Changes of coat cover in primitive horses living on a reserve

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ABSTRACT: Changes in the coat cover are important for mammalian thermoregulation. This is especially true where variable environmental conditions exist throughout the seasons. Coat cover shedding is the replacement of old coat hair with new hair. The process differs in various equids. The aim of the study was to examine the changes in the coat of primitive Polish Konik horses living on a reserve in southeast Poland (50.6319° N). The reserve is located in a temperate climate. The mean temperature is below 0°C in winter (December 8 to March 9) and over 15°C in summer (June 8 to September 8). Five adult mares were included in the study. The study used a specific methodical approach to quantitatively assess coat cover changes. Photos were taken once every 2 wk throughout the whole year to document the state of the mares’ coat. MultiScanBase software was used to analyze 260 photos. The percentage of the skin surface covered with short hair in relation to the surface of the body (without the head, neck, and limbs; short hair body [SHB]) was determined. To assess the topography of coat changes, surface parts covered with short hair within 6 regions of the body (shoulder, back, chest, loins, belly, and hindquarters; short hair part [SHP]) were considered separately. The regression coefficient was calculated for the SHB and the air temperature. Correlations in SHP and SHB between the left and right sides of the body were determined. The correlations within the right side of the body concerned particular SHP. As the results show, the coat changes take place at the same time on both sides of the horse’s body. In spring, the winter hair is shed, and in the fall, the winter hair grows in longer. High regression (0.901; \( P < 0.0001 \)) proved that air temperature strongly affected the coat changes. The most important increase of SHB occurs in April and the first half of May, whereas the main decrease of SHB takes place in September. Changes between SHP are highly correlated (0.967–0.994; \( P < 0.05 \)). Spring and fall coat changes demonstrate that the shoulders, back, and loins require the winter cover for a longer time than the chest and belly, whereas the hindquarters are the least demanding in this respect. The phenomenon may be associated with, among others, the stronger effect of rain and snow on the upper parts of the body.

Key words: coat cover, hair, horse, season, shedding

INTRODUCTION

Changes of the coat cover are important for mammalian thermoregulation, especially under variable environmental conditions of the seasons. Shedding replaces old coat hair while producing new hair. Long winter cover isolates the animal from the cold, wind, snow, or rain. In summer, when the hair is short, the body can easily release the excess warmth. On the other hand, shedding and growing new hair weaken the animal because warmth is lost and nitrogen and sulfurous compounds are absorbed through the growing hair (Dunnett, 2005).

Equids exhibit variability in the time and duration of coat changes (Mazák, 1962b; Dobroruka, 1975). In the domestic horse (Equus caballus; taxonomy used according to Groves and Grubb, 2011), these changes should be taken into account when considering the indoor or outdoor system of maintenance and intensity of feeding crucial for the animal’s growth and welfare (Cymbaluk and Christison, 1989). The alterations in the coat are of importance for herds living on reserves, where the horses are strongly affected by climate conditions. Speed (1960) reported


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a number of ponies with abnormal coats that barely survived or died of exposure on hills in Britain in winter. Horses from sophisticated breeds are usually groomed, which interferes with the timings of the coat shedding. There is little or no human interference on the reserves where some horses live. When considering coat changes as a way of adapting to the environment, horses living on reserves can be analyzed and used as a reference model for sophisticated breeds. Of domestic breeds, the primitive horses lost the least of their natural ability to live under harsh circumstances (Davies Morel et al., 2006; Stachurska et al., 2006).

Studies on the coat changes in domestic horses are scarce and date from the middle of the 20th century (Bílek, 1955; Speed, 1960; Mazák, 1962a,b). The aim of the present study was to examine the coat cover changes of primitive horses living on a reserve.

**MATERIALS AND METHODS**

This study did not require closely approaching the horses; hence, approval of animal procedures was not needed. The authors followed standard institutional guidelines concerning human contact with horses living on reserves.

Among the domestic horses, the primitive, entirely blue-dun colored Polish Konik horse is the most closely related to the extinct wild Tarpan (Equus ferus; Komosa et al., 2013). The breed is included in the Global Strategy for the Management of Farm Animal Genetic Resources, established by the Food and Agricultural Organization (Jezierski and Jaworski, 2008).

Five adult mares of the Polish Konik were included in the study and given numbers: a 6-yr-old (1), two 9-yr-olds (2) and (3), a 16-yr-old (4), and a 29-yr-old (5). The mares were in good condition and health throughout the year. None of the horses showed signs of Cushing’s disease (Schott, 2002). They were born and have been living on the Ostoja Reserve in Roztocze National Park, Zwierzyniec, in southeast Poland (50.6319° N). The park is located in a temperate climate. The mean temperature is below 0°C in winter (December 8 to March 9) and over 15°C in summer (June 8 to September 8; Trenberth, 1983). The enclosed area is 94 ha of mainly forest, some meadows, a stream, and ponds. There are no shelters on the reserve. Human interference is minimal and limited to providing hay during heavy snow cover, once-a-year hoof trimming, and catching yearlings when they are too numerous.

Photos of the coat were taken once every 2 wk, throughout the whole year, to note the state of the coat cover. The objective of the study was not to determine the exact dates that coat changes began or ended as the exact dates are difficult to determine. The objective was to describe the general pattern of the changes, which is more important. The only person taking the photos knew the horses and could easily identify them. The horses were familiar with the person’s figure. Both sides of each horse were photographed while the horse was standing. Of all the photos, 260 photos were selected and analyzed by one person, who used MultiScanBase (Computer Scanning Systems, 2004) software. The mean monthly air temperature throughout the year was obtained from the meteorological station located on the reserve.

In the photos, the regions of the body where the short “summer” hair contrasts with the long “winter” hair identified the areas of the coat cover changes. In Polish Koniks, winter hair is longer than summer hair by 4.6 cm on average (Stachurska et al., 2006). The summer and winter hair also differ in color tone (Stachurska et al., 2004), shape in the cross-section (Kownacki, 1962), and thickness (Stachurska et al., 2007). In the winter coat, apart from longer guard hairs with medulla (core of hair), shorter undercoat hairs without a medulla or with only a thin medulla occur (Stachurska et al., 2006). However, all differences can be detected only by laboratory analyses. In the study, the state of the coat cover was determined as the percentage of the skin surface covered with short hair in relation to the total body surface.

To determine the topography of coat changes, we divided the body into 6 regions along to the following segments (Supplemental Fig. 1): front vertical segment leading from the highest point of the withers; hind vertical segment from the highest point of the hindquarters; horizontal segment across the middle of the body, where the middle point was determined according to the middle of the front vertical segment; front segment of the shoulder; horizontal segment that

![Figure 1. Mean body surface covered with short hair (short hair body [SHB]) in percent of the whole body side in successive months and respective mean temperature of air.](image-url)
follows through the middle of the elbow joint; and horizontal segment that follows through the middle of the knee joint. For simplicity’s sake, the regions were termed as follows, although they do not exactly overlap anatomical regions: A = shoulder, B = back, C = chest, D = loins, E = belly, and F = hindquarters. The software was used to zoom in on one region after the other. The part of the region covered with short hair (short hair part \([\text{SHP}]\)) was outlined, and next, the SHP percentage in relation to the region surface was determined. Finally, all the SHP percentages were transformed into the total percentage of the body surface covered with short hair (short hair body \([\text{SHB}]\)). In the analysis, the images were considered flat, not 3-dimensional. The coat changes on the head, neck, and limbs were not used as part of our study. We assumed that these changes are less important for the basic thermoregulation of the organism. In addition, it would be more difficult to correctly assess the coat changes on the head, neck, and limbs. Likewise, the mane and tail hair, which continually grow and are shed (Detkens, 1967; Dunnett, 2005) and which are less important for thermoregulation, were not considered.

The mean SHB and SHP percentages were analyzed for all 5 mares for successive months. In addition, every 2 wk for 2 mo in the spring and 2 mo in the fall, the intensive changes in the SHP were considered. Correlations in SHP and SHB between the left and right sides of the body were calculated. The correlations within the right side of the body concerned the SHB between the mares and particular SHP. The regressions between SHB and mean air temperature were also analyzed. The coefficients were calculated using the Wilcoxon matched pairs test. Correlation and regression tests were implemented in STATISTIKA software version 12 (StatSoft Inc., 2013).

### RESULTS

In all the analyzed individuals, the percentages of SHP and SHB from the left side and the percentages from the right side of the body were nearly identical (Table 1; Supplemental Fig. 2 and 3). For this reason, further analysis is solely concerned with the right side of the horse’s body.

The Polish Konik horse exhibited marked spring and fall coat changes according to the averaged data (Fig. 1) and individual data (Fig. 2). In April and May, the SHB increased (Supplemental Fig. 2 and 3), while in September and October, it decreased (Supplemental Fig. 4). Generally, there was no SHB from the beginning of November until the beginning of April.

Mean monthly air temperatures in the studied year were typical for the region. The increase in temperature was associated with the growth of the SHB and conversely, the decrease of the SHB took place when the temperature decreased (Fig. 1). The highly significant regression \((P < 0.0001)\) between the mean

<table>
<thead>
<tr>
<th>Body regions</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>Whole body side</th>
</tr>
</thead>
<tbody>
<tr>
<td>Correlation</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
</tr>
</tbody>
</table>

1 \(A = \text{shoulder}; B = \text{back}; C = \text{chest}; D = \text{loins}; E = \text{belly}; F = \text{hindquarters.} \)
2 All correlations significant at \(P < 0.05.\)

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**Figure 2.** Body surface covered with short hair (short hair body \([\text{SHB}]\)) in percent of whole body side in particular mares in successive months.

**Figure 3.** Mean region surface covered with short hair (short hair part \([\text{SHP}]\)) in percent of particular body regions in successive months.

**Figure 4.** Mean region surface covered with short hair (short hair part \([\text{SHP}]\)) in percent of particular body regions during spring intensive cover changes.
percentile SHB and the mean air temperature amounted to 0.901 for all horses and 0.862 to 0.923 for particular individuals (Table 2).

All 5 mares underwent hair coat changes about the same time during the year (Fig. 2). The most prominent SHB increase occurred in April and the first half of May, whereas the main decrease took place in September. The oldest mare, (5), tended to have the shortest SHB most months. The mare still had some long hair even in June and August, while all the other mares were completely covered in short hair. In May and September, the younger horses, (1) and (3), tended to have greater SHB than the other mares. The SHB between the mares were significantly correlated (0.943–0.997 at \( P < 0.05 \); Table 3).

Topographical changes, in particular SHP, took place in similar periods (Fig. 3, 4, and 5). The horses were almost entirely covered with short hair in June, July, and August. As in SHB, differences in the percentile of the SHP were most pronounced in April, May, and September. In April, the SHP on the back were 4 times less than the hindquarter SHP. In October, the back SHP were almost 9 times less than the hindquarter SHP. The differences in SHP were less marked in May (the greatest difference was a difference of 1.2 times) and September (the greatest difference was a difference of 1.3 times).

In the spring, the SHP first appeared on the hindquarters and then on the belly and chest (Fig. 4). Shedding of the winter hair took place more slowly on the shoulders and back. Shedding on the loins lasted even until the end of April. Later, in the first half of May, the latter regions were shed more quickly and almost matched a state similar to the bottom parts and hindquarters. In the fall, the SHP were overgrown with winter hair. The loins were the quickest to gain their winter coat (Fig. 5). The shoulders and belly were next and then the hindquarters, chest, and back. Despite different parts of the body gaining winter hair at different times, all SHP were significantly correlated during the spring and fall coat changes (0.967–0.994 at \( P < 0.05 \); Table 4).

**DISCUSSION**

This is the first study on the changes of the coat in horses based on objective methodology. Sketches of shedding, free ranging animals drawn in the past usually required a lot of effort from the observer. Even for elementary documentation (sketches and classical photos) of the shedding topography, careful observation was required. Digital photos are much more efficient. They save time and enable the identification of particular individuals with certainty. The most valuable tool is the digital analysis of images, which makes it possible to precisely assess the size and location of the short and long hair surface on the horse’s body.

The first question of the study was whether the coat changes proceeded similarly on both sides of the horse. This aspect had not yet been evaluated. As expected, our results showed that changes proceed in a completely symmetrical way. Hence, the whole analysis could have been conducted on only one side.

The second issue was whether the fall change of the coat cover was a shedding of the coat cover because there are differing opinions on the occurrence of fall shedding in horses. Speed (1960) observed that horses shed their coats once a year during the spring. This author expected a gradual transition of the coat properties. In addition, some coat hair may be shed and the coat cover was a shedding of the coat cover because there are differing opinions on the occurrence of fall shedding in horses. Speed (1960) observed that horses shed their coats once a year during the spring.

Our results indicate that the fall coat change consists of growing long winter hair. In typical coat shedding, tufts of hair come off the coat. In the fall, this phenomenon was not observed and only a decrease of the SHP was noted. Our results agree with the findings by Mazák (1962a) about spring coat shedding and the growing of winter hair in the fall. Coat changes also consist of the abovementioned alterations in the hair properties. In addition, some coat hair may be shed and grow throughout the year. To clarify the nomenclature, both spring and fall changes of the winter and summer coats may be simply termed coat cover changes, instead of spring and fall coat changes respectively.

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**Table 2.** Regressions between the percentile body surface covered with short hair (short hair body) and the air temperature

<table>
<thead>
<tr>
<th>Mares</th>
<th>Regression 1</th>
<th>Regression 2</th>
<th>Regression 3</th>
<th>Regression 4</th>
<th>Regression 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>0.923</td>
<td>0.886</td>
<td>0.882</td>
<td>0.892</td>
<td>0.862</td>
</tr>
<tr>
<td>(2)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.901</td>
</tr>
</tbody>
</table>

1All regressions significant at \( P < 0.0001 \).

**Table 3.** Correlations of the percentile body surface covered with short hair (short hair body) between particular mares

<table>
<thead>
<tr>
<th>Mares</th>
<th>Correlation 1</th>
<th>Correlation 2</th>
<th>Correlation 3</th>
<th>Correlation 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>(2)</td>
<td>0.973</td>
<td>0.969</td>
<td>0.907</td>
<td>0.975</td>
</tr>
<tr>
<td>(3)</td>
<td>0.980</td>
<td>0.997</td>
<td>0.984</td>
<td>0.975</td>
</tr>
<tr>
<td>(4)</td>
<td>0.957</td>
<td>0.996</td>
<td>0.943</td>
<td>0.989</td>
</tr>
</tbody>
</table>

1All correlations significant at \( P < 0.05 \).
of hair changes. In previous studies, only the topography of spring coat shedding was considered because the methods used did not allow for the exact determination of the less pronounced fall coat changes. The percentile SHB and SHP seem to be appropriate parameters of the spring and fall coat cover changes.

The capacity for seasonal adaptation to temperature, for example winter hypometabolism, was proved in respect to Shetland ponies (Davies Morel et al., 2006; Brinkmann et al., 2012). A cold, wet spring season may delay the shedding of the winter coat, whereas horses kept in warm stables or covered by rugs do not develop winter coats or they shed quickly and the shedding is almost unnoticeable. The air temperature is associated with the timing of the spring coat shedding in the Przewalski’s horse (Equus przewalskii) according to Mazák (1962a) and in the Asian wild ass (Equus hemionus) according to Rashek (1977). Those findings, however, were not statistically documented. The high regression shown in our study proved the strong influence of the air temperature on the coat changes in the Polish Konik. In our study, it was in April that major coat changes occurred. In April, there was a mean monthly air temperature increase of 10.4°C. Considering the fall, the mares were almost entirely covered with winter hair in October, and yet the main temperature decrease of 9.0°C occurred in December. This phenomenon is in line with earlier findings that apart from the temperature, for example winter hypometabolism, was proved rarely, in mid July (Yasinetskaya, 1999), and the Asian wild ass from the Barsa-Kelmes Island (Kazakhstan) starts the spring shedding in early April and finishes in the middle or end of June (Rashek, 1977). For domestic horses in central Europe, coat shedding is reported to take place at the end of March to the beginning of April (Bilek, 1955), whereas in Exmoor and other mountain and moorland ponies in Britain, the winter coat is shed from the end of March until the end of May (Speed, 1960). Mazák (1962b) observed a tendency for irregularities in the coat shedding of the domestic horse on various stud farms and in zoological gardens. The fall coat change in equids was less documented. In the Przewalski’s horse, it begins in September or October and is completed during the first half of December, whereas in the Asian wild ass, it starts in October and lasts for 6 to 8 wk (both were in the Prague Zoo; Mazák, 1962a). For the Asian wild ass of the Barsa-Kelmes Island, the winter hair starts to grow in September and continues to grow for 80 to 110 d (Rashek, 1977).

In general, the timing and duration of the spring hair shedding and fall hair growth in the present study agree more or less with the timings and durations documented for other equids. However, our results cannot be directly compared to the timings of the coat cover changes in other species or even in other horse breeds, because the other studies were conducted at various geographical latitudes of different mean air temperatures, in different years, and under different management conditions and, in addition, the coat changes were described differently. The coat changes of the Polish Konik were formerly

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![Figure 5. Mean region surface covered with short hair (short hair part [SHP]) in percent of particular body regions during fall intensive cover changes.](image)

<table>
<thead>
<tr>
<th>Body regions</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
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</thead>
<tbody>
<tr>
<td>Correlation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>0.983</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>0.987</td>
<td>0.976</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>0.994</td>
<td>0.980</td>
<td>0.984</td>
<td></td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>0.986</td>
<td>0.969</td>
<td>0.989</td>
<td>0.985</td>
<td></td>
</tr>
<tr>
<td>F</td>
<td>0.981</td>
<td>0.967</td>
<td>0.987</td>
<td>0.981</td>
<td>0.990</td>
</tr>
</tbody>
</table>

1 A = shoulder; B = back; C = chest; D = loins; E = belly; F = hindquarters.

2 All correlations significant at P < 0.05.
studied by Detkens (1967), at the Popielno reserve, 350 km to the north from Zwierzyniec, Poland. The horses at Popielno began to shed their winter coats as soon as January and the process lasted until June. However, the shedding was assessed only subjectively, based on touching and brushing the coat. No measure was taken to distinguish the usual coat hair loss throughout the year from the shedding.

We observed that the shoulders, back, and loins were the last places to shed the winter hair as well as the first to grow such hair in the fall. The hindquarters were the first to lose the winter hair and had SHP for a longer period in the fall. Those facts show that the shoulders, back, and loins probably require the winter coat for a longer period than the bottom parts of the horse, whereas the hindquarters are the least demanding in this respect. The phenomenon may be associated with, among others, the stronger effect of rain and snow on the upper parts of the body. However, the high correlations between the percentile SHP demonstrate that, generally, the changes of coat in certain parts proceed in a comparable way.

The general pattern of spring coat shedding in Polish Koniks found in our study agrees with that observed in the Asian wild ass, plains zebra, and Hartmann’s mountain zebra in which the winter hair is shed earlier on the belly than on the upper parts (Mazák, 1962b; Dobroruka, 1975). Interestingly, according to Mazák (1962a,b) and Dobroruka (1975), in the Przewalski’s horses, kiangs, and Grévy’s zebras, the shedding of the winter coat cover proceeds differently: first on the head and neck, somewhat later on the pelvic region, then on the flanks and front parts of the limbs, and finally on the belly and medial and caudal sides of the limbs.

It seems that the patterns do not include a phylogenetic signal, because sister taxa of equids, for instance the Przewalski’s horse and domestic horse, Asian wild ass, and kiang as well as Grévy’s zebra and the plains zebra, exhibit a different succession of the spring coat shedding (Vilstrup et al., 2013). The differences in the duration and topography of the coat cover changes found between the Polish Koniks and the Przewalski’s horses as well as other equids indicate the need for further investigation into the process in various horse types or breeds. Other concerns to be examined are the mechanisms involved in the coat changes with respect to the age, sex, and pregnancy or other physiological factors. Previous observations show a longer duration of coat shedding in foals than in adults (Mazák, 1962a; Detkens, 1967). It can also be observed that old, ill, or thin horses shed their coats for a longer period of time.

The coat and hair change parameters can be assumed as adaptation criteria of indigenous groups of animals to local conditions of reintroduction projects (Bouman et al., 1994; Yasinetskaya, 1999). Primitive horse breeds (e.g., Exmoor pony, Polish Konik horse) or wild species (Przewalski’s horse and Asian wild ass) are increasingly used in the reintroduction of free ranging equine or grazing projects in Europe (Davies Morel et al., 2006). Our study indicates the utility of the presented specified methodical approach for an accurate quantitative assessment of coat cover changes. The method is also meant to provide for a better understanding of coat changes in domestic and wild equids.

In conclusion, the changes of coat cover in the primitive Polish Konik horse living on the reserve consist of a spring shedding of winter hair and of growing long winter hair in the fall. The coat cover changes take place at the same time on both sides of the horse’s body. High regression proved the strong influence of air temperature on the process. The most important increase of SHB occurs in April and the first half of May, whereas the main decrease of SHB takes place in September. The progressive coat shedding on the body shows that the shoulders, back, and loins require the winter cover for a longer time than the chest and belly, whereas the hindquarters are the least demanding in this respect.

LITERATURE CITED


Coat cover changes in primitive horses


StatSoft Inc. 2013. STATISTICA software, version 12, Tulsa, OK.

