Body indices for the pantaneiro horse

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Abstract

Body index measurements on 2248 horses registered by the Brazilian Association of Pantaneiro Horse Breeders (ABCCP), in the period from 1972 to 2000 were analyzed. Data was analyzed using SAS and DFREML to calculate genetic parameters. The Dactyl Thoracic Index indicated that these animals are intermediary (not light horses but not suitable for traction), while the BARON and CREVAT index confirmed this result. The Chest Index presented animals that are good for speed as they have long legs but looking at the Body index the indication was that these horses are neither suitable for speed nor traction (intermediary). The analysis of other conformation indices indicated that, in general, these horses are medilines, show good speed and chest development, making them suitable for dealing with cattle and resistance for long treks. The environmental factor analysis verified that these horses have changed in recent years possibly due to selection by the breeder which may affect their adaptive capacity.

Introduction

The Pantaneiro Horse is a naturalized breed of the Pantanal region of Brazil. This horse had its probable origin from Iberian horses introduced by Spanish settlers, especially in the 16th and 17th centuries, and by Portuguese settlers in the 18th century.[1] As a consequence of natural selection for more than two centuries, with little or no human interference, an animal well adapted to the environment appeared.[2,3] At the end of the 19th century, the population of the breed was severely reduced mainly due to *Peste das cadeiras* (Trypanossomiasis). Later, other menaces to survival appeared, mainly indiscriminate crossbreeding and more recently Equine Infectious Anemia (EIA). This genetic resource was saved from extinction by the creation of the Brazilian Association of Pantaneiro Horse Breeders (ABCCP), in 1972. The main use of this horse is managing cattle, which is the principal economic activity in the region.

By now, the breeders are interested in selection and improvement of the breed, principally in its body conformation. Although conformation is related to performance, selection should be directed to ensure the breed doesn't lose its traits attained through natural selection.[4] According to Giannoni[5], the affirmation that 'form predicts function' is somewhat generic, as the performance of horses is influenced by morphological, physiological, and psychic factors as well as the environment. Therefore, the form is only an indication of the production value of the animal. Conformation and performance traits are heritable and influenced by environmental factors.[6]

Conformation of the horse has been studied by various authors, based principally on body measures.[6,7,8] Body indices are used to determine aptitude for certain services such as velocity, resistance and traction. This

study aims to determine some body indices for Pantaneiro Horses registered by the ABCCP and the influence of genetic and phenotypic factors on them.

Material and Method

Data was collected by the ABCCP, in the period from 1972 to 2000. Biometric measures at time of register was available on 2248 animals. These included withers height (WH), back height (BH), croup height (CH), midback height (MBH), head length (HL), neck length (NL), back-loins length (BLL), croup length (CL), shoulder bone length (SBL), body length (BL), head width (HW), chest width (CW), hip width (HiW), thorax perimeter (TP) and shin bone perimeter (SBP). The measurements were taken in accordance with descriptions in Costa et al.[7] and Ribeiro[9]. Analysis of these individual traits can be found in Miserani et al.[6].

From these measurements conformation indices were calculated according to Simões[10], Martin–Rosset[11], Torres and Jardim [12], Ribeiro[9], Franci et al.[13] and Santos et al.[4]:

Body Index (BI): = BL/TP. When this is greater than 0.90, the animal is longiline, more apt for speed; between 0.86 and 0.88, mediline, and less than 0.85, breviline, more apt for force.

Relative Body Index (RBI): = BL x 100/WH.

Dactyl Thorax Index (DTI): = SBP/TP. The DTI may not be less than 0.105 in light horses, up to 0.108 in intermediary horses, up to 0.110 in light traction animals and up to 0.115 in heavy traction horses. This index also indicates thoracic development.

Pectoral Index (PI): = MBH/SUH (where SUH is space under horse). When the back height is less than the space under the horse the animal is considered "far from ground", this being a trait which favors speed due to relatively long legs;

Thoracic development (TD) =TP/WH. This indicates thoracic development of the animal, with values above 1.2 indicating animals with good TD.

Body ratio (BR): = WH/CH. If the withers are lower than the croup the animal is low in front and vice versa. Both are considered defects and this inequality in heights may hinder both gait and resistance.

BARON & CREVAT: $= TP^2 /WH$. The greater the index the closer the animal is to a traction type, lower the weaker the animal for this type of work, also called Conformation Index.

Weight (W) $= TP^3*80$. Weight above 550 kg correspond to large or hypermetric horses, between 350 and 550 kg medium or eumetric horses and less than 350 kg small or elipometric horses.

Tare Index 1 (trot or gallop) (TI1) = TP^2 x 56 / WH; indicates weight that can be carried at trot or gallop;

Tare Index 2 (walk) (TI2) = TP^2x 95 / WH; indicates weight that can be carried at walking pace;

Compact Index 1 (CI1) = (W/WH)/ 100; indicates how compact the horse is. Horses suitable for traction have values above 3.15. Values close to 2.75 indicate light traction and close to 2.60 indicate horses suitable for riding.

Compact index 2 (CI2) = (W/(WH-1)]/100): This index also indicates the aptitude of the animal. Values above 9.5 indicate heavy traction animals, between 8.0 and 9.5 indicate animals suitable for light traction and between 6.0 and 7.75 indicate riding animals.

Riding Comfort degree (CD) = BH – (WH+CH)/2: Indicates the inclination of the back of the animal where the saddle sits.

All data were analyzed using SAS[14] procedures including General Linear Model (GLM), Correlation (CORR), Principal Component (PRINCOMP), Frequency (FREQ), as well as the procedures for charts (CHART) and means (MEANS). Heritabilities as well as genetic and phenotypic covariances were calculated using DFREML[15]. Fixed effects included register type (open or closed book), sex and age of the horse, month and year at registration as well as Pantanal subregion where the horse

was raised.

The model used for evaluation of the fixed effects was:

$$Y_{ijklmno} = m + S_i + R_j + A_k + Y_l + M_m + B_n + C_o + e_{ijklmno}$$ where:

$Y_{ijklmno}$ = dependent variable; one of the index measures;

μ = general mean, associated with the dependent variable;

S_i = fixed effect of ith animal sex (i = Male or Female);

R_j = fixed effect of jth sub-region (j = 1,...,10);

A_k = fixed effect of kth age at registration (k = 2,...,9);

Y_l = fixed effect of lth year of birth (l =1963,...,2000);

M_m = fixed effect of mth month of birth (m=1,…,12)

B_n = fixed effect of nth registration book (open or closed);

C_o = fixed effect of oth coat color (1,…,12);

$e_{ijklmno}$ = random residual associated with each variation.

For the genetic analysis the general model for this analysis was:

$$Y = X\beta + Z_1\alpha + e$$ where:

Y is a vector (N x 1) of animal observations;

β is the fixed effects vector, associated with the incidence matrix X;

α is the vector of direct genetic effects, associated with the incidence matrix, Z_1;

e is the random error effects matrix.

Results and Discussion

According to Correa Filho[16] and Domingues[3], the Pantaneiro Horse is probably of Lusitanian origin (Celtic Lusitanian, Barbo or Andaluz), crossed with Arab and Argentinian Creole. Cothran et al.[17] showed the close genetic relationships of this breed with those from the Iberian Peninsula (Andaluz and Lusitanian) as well as other Brazilian horses, especially Mangalarga. The overall body shape is referred to as conformation. It is basically the result of many heritable traits, although environmental factors help shape the horse's body. Although concepts of perfect conformation vary among breeds, all breed registries agree that the overall quality and balance of a horse's build should be symmetrical and proportional to its size.[18] Fontes et al.[19] established the pattern for the Pantaneiro horse. For registration, the males must have a minimum wither height of 1.40 m and females 1.35 m.

The summary of the analysis of variance is in table 1. Coefficients of variance (CV) were in general low for these indices (< 10%) and coefficients of determination ranged from 0.185 to 0.394 showing that there are other unidentified sources of variation. Mawdsley et al.[20] found CVs higher than 10% for most traits studied in English Thoroughbreds while Sabeva[21] found low

Table 1 - Summary of analysis of variance of body indexes of the Pantaneiro horse registered by the Brazilian Association of Pantaneiro Horse Breeders (1972 to 2000)

	BR	RBI	PI	DTI	Weight	BI	TD	BC	TI1	TI2	CI1	CI2	CD
Book	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Sex	**	**	**	**	**	**	**	ns	ns	ns	*	*	ns
Month of register	ns	**	**	**	**	**	**	**	**	**	**	**	ns
Year of register	**	**	**	**	**	**	**	**	**	**	**	**	ns
Subregion	**	**	**	**	**	**	**	**	**	**	**	**	ns
Coat colour	*	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Age	ns	**	**	*	ns	ns	ns	ns	ns	ns	ns	ns	*
CV	0.725	1.990	4.475	4.251	9.914	3.515	7.461	6.221	6.221	6.221	8.351	8.553	17.521
Mean	0.994	102.42	0.582	0.109	341.01	0.874	1.288	1.891	105.91	179.68	2.519	8.675	-0.034

** P<0.01; * P< 0.05; ns = not significant; CV = Coefficient of variation; BI = Body index; RBI = Relative Body Index; DTI = Dactyl Thorax Index; PI = Pectoral Index; BR = Body Ratio; TD = Thoracic development; BC = Baron & Crevat; TI = tare index, CI – compact index; CD – comfort degree (See text for details)

CVs for linear measures in crossbreds between Thoroughbreds and east European riding horses from Bulgaria. This may also be a reflection of the low number of stallions registered by the Breeder's Association[22], (300 males were registered between 1971 and 2000) or the fact that the limits for registration are not adequate to the reality of the breed.[5]

Year of register and subregion were significant (P< 0.01) for all indices studied, and month of register was not significant for BR but significant for other indices. This may be due to the quality of pasture, nutritional state of the animals and variations due to different technicians measuring the animals. The nutritional management of the horses in the Pantanal is especially affected by the rainy season when pastures are flooded[1], when the number of forage species in natural pastures is reduced. The linear measures reflect this, with a decrease in several measurements. This is in agreement with the literature for other Brazilian breeds.[7,23]

In general, sex was significant (P<0.01) for all indices, except Baron and Crevat and tare carrying indices. In other studies, sex tended not to be a significant source of variation for some linear measures[24], but not al.[25]. The fact that some traits were not significantly affected by sex may be due to greater care taken in presentation and registration of stallions.[7]

Most traits were not affected by age. This may be due to the fact that the ABCCP has minimum requirements for height traits involved in many of the indices (135 cm for females and 140 cm for males), therefore requiring animals to be older at registration. According to Miserani[26] the ideal age for registration of these horses is 4 years, in agreement with Reed and Dunn[27] and Santos et al.[28].

Mean weight of the animals was 352kg for males and 334 kg for females. According to FAO[29] males are 425kg and females 325kg. Animals registered in the rainy season were lighter (313kg) than those registered in the dry season (352kg). During the dry season, there is usually an increase in the environments with favorable conditions for horses, such as borders of permanent and temporary lakes and pools. The quality of forage in these areas is higher and consequently the animals have a better conformation.[30] Animals from Jangada, Araputanga, Maracaju and Rondonópolis were heavier than the other subregions.

A BR of 0.994 shows that these animals are well proportioned (withers and croup heights approximately equal), an important trait for the health and resistance of the animals.[9] The animal depends on these traits for resistance during long arduous treks. Imbalance in this index may indicate a susceptibility to problems in the joints in the anterior and posterior limbs of the animal, thereby damaging the skeleton.[8]

Overall the BI had a mean of 0.874, therefore the animals are considered mediolines (not specifically apt for speed or traction), although in some years, especially at the beginning of registration (72; 73; 74; 75; 78; 80; 81; 82; 83 as well as 1999) they were shown to be longlines. This may be due to selection within the breed in more recent times for this type of horse. Other reasons included differences in pasture quality, nutritional state of the animals, general management and differences in measures taken by different technicians at registration. This is also in agreement with literature on other Brazilian breeds.[7,23]

The subregions Barão de Melgaço, Araputanga, Jaciara, Rondonópolis and Jangada, had horses which tended to be brevilines (apt for traction), but in other regions they were mediolines. The Brazilian Pantanal is very heterogenic with ten distinct subregions being identified[31], each with its own charcateristics, ecologically different: Cácares, Poconé, Barão de Melgaço, Paiaguás, Nhecolândia, Paraguai, Aquidauana, Miranda, Abobral and Nabileque[32]. In general, the differences in shape between the horses was in accorandance with the distribuition within these Pantanals, indicating possible differences between the animals bred in

different regions, which need to be better studied. The first horses arrived in the Pantanal region became acclimatised and multiplied in accordance with the specific environment in each subregion to give different phenotypes.[1] Only after the formation of the ABCCP in 1972, was it possible to unite these various phenotypes to form the Pantaneiro breed. Recently, Fuck et al.[33] studying the genetics of this breed using RAPD markers found significant differences between horses coming from different regions.

The mean BI for the sexes individually (both males and females) was 0.874, also indicating medioline animals, different from that indicated by Santos et al.[4] who found a mean BI of 0.90 for males and 0.88 for females, classifying them as longliolines and mediolines respectively. These differences may be due to selection pressure applied in recent years. Younger animals tended to be breviolines while with age they became more medioline.

The general mean for RBI was 102.42. Mean values for RBI were 102.2 for males and 102.59 for females. These are close to the values found by Franci et al.[13] in Avelignese horses where the indices were 102.6 and 104.3 for males and females respectively.

Data from TI calculations show that these animals can carry on average 106kg at a trot or gallop and up to 180kg at a walk. These weights are lower than those found for the Campeiro Horse.[32] Sex did not significantly affect these traits.

The two CI calculated showed contrasting results; while CI1 showed the animals were more adapted for riding (mean 2.519), CI2 indicated animals adapted for light traction (mean 8.675). These indices are somewhat lower than those calculated for the Campeiro horse (2.915 and 9.558 respectively). The DTI mean was 0.110 for males and 0.108 for females, thereby classifying them as intermediate or light traction animals. This indicates a good thoracic development in these animals. Animals registered in 2000 were shown to be light, non-traction animals maybe due to

changes in selection objectives by the breeders. Sub-regions were shown not to differ for this trait except for Tangará da Serra where animals were more of the traction type. Age also affected this index with older animals more suited for traction. As the older animals tended to be registered in the earlier years of the association this may also represent selection preferences for these animals. The BC Index, with a mean value of 1.891, confirmed this result.

The PI was 0.572 and 0.584 for males and females respectively. These animals may therefore be considered "far from the ground", thereby classified for speed due to relatively long legs. PI also tended to increase with age, with a decrease after 10 years of age, indicating improved pectoral development in adult horses with subsequent loss as the horses reach the end of their useful life.

TD showed animals with good thoracic development and was also affected by sex. Zamborlini[8] stated that a wide, deep and muscular thorax is important in the horse to permit physical vigor. A small thorax is associated with lack of good musculature and deficiencies in the cardio-vascular system. A horse with an excessively large thorax is also not desirable as the center of gravity moves to the front of the horse. When selecting animals this trait should therefore be taken into account. CD was within the ideal range[9], giving comfort to the rider and helping to avoid certain lesions.

Inbreeding levels, calculated from genealogy of the animals using MTDFREML, were low and careful control of this factor is necessary to maintain these levels.

Table 2 shows heritabilities as well as genetic and phenotypic correlations between these body indices. In general heritabilities were high (0.34-0.78) indicating genetic variation for selection. Literature on genetic analyses for these indices is scarce, but they are in agreement with heritabilities for individual body measures for the same horses[6], as well as similar indices for Campeiro Horses[32]. It is possible that the

Table 2 - Phenotypic (below diagonal) and genetic (above diagonal) correlations between body indexes in the pantaneiro horse and their heritabilities. Brazilian Association of Pantaneiro Horse Breeders (1972 to 2000)

	BR	RBI	PI	DTI	W	BI	TD	BC	TI1	TI2	CI1	CI2	CD
BR		0.98	0.99	0.99	0.98	-1.00	1.00	-0.49	1.00	-0.36	1.00	1.00	1.00
RBI	-.10***		-1.00	1.00	1.00	-0.74	-0.65	-0.06	-0.01	-0.01	0.23	0.21	-1.00
PI	-.23***	0.17***		1.00	1.00	-.99	1.00	-.23	1.00	-.32	1.00	1.00	1.00
DTI	0.11***	0.03 ns	0.01 ns		1.00	-.90	1.00	1.00	1.00	1.00	1.00	1.00	1.00
W	0.02ns	-.07*	0.09***	-.31***		-0.76	1.00	1.00	1.00	0.94	-1.00	1.00	1.00
BI	-.02 ns	0.90***	0.04 ns	0.21***	-.40***		-0.83	-0.09	-1.00	1.00	-091	-1.00	-1.00
TD	-.03 ns	0.04 ns	0.15***	0.19***	-.05 ns	0.15***		0.99	0.84	1.00	1.00	1.00	1.00
BC	-.07*	-.03 ns	0.19***	-.37***	0.94***	-.43***	-.16***		1.00	1.00	1.00	1.00	-1.00
TI1	-.07*	-.02 ns	0.19***	-.37***	0.94***	-.43***	-.16***	1.00***		-0.55	-0.99	-1.00	-1.00
TI2	-.07*	-.02 ns	0.19***	-.37***	0.94***	-.43***	-.16***	1.00***	1.00***		-0.97	0.16	0.17
CI1	-.04 ns	-.04 ns	0.16***	-.35***	0.98***	-.42***	-.12***	0.99***	0.99***	0.99***		1.00	1.00
CI2	-.17***	0.03 ns	0.30***	-.40***	0.70***	-.39***	-.30***	0.89***	0.89***	0.89***	0.84***		1.00
CD	0.07*	-.02 ns	0.06 ns	-.09***	-.12***	-.01 ns	-.05 ns	-.09**	-.09**	-.09**	-.11***	-.03 ns	
h^2	0.55	0.43	0.52	0.58	0.46	0.78	0.54	0.56	0.46	0.47	0.44	0.34	0.37
se	0.08	0.05	0.07	0.07	0.08	0.08	0.06	0.07	0.07	0.06	0.07	0.05	0.08

*** $P<0.001$; ** $P<0.01$; * $P< 0.05$; ns = not significant; BI = Body index; RBI = Relative Body Index; DTI = Dactyl Thorax Index; PI = Pectoral Index; BR = Body Ratio; TD = Thoracic development; BC = Baron & Crevat; TI = tare index, CI – compact index; CD – comfort degree (See text for details); h^2 – direct heritability, se – standard error of heritability estimate

selection directives used by the Pantaneiro horse breeders along with the population structure contributed to the high heritabilities encountered here.

Motta and Giannoni[34], studying the Mangalarga breed, found heritability estimates for head, neck and shoulder traits of 0.68, 0.75 and 0,44 respectively. Motta[35] also studied race performance, independent of the means of measurement and found low to medium values for heritabilities. In studies carried out by Zamborlini[8] on the Mangalarga Marchador breed, heritability estimates for body measures of between 0.38 (hip height) and 0.68 (neck length), with a mean heritability of 0.58. Costa et al.[7], studying the Brazilian Pony estimated heritabilities between 0.24 (neck length) a 0.52 (shoulder height). It can be noticed that the tendency in all cases is towards medium to high heritability while individual values within breeds vary greatly due to different selection criteria and management systems within each breed. As several different technicians carry out the registration, errors in the measurement may have occurred and should be taken into consideration.

Both genetic and phenotypic correlations ranged from high positive to high negative. High correlations (either positive or negative) tend to be between those traits based on TP and/or WH (includinig W, BC, TI1, TI2, CI1, CI2), while low correlations tend to be with indices not involving these traits. Genetic correlations with RBI tended to be low, except with PI, DTI and W. Phenotypic correlations with PI, BR, RBI and DTI were also low. These correlations are in general different from those found by Miserani et al.[6] and McManus et al.[32].

Other authors noted a similar tendency towards high genetic correlations between linear measures in horses. In the Brazilian Pony Breed, genetic correlations varied between 0.32 and 1.00[7], the lowest between dorsal-lumbar length and chest width while the largest was between neck length and body length. For the Mangalarga Marchador, Zamborlini[8] found genetic correlation between the height of the shoulder and hip height of 0.90 and hip height and body length of 0.70. In general, these results indicate that selection for one of these traits will result in

an increase in the general size of the breed. These high correlations may be due to the same few genes acting on these traits[34] but more likely are due to the low coefficient of variation for the traits measured and may be related to individual preferences of the technicians who took the measurements.

In terms of performance, specific favorable traits may outweigh the lack of perfection in other traits. In general, the Pantaneiro horse has body characteristics developed through natural selection. According to Martin et al.[18], a horse should be judged by its ability to perform desired movements and functions, particularly if it is being selected for purposes other than breeding. When a breeder has set his goals and established minimum standards for desirable traits, he should make a more detailed study of pedigree, performance and conformation.

Nowadays, the breeders are interested in selecting the Pantaneiro horse for expositions and auctions. Therefore the emphasis is on correct conformation and they have changed the natural environment, especially the diet, sometimes, without adequate criteria. The evaluation of genetic merit of the Pantaneiro horse population should include adaptability to the local environment, resistance against diseases and other traits balanced according to the intended use. Bodó[36] considered that the harmonization of selection and preservation is difficult and that they may be totally opposed to each other.

Conclusion

From the data available, the Pantaneiro horse can be classified as mediline, not specially apt for speed or traction, with good thoracic development and thereby suitable for managing cattle and resistance for long treks. In recent years, several indices have changed possibly due to selection which may affect the beneficial traits of these horses in the future. Heritabilities tend to be high indicating that selection for these indices should be successful in changing the shape of this breed. Inbreeding levels from available genealogy were low and careful control of this factor is necessary to maintain these levels.

Índices corporais para o cavalo pantaneiro

Resumo

Foram estudados índices zootécnicos de 2.248 animais registrados na Associação Brasileira de Criadores do Cavalo Pantaneiro (ABCCP), no período compreendido entre 1972 e 2000. Os dados foram analisados usando o programa SAS e o DFREML para estimação de parâmetros genéticos. Na análise dos índices corporais, o índice dáctilo torácico (IDT) apresentou animais intermediários (nem leves e nem aptos para tração). O índice de BARON e CREVAT também confirmou este resultado. Na determinação do índice peitoral (IP), os animais foram considerados, em geral, favoráveis à velocidade por apresentarem membros longos. Já no índice corporal (IC), a maioria dos animais não foi apta à velocidade e nem à tração (mediolíneos). Através da análise dos índices de conformação verificou-se que, em geral, os Pantaneiros são mediolíneos, aptos para velocidade e possuem bom desenvolvimento torácico, proporcionando velocidade na lida do gado e resistência a longas caminhadas. Na análise dos fatores ambientais, verificou-se que nos últimos anos alguns índices têm sofrido alterações, provavelmente devido à seleção já exercida pelo criador, que pode afetar a capacidade de adaptação dos cavalos.

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