



## SELECTED FACTORS INFLUENCING THE BEHAVIOR OF HORSES OUTSIDE THE STABLE DURING DIFFERENT SEASONS

Ewa Jastrzębska and Aleksandra Pawłowska\*

Department of Horse Breeding and Riding, Faculty of Animal Bioengineering, University of Warmia and Mazury, Oczapowskiego 5, 10-719 Olsztyn, Poland

\*Corresponding author: [aleksandra.pawlowska@uwm.edu.pl](mailto:aleksandra.pawlowska@uwm.edu.pl)

ORCID:

Ewa Jastrzębska – <https://orcid.org/0000-0001-8017-8594>

Aleksandra Pawłowska – <https://orcid.org/0009-0007-2716-8267>

### Abstract

Horse behavior is highly diverse and influenced by multiple factors. The aim of this study was to investigate the influence of selected factors on the frequency of social and comfort behavior in horses residing in a sandy paddock and pasture during different seasons. The study included a herd of 20 horses – 14 geldings and 6 mares. The youngest was three years old, the oldest was 21 years old, and the rest of the horses were in the 4 to 19 age range. The research involved observing the behavior of horses outside the stable, on the pasture and in a sandy paddock during four seasons. An ethogram was created to document specific social and comfort behavior. Weather conditions data for each day were collected using an anemometer. Statistically significant differences were observed in the occurrence of specific behavior between mares and geldings. The age of the horses did not affect the occurrence of specific behavior. Statistically significant correlations were found between weather conditions during the four seasons and the occurrence of social and comfort behavior. The research demonstrated that gender and weather conditions influence the occurrence of social and comfort behavior in horses.

**Key words:** horse, behavior, seasons, atmospheric conditions, weather

Behavior is a coordinated set of responses by an individual aimed at satisfying specific biological, psychological or social needs, occurring under the influence of internal or external factors. It is a complex system of an animal's responses to signals originating from the external environment or from within the organism itself, as well as the animal's reactions to its surrounding environment (Kokocińska Kaleta, 2016). Researchers define behavior as the link between the nervous system and the animal's environment (Seaman et al., 2002).

Understanding animal behavior requires knowledge of the immediate causes of its occurrence, including external stimuli, internal factors and processes within the organism (Thorne et al., 2005). Specific behavior can be influenced by human intentions, interactions between animals, excitability or the ability to remember and learn. Decreased welfare in horses is often associated with improper human management, such as poor quality feed, insufficient feeding time, social isolation or lack of free movement (Hausberger et al., 2008; Hemsworth et al., 2015; Hoffmann et al., 2012; Thorne et al., 2005; Visser and Van Wijk-Jansen, 2012). These issues can be mitigated by improving the knowledge and skills of horse enthusiasts (Visser and Van Wijk-Jansen, 2012).

Interactions between horses and humans are crucial in shaping behavior, especially in young animals. Understanding the behavioral reactions of horses significantly influences their daily handling and care (Jezierski et al., 1999). Additionally, factors such as age, gender, condition, level of dominance, presence of a foal, weather and climate impact behavior (Klocek and Olczak, 2013; Thorne et al., 2005). The way horses are trained also influences their behavior (Fenner et al., 2020; Hausberger et al., 2008). Differences in behavioral traits among individuals of the same species may stem from each individual's temperament (Seaman et al., 2002). Individual behavior variations reflect the feelings and emotions experienced by animals (Mills, 1998).

Ethology, one of the most important behavioral sciences, deals with the description, determination and specification of behavior and the analysis of its causes (Goodwin, 1999; Kokocińska and Kaleta, 2016). The main categories of horse behavior include: feeding, resting, moving, maintenance, and social and reproductive behavior (McDonnell, 2003). The multitude of categories and classifications, as well as the way they are perceived by different authors, complicates the analysis of the topic regarding horse behavior.

Animal behavior should be studied in their natural environment, where the biological significance can be captured. All behavior present in a given species constitutes an ethogram, which should encompass all possible animal behavior (Seaman et al., 2002). Ethograms are often used in scientific research as observational tools, for example, to identify pain in horses based on their behavior while ridden (Dyson et al., 2022; Dyson and Van Dijk, 2020; Garcia et al., 2023; Ladewig et al., 2022), to describe facial expressions in ridden horses (Mullard et al., 2017), or to analyze social bonds in an equid social ethogram (McGreevy et al., 2009).

Observations of animal behavior are a reliable source of information about welfare levels. The rapid development of research on animal behavior is essential for breeding practice, contributing to improving systems for their maintenance and use. Understanding horse behavior helps ensure their well-being by providing suitable living conditions and meeting their basic needs (Kokocińska and Kalleta, 2016). Social contact and companionship, free movement and access to forage are fundamental needs for horses (Dierendonck et al., 2004; Krueger et al., 2021). The herd provides security and allows alerting about threats, satisfying innate drives and presenting various social behaviors. Social deprivation is a strong stressor for horses, leading to a decline in well-being, intense fear and various emotional and behavioral problems (Janczarek et al., 2020).

Pasture-based or free-range systems offer higher welfare levels if breeders understand horses' responses to environmental conditions. General behavior patterns are genetically determined and species-specific, but individual personality differences should also be considered (Klocek and Olczak, 2013). In biometeorology, studies measure physiological parameters as health and performance indicators to examine how weather, climate, seasonality and environmental changes affect health, productivity and well-being. Rising temperatures adversely affect the health of humans, animals and plants (Anderson et al., 2021). Fluctuations in body temperature can harm animal efficiency as many physiological processes depend on temperature (Luz et al., 2022). Individual sensitivity to weather conditions is of great importance, with common symptoms including muscle and joint pains, emotional instability, drowsiness and weakness (Janczarek et al., 2015).

Overprotective owners often confine horses to stables due to unsuitable weather conditions, leading to a lack of movement, improper nutrition and inadequate care, resulting in enfeeblement, reduced adaptability, increased disease susceptibility and higher injury likelihood (Janczarek et al., 2020). The multifaceted nature and diversity of behavior and weather phenomena make studying their relationships challenging. Biometeorology knowledge helps understand and predict behavior changes in animals accompanying humans.

The aim of this study was to investigate the influence of selected factors on the frequency of social and comfort behavior in horses on a sandy paddock and pasture during different seasons.

## Material and methods

The research was conducted between February and May 2021 and between January and December 2022 at the Equestrian Center of the Department of Horse Breeding and Riding at the University of Warmia and Mazury in Olsztyn during a 90-hour observation period. The study included a herd of 20 horses – 14 geldings and 6 mares. The majority of the studied population were Silesian horses – nine individuals, while the rest of the herd consisted of two ponies, two Polish cold-blooded horses, two Polish sport horses, two noble-type horses, two Hucul horses, and one Malopolski horse. The youngest individual was three years old, the oldest was 21 years old, and the others ranged in age from 4 to 19 years (Table 1).

Table 1. Characteristics of geldings and mares, n=20

| No. | Year of birth | Age (years) | Breed                  | Gender  |
|-----|---------------|-------------|------------------------|---------|
| 1.  | 2006          | 16          | Silesian Horse         | gelding |
| 2.  | 2015          | 7           | Silesian Horse         | gelding |
| 3.  | 2017          | 5           | Silesian Horse         | gelding |
| 4.  | 2016          | 6           | Silesian Horse         | gelding |
| 5.  | 2017          | 5           | Silesian Horse         | gelding |
| 6.  | 2008          | 14          | Silesian Horse         | gelding |
| 7.  | 2008          | 14          | Silesian Horse         | gelding |
| 8.  | 2014          | 8           | Silesian Horse         | mare    |
| 9.  | 2006          | 16          | Pony                   | gelding |
| 10. | 2008          | 14          | Polish Coldblood Horse | mare    |
| 11. | 2003          | 19          | Polish Sport Horse     | gelding |
| 12. | 2009          | 13          | Noble-type Horse       | gelding |
| 13. | 2018          | 4           | Polish Coldblood Horse | gelding |
| 14. | 2016          | 6           | Noble-type Horse       | mare    |
| 15. | 2019          | 3           | Hucul Horse            | mare    |
| 16. | 2016          | 6           | Malopolski Horse       | mare    |
| 17. | 2015          | 7           | Silesian Horse         | gelding |
| 18. | 2017          | 5           | Pony                   | mare    |
| 19. | 2001          | 21          | Polish Sport Horse     | gelding |
| 20. | 2010          | 12          | Hucul Horse            | gelding |

The research involved observing the behavior of horses during specific hours outside the stable, i.e., in the pasture from July to October and in a sandy paddock during the remaining months of the year. Human interference in the horses' behavior while they were outside the stable was minimized.

The study analyzed the influence of age and gender on the occurrence of social and comfort behaviors in horses over 90 hours of observation, as well as the impact of selected meteorological factors categorized into four seasons (winter from 22 December to 21 March, spring from 21 March to 22 June, summer from 22 June to 23 September, autumn from 23 September to 22 December). Behavior was recorded at 8:30 AM, 9:30 AM, and 10:30 AM for 60 minutes each, with the observation

time selected each day to ensure an equal distribution of observations during these hours.

For the purposes of the study, an ethogram (Table 2) was created that considered specific social and comfort behavior. It included positive social behavior: 1) mutual grooming, 2) nuzzling, 3) halter manipulation, 4) play fighting, 5) mutual nibbling, and negative social behavior: 1) biting, 2) kicking, 3) squealing, 4) chasing, and comfort behavior: 1) rolling, 2) scratching, 3) locomotor play (frolic), 4) yawning, 5) tire manipulation (McDonnell and Haviland, 1995; McDonnell and Poulin, 2002; Torcivia and McDonnell, 2021).

Behavior was recorded using a digital camera (JVC, Everio) or was immediately noted using a system where 0 indicated that a particular behavior was not observed, 1 indicated that the behavior occurred once during the observation period, 2 indicated that the behavior occurred twice during the observation period, etc.

Information about the atmospheric conditions was collected using the anemometer (Kestrel 3000, Reguły, Poland). The measurements of the anemometer included current wind speed (m/s), maximum wind speed (m/s), average wind speed (m/s), air temperature (°C), relative air humidity (%), heat index (°C) and dew point temperature (°C).

A statistical analysis was conducted using the Statistica 13.3 software (StatSoft). Descriptive statistics (mean, median, standard deviation) of the studied variables were calculated. Student's t-test was used to analyze the following variables: grooming, nuzzling, halter manipulation, mutual nibbling, kicking, rolling, locomotor play (frolic), yawning, and tire manipulation. A Mann-Whitney U test was used to compare data related to gender. Additionally, Spearman's rank correlation was conducted to determine the influence of weather conditions on the frequency of horse behaviors in each season. The significance level was set to  $\alpha < 0.05$ .

Table 2. Ethogram created for research purposes

| Behavior        |                         | Explanation of behavior                                                                                                                                                                                                                                                                                                                                                                                                                   |
|-----------------|-------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Social positive | Mutual grooming         | Two individuals stand facing each other, typically with head-to-shoulder or head-to-tail contact. They sniff each other, using lips and teeth to grasp a piece of skin and intensely nibble it, grooming the neck, mane, withers, shoulder, back, rump, tail switch. This activity can be prolonged, occasionally switching sides (McDonnell and Haviland, 1995; McDonnell and Poulin, 2002).                                             |
|                 | Nuzzling                | Touching and pressing the head against the body, shoulder, neck or head of another horse (McDonnell et al., 2002).                                                                                                                                                                                                                                                                                                                        |
|                 | Halter manipulation     | Opening the mouth near the head of another individual to grab the halter, seizing, manipulating and tugging on an object using the lips and teeth (McDonnell and Haviland, 1995; McDonnell and Poulin, 2002).                                                                                                                                                                                                                             |
|                 | Play fighting           | Standing on hind limbs and assuming an upright posture with alternating chasing, poking, nibbling and pushing of the other individual (McDonnell and Haviland, 1995).                                                                                                                                                                                                                                                                     |
|                 | Mutual nibbling         | Gripping a piece of the other individual's body with lips and teeth, typically around the neck or limbs (McDonnell and Haviland, 1995; McDonnell and Poulin, 2002).                                                                                                                                                                                                                                                                       |
| Social negative | Biting                  | Aggressively extending the head and neck towards the other individual with ears pressed back, followed by opening the mouth and seizing the body with incisors, typically targeting the head, chest or limbs of the other individual (McDonnell and Haviland, 1995).                                                                                                                                                                      |
|                 | Kicking                 | Kicking with one or both hind limbs toward the other individual, where the front limbs remain in contact with the ground. The limbs are suddenly bent and lifted or the hind limbs are rapidly thrust backward with the body weight transferred onto the front limbs. Prior to the kick, there might be an energetic tucking of the tail, the neck may be lowered and the hind limb may strike the ground (McDonnell and Haviland, 1995). |
|                 | Squealing               | Issuing short, sharp, high-pitched sounds (Torcivia and McDonnell, 2021).                                                                                                                                                                                                                                                                                                                                                                 |
|                 | Chasing                 | Lowering the neck and head with ears laid back towards the opponent, lips might be tightened, accompanied by visual pressure. The horse may move toward the other individual without physical contact (McDonnell and Haviland, 1995).                                                                                                                                                                                                     |
| Comfort         | Rolling                 | It usually occurs in muddy or sandy terrain, often preceded by sniffing and digging the front limb into the ground. It involves transitioning from a standing position to lying on the sternum, followed by rotations from the sternum position to dorsal recumbency with flexed limbs. The head and neck assist in rolling. After standing up, there might be a body shake (McDonnell and Haviland, 1995).                               |
|                 | Scratching              | Nibbling, biting, rubbing one part of the body against another, licking with the tongue and nibbling with incisors, rubbing the muzzle on the forearm. During scratching with a hoof, the body is bent to one side, the hind limb on that side is extended forward and the hoof rubs against the lowered head or neck (Torcivia and McDonnell, 2021).                                                                                     |
|                 | Locomotor play (frolic) | Vigorous locomotor activity without a visible purpose, solitary or group running, often with exaggerated galloping, neighing, kicking, body twists, head shaking, and other energetic movements. Later, a return to calmer activities occurs (McDonnell and Poulin, 2002).                                                                                                                                                                |
|                 | Yawning                 | Head and ears in a relaxed position, the mouth opens and a deep inhale occurs. The eyes might be closed, the head lifts, often slightly rotating. The jaw may shift side to side, followed by a silent exhale. There is often a series of consecutive yawns (3–5) and after yawning, lip licking, tongue protrusion, and chewing may occur (Torcivia and McDonnell, 2021).                                                                |
|                 | Tire manipulation       | Biting, tapping an object with a limb, taking the object into the mouth, which may be held by the lips or teeth, with the head lifted while holding the object in the mouth (McDonnell and Poulin, 2002).                                                                                                                                                                                                                                 |

## Results

### Horse behavior influenced by gender

Geldings statistically exhibited significantly more positive social behavior such as nuzzling, halter manipulation, play fighting, mutual nibbling, and locomotor play (which falls under comfort behavior) than mares. Mares, on the other hand, showed statistically significantly more negative social behavior like kicking and squealing than geldings. There were no statistically significant differences in the occurrence of other social and comfort behavior (Table 3).

The average number of registered social behavior, both positive and negative, as well as comfort behavior, differed between mares and geldings. Figures 1–3 present the average number of each behavior accounting for gender throughout the study.

### Horse behavior influenced by age

Statistically significant correlations between age and social positive, negative and comfort behavior were not observed (Table 4).

Table 3. Influence of gender on the frequency of horse behavior

| Behavior        |                         | Gelding |        |       | Mare |        |      | p           |
|-----------------|-------------------------|---------|--------|-------|------|--------|------|-------------|
|                 |                         | mean    | median | SD    | mean | median | SD   |             |
| Social positive | Mutual grooming         | 28.9    | 24.0   | 21.3  | 25.9 | 31.0   | 23.6 | 0.76        |
|                 | Nuzzling                | 50.5    | 53.0   | 22.7  | 22.6 | 23.0   | 16.5 | <b>0.01</b> |
|                 | Halter manipulation     | 165.7   | 163.0  | 127.0 | 3.4  | 3.0    | 3.8  | <b>0.00</b> |
|                 | Play fighting           | 55.6    | 46.0   | 44.8  | 0.3  | 0.0    | 0.5  | <b>0.00</b> |
|                 | Mutual nibbling         | 28.4    | 22.0   | 19.8  | 5.7  | 4.0    | 5.8  | <b>0.01</b> |
| Social negative | Biting                  | 12.0    | 7.0    | 11.2  | 4.0  | 4.0    | 3.6  | 0.10        |
|                 | Kicking                 | 8.0     | 6.0    | 5.0   | 15.6 | 16.0   | 8.0  | <b>0.02</b> |
|                 | Squealing               | 1.5     | 1.0    | 1.7   | 53.4 | 36.0   | 59.6 | <b>0.00</b> |
|                 | Chasing                 | 64.3    | 42.0   | 71.6  | 25.1 | 26.0   | 25.5 | 0.24        |
| Comfort         | Rolling                 | 15.9    | 16.0   | 6.5   | 11.7 | 9.0    | 12.0 | 0.30        |
|                 | Scratching              | 35.2    | 28.0   | 20.7  | 20.7 | 11.0   | 16.7 | 0.06        |
|                 | Locomotor play (frolic) | 40.5    | 38.0   | 23.4  | 18.3 | 15.0   | 12.8 | <b>0.03</b> |
|                 | Yawning                 | 23.0    | 20.0   | 22.2  | 14.6 | 13.0   | 14.1 | 0.37        |
|                 | Tire manipulation       | 12.1    | 8.0    | 12.7  | 2.3  | 2.0    | 2.8  | 0.06        |

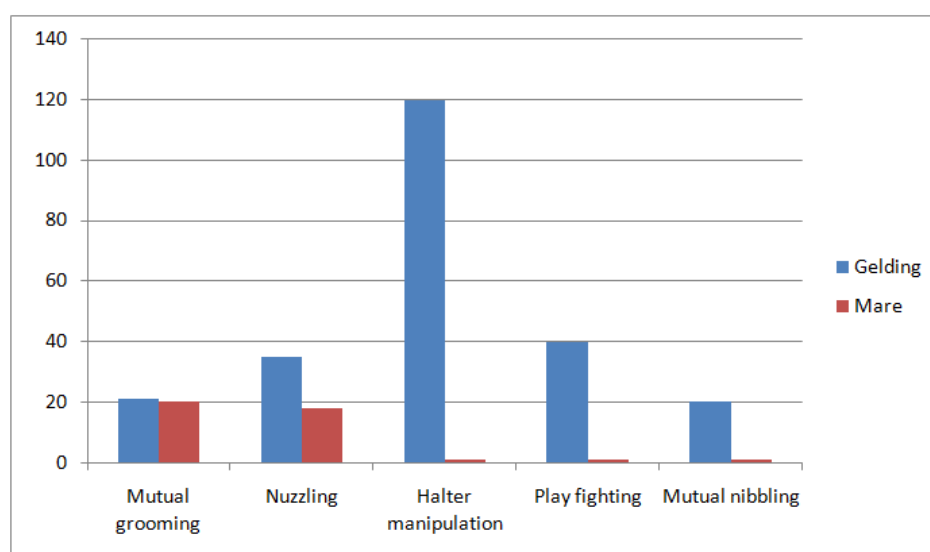


Figure 1. The average number of positive social behaviors in horses by gender

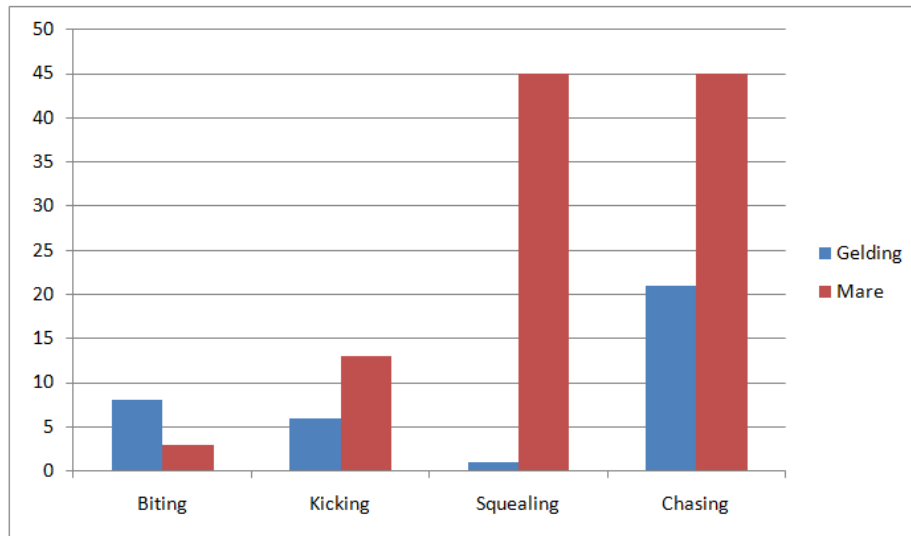


Figure 2. The average number of negative social behaviors in horses by gender

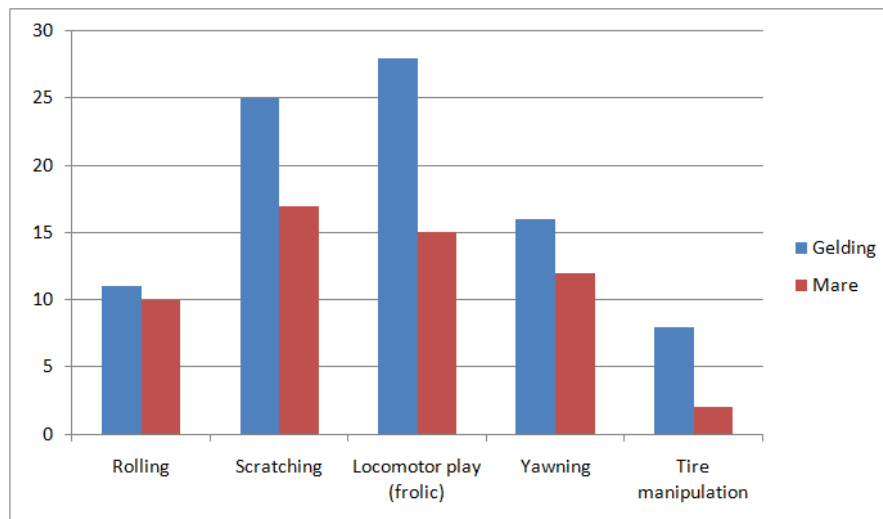


Figure 3. The average number of comfort behaviors in horses by gender

Table 4. Influence of age on the frequency of specific behavior

| Behavior        |                     | Age at the time of testing |
|-----------------|---------------------|----------------------------|
|                 |                     | R; p                       |
| Social positive | Mutual grooming     | -0.22; 0.33                |
|                 | Nuzzling            | -0.06; 0.78                |
|                 | Halter manipulation | -0.20; 0.36                |
|                 | Play fighting       | -0.02; 0.92                |
|                 | Mutual nibbling     | -0.05; 0.81                |
| Social negative | Biting              | 0.14; 0.52                 |
|                 | Kicking             | 0.09; 0.68                 |
|                 | Squealing           | -0.08; 0.72                |
|                 | Chasing             | 0.18; 0.41                 |
| Comfort         | Rolling             | 0.08; 0.72                 |
|                 | Scratching          | 0.10; 0.66                 |
|                 | Frolic              | -0.09; 0.70                |
|                 | Yawning             | 0.12; 0.58                 |
|                 | Tire manipulation   | -0.13; 0.55                |

Table 5. Influence of selected atmospheric factors on the frequency of specific horse behaviors by season – WINTER

| Anemometer                                                                                                                                                                                                                                                     | Social behavior |       |       |       |       |              |              |       |       |              | Comfort behavior |             |       |              |              |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|-------|-------|-------|-------|--------------|--------------|-------|-------|--------------|------------------|-------------|-------|--------------|--------------|
|                                                                                                                                                                                                                                                                | positive        |       |       |       |       | negative     |              |       |       |              | R                | Sc          | Lp    | Y            | Tm           |
|                                                                                                                                                                                                                                                                | Mg              | N     | Hm    | Pf    | Mn    | B            | K            | S     | Ch    |              |                  |             |       |              |              |
| Current wind speed (m/s)                                                                                                                                                                                                                                       | R               | -0.06 | -0.19 | 0.18  | 0.25  | -0.15        | -0.08        | -0.03 | -0.02 | 0.08         | <b>0.40</b>      | -0.11       | 0.19  | -0.24        | 0.03         |
|                                                                                                                                                                                                                                                                | p               | 0.71  | 0.26  | 0.29  | 0.14  | 0.38         | 0.64         | 0.85  | 0.91  | 0.66         | <b>0.02</b>      | 0.53        | 0.25  | 0.14         | 0.88         |
| Maximum wind speed (m/s)                                                                                                                                                                                                                                       | R               | -0.05 | -0.12 | 0.11  | 0.12  | -0.15        | -0.08        | -0.05 | 0.15  | 0.04         | 0.22             | -0.14       | 0.00  | <b>-0.33</b> | -0.10        |
|                                                                                                                                                                                                                                                                | p               | 0.79  | 0.46  | 0.52  | 0.47  | 0.39         | 0.65         | 0.76  | 0.36  | 0.81         | 0.19             | 0.41        | 0.99  | <b>0.05</b>  | 0.54         |
| Average wind speed (m/s)                                                                                                                                                                                                                                       | R               | -0.07 | -0.10 | 0.07  | 0.10  | -0.24        | -0.13        | -0.13 | 0.15  | -0.07        | <b>0.35</b>      | 0.04        | 0.14  | -0.27        | -0.04        |
|                                                                                                                                                                                                                                                                | p               | 0.70  | 0.55  | 0.70  | 0.54  | 0.16         | 0.46         | 0.45  | 0.39  | 0.68         | <b>0.03</b>      | 0.82        | 0.41  | 0.11         | 0.84         |
| Air temperature (°C)                                                                                                                                                                                                                                           | R               | -0.21 | -0.09 | 0.00  | -0.20 | <b>-0.34</b> | <b>-0.58</b> | -0.22 | -0.21 | <b>-0.39</b> | 0.25             | <b>0.49</b> | -0.17 | -0.22        | <b>-0.42</b> |
|                                                                                                                                                                                                                                                                | p               | 0.22  | 0.61  | 0.99  | 0.23  | <b>0.04</b>  | <b>0.00</b>  | 0.20  | 0.20  | <b>0.02</b>  | 0.14             | <b>0.00</b> | 0.32  | 0.18         | <b>0.01</b>  |
| Relative air humidity (%)                                                                                                                                                                                                                                      | R               | 0.06  | -0.05 | 0.03  | 0.23  | 0.06         | 0.01         | 0.30  | 0.12  | 0.00         | 0.11             | -0.23       | 0.06  | -0.13        | 0.13         |
|                                                                                                                                                                                                                                                                | p               | 0.74  | 0.79  | 0.88  | 0.18  | 0.71         | 0.97         | 0.07  | 0.46  | 0.98         | 0.51             | 0.18        | 0.72  | 0.44         | 0.44         |
| Heat index (°C)                                                                                                                                                                                                                                                | R               | -0.10 | -0.09 | 0.11  | -0.29 | -0.25        | <b>-0.43</b> | -0.21 | -0.25 | -0.27        | -0.04            | <b>0.51</b> | -0.30 | -0.04        | <b>-0.48</b> |
|                                                                                                                                                                                                                                                                | p               | 0.54  | 0.61  | 0.50  | 0.08  | 0.14         | <b>0.01</b>  | 0.21  | 0.14  | 0.10         | 0.83             | <b>0.00</b> | 0.07  | 0.81         | <b>0.00</b>  |
| Dew point temperature (°C)                                                                                                                                                                                                                                     | R               | -0.19 | -0.20 | -0.08 | -0.29 | -0.24        | <b>-0.49</b> | -0.05 | 0.00  | <b>-0.45</b> | 0.07             | 0.32        | -0.15 | -0.16        | <b>-0.42</b> |
|                                                                                                                                                                                                                                                                | p               | 0.26  | 0.24  | 0.64  | 0.08  | 0.15         | <b>0.00</b>  | 0.77  | 0.99  | <b>0.01</b>  | 0.70             | 0.05        | 0.37  | 0.34         | <b>0.01</b>  |
| Mg – Mutual grooming, N – Nuzzling, Hm – Halter manipulation, Pf – Play fighting, Mn – Mutual nibbling, B – Biting, K – Kicking, S – Squealing, Ch – Chasing, R – Rolling, Sc – Scratching, Lp – Locomotor play (frolic), Y – Yawning, Tm – Tire manipulation. |                 |       |       |       |       |              |              |       |       |              |                  |             |       |              |              |

Mg – Mutual grooming, N – Nuzzling, Hm – Halter manipulation, Pf – Play fighting, Mn – Mutual nibbling, B – Biting, K – Kicking, S – Squealing, Ch – Chasing, R – Rolling, Sc – Scratching, Lp – Locomotor play (frolic), Y – Yawning, Tm – Tire manipulation.

Table 6. Influence of selected atmospheric factors on the frequency of specific horse behaviors by season – SPRING

| Anemometer                                                                                                                                                                                                                                                     | Social behavior |       |             |             |             |             |       |             |       | Comfort behavior |       |             |             |             |       |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|-------|-------------|-------------|-------------|-------------|-------|-------------|-------|------------------|-------|-------------|-------------|-------------|-------|
|                                                                                                                                                                                                                                                                | positive        |       |             |             |             | negative    |       |             |       | R                | Sc    | Lp          | Y           | Tm          |       |
|                                                                                                                                                                                                                                                                | Mg              | N     | Hm          | Pf          | Mn          | B           | K     | S           | Ch    |                  |       |             |             |             |       |
| Current wind speed (m/s)                                                                                                                                                                                                                                       | R               | 0.37  | <b>0.72</b> | 0.12        | 0.35        | <b>0.53</b> | 0.24  | 0.00        | -0.20 | <b>0.44</b>      | 0.18  | 0.16        | 0.28        | -0.33       | 0.18  |
| Maximum wind speed (m/s)                                                                                                                                                                                                                                       | p               | 0.07  | <b>0.00</b> | 0.57        | 0.09        | <b>0.01</b> | 0.26  | 0.98        | 0.35  | <b>0.03</b>      | 0.41  | 0.44        | 0.18        | 0.12        | 0.40  |
|                                                                                                                                                                                                                                                                | R               | 0.18  | <b>0.47</b> | 0.07        | 0.27        | 0.21        | 0.23  | -0.23       | -0.30 | 0.23             | 0.29  | 0.09        | 0.23        | -0.48       | 0.04  |
| Average wind speed (m/s)                                                                                                                                                                                                                                       | p               | 0.40  | <b>0.02</b> | 0.75        | 0.20        | 0.33        | 0.28  | 0.27        | 0.16  | 0.28             | 0.17  | 0.69        | 0.27        | <b>0.02</b> | 0.87  |
|                                                                                                                                                                                                                                                                | R               | 0.19  | <b>0.53</b> | 0.28        | <b>0.44</b> | 0.29        | 0.21  | -0.07       | -0.20 | 0.26             | 0.26  | -0.09       | <b>0.43</b> | -0.61       | 0.13  |
| Air temperature (°C)                                                                                                                                                                                                                                           | p               | 0.36  | <b>0.01</b> | 0.19        | <b>0.03</b> | 0.17        | 0.32  | 0.76        | 0.35  | 0.22             | 0.22  | 0.66        | <b>0.04</b> | <b>0.00</b> | 0.56  |
|                                                                                                                                                                                                                                                                | R               | -0.06 | -0.13       | -0.60       | -0.65       | -0.25       | 0.08  | -0.35       | -0.10 | 0.13             | -0.40 | <b>0.54</b> | -0.61       | <b>0.66</b> | -0.18 |
| Relative air humidity (%)                                                                                                                                                                                                                                      | p               | 0.78  | 0.55        | <b>0.00</b> | <b>0.00</b> | 0.23        | 0.69  | 0.09        | 0.64  | 0.55             | 0.05  | <b>0.01</b> | <b>0.00</b> | <b>0.00</b> | 0.39  |
|                                                                                                                                                                                                                                                                | R               | -0.21 | -0.26       | 0.24        | 0.23        | -0.08       | -0.05 | <b>0.49</b> | 0.34  | -0.05            | 0.19  | -0.29       | 0.19        | -0.44       | 0.25  |
| Heat index (°C)                                                                                                                                                                                                                                                | p               | 0.33  | 0.22        | 0.25        | 0.28        | 0.71        | 0.80  | <b>0.02</b> | 0.10  | 0.83             | 0.38  | 0.17        | 0.38        | <b>0.03</b> | 0.23  |
|                                                                                                                                                                                                                                                                | R               | -0.09 | -0.13       | -0.58       | -0.59       | -0.21       | 0.07  | -0.32       | -0.05 | 0.06             | -0.31 | <b>0.49</b> | -0.57       | <b>0.65</b> | -0.21 |
| Dew point temperature (°C)                                                                                                                                                                                                                                     | p               | 0.67  | 0.54        | <b>0.00</b> | <b>0.00</b> | 0.32        | 0.73  | 0.13        | 0.81  | 0.79             | 0.14  | <b>0.02</b> | <b>0.00</b> | <b>0.00</b> | 0.31  |
|                                                                                                                                                                                                                                                                | R               | -0.23 | -0.21       | -0.46       | -0.56       | -0.24       | -0.07 | -0.32       | 0.13  | -0.13            | -0.23 | 0.40        | -0.49       | <b>0.61</b> | -0.08 |
|                                                                                                                                                                                                                                                                | p               | 0.27  | 0.32        | <b>0.02</b> | <b>0.00</b> | 0.26        | 0.73  | 0.13        | 0.55  | 0.55             | 0.27  | 0.06        | <b>0.02</b> | <b>0.00</b> | 0.70  |
| Mg – Mutual grooming, N – Nuzzling, Hm – Halter manipulation, Pf – Play fighting, Mn – Mutual nibbling, B – Biting, K – Kicking, S – Squealing, Ch – Chasing, R – Rolling, Sc – Scratching, Lp – Locomotor play (frolic), Y – Yawning, Tm – Tire manipulation. |                 |       |             |             |             |             |       |             |       |                  |       |             |             |             |       |

Mg – Mutual grooming, N – Nuzzling, Hm – Halter manipulation, Pf – Play fighting, Mn – Mutual nibbling, B – Biting, K – Kicking, S – Squealing, Ch – Chasing, R – Rolling, Sc – Scratching, Lp – Locomotor play (frolic), Y – Yawning, Tm – Tire manipulation.

Table 7. Influence of selected atmospheric factors on the frequency of specific horse behaviors by season – SUMMER

| Anemometer                                                                                                                                                                                                               | Social behavior |       |       |              |              |              |       |       |       | Comfort behavior |       |             |       |       |   |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|-------|-------|--------------|--------------|--------------|-------|-------|-------|------------------|-------|-------------|-------|-------|---|
|                                                                                                                                                                                                                          | positive        |       |       |              |              | negative     |       |       |       | R                | Sc    | Lp          | Y     | Tm    |   |
|                                                                                                                                                                                                                          | Mg              | N     | Hm    | Pf           | Mn           | B            | K     | S     | Ch    |                  |       |             |       |       |   |
| Current wind speed (m/s)                                                                                                                                                                                                 | R               | -0.06 | 0.06  | 0.19         | 0.35         | 0.23         | -0.35 | 0.25  | 0.20  | <b>0.57</b>      | 0.31  | -0.19       | 0.11  | 0.07  | * |
|                                                                                                                                                                                                                          | p               | 0.83  | 0.84  | 0.48         | 0.19         | 0.39         | 0.18  | 0.35  | 0.45  | <b>0.02</b>      | 0.24  | 0.47        | 0.69  | 0.79  | * |
| Maximum wind speed (m/s)                                                                                                                                                                                                 | R               | -0.03 | 0.02  | 0.14         | -0.01        | -0.04        | -0.37 | 0.20  | 0.11  | 0.23             | 0.21  | 0.11        | 0.36  | 0.05  | * |
|                                                                                                                                                                                                                          | p               | 0.90  | 0.94  | 0.60         | 0.96         | 0.88         | 0.16  | 0.45  | 0.69  | 0.40             | 0.43  | 0.68        | 0.17  | 0.86  | * |
| Average wind speed (m/s)                                                                                                                                                                                                 | R               | -0.03 | -0.09 | 0.18         | -0.2         | 0.08         | -0.18 | 0.35  | 0.24  | 0.35             | 0.19  | 0.00        | 0.32  | 0.12  | * |
|                                                                                                                                                                                                                          | p               | 0.92  | 0.74  | 0.50         | 0.94         | 0.76         | 0.49  | 0.18  | 0.37  | 0.19             | 0.49  | 0.99        | 0.22  | 0.66  | * |
| Air temperature (°C)                                                                                                                                                                                                     | R               | 0.28  | -0.33 | <b>-0.69</b> | <b>-0.51</b> | <b>-0.80</b> | 0.23  | -0.20 | -0.42 | -0.45            | -0.09 | <b>0.57</b> | -0.04 | -0.36 | * |
|                                                                                                                                                                                                                          | p               | 0.29  | 0.22  | <b>0.00</b>  | <b>0.04</b>  | <b>0.00</b>  | 0.39  | 0.46  | 0.10  | 0.08             | 0.74  | <b>0.02</b> | 0.90  | 0.18  | * |
| Relative air humidity (%)                                                                                                                                                                                                | R               | 0.07  | 0.07  | -0.20        | 0.22         | 0.14         | 0.01  | 0.14  | 0.17  | 0.39             | 0.11  | -0.29       | -0.33 | 0.08  | * |
|                                                                                                                                                                                                                          | p               | 0.78  | 0.79  | 0.46         | 0.41         | 0.62         | 0.98  | 0.62  | 0.53  | 0.14             | 0.69  | 0.27        | 0.21  | 0.77  | * |
| Heat index (°C)                                                                                                                                                                                                          | R               | 0.24  | -0.25 | <b>-0.70</b> | -0.48        | <b>-0.83</b> | 0.16  | -0.20 | -0.43 | <b>-0.58</b>     | -0.24 | <b>0.64</b> | -0.14 | -0.25 | * |
|                                                                                                                                                                                                                          | p               | 0.37  | 0.35  | <b>0.00</b>  | 0.06         | <b>0.00</b>  | 0.55  | 0.46  | 0.09  | <b>0.02</b>      | 0.37  | <b>0.01</b> | 0.59  | 0.36  | * |
| Dew point temperature (°C)                                                                                                                                                                                               | R               | 0.15  | -0.26 | <b>-0.68</b> | -0.34        | <b>-0.83</b> | -0.14 | -0.35 | -0.49 | -0.48            | -0.13 | <b>0.63</b> | -0.22 | -0.22 | * |
|                                                                                                                                                                                                                          | p               | 0.58  | 0.33  | <b>0.00</b>  | 0.20         | <b>0.00</b>  | 0.62  | 0.18  | 0.05  | 0.06             | 0.63  | <b>0.01</b> | 0.40  | 0.41  | * |
| Mg – Mutual grooming, N – Nuzzling, Hm – Halter manipulation, Pf – Play fighting, Mn – Mutual nibbling, B – Biting, K – Kicking, S – Squealing, Ch – Chasing, R – Rolling, Sc – Scratching, Lp – Locomotor play (frolic) |                 |       |       |              |              |              |       |       |       |                  |       |             |       |       |   |

Mg – Mutual grooming, N – Nuzzling, Hm – Halter manipulation, Pf – Play fighting, Mn – Mutual nibbling, B – Biting, K – Kicking, S – Squealing, Ch – Chasing, R – Rolling, Sc – Scratching, Lp – Locomotor play (frolic), Y – Yawning, Tm – Tire manipulation, \* – The behavior did not occur due to the lack of a tire in the pasture.

Table 8. Influence of selected atmospheric factors on the frequency of specific horse behaviors by season – AUTUMN

| Anemometer                 | Social behavior |       |       |       |       |          |       |       |       |       | Comfort behavior |       |       |       |       |
|----------------------------|-----------------|-------|-------|-------|-------|----------|-------|-------|-------|-------|------------------|-------|-------|-------|-------|
|                            | positive        |       |       |       |       | negative |       |       |       |       | R                | Sc    | Lp    | Y     | Tm    |
|                            | Mg              | N     | Hm    | Pf    | Mn    | B        | K     | S     | Ch    |       |                  |       |       |       |       |
| Current wind speed (m/s)   | R               | 0.26  | 0.03  | -0.20 | -0.30 | 0.02     | -0.44 | -0.32 | 0.03  | 0.08  | -0.17            | 0.17  | -0.15 | -0.44 | 0.05  |
|                            | p               | 0.39  | 0.93  | 0.52  | 0.32  | 0.95     | 0.13  | 0.28  | 0.93  | 0.79  | 0.58             | 0.59  | 0.63  | 0.14  | 0.86  |
| Maximum wind speed (m/s)   | R               | 0.16  | 0.07  | -0.19 | -0.21 | 0.12     | -0.33 | -0.41 | 0.07  | 0.18  | -0.30            | 0.19  | -0.18 | -0.27 | 0.20  |
|                            | p               | 0.60  | 0.83  | 0.53  | 0.49  | 0.69     | 0.28  | 0.17  | 0.83  | 0.56  | 0.32             | 0.54  | 0.56  | 0.38  | 0.52  |
| Average wind speed (m/s)   | R               | 0.16  | 0.04  | -0.16 | -0.20 | 0.15     | -0.30 | -0.36 | 0.10  | 0.12  | -0.24            | 0.20  | -0.12 | -0.28 | 0.12  |
|                            | p               | 0.59  | 0.89  | 0.61  | 0.52  | 0.63     | 0.33  | 0.22  | 0.75  | 0.70  | 0.43             | 0.52  | 0.69  | 0.35  | 0.71  |
| Air temperature (°C)       | R               | 0.12  | -0.28 | -0.79 | -0.63 | -0.04    | -0.26 | -0.21 | -0.05 | -0.12 | 0.11             | 0.08  | -0.20 | 0.18  | -0.62 |
|                            | p               | 0.70  | 0.35  | 0.00  | 0.02  | 0.89     | 0.39  | 0.49  | 0.87  | 0.69  | 0.72             | 0.81  | 0.51  | 0.55  | 0.02  |
| Relative air humidity (%)  | R               | -0.08 | 0.05  | -0.01 | 0.00  | 0.09     | -0.35 | -0.21 | 0.05  | 0.17  | -0.14            | -0.32 | -0.33 | -0.38 | 0.08  |
|                            | p               | 0.78  | 0.87  | 0.97  | 0.99  | 0.78     | 0.25  | 0.50  | 0.86  | 0.58  | 0.64             | 0.29  | 0.26  | 0.20  | 0.80  |
| Heat index (°°C)           | R               | 0.00  | -0.35 | -0.86 | -0.69 | -0.22    | -0.54 | -0.62 | -0.25 | -0.03 | -0.35            | 0.01  | -0.49 | 0.30  | -0.29 |
|                            | p               | 0.99  | 0.25  | 0.00  | 0.01  | 0.48     | 0.06  | 0.02  | 0.42  | 0.91  | 0.24             | 0.97  | 0.09  | 0.32  | 0.34  |
| Dew point temperature (°C) | R               | 0.06  | -0.37 | -0.87 | -0.71 | -0.12    | -0.56 | -0.46 | -0.10 | -0.07 | -0.23            | 0.02  | -0.51 | 0.11  | -0.46 |
|                            | p               | 0.84  | 0.21  | 0.00  | 0.01  | 0.69     | 0.04  | 0.11  | 0.75  | 0.81  | 0.44             | 0.95  | 0.08  | 0.71  | 0.11  |

Mg – Mutual grooming, N – Nuzzling, Hm – Halter manipulation, Pf – Play fighting, Mn – Mutual nibbling, B – Biting, K – Kicking, S – Squealing, Ch – Chasing, R – Rolling, Sc – Scratching, Lp – Locomotor play (frolic), Y – Yawning, Tm – Tire manipulation.

Mg – Mutual grooming, N – Nuzzling, Hm – Halter manipulation, Pf – Play fighting, Mn – Mutual nibbling, B – Biting, K – Kicking, S – Squealing, Ch – Chasing, R – Rolling, Sc – Scratching, Lp – Locomotor play (frolic), Y – Yawning, Tm – Tire manipulation.

### Horse behavior influenced by atmospheric conditions

Analyzing the relationships between weather conditions and horse behavior observed during the winter, statistically significant negative correlations were found between maximum wind speed and yawning, in temperature and nibbling, biting and tire manipulation, heat index and biting and tire manipulation, as well as between dew point temperature and biting, chasing and tire manipulation.

Statistically significant positive correlations were also observed between current wind speed and rolling, average wind speed and rolling, air temperature and scratching as well as between heat index and scratching.

No statistically significant correlations were found between the remaining weather factors and the remaining social positive, negative and comfort behaviors (Table 5).

When examining the relationships between weather conditions and horse behavior observed during the spring, statistically significant negative correlations were noted between maximum wind speed and yawning, average wind speed and yawning, air temperature and halter manipulation, play fighting and locomotor play, relative air humidity and yawning as well as between heat index and scratching. Statistically significant positive correlations were also observed between current wind speed and nuzzling, nibbling and chasing, maximum wind speed and nuzzling, average wind speed and nuzzling, play fighting and locomotor play, air temperature and scratching and yawning, relative air humidity and kicking, heat index and halter manipulation, play fighting and locomotor play as well as between dew point temperature and halter manipulation, play fighting and locomotor play.

No statistically significant correlations were found between the remaining weather factors and the remaining social positive, negative and comfort behaviors (Table 6).

During the analysis of the relationships between weather conditions and horse behavior observed in the summer, statistically significant negative correlations were observed between air temperature and halter manipulation, play fighting and nibbling, heat index and halter manipulation, nibbling and chasing as well as between dew point temperature and halter manipulation and nibbling. Statistically significant positive correlations were also observed between current wind speed and chasing, air temperature and scratching, heat index and scratching as well as between dew point temperature and scratching.

No statistically significant correlations were found between the remaining weather factors and the remaining social positive, negative and comfort behaviors (Table 7).

When examining the relationships between weather conditions and horse behavior observed during the autumn, statistically significant negative correlations were found between: air temperature and halter manipulation, play fighting and tire manipulation, heat index and halter manipulation, play fighting and kicking as well as between dew point temperature and halter manipula-

tion, play fighting and biting. No statistically significant correlations were found between the remaining weather factors and the remaining social positive, negative and comfort behaviors (Table 8).

### Discussion

In the available literature, the number of studies on the influence of various factors on horse behavior is significantly increasing. This research is important for horse owners, trainers, veterinarians and anyone interested in equine behavior.

In the current study, it was observed that age did not impact the occurrence of social and comfort behavior, suggesting a need for further investigation in this area. While age does affect the physiological response to weather conditions and the reproductive activity of mares (Klocek and Olczak, 2013), it did not seem to influence the behavioral aspects we studied.

Social bonds were analyzed among mares released on pasture in various configurations. The duration of specific behavior and heart rate variability were examined, revealing that expressions of friendship and camaraderie were most pronounced in a herd with an established hierarchy. Individual release in the paddock is not recommended as it disrupts social behavior, leading to increased emotional excitability (Janczarek et al., 2019). In the current study, it was observed that geldings exhibited significantly more positive social behavior, such as nuzzling, halter manipulation, play fighting and nibbling, than mares. The only exception was mutual grooming, where no significant differences were noted. Mares displayed significantly more negative behavior, such as kicking and squealing, than geldings. However, this group also exhibited negative social behavior like biting and chasing. These differences may be related to hormonal variations and the roles they play in the herd.

The aim of biometeorological research is to examine how the body responds to changing environmental factors and to find ways to mitigate their negative impacts. Various studies (Bernátková et al., 2022; Górecka-Bruzda et al., 2020; Janczarek et al., 2015; Jodkowska et al., 2015; Klocek and Olczak, 2013; Snoeks et al., 2015; Topczewska, 2014; Zharkikh and Andersen, 2009) indicate a clear relationship between weather conditions and horse behavior. In the current study, the impact of atmospheric conditions on horse behavior was examined. It was found that the occurrence of social and comfort behavior was most influenced by increasing wind speed and temperature parameters such as air temperature, dew point temperature and heat index. Dew point temperature is particularly significant concerning atmospheric conditions. A higher dew point temperature may indicate more uncomfortable and muggy conditions due to higher moisture content in the air. The heat index is used to determine how intensely an organism feels heat or cold based on air temperature and humidity. The heat index is especially

important in periods when air temperature and humidity are high. Under such conditions, an individual might have difficulty regulating body temperature through thermoregulatory processes.

Atmospheric factors could disrupt the normal behavior of recreational horses. Changes in behavior were noted when air temperatures exceeded 26°C and wind speeds exceeded 5.5 m/s, conditions that decrease mood and willingness to work in horses (Janczarek et al., 2015). Additionally, weather conditions significantly influenced the internal and surface body temperatures of horses on paddocks during summer (Janczarek et al., 2020). Air temperature affects various forms of horse behavior, including rest, locomotor activity, seeking shelter and the occurrence of stereotypical behavior (Klocek and Olczak, 2013). High temperatures can lead to discomfort and increased aggression, while low temperatures combined with rain or strong winds can increase physical activity, restlessness, impatience and frustration. Horses tend to adopt an alert position more frequently on cooler, windy days. Very high temperatures result in drowsiness and decreased activity, similar to the effects of heavy cloud cover and increased humidity (Janczarek et al., 2015; Klocek and Olczak, 2013).

A study of Hucul horses showed that seasons impact their behavior and condition (Topczewska, 2014). Observations indicated that grazing and resting occupied the most significant amount of time. Weather conditions notably affected the duration of specific activities, with significant correlations found between horse behavior, air temperature and relative humidity (Geringer de Oedenberg et al., 2010). Research on Polish Konik horses in natural conditions analyzed mobility across different habitats and seasons, showing that season, habitat, time of day and their interactions significantly influence movement patterns (Pikuła et al., 2022). Similarly, Polish Primitive Ponies kept in a reserve system showed that air temperature significantly affected the frequency and extent of daily migration, with higher temperatures leading to more frequent but shorter stays in particular areas (Jodkowska et al., 2015).

Studies on Przewalski horses raised in conditions resembling their natural habitat revealed that feeding behavior constituted a significant portion of their overall activity, with notable seasonal variations. Activity levels were lowest during winter (Berger et al., 1999), with grazing increasing on cloudy and windy days and being more frequent in autumn. Social interactions were more common at higher temperatures, with increased occurrences in summer (Bernátková et al., 2022). It was found that male Przewalski horses exhibited few agonistic behaviors. Most commonly observed were friendly interactions (Zharkikh and Andersen, 2009). Research on Hucul horses during all-day grazing in mountainous terrain indicated that they spent the most time grazing, standing and walking, with minimal time on other activities. Factors such as season, weather conditions and insect annoyance influenced daily food intake (Jodkowska et

al., 2013). Comparative studies on horses seeking shelter showed varying results, with some indicating shelter use primarily during rainy and windy days, while others found shelter sought mostly on hot, sunny days. Increased insect activity may explain these discrepancies, as horses seek shelter from insects more than from the weather (Snoeks et al., 2015).

When horses are on the pasture, there is a noticeable decrease in interactions between individuals due to the continuous need for food intake. This indicates that not only individual factors such as age, gender, and weather but the sum of these factors, as well as other factors such as the environment, the need for food intake, genetics, and instincts, all influence horse behavior.

### Conclusions

The conducted research found that gender of the horses influenced the occurrence of social behavior. Geldings exhibited statistically more positive social behavior, such as nuzzling, halter manipulation, play fighting, and nibbling than mares. Mares displayed statistically more negative social behavior, like kicking and squealing, than geldings. Among geldings, negative social behavior, i.e., like biting and chasing, was more frequent than among mares.

The age of the horses did not significantly affect the number of social and comfort behaviors, although differences in the number of particular behaviors were visible in various age groups.

Weather conditions had an impact on horse behavior. During the winter, strong wind, low air temperature, heat index and dew point temperature primarily influenced the more frequent occurrence of comfort behavior. In spring, strong wind, high air humidity and dew point temperature affected positive social and comfort behavior. During the summer, heat index and dew point temperature played a significant role in the occurrence of primarily comfort behavior but also positive and negative social behavior. In warm seasons, increased insect activity was observed, contributing to the occurrence of more comfort behavior in horses. Being on pasture during this time led to a significant decrease in social interactions. In autumn, decreasing air temperature, heat index and dew point temperature influenced the more intense appearance of positive social behavior.

### Conflicts of interest

The authors declare no conflict of interest.

### Ethics approval

This study used non-invasive means in the form of video recordings of horse behavior. Animal care was in accordance with the Directive 2010/63/EU of the European Parliament.

### Funding

This article was financed by the Minister of Science, Poland, under “The Regional Initiative of Excellence Program”.

## References

- Anderson V., Leung A., Mehdipoor H., Janicke B., Milosevic D., Oliveira A., Manavvi S., Kabano P., Dzyuban Y., Aguilar R., Agan P.N., Kunda J.J., Garcia-Chapeton G., Carvalho Fonsêca V.F., Tavares Nascimento S., Zurita-Milla R. (2021). Technological opportunities for sensing of the health effects of weather and climate change: A state-of-the-art-review. *Int. J. Biometeorol.*, 65: 779–803.
- Berger A., Scheibe K., Eichhorn K., Scheibe A., Streich J. (1999). Diurnal and ultradian rhythms of behavior in a mare group of Przewalski horses measured throughout one year under semi-reserve conditions. *Appl. Anim. Behav. Sci.*, 64: 1–17.
- Bernátková A., Oyunsaikhan G., Šimek J., Komárková M., Bobek M., Ceacero F. (2022). Influence of weather on the behaviour of reintroduced Przewalski's horses in the Great Gobi B Strictly Protected Area (Mongolia): implications for conservation. *BMC Zool.*, 7: 1–17.
- Dierendonck M., Sigurjónsdóttir H., Colenbrander B., Thorhallsdóttir A. (2004). Differences in social behavior between late pregnant, post-partum, and barren mares in a herd of Icelandic horses. *Appl. Anim. Behav. Sci.*, 89: 283–297.
- Dyson S., Van Dijk J. (2020). Application of a ridden horse ethogram to video recordings of 21 horses before and after diagnostic analgesia: Reduction in behaviour scores. *Equine Vet. Educ.*, 32: 104–111.
- Dyson S., Martin C., Bondi A., Ellis A. (2022). The influence of rider skill on ridden horse behaviour, assessed using the Ridden Horse Pain Ethogram, and gait quality. *Equine Vet. Educ.*, 34: 308–317.
- Fenner K., Dashper K., Serpell J., McLean A., Wilkins C., Klinck M., Wilson B., McGreevy P. (2020). The development of a novel questionnaire approach to the investigation of horse training, management and behaviour. *Animals*, 10: 1–11.
- Garcia H., Lindegaard C., Dyson S. (2023). Application of a Ridden Horse Pain Ethogram in Icelandic horses: A pilot study. *Equine Vet. Educ.*, 35: 478–488.
- Geringer de Oedenberg H., Kamińska K., Bogucka L. (2010). Observations of behaviour of Hucul horses held in herds and weather influence on their activities (in Polish). *Sci. J. Univ. Environ. Life Sci. Wrocław*, 577: 155–162.
- Goodwin D. (1999). The importance of ethology in understanding the behaviour of the horse. *Equine Vet. J. Suppl.*, 28: 15–19.
- Górecka-Bruzda A., Jaworski Z., Jaworska J., Siemieniuch M. (2020). Welfare of free-roaming horses: 70 years of experience with Konik Polski breeding in Poland. *Animals*, 1094: 1–15.
- Hausberger M., Roche H., Henry S., Visser K. (2008). A review of the human–horse relationship. *Appl. Anim. Behav. Sci.*, 109: 1–24.
- Hemsworth L., Jongman E., Coleman G. (2015). Recreational horse welfare: The relationships between recreational horse owner attributes and recreational horse welfare. *Appl. Anim. Behav. Sci.*, 165: 1–16.
- Hoffmann G., Bentke A., Rose-Meierhöfer S., Berg W., Mazetti P., Hardarson G. (2012). Influence of an active stable system on the behavior and body condition of Icelandic horses. *Animals*, 6: 1684–1693.
- Janczarek I., Wilk I., Zalewska E., Bocian K. (2015). Correlations between the behavior of recreational horses, physiological parameters and summer atmospheric conditions. *Anim. Sci. J.*, 7: 721–728.
- Janczarek I., Wiśniewska M., Wilk I., Liss M., Wnuk-Pawlak E., Dybczyńska M. (2019). Assessment of affiliative behaviour in mares. *Sci. Ann. Pol. Soc. Anim. Prod.*, 2: 49–58.
- Janczarek I., Wnuk-Pawlak E., Wiśniewska A., Dziuban D., Frątczak M., Raś B. (2020). Body temperature of horses spending time in paddocks in various weather conditions during the summer. *Sci. Ann. Pol. Soc. Anim. Prod.*, 16: 53–66.
- Jeziński T., Jaworski Z., Górecka A. (1999). Effects of handling on behaviour and heart rate in Konik horses: comparison of stable and forest reared youngstock. *Appl. Anim. Behav. Sci.*, 62: 1–11.
- Jodkowska E., Jantoń A., Dobrowolski M. (2013). Hucul horses herd behavior on pasture. *Sci. J. Univ. Environ. Life Sci. Wrocław*, 600: 29–36.
- Jodkowska E., Kuźniak A., Piśula R., Smugała M. (2015). Analysis of Polish primitive ponies migration under registration of the global positioning system. *J. Vet. Sci.*, 2: 1–5.
- Kłoczek C., Olczak K. (2013). The influence of selected weather phenomena on horse behavior (in Polish). *Med. Weter.*, 69: 602–605.
- Kokocińska A., Kaleta T. (2016). The role of ethology in animal welfare. *Sci. Ann. Pol. Soc. Anim. Prod.*, 1: 49–62.
- Krueger K., Esch L., Farmer K., Marr I. (2021). Basic needs in horses? – A literature review. *Animals*, 1798: 1–16.
- Ladewig J., McLean A., Wilkins C., Fenner K., Christensen J., McGreevy P. (2022). A review of The Ridden Horse pain Ethogram and its potential to improve ridden horse welfare. *J. Vet. Behav.*, 54: 54–61.
- Luz M., Maia C., Filho J. (2022). Equine rolling behavior: thermoregulation mechanism after exercise and substrate preference. *J. Appl. Anim. Welf. Sci.*, 1–10.
- McDonnell S. (2003). Practical field guide to horse behavior: the equid ethogram. Eclipse Press, Lexington.
- McDonnell S., Haviland J. (1995). Agonistic ethogram of the equid bachelor band. *Appl. Anim. Behav. Sci.*, 43: 147–188.
- McDonnell S., Poulin A. (2002). Equid play ethogram. *Appl. Anim. Behav. Sci.*, 78: 263–290.
- McGreevy P., Oddie C., Burton F., McLean A. (2009). The horse–human dyad: Can we align horse training and handling activities with the equid social ethogram? *Vet. J.*, 181: 12–18.
- Mills D. (1998). Personality and individual differences in the horse, their significance, use and measurement. *Equine Vet. J. Suppl.*, 27: 10–13.
- Mullard J., Berger J., Ellis A., Dyson S. (2017). Development of an ethogram to describe facial expressions in ridden horses (FEReq). *J. Vet. Behav.*, 18: 7–12.
- Piśula R., Zaborski D., Grzesiak W., Smugała M. (2022). An analysis of the annual mobility of Polish Konik horses depending on habitat, season, and time of the day. *Arch. Anim. Breed.*, 65: 239–247.
- Seaman S., Davidson H., Waran N. (2002). How reliable is temperament assessment in the domestic horse (*Equus caballus*)? *Appl. Anim. Behav. Sci.*, 78: 175–191.
- Snoeks M., Moons C., Ödberg F., Aviron M., Geers R. (2015). Behavior of horses on pasture in relation to weather and shelter – A field study in a temperate climate. *J. Vet. Behav.*, 10: 561–568.
- Thorne J., Goodwin D., Kennedy M., Davidson H., Harris P. (2005). Foraging enrichment for individually housed horses: Practicality and effects on behaviour. *Appl. Anim. Behav. Sci.*, 94: 149–164.
- Topczewska J. (2014). An attempt to assess the welfare of horses maintained in herd systems. *Archiv Tierzucht.*, 24: 1–9.
- Torcivia C., McDonnell S. (2021). Equine discomfort ethogram. *Animals*, 580: 1–21.
- Visser K., Van Wijk-Jansen E. (2012). Diversity in horse enthusiasts with respect to horse welfare: An explorative study. *J. Vet. Behav.*, 7: 295–304.
- Zharkikh T., Andersen L. (2009). Behaviour of bachelor males of the Przewalski horse (*Equus ferus przewalskii*) at the reserve Askaniya Nova. *Zool. Garten N.F.*, 78: 282–299.

Received: 22 I 2024

Accepted: 9 X 2024