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# Inheritance of coat colour in Slovak Pinzgau cattle

# Dedivosť sfarbenia slovenského pinzgauského dobytka

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## Abstract

The objective of the work was analysis of chestnut coat colour inheritance of Slovak Pinzgau cattle in accordance to age and farming system. In 304 cows of breeding groups P0,P1,P2 and R3 born between 2000 to 2010 from four breeding herds (4 agricultural cooperatives and JSC: PD Smrečany – farm Veterná Poruba, PD Spišské Bystré – farm Kvetnica, Agria Liptovský Ondrej JSC – farm Liptovská Porúbka, PD LČV Čimhová) was measured intensity of coat colour. For objective measurement of coat colour the handheld Minolta Chromameter CM-2600d was applied using the CIE L*a*b* colour space. The instrument recorded the values L*, a* and b*. The L* value shows the lightness of the colour, a* value indicates the red/green, while the b* value indicates the yellow/blue chromaticity of the colour. The values C* (Chroma/saturation) and h (hue) were derived from the values a* and b*. Average lightness in observed animals was 22.60; average of the red chroma was 8.84 resp. 13.32 for the yellow chroma. Saturation of coat colour was 16.19 resp. 0.97 for hue.

**Keywords:** Colour inheritance**,** hue, lightness, Pinzgau cattle, rearing system, saturation

## Abstrakt

Cieľom práce bola analýza dedivosti gaštanovo hnedého plášťového sfarbenia pinzgauských kráv na Slovensku vo vzťahu k veku a systému chovu. Celkovo bolo hodnotených 304 kráv plemenných skupín P0, P1, P2 a R3 narodených v rozpätí rokov 2000 až 2010, pochádzajúcich zo 4 šľachtiteľských chovov (PD Smrečany - farma Veterná Poruba, PD Spišské Bystré - farma Kvetnica, Agria Liptovský Ondrej a.s. - farma Liptovská Porúbka, PD LČV Čimhová), u ktorých bola meraná intenzita hnedého sfarbenia. Pre objektívne meranie intenzity sfarbenia bol použitý prenosný chromameter Minolta CM-2600d so zisťovaním farebného priestoru na škále CIEL*a*b*. Zariadenie zaznamenávalo hodnoty L*, a*, b*. L* zodpovedá jasu sfarbenia a* poukazuje na mieru sfarbenia na škále od červenej k zelenej a b* naopak na škále od žltej k modrej. Taktiež bola meraná saturácia (C) a odtieň (h). Priemerné zistené hodnoty boli (s.d. v zátvorke): 22,60 (4,62) pre jas, 8,84 (2,42)

pre intenzitu červenej a 13,32 (3,75) pre intenzitu žltej farby. Saturácia sfarbenia bola 16,19 (3,62). Hodnota odtieňa bola 0,97 (0,17).

**Kľúčové slová:** Dedivosť sfarbenia, jas, odtieň, pinzgauský dobytok, systém odchovu, sýtosť

## Detailný abstrakt

Poznanie genetickej variability znakov ohrozených plemien patrí k základným predpokladom ich úspešného manažmentu,. V prípade ohrozených populácií je zvyšujúci sa záujem o genetickú variabilitu nielen produkčných, reprodukčných ako aj funkčných znakov a vlastnosti ale stále viac aj znakov a vlastností popisujúcich zovňajšok, ktoré nie sú spojené s produkciou ale najmä s oblasťou chovu, preferenciami chovateľov a kultúrno-historickými väzbami.
Cieľom práce bola analýza gaštanovohnedého plášťového sfarbenia pinzgauských kráv na Slovensku vo vzťahu k veku a systému chovu. Celkovo bolo hodnotených 304 dojníc plemenných skupín P0, P1, P2 a R3 narodených v rozpätí rokov 2000 až 2010, pochádzajúcich zo 4 šľachtiteľských chovov (PD Smrečany - farma Veterná Poruba, PD Spišské Bystré - farma Kvetnica, Agria Liptovský Ondrej a.s. - farma Liptovská Porúbka, PD LČV Čimhová), u ktorých bola meraná intenzita hnedého sfarbenia. Pre objektívne meranie intenzity sfarbenia bol použitý prenosný chromameter Minolta CM-2600d so zisťovaním farebného priestoru na škále CIEL*a*b*. Zariadenie zaznamenávalo hodnoty L*, a*, b*. L* zodpovedá jasu sfarbenia a* poukazuje na mieru sfarbenia na škále od červenej k zelenej a b* naopak na škále od žltej k modrej. Pre matematicko-štatistické hodnotenie bol použitý SAS Enterprise Guide ver. 4.2. Pre analýzu komponentov variancie hodnoty C* (saturácia) a h (odtieň) bola zostavená modelová rovnica, ktorej pevnými efektmi boli plemenný typ, mesiac a rok narodenia, systém chovu a línia otca. Priemerná nameraná hodnota (s.d. v zátvorke) jasu bola 22,60 (4,62), intenzita červenej (a*) 8,84 (2,42) a 13,32 (3,75) pre intenzitu žltej farby (b*). Saturácia sfarbenia bola v priemere 16,19 (3,62) a hodnota odtieňa 0,97 (0,17). Systém chovu determinoval 12,79% variability jasu, 16,47% odtieňa resp. 4,1% saturácie, naopak efekt chovateľa vysvetlil 37,29% resp. 55,15% variability jasu a odtieňa a bol bez vplyvu na saturáciu. Mesiac a rok narodenia nemali vplyv na intenzitu sfarbenia. Výsledky poukázali na to, že saturácia je najstálejšia z hodnotených vlastností sfarbenia bez vplyvu stáda, systému chovu, línie otca ako aj efektov prostredia. Odtieň je znak, ktorý pomerne dobre vystihuje sfarbenie, a z tohto dôvodu je predpoklad jeho ďalšieho využitia v analýzach ako aj k štúdiu na molekulárnej úrovni.

## Introduction

Knowledge of genetic variation of traits of endangered breeds belongs to the principal prepositions of its successful management. The genetic variability of endangered populations is not only focused on production, reproduction as well as functional traits and characteristics but even more on traits and characteristics describing type, which are connected not only with production but mainly with area of breeding, breeders preferences and cultural and historical heritage. One of the most typical type traits of Pinzgau cattle is its colour, which is described as chestnut brown coat colour, delimited with white belt, starting at withers, along back to the tail head, tail, udder, barrel to the top of the chest. Further, dark coat colour is one of

the traits, which are appreciated of breeders from subtropical and tropical regions of America and Africa, connected with protection of organism from UV radiation. Beside its typical type traits, the Pinzgau cattle is characterized with complex of production and reproduction traits. In Central and Eastern Europe is Pinzgau breed kept as dual - purpose with combined milk and meat production or in suckling cow-calf system. On the American continents and in South Africa is breed farmed as uni-purpose beef cattle, where farmers appreciate superior genetic background in milk production and lactation curve shape, as well as complex of maternal traits favouring this breed in cow-calf system.

Population of Pinzgau cattle bred as dual-purpose type in Europe is endangered. Nucleus is based upon populations registered in Herd book of Austria and Slovakia. Despite of high endangerment, when annual decrease of population size was more than 10% after 1997 in Slovakia (Kasarda and Kadlečík, 2010), is nucleus sustainable in Slovakia and Austria. Positive is the fact, that the population is presenting positive genetic trend in observed traits. The management of breeding is specific in Slovakia where the genetic reserve is bred under intensive farming conditions in sub-mountainous regions. The nucleus of the breed is formed from almost 50% (in Slovakia) and more than 65% (in Austria) of animals in suckling cow-calf system (PSSR, 2012; Kimberger, 2012 - personal communication). Breeders in Slovakia and Austria are interested in future development of breed, when integrating complex of traits to be part of the selection index, as genetic evaluation of growth intensity (Kasarda et al., 2009), genetic evaluation of longevity (Mészáros et al., 2010) as well as genetic evaluation of meat production (Krupa et al., 2008) in suckling cow system. Miesenberger (1997) set up the Total Merit Index in Austria used also in Pinzgau cattle. Austrian Pinzgau Breeders Association joined into genomic evaluation of production traits (Sölkner and Mészáros, 2012 personal communication).

The great advantage, aside of possible use of genomic data in an evaluation of genomic values and enlargement of selection possibilities, is opportunity of more detailed view on diversity of Pinzgau gene-pool and possibility of of selection's adaptation to protect as much diversity as possible aside of sustainable genetic gain. Simultaneously use of genomic data in study of inheritance of characteristics and traits is possible. Under this context, study is primarily oriented on traits determined by major genes to which also belongs color. There are loci known, responsible for specific signs in Simmental cattle (Fontanesi et al., 2010, Reinsch et al., 1999), loci responsible for greying in Lipizzan horses (Sölkner et al., 2004).

Heritability is from breeders point of view one of the most important parameters of the trait in population, defined as ratio between genetic and phenotypic variance. The low heritability of trait in population (even close to 0) causes that in population doesn't exists the trait's genetic variance, between individuals aren't genetic differences and breeding action hasn't sense. In opposite very high heritability points, that most of differences between individuals is caused genetically and therefore breeding actions are effective and the heritability has major influence in selection and prediction of genetic gain (Schüler et al., 2001).

For hair colour of cattle is expected high heritability. Becerril et al. (1996) presented high heritability (0.70) for percentage of white colour in coat of Holstein cattle, which allow to fast changes according to selection. Whereas colour of cattle is identified by breeders historically, has its social and cultural as well as economic value. The aim of the study is to describe the genetic diversity of coat colour of Pinzgau cattle. Basic

hypothesis is that even alone presence of chestnut brow colour is autosomaly inherited, existing deviation as lightness, chroma -saturation or hue are of quantitative basis and are inherited as complex traits determined by number of minor genes. From point of future use of genomic data, the goal is to identify traits and characteristics and their level of inheritance as the contribution to the studies of diversity of traits of endangered populations.

## Materials and Methods

In total 304 cows of Slovak Pinzgau breed (breeding group P0, P1, P2, R3) born between 2000 and 2010 from four nucleus herds were used for analysis:

- PD Smrečany – Farm Veterná Poruba – 51,
- PD Spišské Bystré – Farm Kvetnica – 28,
- Agria Liptovský Ondrej JSC – Farm Liptovská Porúbka – 169,
- PD LČV Čimhová – 56.

Animals from Agria Liptovský Ondrej, JSC were the only one under conventional dual-purpose breeding with milk production. Cows were measure in time of afternoon milking, in the manipulation corridor after milking parlour. Remaining animals were kept under suckling cow farming system with grazing on the pasture. Animals were measured in manipulation corridors belonging to the barns.
Objective measurement of coat color was realized with handheld chromameter Minolta CM-2600d with use of CIEL*a*b* colour space. Data were stored according to animal number within the equipment's internal storage sequentially. Colour of animals was measured between right resp. left hip and rips area according to conditions on the farm. Levels of L*, a*, b* were obtained on scale +/- 100 (for L*) resp. +/- 60 (for a*, b*). Those 3 measures defined colour within 3D colour space according to Radácsi (2008). Animal recording data as well as pedigree data were obtained for measured animals in cooperation with Breeding Services of Slovak Republic s. e. from official animal recording system.
To express saturation C*, observed values of a* and b* was recalculated using following formula of Toth et al. (2006):

$$C^* = \sqrt{(a^*)^2 + (b^*)^2}$$

Hue (H) of the coat color was recalculated using following formula (Introduction to Colour Spaces, 2012):

$$h = arctan\frac{b^*}{a^*}$$

Software SAS Enterprise Guide ver. 9.2 was used for subsequent analysis and expression of statistical measures. One-way vs. multi trait linear models were used for analysis of variance.
Model equation:

$$Y_{jklmno} = \mu + Breeder_j + Typ_k + Mnar_l + Rnar_m + Line_n + Breedg_o + e_{jklmno}$$

where single parameters were as follows: Yijklmno = evaluated trait (L*, a*, b*, C*, h)
μ = average value
$Breeder_j$ = breeder (j=4: PD Smrečany – farm Veterná Poruba, PD Spišské Bystré – farm Kvetnica, Agria Liptovský Ondrej JSC – farm Liptovská Porúbka, PD LČV Čimhová)
$Typ_k$ = farming system (k=2: suckling, dairy) Mnar l = month of birth (l=12)
$Rnar_m$ = year of birht (m=11: 2000, 2001, ...,2010) – fixed effect Line n = sire line (n= 32)

$Breedg_o$ = breeding group (o = 4: P0, P1, P2, R3) $e_{jklmno}$ = error
For estimation of heritability random effect of individual was introduced to the model equation.

## Results and Discussion

Evaluated were 304 cows of Slovak Pinzgau breed including crossbreed animals from 4 farms. In whole dataset was observed average lightness L* = 22.60 (s.d. = 4.62). (Table 1) Comparable results were obtained in work of Toth et al. (2006) in population of Nonius horses coloured bay/chestnut (L*= 23.83 – 24.59). On the other hand Lipizzan horses provided highest values of L*= 70.88. Rádacsi et al. (2006) recorded L* from 45.59 to 64.24 in population of Hungarian grey cattle which is of lighter coat colour compared to Pinzgau. Average observed value of red chroma a* was 8.84 (s.d. = 2.42) (Table 1). Toth et al. (2006) observed in population of Gidran horses a*= 8.50 – 8.65. Radácsi et al. (2006) observed in contrary in Hungarian grey cattle a*= 3.53 – 7.22. Average value of yellow chroma b* in whole dataset was 13.32 (s.d. = 3.75) (Table 1). Toth et al. (2006) observed in set of chestnut horses values b*= 11.53 – 11.74. Radácsi et al. (2006) observed for Hungarian grey cattle higher values b*= 11.99 – 16.08. Saturation C* is derived from a* and b* and its value in measured animals was C*= 16.19 (Table 1). Saturation of black coated horses in work of Toth et al. (2006) was C* = 2.35 – 2.45 resp. C*= 4.73 – 6.75 for grey Lipizzan coat colour which is in contrary with chestnut coloured horses with C*= 14.51 – 14.60. Colour hue is described with parameter H, where average value in the data were H = 0.97, which means more red. This parameter and its results are firstly described in our paper (Table 1).

Table 1. Basic statistical parameters of L*, a*, b*, C* and h of coat colour at particular farms and total

| | | Veterná Poruba (n=51) | Kvetnica (n=28) | Liptovská Porúbka (n=169) | Čimhová (n=56) | Total (n=304) |
|---|---|---|---|---|---|---|
| L* | $\bar{x}$ | 22.25 | 25.62 | 24.07 | 16.96 | 22.60 |
| | s.d. | 2.17 | 3.19 | 2.68 | 6.52 | 4.62 |
| | $X_{min}$ | 18.79 | 20.71 | 16.89 | 1.30 | 1.30 |
| | $X_{max}$ | 27.54 | 33.24 | 36.59 | 37.45 | 37.45 |
| a* | $\bar{x}$ | 9.07 | 10.19 | 9.72 | 5.31 | 8.84 |
| | s.d. | 1.28 | 1.78 | 1.34 | 2.77 | 2.42 |
| | $X_{min}$ | 6.36 | 7.33 | 6.34 | 1.10 | 1.10 |
| | $X_{max}$ | 11.53 | 13.23 | 13.61 | 12.21 | 13.61 |
| b* | $\bar{x}$ | 11.77 | 14.06 | 12.80 | 15.90 | 13.32 |
| | s.d. | 2.62 | 3.93 | 3.08 | 4.98 | 3.75 |
| | $X_{min}$ | 7.36 | 8.48 | -1.72 | 2.08 | -1.72 |
| | $X_{max}$ | 18.32 | 23.08 | 23.6 | 27.12 | 27.12 |
| C* | $\bar{x}$ | 14.88 | 17.39 | 16.13 | 16.97 | 16.19 |
| | s.d. | 2.80 | 4.18 | 3.04 | 5.04 | 3.62 |
| | $X_{min}$ | 10.16 | 11.21 | 8.80 | 4.43 | 4.43 |
| | $X_{max}$ | 21.56 | 26.60 | 27.24 | 28.14 | 28.14 |
| H | $\bar{x}$ | 0.91 | 0.93 | 0.91 | 1.24 | 0.97 |
| | s.d. | 0.05 | 0.06 | 0.10 | 0.19 | 0.17 |
| | $X_{min}$ | 0.81 | 0.83 | -0.15 | 0.49 | -0.15 |
| | $X_{max}$ | 1.04 | 1.05 | 1.05 | 1.49 | 1.49 |

Table 2. Basic statistical parameters of L*, a*, b*, C* and h of coat color according to breeding group and total

| | | $P_0$ (n=263) | $P_1$ (n=26) | $P_2$ (n=12) | $R_2$ (n=3) | Total (n=304) |
|---|---|---|---|---|---|---|
| L* | $\bar{x}$ | 22.72 | 22.30 | 20.39 | 23.51 | 22.60 |
| | s.d. | 4.59 | 4.87 | 4.91 | 2.41 | 4.62 |
| | $X_{min}$ | 1.30 | 10.99 | 9.73 | 20.74 | 1.30 |
| | $X_{max}$ | 37.45 | 29.37 | 26.71 | 25.14 | 37.45 |
| a* | $\bar{x}$ | 8.91 | 8.85 | 6.94 | 10.01 | 8.84 |
| | s.d. | 2.34 | 2.36 | 3.71 | 0.53 | 2.42 |
| | $X_{min}$ | 1.10 | 1.84 | 2.3 | 9.52 | 1.10 |
| | $X_{max}$ | 13.61 | 11.48 | 12.16 | 10.58 | 13.61 |
| b* | $\bar{x}$ | 13.15 | 14.41 | 14.86 | 12.40 | 13.32 |
| | s.d. | 3.82 | 3.42 | 2.61 | 2.03 | 3.75 |
| | $X_{min}$ | -1.72 | 7.94 | 11.21 | 10.06 | -1.72 |
| | $X_{max}$ | 27.12 | 21.95 | 19.54 | 13.66 | 27.12 |
| C* | $\bar{x}$ | 16.08 | 17.11 | 16.73 | 15.96 | 16.19 |
| | s.d. | 3.70 | 3.21 | 2.92 | 1.84 | 3.62 |
| | $X_{min}$ | 4.43 | 11.16 | 11.53 | 13.85 | 4.43 |
| | $X_{max}$ | 28.14 | 23.21 | 21.39 | 17.28 | 28.14 |
| H | $\bar{x}$ | 0.96 | 1.01 | 1.15 | 0.89 | 0.97 |
| | s.d. | 0.17 | 0.16 | 0.21 | 0.07 | 0.17 |
| | $X_{min}$ | -0.15 | 0.79 | 0.87 | 0.81 | -0.15 |
| | $X_{max}$ | 1.49 | 1.42 | 1.41 | 0.94 | 1.49 |

Highest variability of values was observed on farm of PD LČV Čimhová and lowest on farm Veterná Poruba. Darkest animals were observed in PD LČV Čimhová (L*= 16.96) and lightest in Kvetnica (L*= 25.62). Highest saturation of red/yellow colour was observed in Kvetnica (C*= 17.39) and lowest in Veterná Poruba (C*= 14.88). Hue values were low in all animals, what means colour is based more on red. Farming system described 12.79% in lightness, 16.47% in hue resp. 4.10% in saturation of total phenotypic variance, whereas effect of breeders explains 37.29% and 55.15% for lightness and hue, respectively and has no effect in saturation. Sire line described 28.42 in lightness and 19.45% of total variance of hue. Month and year of birth resp. breeding group did not significantly affect total phenotypic variance of observed parameters. Results show that saturation is most fixed within breed with almost no differences within analysed herds, farming systems, sire lines and environmental effects. Hue seems to be very descriptive measure which could be used in subsequent analyses even on molecular data basis.

Table 3. Heritability of selected coat colour parameters L*, C* and H

| Trait | heritability/$h^2$ | s.e. |
|---|---|---|
| L* | 0.2427 | 0.02526 |
| C* | 0.5787 | 0.02496 |
| H | 0.1730 | 0.03042 |

Inheritance of L* which describes the lightness of colour was low ($h^2$ > 0.2427). Lower heritability was observed in case of H which is described as shade (0.1730). Medium high heritability was observed in case of saturation C* (0.5787). Low estimated values of the heritability could be caused by model complexity, which could affect the

distribution of total observed variability and partially by limitation of relationship matrix. Further research according to accurate description of model parameters will be needed to estimate heritability of coat colour with higher reliability.

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