed or sexes. Most common colors were chestnut (28%), dark bay (18%) in Yuta, dark bay (25%), followed by gray (21%) and chestnut (18%) in Boeta (Table 2).

Majority of Sharta was dark bay (40%), followed by gray (20%). Twenty-eight percent of Yuta possessed face mark mainly star and 10 % had leg marks. About 18 % of Boeta had face mark and were generally plain legged. Sharta were plain faced and 50% possessed leg marks.

The least square means of body measurements for the aggregated sex are presented in Table 3. The results indicated significant differences ($p \leq 0.05$) across horse types but the same was not true between the sexes (irrespective of all the breeds). The results further indicated that Ear Length (EL), Barrel Length (BL), Back Height (BH), Body Length (BL), and Heart Girth (HG) of Yuta horses were not significantly different from Sharta but significantly lower than Boeta ($p \leq 0.05$). This suggests Boeta horses are taller and lengthier body compared to other two breeds.

The hierarchical cluster analysis using overall squared Euclidean distances for aggregated gender grouped into two main clusters; viz. stocky, heavy and large body sized Boeta and slightly smaller, agile and elegant Yuta-Sharta group (Figure 3).

Table 2 Frequency of coat colors and markings.

Type (N)	Coat Color	%	Face Mark	%	Leg Mark	%
Yuta (272)	Chestnut	28	Plain	61.2	Plain	89.5
	Dark bay	18	Star	21.6	Coronet	6.4
	Gray	12	Stripe	4.9	Others	4.1
	LCN*	13	Blaze	1.1		
	Palmino	8	Other	1.1		
	Others	21				
Boeta (30)	Dark bay	25	Plain	82.0	Plain	100
	Gray	15	Star	18.0		
	Chestnut	18				
	LCN	14				
	Others	21				
Sharta (20)	Dark bay	40	Plain	100	Plain	50.0
	Gray	20			Coronet	40.0
	Others	40			Stocking	14.3

*LCN Liver Chestnut

Table 3 Least Squares Means (±SEM) of biometric measurements of aggregated gender of horse types in Bhutan.

Trait	Boeta	Sharta	Yuta
EL	16.9(0.4)^{a}	13.5(0.7)^{b}	14.1(0.1)^{b}
SD	58.0(1.5)^{a}	51.9(3.0)^{ab}	53.7(0.4)^{b}
WH	128.0(1.2)^{a}	121.5(2.4)^{b}	122.9(0.3)^{b}
HG	151.9(2.3)^{a}	139.8(4.4)^{ab}	151.9(0.6)^{b}
BkH	122.9(1.3)^{a}	116.8(2.5)^{ab}	118.8(0.3)^{b}
BrL	73.3(1.3)^{a}	64.4(2.4)^{ab}	67.9(0.3)^{b}
BL	135.8(2.2)^{a}	131.6(4.2)^{ab}	129.5(0.5)^{b}
CLf	21.5(0.5)^{a}	20.2(1.0)^{ab}	19.6(0.1)^{b}
CCf	17.6(0.4)^{a}	16.9(0.7)^{ab}	16.2(0.1)
HL	13.2(0.3)^{a}	12.3(0.7)^{ab}	11.6(0.1)^{b}
HW	10.5(0.2)^{a}	9.8 (0.5)^{ab}	9.7(0.1)^{b}

^{a,b}Means in same row with different superscript indicate significant difference at $p \leq 0.05$. EL ear length, FL face length, SD shoulder depth, HG heart girth, BkH back height, BrL Barrel Length, BL body length, CLf Canon length (forearm), CCf Canon circumference (forearm), HL Hoof length; HW; Hoof width.

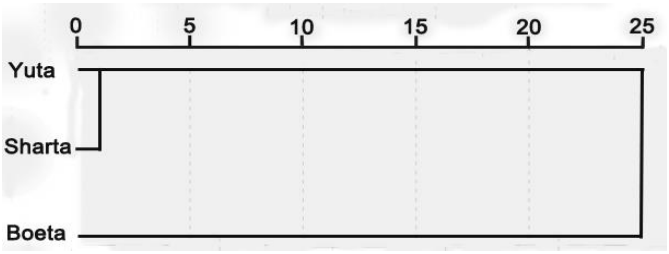

Figure 3 Dendrogram using average linkage between the types (Rescaled distance cluster combine).

DISCUSSION

Coat colors, face and leg marks

The variation in coat color in horse is attributed to selective breeding especially among the traditional societies (Ludwig et al. 2009) and an effect of dominant, recessive and their interactions at different locus. Apart from identification, the genes of coat color are increasingly associated with risk and severity of diseases (Teixeira et al. 2013) and diagnosis and control of diseases (Li et al. 2010).

Within Bhutan, coat color and body markings are important considerations for use of horses in religious, cultural and personal context. There is a specific coat colors and markings requirement for use as a *Chipta* (riding pony) during religious ceremonies (Gurung 2008) and *Chipdrel* (traditional welcome procession) (Rigzin 2011). As such, the choice of particular coat colors and markings by a person are based on one's astrological signs and believed to bring good talisman (Gurung 2008). The dominance of bay, gray and chestnut in studied population is consistent with Nozawa et al. (2007). Gray coat colors are also reported to be dominant in native Chinese horses (Gao et al. 2015).

There were no differences in body measurements between the sexes in the study. These observations are in accordance with those of Gupta et al. (2012) who also reported no significant differences between sexes for Marwari and Kathiawari breeds on selected set of traits (WH). The morphometric measurements *viz.* WH, BL, HG, CL and CC of Bhutanese horses are comparable to other mountain horses/ponies such as Manipuri, Spiti, Zanskari, and Bhutia of Indian sub-continent (Gupta et al. 2012). The WH and BL of Mongolian horses (128 cm) (Cheng 1984) and Yuta were similar to Boeta but higher than Yuta and Sharta. However, Yuta and Sharta were relatively larger than Jianchang (WH 115, BL 114) and Lijang (WH 117; BL 115) mountain pony. Ujumqin and Kazakh horse breeds are larger than all Bhutanese horse types. The Bhutanese horses, particularly Yuta and Sharta were also similar to Exmoor pony (Brown et al. 2013) in WH, CC but smaller in BL and HG.

Phenotypic description, geographical distribution and population

Yuta

Yuta horse is the most predominant horse population (more than 90%) and are distributed throughout the country (DoL 2014). Apart from their surefootedness and endurance, the advantage of smaller body size of Yuta in rough terrain and easy management makes it the most preferred horse type in Bhutan. They have strong forelimbs with narrow chests, close-hocked hind limbs and hard and solid hooves (Gurung et al. 1999; Gurung 2008). The measurements (cm) for the breed (height at withers 123.4; heart girth 140.5; and canon circumference 15.3 cm) reported by Gurung (2008) are comparable to the findings of this study. The Bhutanese local

horses are taller than the mountain pony breeds of Southeast Asia; Yunan native horse, Thai native horse, Vietnamese native horses, and Bangladesh native horses but smaller than the Mongolian native horses (Nozawa et al. 2007). In this study, the parameters such as WH, BL and HG of Yuta are comparable with that of some horse breeds of India (Spiti, Bhutia, and Zanskari) (Gupta et al. 2012).

Although no cases of Bhutia breed was encountered during the survey, Bhutan has been mentioned as home tract to Bhutia (Gupta et al. 2012) and in particular much sought after breed *Bhutia Tangun* (Pemberton's report on Bhootan of 1838 and Ashley Eden's report on the State of Bootan and on the Progress of the Mission of 1863-64). This indicates Yuta horses perhaps may be synonymously known as Bhutia outside Bhutan. The export of Bhutanese horse to India and reference to Bhutan as home tract to Bhutia horses in literature in part support their synonymy.

Boeta

Boeta horse is another popular horse type in northern region of the country and well known for pack and riding. They are distributed in Tsento (Paro) (27.43° N, 89.25° E), Esu and Talong (27.43° N, 89.25° E) of Haa, Laya (27.89° N, 89.73° E) of Gasa, Lingshi (27.97° N, 89.45 °E) of Thimphu, and Bumdiling (27.74° N, 91.42° E) of Tashiyangtse districts of Bhutan. These horses originate from bordering areas in Tibet (China). Boeta literarily means horse (*ta*) from Tibet (*Boed)*. Currently, the population of Boeta horses are fast dwindling and is estimated to be about 100 horses in these areas.

Boeta horses in general are larger in body size compared to the Yuta horses. They are larger than Bhutia horses (Gupta et al. 2012), especially in EL, BL, HG, WH, CL, BkH, HL, and HW. The morphometric measurements of Boeta horses by Gurung et al. (1999) were WH (116 cm), HG (136 cm), and CC (14 cm). The values reported by Gurung (2008) for the traits (WH (124.4 cm), HG (143.6 cm) and CC (16.1 cm)) are slightly lower than in the current study. Hierarchical cluster analysis of body parameters groups Boeta horses as phenotypically different from Yuta and Sharta horses.

Sharta

The Sharta horses are the sub-districts of Bhutan neighboring the Indian state of Arunachal Pradesh namely Merak (27.32° N, 91.74 °E) and Sakten (27.40° N, 91.92° E) of Tashigang and Toedtso (27.50° N, 91.63 °E) of Tashiyangtse. In the past, the informal exchange of horses was common among these bordering regions. Sharta literally means horses from Shar (alternative name for Arunachal Pradesh). Arunachal Pradesh including Bhutan are considered as the home tracts of Bhutia horses (Gupta et al. 2012). The comparison of biometric measurements of Sharta with Bhutia horses shows more morphological similarity than Boeta or Yuta. The population of Sharta is estimated to be less than 100 animals in these areas combined. The similarity of Sharta and Yuta and further to that of Bhutia horses in literature points to synonymy and genetic similarity compared to other horse types.

CONCLUSIONS

Yuta horses to an extent are morphologically different from Boeta and are more similar to Sharta horses. Yuta horse is an important genetic resource for conservation, considering its long use and adaptation to Bhutanese environment. The morphological similarities of Yuta with Sharta and Bhutia horse in literatures warrant molecular studies for determining phylogeny, genetic diversity and management of Yuta genetic resources in the country.

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