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Original Research Article

Acoustic Divergence in Domestic Horses

Stepanka Holeckova[1], Richard Policht[2]

[1] *Faculty of Tropical AgriSciences, Czech University of Life Sciences Prague, Czech Republic*
[2] *Ethology group, Institut of Animal Science, Praha, Uhříněves, Czech Republic*

Abstract

We tested whether pronounced morphological variability of horses caused by artificial selection was followed also by variation in their vocalization. We compared whinnies of 10 breeds representing horse varieties both in morphology and history using discrimination analyses (Wilks´ lambda = 0.070). Whinnies of Shetland pony were the most distinct from calls of other breeds (74.1% classification success). This result is in agreement with distinction based on morphological features. Whinnies of the primitive Hucul horse belonged among the most correctly classified ones (73.5%). Classification results of both Old Kladruby horse colour forms were very different: whinnies of the grey form revealed the least successful classification (18.9%) whilst calls of the black form showed one of the best classification outputs (72.4%). A surprising result was the extreme vocal distinction between the heaviest breeds, confirmed by discrimination analysis, the Czech-Moravian Belgian (55.5%), and Silesian Noriker (51.4%). This finding was contrary to their morphological similarity.
The relationship between morphological and acoustical variables revealed a significant correlation ($r < -0.57$). Our results did not confirm the hypothesis of acoustic distinction in horse breeds based simply on their morphology. However, whinnies of an old breed, the Shetland pony, were the most distinct ones from all the others. The other old breeds, the Thoroughbred and the Old Kladruby horses, clustered together with the modern Czech warmblood. Our results seem to not confirm the second hypothesis of vocal distinction based on the length of time since establishment of the respective breed. Significant differences among horse breeds indicate the process of vocal distinction during the process of artificial selection.

Keywords: morphology; breed; history; communication; whinny.

INTRODUCTION

Domestication of horses is a popular issue in equine research but we know practically nothing about whether and how such artificial selection may have altered communication signals in horses since the time of their domestication. Some authors used breeds of domesticated animals to simulate the evolution of several traits through artificial selection (e.g. Price, 2002a; Rice and Hostert, 1993). Although some aspects of vocalization in domesticated animals have been studied, we still lack fundamental knowledge of inter-breed variation across different breeds.

Previous comparative research showed that long-distance calls of wild and domestic stallions diverged according to their social arrangement (equids forming harems vs. those without permanent breeding units), see Policht et al. (2011). The authors assumed the body size to be the most probable explanation for this pattern in harem equids but there is a need for more breeds including small and heavy forms (e.g. ponies and heavy cold blooded horses) for more robust comparison to clarify this question.

Although horses belong among frequently studied domesticated animals, only few studies related to their vocalization have been conducted so far (e.g. Ki Kim et al., 2010). Their repertoire includes both vocal and non-vocal sounds (see the review by Yeon, 2012). It is known that some of these vocalizations vary according to behavioural context, individual identity, social status, physiological state, sex and body size (Rubenstein and Hack, 1992; Lemasson et al., 2009; Proops et al., 2009; Ki Kim et al., 2010; Pond et al., 2010).

Domestication often resulted in a reduction of body size of animals with few notable exceptions (Price, 2002b). Horses belong among them; they are commonly larger than their wild counterparts (Tchernov and Horwitz, 1991) but humans also selected several incomparable smaller and heavier forms as well. Thus, horses could be an interesting model for the study of the influence of body size on the design of vocalization, as size and body conformation were under strong selection for critically important traits in nearly all horse breeds (Brooks et al., 2010). Another question is whether the time since these breeds originated was sufficient to evolve significant distinction in some of their vocal signals. One of the best potential signals encoding such distinction could represent the whinny. This signal plays an important role in long-distance communication of horses including information transfer about individual identity and body size (Lemasson et al., 2009; Proops et al., 2009).

Therefore our study aimed to assess (1) whether acoustic traits are significant predictors of breed membership, (2) whether such acoustical distinction could be explained by morphological distinctness of breeds, and we were also interested in (3) whether the two colour varieties of the Old Kladruby horse significantly differ as well.

MATERIALS AND METHODS

Subjects and study site

We selected ten breeds of horses kept in the Czech Republic: Czech Warmblood, Thoroughbred, Shagya Arabian horse, black and grey form of the Old Kladruby horse, Silesian Noriker, Czech-Moravian Belgian horse, Haflinger, Shetland pony and Hucul horse. Some of them with origin from a Bohemian region like the Old Kladruby horse, Silesian Noriker, Czech-Moravian Belgian horse and Hucul belong among endangered horse breeds in the Czech Republic (Vostrý et al., 2011a). For the purpose of our study we considered both colour varieties of the Old Kladruby horse as independent breeds. They are also bred separately since 1945 and differ markedly in several morphological traits (Jakubec et al., 2009).

The Old Kladruby horse was established at the end of the 18th and the beginning of the 19th century on the basis of Old Spanish and Old Italian horses (Jakubec et al., 2009) with pedigrees spanning over three centuries (Vostrý et al., 2011b). Silesian Noriker originated on the basis of imports of original Noriker and Bavarian cold-blooded stallions in the last approximately 100 years, and the Czech-Moravian Belgian has originated in the last approximately 120 years by imports of Belgian and Walloon stallions (Vostrý et al., 2011a). The Hucul horse is considered as a direct descendant of the Tarpan horse or alternatively as a result of cross-breeding between Tarpan horses and Mongol domestic horses. Their first stud farm was established in the 19th century in Romania (Georgescu et al., 2011). Shagya Arabian horse was confirmed as a breed in 1978 and until this time has been considered as a variety of the Arabian breed (Doliş et al., 2011). Thoroughbred belongs among the oldest domestic animals at all with pedigree records spanning 300 years (Cunningham et al., 2001; Hill et al., 2002). Haflinger horse originated in Northern Italy in the second half of the 19th century by crossing local mares with Arab stallions (Sabionni et al., 2007). Czech Warmblood was formed as a new breed for sport performance (Jiskrová et al., 2002; Ignor and Cieśla, 2009) and recreation, with mainly Thoroughbred, Hanoverian, Holstein and Trakehnen horses (Ignor and Cieśla, 2009) used. The name of this breed was established in 1983. The Stud Book of the Shetland pony was established in 1890 by the Shetland Pony Stud Book Society (www.shetlandponystudbooksociety.co.uk).

The records were obtained in 22 localities of the Czech Republic including seven private studs. The horses under study belonged to both state and private owners and lived in social groups, on pasture or in box stalls. Study localities included several kinds of housing. Písek and Tlumačov kept only breeding stallions of various breeds. Stallions lived in large box stalls with the possibility of moving in paddocks. At the Slatiňany state stud farm, breeding stallions, mares and their foals of black form of the Old-Kladruby horses are kept. Stallions are housed in large box stalls, breeding mares without foals are tied in stables and mares with foals in box stalls or in individual housing. Private stud farms Klokočov and Janovice, breeds the cold-blooded horses: Czech-Moravian Belgian horse and Silesian Noriker. In another private stud farm Kadov and Bělčice Shetland ponnies are kept and bred. Vrchovany, Nebanice, Rakvice, Sukorady, Ctidružice and Benešov represent private farms housing horses for recreation, breeding and sport. They are kept in stalls or on pastures. Horses were fed hay, grass, and granules or feeding mixture and water was provided *ad libitum*.

Recordings

The whinnies of 120 individuals were recorded between July 2010 and December 2012. Calls were recorded using digital recorder Marantz PMD 620 (frequency response 20 – 20 000 Hz) with sampling rate of 44.1 kHz with a 16 bit sample size and saved in wav format. The calls were recorded from a distance of 2 to 10 m. Whinnies occurred after separation of the focal individual from others or they were elicited by playback of whinnies. They were recorded mainly in outdoor conditions but some of them also in stables. The recorded calls did not differ based on outdoors/indoors conditions or spontaneous vs. induced context (Mann Whitney U-test: $p > 0.05$), so that they were included in the following analyses together.

We also recorded the age, sex, breed and basic morphological measurements (height at withers, thoracic perimeter, width of head, cannon bone perimeter, length of head) of all studied individuals.

Acoustic analyses

For the following analyses only good quality and non-overlapped calls were selected. From the selected signals we constructed spectrograms of the following parameters: FFT 1024, Hann window, frame size 100%, overlap 87.5%, frequency resolution 43 Hz and temporal resolution 2.9 ms with the help of Avisoft-SASLab Pro 5.1.01 (Specht, 2010).

We analysed only calls that contained all three typical parts of whinny: Introduction, Climax and End (Waring, 2003; Lemasson et al., 2009). Whinnies with the absence of any of these structural parts were less frequent and they were excluded from the following comparisons.

Before the analysis, intensities of calls were standardised to comparable level using the fiction Root Mean Square in Avisoft. In this software, we measured the following acoustical parameters directly from the spectrograms: duration, start and end frequency of Introduction, Climax and End part, call duration (duration of the whole whinny) and fundamental frequency of Introduction. In addition, these spectrograms were saved as a txt format for the analyses in LMA 2008 acoustical software developed by K. Hammerschmidt, that extracts the number of acoustical parameters based on the statistical distribution of an amplitude in the spectrum containing bands of dominant frequency including their global and local modulations, main energy peaks and global energy distribution (Schrader and Hammerschmidt, 1997; Fischer et al., 2001).

Statistical analyses

Highly correlated acoustic parameters ($r > 0.77$) were excluded to minimize loss of information. Before the statistics, the data were standardized by subtracting the mean from each value and dividing it by the standard deviation. Such transformation brings all values to compatible units regardless of their distributions and original units of measurement, and forms a distribution with a mean of 0 and a standard deviation of 1. It creates the distributions of values easy to compare across variables and makes the results entirely independent upon the ranges of values or the units of measurements (StatSoft, Inc. 2012).

We applied a stepwise discriminant function analysis (DFA) with more conservative cross-validation of group classification using “leave-one-out” procedure in IBM SPSS Statistics 19, based on deleting one variable out of the tested data followed by testing of the ability of discrimination functions to predict group membership (the breed). The principle of validation of DFA is that part of the data are used to create a model, and another part of data are used for testing. Prior probability means classification based on chance only.

Multi-variate tests were performed using of IBM SPSS Statistics 19 and the uni-variate statistics in STATISTICA ver.10.

RESULTS AND DISCUSSION

We analyzed 1047 whinnies of 120 individual horses belonging to ten breeds. The resulting model of DFA included 29 variables (Wilks´ lambda = 0.070). Whinnies of 120 individuals were assigned with overall 61.3% classification success to the correct breed and validation procedure classified with 56%. The first two canonical functions explained 60.9% (see Figure 1) and three functions 73.4% of variation. The best classification result reached was for Shetland pony 74.1% (73.2 % of validated DFA), followed by Hucul horse 73.5 % (61.8 %) and black Old Kladruby horse, respectively 72.4% (63.4%), (see Table 1). In contrast to the black Old Kladruby horse, the grey Old Kladruby horse showed a less successful classification, 24.3% (18.9%). Most horses reached more than 50% classification result: Thoroughbred 57% (55.1%), Czech-Moravian Belgian horse 60.9% (55.5%), Silesian Noriker 56.2% (51.4%), Haflinger horse 63.3% (56.1%), Czech Warmblood 57.9% (53.3%), and Shagya Arabian horse 54.5% (40.9%).

Whinnies of Shetland pony were ferquently classified incorrectly as calls of Czech-Moravian Belgian horse (11.6%) and Haflinger (4.5%), (see Table 2). Calls of black Old Kladruby horse (12.2%) were classified as Czech Warmblood’s calls and 7.3% as Silesian Noriker calls. Whinnies of the least successfully classified horse, the grey Old Kladruby horse, were surprisingly incorrectly classified as calls of Czech Warmblood (29.7%) and 16.2% as calls of the second colour form, black Old Kladruby horse. The same number of whinnies were evaluated as calls of Silesian Noriker (16.2%), and 12.2% whinnies of Haflinger were classified as Czech-Moravian Belgian horse calls, 7.2% as Silesian Noriker’s and 6.5% were assigned to Czech Warmblood. DFA in Thoroughbred identified 17.8% of its calls incorrectly as calls of Czech Warmblood and 8.4% as calls of black Old Kladruby horse and Silesian Noriker. For Czech Warmblood, 16.8% of whinnies were categorized as those of Silesian Noriker‘s and 11.7% as black Old Kladruby horse calls. The heaviest breeds included Czech-Moravian Belgian horse and Silesian Noriker. Calls of the first one mostly failed in classification as Haflinger (14.1%), black Old Kladruby horse (11.7%) and Czech Warmblood (9.4%). Whinnies of the second heavy breed, the Silesian Noriker, were mostly incorrectly classified as calls of Czech Warmblood (19.2%) and Thoroughbred (12.3%). Surprisingly high percentage (31.8%) of Shagya Arabian horse whinnies were incorrectly identified as calls of black Old Kladruby horse, 13.6 % as those of Haflinger. Finally, 14.7% calls of Hucul were incorrectly assigned to Czech-Moravian Belgian and 8.8% to Haflinger and Silesian Noriker, respectively.

The most important acoustic parameters for distinction of horse breeds were df2med (median of the 2nd dominant frequency band) ($r=0.63$), f2pr (percent of time segments where the 2^{nd} global frequency peak could be found) ($r=0.54$), pftrmean (mean deviation in Hz between peak frequency and linear trend) (r=0.46), q2med (median frequency of the 2nd distribution of frequency amplitude) (r = 0.44), q1med (median frequency of the 1st distribution of frequency amplitude) (r = 0.41), and start Intr F (start frequency of Inroduction) (r = 0.38). These parameters showed the largest absolute correlation with the first canonical function. Pftrfak (factor of linear trend of peak frequency = global modulation) (r = 0.61) and end Clim F (end frequency of Climax) (r = 0.28) mostly correlated with the second canonical function of DFA.

Table 1. Classification results of studied breeds based on two discrimination analysis: (1) based on acoustic parameters of their whinnies and (2) morphological measurements
Notes: Prior (prior probability-classification by chance), Valid. (cross-validated DFA).

Acoustics			Morphology			
Breed	Prior	DFA	Valid.	Prior	DFA	Valid.
TH	10.2	57.0	55.1	10.0	75.0	75.0
CW	18.9	57.9	53.3	19.2	95.7	91.3
CB	12.2	60.9	55.5	8.3	40	40.
0SN	14.0	56.2	51.4	11.7	78.6	64.3
KG	3.5	24.3	18.9	7.5	44.4	33.3
KB	11.8	72.4	63.4	13.3	75.0	68.8
SA	2.1	54.5	40.9	4.2	60.0	60.0
HF	13.3	63.3	56.1	9.2	100	90.9
HC	3.3	73.5	61.8	3.3	25.0	0.0
SP	10.7	74.1	73.2	13.3	100.0	100.0

Legend : TH – Thoroughbred, CW – Czech Warmblood, CB – Czech Belgian, SN – Silesian Noriker, KG – Old Kladruby grey, KB - Old Kladruby Black, SA – Shagya Arabian,
HF- Haflinger, HC – Hucul, SP – Shetland Pony

Additionally, we conducted a second discrimination analysis to compare distinction of studied horse breeds based on morphological measurements which included height at withers, length of head, thoracic perimeter and ratio of width of head to length of head (other measurements were highly correlated). The resulting model of DFA (Wilks' Lambda = 0.003) contained all four significant variables ($p < 0.001$). The first two functions had Eigenvalue > 5 and explained 98% of overall variation.

Based on morphological measurements, individuals of Shetland pony were classified with 100% success. Higher classification results were also achieved in horses of Czech Warmblood, 95.7% (91.3% of validated DFA), Thoroughbred (75% both validated and not validated DFA), and black Old Kladruby horse 75% (68.8%), but horses of the second Kladruby breed – grey Old Kladruby horse and Hucul horse were classified with the least success (grey Old Kladruby: 44.4% result and 33.3% after validation procedure, and Hucul: 25% classification output and 0% result after validation, respectively); see Table 1.

Classification success based on morphological and acoustic parameters did not show a stronger correlation (Spearman correlation, $r = 0.36$, $n = 10$, $p > 0.05$), (see Figure 2). Figure 3 shows spectrograms of Czech Warmblood, Czech-Moravian Belgian and Shetland pony. The most morphologically different Shetland pony reached high classification success also in acoustics. Other more morphologically distinct breeds, like Haflinger, Thoroughbred, Czech Warmblood or black form of the Old Kladruby horse showed good classification both in acoustics and morphology. Hucul showing good classification result in its whinnies did practically not differ in morphology. Such unexpected result in this obviously distinct horse breed was caused by the fact that all individuals were misclassified as those of Haflingers. Consistently weak classification both in acoustics (18.3%) and morphology (33.3%) was shown in the grey form of the Old Kladruby horse, which was in 44.4% morphologically assigned to the black form of the Old Kladruby horse.

We additionally tested the degree of distinction among horse breeds in 14 selected acoustical parameters which were

Table 2. Percentage of whinny classification success (cross-validated, DFA) in studied breeds (row) into own (correct classification) and other breeds (columns) (incorrect classification)

	Predicted breed membership									
Breed	TH	CB	CW	HC	HF	KG	KB	SA	SP	SN
TH	**55.1**	0.9	17.8	0.0	6.5	2.8	8.4	0.0	0.0	8.4
CB	0.8	**55.5**	9.4	1.6	14.1	0.8	11.7	0.8	1.6	3.9
CW	6.6	2.5	**55.3**	0.0	4.6	0.5	11.7	1.5	2.5	16.8
HC	0.0	14.7	2.9	**61.8**	8.8	0.0	0.0	2.9	0.0	8.8
HF	5.8	12.2	6.5	0.7	**56.1**	1.4	5.0	2.2	2.9	7.2
KG	8.1	8.1	29.7	0.0	2.7	**18.9**	16.2	0.0	0.0	16.2
KB	1.6	4.9	12.2	0.0	3.3	4.9	**63.4**	2.4	0.0	7.3
SA	0.0	4.5	4.5	4.5	13.6	0.0	31.8	**40.9**	0.0	0.0
SP	0.0	11.6	3.6	0.9	4.5	0.9	1.8	0.0	**73.2**	3.6
SN	12.3	2.7	19.2	0.0	4.1	0.7	7.5	1.4	0.7	**51.4**

For legend, see Table 1.

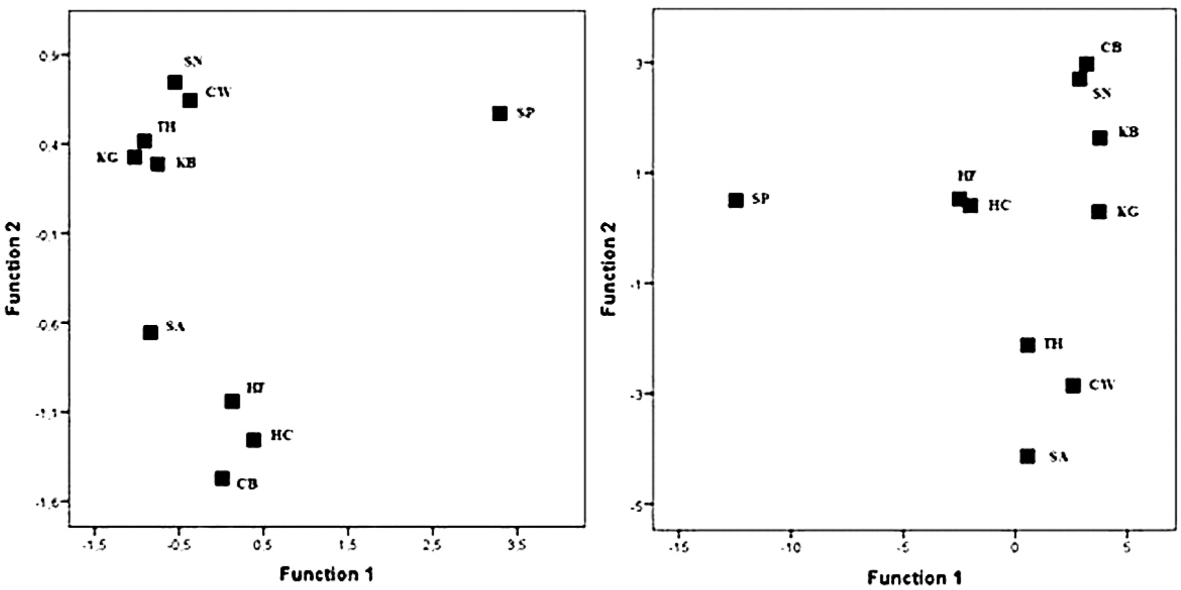

Figure 1. Group centroids belonging to different horse breeds based on: (a) acoustic analyses of their whinnies and (b) morphological measurements (b) in the space of the first two functions of DFA.

Horse breeds: (TH) Thoroughbred, (CW) Czech Warmblood, (CB) Czech-Moravian Belgian horse, (SN) Silesian Noriker, (KG) Old Kladruby horse – grey form, (KB) Old Kladruby horse – black form, (SA), (HF) Haflinger, (HC) Hucul horse, (SP) Shetland pony.

the most important for breed classification based on DFA and parameters representing obvious parts of horse whinnies previously described by Waring (2003): introduction, climax and end. Breeds differed significantly in most of tested parameters (Kruskal-Wallis ANOVA, d.f. = 9, n = 120, $p < 0.004$), see Table 3. For example, whinnies of the smallest breed (Shetland pony) reached higher frequencies in frequency parameters and the shortest duration of the climax part.

We also tested correlations between the acoustic and morphological variables (see Table 3). The strongest correlations were found between height at withers and stItr

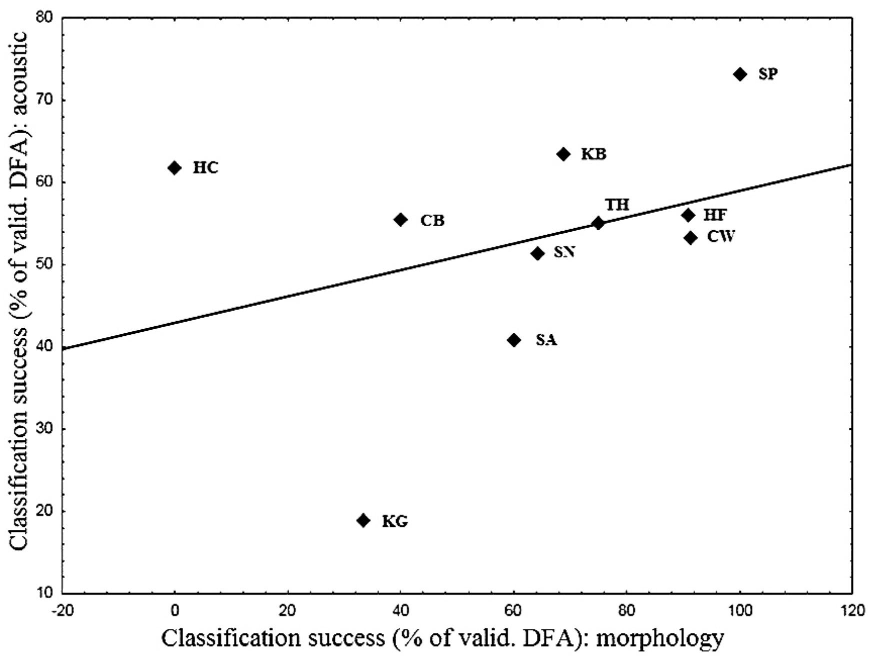

Figure 2. Spearman correlation of correct classifications (percentage of cross-validated DFA) of horse breeds based on morphological and acoustical parameters (r = 0.43, n = 10, $p > 0.05$).

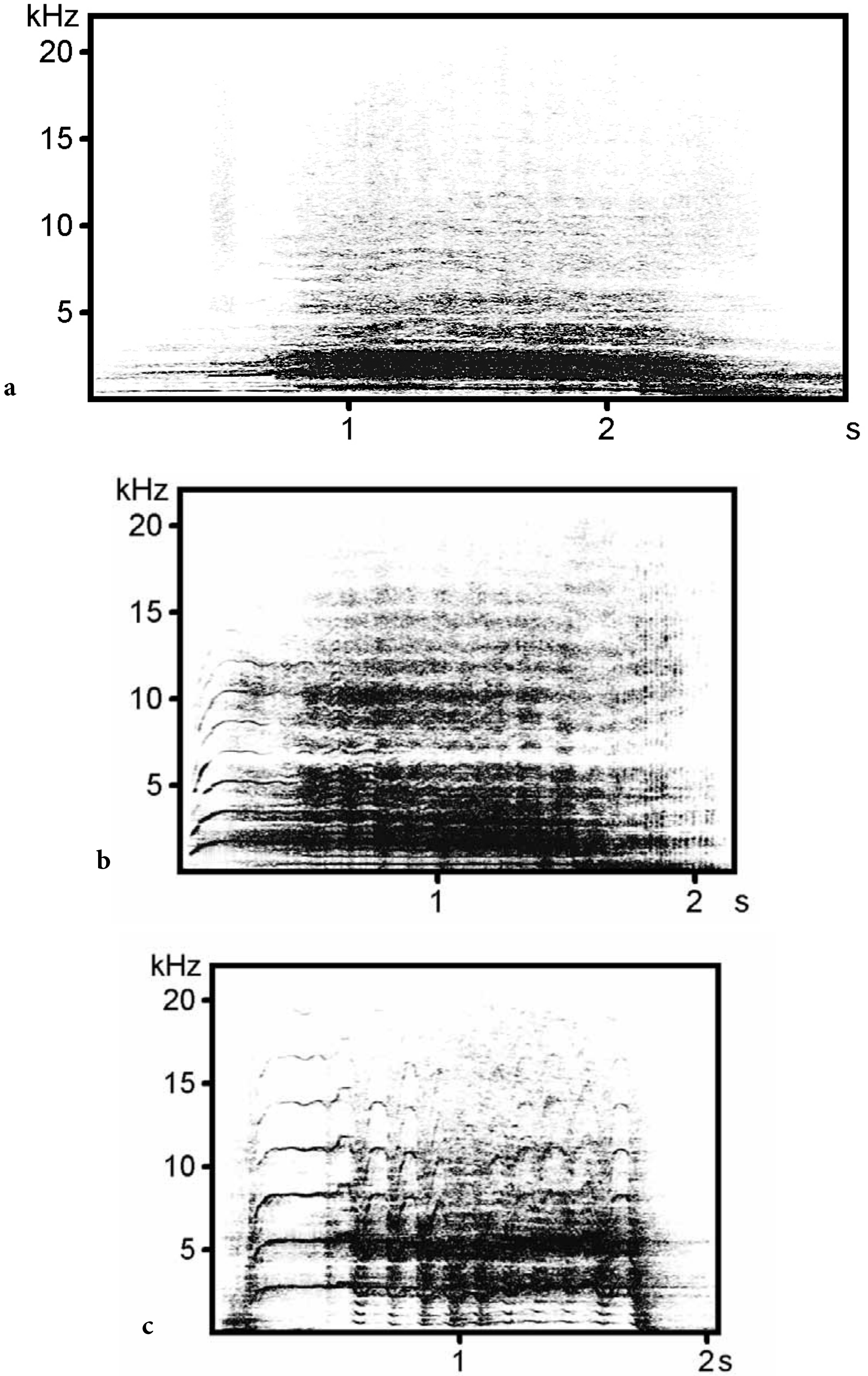

Figure 3. Spectrograms of whinny from (a) Czech Warmblood, (b) Czech-Moravian Belgian, and (c) Shetland pony. Spectrograms represent three dimensions of the sounds: frequency (y axis), time (x axis) and intensity (colour intensity).

F (start F of Introduction) (r = -0.57) and df2med (median of the 2nd dominant frequency band) (r = -0.55). The same acoustic parameters similarly correlated with length of head: stItr F (r = -0.52) and df2med (r = -0.51). Horse weight was mostly correlated with stItr F (r = -0.51). Thoracic perimeter mostly correlated with stItr F (r = -0.45) as well

Table 3. Distinction of breeds in 14 selected acoustical parameters which were found to be the most important ones for breed classification based on DFA

Acoust. Parameter	Kruskal-Wallis ANOVA H H (9, N= 120)	p *
Call		
Duration	23.9	0.0040
Introduction		
Duration	13.9	0.1026
end frequency	30.3	0.0004*
+start frequency	52.7	<0.0001*
Climax		
Duration	28.6	0.0008*
end frequency	23.7	0.0048
End		
Duration	20.8	0.0134
end frequency	51.2	<0.0001*
+df2med	52.3	<0.0001*
+f2pr	40.8	0.0001*
+pftrmean	28.8	0.0007*
+q2med	36.7	0.0002*
+q1med	41.8	<0.0001*
+pftrfak	41.4	<0.0001*

as with cannon bone perimeter (r = -0.42). Width of head correlated more both with stItr F (r = -0.48) and df2med (r = -0.45). Neither age nor sex did affect any of teh tested acoustic parameters (see Table 3). Lemasson et al. (2009) found a bit higher correlation between the same parameters (start frequency vs. height at withers; r = - 0.69) based on 33 individuals of 18 breeds including the crosses.

Next we summarised the origin of studied breeds to discuss its potential importance for vocal distinction. The origin history in some breeds is poorly documented or determination of more exact time is complicated because even if there is a date of establishing a breed, their pedigree is often spanning over centuries. The history of Thoroughbred and the Old Kladruby horse reaches to 16 th century and Czech-Moravian Belgian horse and Shagya Arabian horse to 18th century, Silesian Noriker, Haflinger and Hucul to 19th century. Czech Warmblood represents a modern horse established during 20th century. Shetland pony is considered to be a very old breed. The first written record of the Shetland pony was in 1603 and the Stud Book was being formed in 1890 (Shetland Pony Stud Book Society).

At the end we compared both colour varieties of the Old Kladruby horse independently of other breeds. Neither colour form did significantly differ in any of acoustical parameters when we excluded mares that were present only in grey form of this breed. When we included these mares into the comparison, one acoustical parameter, duration of introduction, was significantly different (Mann Whithey U Test: p = 0.032).

Classification results from acoustical data were not more highly correlalated with the morphological data; this means that more morphologically distinct forms do not strongly differ in their vocalization. Thus our results did not confirm the hypothesis of acoustic distinction in horse breeds based simply on their morphology as previously assumed (Policht et al., 2011). One of explanations for a pattern of vocal differences could lie in the history of the studied breeds, their origin time and/or founding breeds. Whinnies of the very old breed, the Shetland pony were the most distinct from calls of all other breeds, and whinnies of other old breeds, such as Thoroughbred and the Old Kladruby horse clustered together. In contrary, the Czech warmblood as a representative of modern breeds, was also located in their vicinity. These facts including the results of other breeds do

Table 4. Spearman correlations of morphological measurements and acoustical parameters

	durat.	q1med	q2med	df2med	stItr F	f2pr	pftrfak	pftrmean	end Int F	end Cli F	end End F
HW	0.01	**-0.41**	**-0.44**	**-0.55**	**-0.57**	**-0.46**	0.13	**-0.35**	**-0.26**	-0.12	0.04
TP	-0.09	**-0.25**	**-0.35**	**-0.37**	**-0.45**	**-0.33**	-0.05	**-0.38**	**-0.24**	**-0.27**	-0.04
CB	-0.17	**-0.25**	**-0.36**	**-0.36**	**-0.42**	**-0.38**	-0.04	**-0.38**	**-0.30**	**-0.29**	-0.09
WH	-0.13	**-0.33**	**-0.39**	**-0.45**	**-0.48**	**-0.40**	-0.08	**-0.34**	**-0.31**	**-0.30**	-0.10
LH	-0.10	**-0.36**	**-0.40**	**-0.51**	**-0.52**	**-0.43**	-0.02	**-0.34**	**-0.27**	**-0.24**	-0.09
WH/LH	-0.12	-0.15	0.10	**-0.21**	0.17	0.14	**-0.18**	0.05	-0.07	-0.12	-0.04
Weight	-0.07	**-0.30**	**-0.40**	**-0.44**	**-0.51**	**-0.40**	-0.02	**-0.40**	**-0.27**	**-0.26**	-0.01
Age	0.14	-0.15	-0.08	-0.17	-0.15	**-0.07**	**-0.20**	0.02	-0.13	-0.02	-0.14
Sex	-0.12	0.01	-0.04	-0.04	0.02	-0.09	0.10	0.02	-0.06	-0.03	-0.01

Legend: (HW- height at whithers, TP - thoracic perimeter, CB- cannon bone perimeter, LH – length of head, WH – width of head; thick litter means p < 0.05). Durat (duration), q1med (median frequency of the 1nd distribution of frequency amplitude), q2med(median frequency of the 2nd distribution of frequency amplitude), df2med (df2med (median of the 2nd dominant frequency band) , stItr F (start frequency of Introduction), f2pr (percent of time segments where the 2nd global frequency peak could be found), pftrfak (factor of linear trend of peak frequency = global modulation), pftrmean (mean deviation in Hz between peak frequency and linear trend), end Int F (end frequency of Itroduction), end Cli F (end frequency of Climax), end End F (end frequency of End).

not confirm the pattern of vocal distinction based on breed origin. The question arises about the key factors determining the pattern of vocal distinction we found in the breeds under study.

Significant differences among horse breeds indicate the process of vocal distinction during the process of artificial selection. The inter-breed variability, demonstrated in this work opens a set of interesting questions about the influence of domestication on communication. Such acoustical distinction on a breed level should be confirmed in further studies including other domestic animals.

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Corresponding author:

Štěpánka Holečková
Faculty of Tropical AgriSciences
Czech University of Life Sciences Prague
Kamýcká 129, 165 21
Praha 6, Czech Republic
E-mail: corrdelie@gmail.com