Journal of Veterinary Behavior 29 (2019) 118–127

Contents lists available at ScienceDirect

Journal of Veterinary Behavior

journal homepage: www.journalvetbehavior.com

Equine Research

Reliability of a descriptive reference ethogram for equitation science

Marc Pierard [a,*], Paul McGreevy [b], Rony Geers [a]

[a] Department of Biosystems, KU Leuven, Leuven, Belgium
[b] Faculty of Veterinary Science, University of Sydney, New South Wales, Australia

ARTICLE INFO

Article history:
Received 10 March 2018
Received in revised form
3 September 2018
Accepted 3 October 2018
Available online 11 October 2018

Keywords:
ethogram
equine
structural behavioral definitions

ABSTRACT

An ethogram and its components, correctly defined behavior units, are the fundamental measuring tools for (applied) ethology and, therefore, also for equitation science, the nascent discipline that gathers evidence based on horse training, handling, and riding. However, there is currently no consensus on names and definitions of equine behaviors, and no purely descriptive ethogram for horses is available. As structural descriptions of behavioral units are a starting point for experimental enquiries into their function, cause, or ontogeny, this project sets out to draft and test the reliability of a descriptive reference ethogram for domestic horses (*Equus caballus*). Classification, names, and definitions of behaviors were descriptive and assigned to categories according to structural similarities. An international panel of participants (n = 23) was established to represent both researchers in equitation science and practitioners, including trainers, riders, coaches, and veterinarians. A part of the ethogram was tested by asking the panel to score 30 short video clips for 20 different behaviors and requesting feedback on the ethogram. Statistical analyses with logistic mixed models showed that variability between observers (<0.0001) was considerably lower than between video clips (0.15), indicating a high reliability of behavioral scoring. This reliability remained even when only considering the three most commented on behaviors (turn, jump, and buck) (clip 2.72, panelist 0.01). There was no significant difference between researchers and practitioners, but the variability of scores for simple video clips (one or two behaviors) differed significantly from more complex ones ($P < 0.0001$). This preliminary descriptive ethogram for horses in domestic contexts merits further development and will require the addition of more behaviors and therefore more fine-tuned definitions.

Introduction

Applied ethology of horses is a fundamental element of equitation science which, among other goals, aims to measure and interpret the behavior of horses during interactions with humans (McGreevy, 2007). Discrete behavioral events and states are the measuring units of ethology (Drummond, 1981). Defining behavioral units in a manner that allows different observers to reliably identify them is crucial for the development of equitation science and for communication among researchers, practitioners, and anyone concerned with equitation and horse welfare. Even though behavioral definitions cannot and should not be as rigid as those of the SI measuring units in physics and chemistry, equitation science would benefit from enhanced transparency of and rigor in behavioral definitions and some form of reference ethogram that can provide the starting point for every observational research project or practical application.

Behavior is studied extensively in all life sciences, including equitation science, even though there may be no absolute consensus on what exactly behavior entails (Lazzeri, 2014; Levitis et al., 2009). To keep behavioral data manageable and relevant, it is necessary to define units of measurement, which represent an arbitrary selection of available information (Hinde, 1966; Hogan, 2015; Purton, 1978). An ethogram contains an inventory of well-defined behavior units and includes either a complete repertoire of a taxonomic unit or the set of behaviors used in a particular study (Lehner, 1998; Martin and Bateson, 2007).

Attempts have been made to devise standardized methods to describe behavior (e.g., Schleidt and Crawley, 1980; Schleidt et al., 1984), but, so far, none has been widely applied. Behavioral units can be defined to reflect their structural, functional, and causal

* Address for reprint requests and correspondence: Marc Pierard, PhD, Department of Biosystems, KU Leuven, Kasteelpark Arenberg 30, Leuven B-3001, Belgium.
E-mail address: marcalpierard@yahoo.com (M. Pierard).

https://doi.org/10.1016/j.jveb.2018.10.001
1558-7878/

attributes, depending on the focus of the particular research project. The basic definition of a behavioral unit is structural and focuses on spatiotemporal patterns of muscular actions, resulting in descriptions of postures, movements, and vocalizations (Hinde, 1966; Martin and Bateson, 2007). In contrast to a structural definition, a functional definition acknowledges the consequences of behaviors and their effects on the animal or its environment, including other animals (Hinde, 1966; Martin and Bateson, 2007). Causal definitions are based on physiological or environmental triggers for behaviors (Hinde, 1966). Some ethograms contain elements of different definition types, either in the ethographic definitions themselves or in the classification of behaviors. Such a mix should be implemented carefully and explained clearly to avoid potential issues, such as the same structurally defined movements representing more than one function simultaneously or different functions under varying contexts (Purton, 1978).

The importance of ethograms for equitation science has been recognized (Hall and Heleski, 2017; Pierard et al., 2015). Several valuable sources containing definitions of horse behavior are available (e.g., Glatthaar, 2012; McDonnell, 2003; McGreevy, 2012; Waring, 2003) and many scientific articles contain custom-made ethograms of specific behaviors (Pierard et al., 2015 contains a nonexhaustive list of 30 of the most extensive study ethograms), but ethographic definitions within these inventories are highly variable and not always compatible with each other. Existing ethograms represent different types of definitions or classifications, often mixed within a single ethogram. They range from structural, only describing what the horse does, to more functional or causal, focusing on effects or triggers of the behaviors. However, it is crucial to know the range and structure of behaviors an animal executes before the function, cause, or ontogeny of those behaviors can be thoroughly examined (Lorenz, 1960; Lorenz, 1973; Purton, 1978; Tinbergen, 1963).

The aim of the present study was primarily to develop a first draft of a reference ethogram for domestic horses, using only structural descriptions and classifications. To this end, a number of existing equine ethograms, used by equitation scientists, were compared. Behavioral units were defined and grouped according to their structural similarities. The ethogram was intended to encompass all aspects of horses' activities.

The most extensive sources on equine behavior were consulted in preparation of the first version of the reference ethogram. None were found to be purely descriptive or to use only structural definitions and classifications. Two of them are equine ethograms. The ethogram by McDonnell (2003) is the most extensive and is intended for both researchers and practitioners. The definitions contain general structural elements but often also functional aspects, while the classification also contains functional distinctions. The book by Glatthaar (2012) contains an ethogram in three languages. The definitions are mostly structural, but each behavior is also defined by the context in which it occurs and this is mostly referring to function or cause. Two textbooks on equine behavior are often cited and also provide extensive information on structure, function, cause, and ontogeny of individual behaviors. The book by Waring (2003) contains a table with 143 elements of the equine ethogram. Details are provided in functionally organized chapters. It includes several figures with drawings showing sequential stages of behavioral responses as indications of function or emotional state. Behaviors are described by a combination of structural, causal, and functional elements. McGreevy (2012) provides detailed information of many behaviors, dispersed over the different chapters. Behavioral definitions contain structural, causal, and functional aspects. A third textbook, on equine locomotion, by Back and Clayton (2013) contains extensive information on biomechanics. Its fifth chapter, on gaits and interlimb coordination, provides detailed information and figures on structural aspects of gaits.

A test panel was established to determine the reliability of the draft ethogram via a survey and members of the test panel also provided feedback. The study ethogram for the current reliability study was limited in scope for practical and methodological reasons. The draft reference ethogram is a first step in the development of the anticipated full species ethogram, which will inevitably be longer. The reliability study and the feedback from the panelists were used to improve the draft reference ethogram. The study ethogram focused mostly on locomotion, which, unsurprisingly, forms an important part of the anticipated complete ethogram and represents a fundamental domain when evaluating horses in equitation science.

Materials and methods

Survey ethogram

A first draft of the reference ethogram was compiled. It comprised 65 behavior categories. The first draft reflected existing definitions and classifications. Many study ethograms in peer-reviewed articles were consulted (see Pierard et al., 2015 for a list of the most important ones). The most influential sources were existing ethograms (Glatthaar, 2012; McDonnell, 2003), general textbooks on equine behavior (McGreevy, 2012; Waring, 2003), and a textbook on equine locomotion (Back and Clayton, 2013). To keep it manageable for the test panelists (n = 23; details in the following), both in terms of time and complexity, 21 behaviors were selected for the survey, focusing on locomotion. Table 1 contains the ethogram used in the survey.

Survey protocol and participants

The survey was based on 35 video clips of horses running loose in an arena, being worked in-hand, or being ridden. Clips were selected to represent different elements of the study ethogram, either alone or in combination. To avoid confusion, clips showed only 1 horse, except for 4 clips that showed 2 horses performing the same behaviors. Inclusion criteria for video clips were that the whole horse had to be visible the whole time and lighting and contrast had to be good enough to make observations easy. The panelists received a document explaining how to score the videos, including explanations of potential scores for the first five video clips (walk, rear/turn, walk/turn, canter/buck/kick, lie down/roll/get up). They were asked to score the remaining 30 video clips, naming any behaviors from the provided ethogram that they observed in the clip. Video clips ranged from very simple behaviors to more complex combinations of fast movements, lasting from 1 to 9s. An Excel-file was provided as a standard score sheet. Video clips and documents were uploaded to Dropbox and participants received a link to access the material. Panelists used their own computers and software to view the video clips. They could view the clips repeatedly in real time or slow motion, depending on available software.

Participants (n = 23), representing both researchers and practitioners, were personally invited by email. This closed format, allowing only invited experts to participate, was chosen to control the quality of the participants' responses, their independence, and their diversity. All participants were highly experienced. They were classified as researchers if they were involved in original research and had at least 5 peer-reviewed publications on any aspect of equitation science. Practitioners included international judges, trainers, and riders, but also veterinarians and staff members of horse welfare organizations. To avoid linguistic issues, native

Table 1
Ethogram of 21 behavioral units provided to the survey panel of 23 experts to score behaviors present in 30 video clips

I. Whole body

A. Locomotion

Locomotion literally means moving from a certain place. In this document, the term locomotion is used in the broadest sense, indicating the body as a whole moved from its initial position in any direction. Standing is an exception, but is included in this section as it represents an action of the whole body and it forms a continuum with the other movements.

1. Stand

The horse is standing on 3 or 4 limbs without moving in any direction. The head and neck can move without movement of the limbs. Depending on the necessities of the study, this can include the horse slightly repositioning one or more limbs, while remaining at or very close to the original position.

2. Walk

The horse moves its 4 feet individually with each stride showing a 4-beat tact. The feet move in a sequence: left front, right hind, right front, left hind. This is a diagonal walk, but some horses show a lateral walk (left front, left hind, right front, right hind). In a slow walk, horses will have 2 or 3 limbs in stance phase (weight-bearing). Some horses can show variations on the walk, but it is always a 4-beat gait. Some faster variations can show only 1 foot in stance phase at some stages of the stride.

3. Trot

The horse moves in a 2-beat gait with pairs of limbs (1 front and 1 hindlimb) moving simultaneously, with a short suspension phase between stance phases of both pairs of limbs. The most common form of trot is characterized by diagonal pairs of limbs moving together, while a lateral variation also exists. The synchrony between paired limbs is not always perfect. The forward movement of the horse can vary, up to not going forward at all (piaffe) and, in extreme cases, even going slightly backward.

4. Canter

The horse moves in an asymmetrical 3-beat gait. Horses are called being on the left or right lead, according to the leading front and hindlimb. The canter on the right lead shows the following sequence: left hind, diagonal pair of right hind and left front, right front, followed by a suspension phase. The diagonal pair is not always perfectly synchronized. A lead change is the transition from right lead to left, or vice versa. This can start with a change of the front limbs, followed by the hindlimbs in the next stride, or it can be executed during the suspension phase (in which case it starts with the hindlimbs). The forward movement of the horse can vary, up to not going forward at all and, in extreme cases, even going slightly backward.

5. Gallop

The gallop is a faster version of the canter, with the diagonal pair clearly dissociated. The leading hind leg can differ, which accounts for the difference between a rotary (leading hindlimb ipsilateral to leading front limb) and a transverse (leading hindlimb contralateral to leading front limb) gallop. A rotary gallop with right lead has the following sequence of footfalls: right hind, left hind, left front, right front. A transverse gallop on the right lead has this sequence of footfalls: left hind, right hind, left front, right front. The rotary gallop is not typical for horses, but is sometimes temporarily seen. A lead change is the transition from right lead to left, or vice versa. This can start with a change of the front limbs or it can be executed during the suspension phase (in which case it starts with the hindlimbs). Typically the gallop only has one suspension phase after the leading front limb begins its swing phase. Exceptionally the gallop may contain 2 suspension phases, with a brief second one added between the last hindlimb taking off and the first front limb landing.

6. Back-up

The horse moves backward. This can be a 4-beat gait, with each foot moving separately, or a 2-beat movement, with diagonal pairs moving simultaneously, without a suspension phase.

7. Jump

The horse pushes off the ground and forward with both hindlimbs, followed by a suspension phase and landing. The landing can vary: it can be on one or both front limbs, on front limbs and one or two hindlimbs or on one or two hindlimbs. Both pairs of limbs can be more or less coordinated in space and time. Sometimes a horse can take off with all 4 limbs simultaneously ('crow hopping') and land with a variation of limb sequence.

(*continued on next column*)

Table 1 (*continued*)

8. Buck

The horse pushes both hindlimbs off the ground at the same time, resulting in the pelvis being higher than the withers. This can be done while standing or while moving.

9. Rear

The horse raises both front limbs off the ground, without forward movement. It can sometimes be combined with movement of the hindlimbs, while the front limbs are still up in the air.

10. Lie down

This behavior is about a controlled transition from an upright position to a recumbent position. Falling is much less standardized as it depends on numerous variables, many of which are out of the horse's control. When lying down, a horse will first slightly flex all 4 limbs. Then it will flex its front limbs until one shoulder touches the ground. It will continue by further flexing its hindlimbs, gradually increasing the contact zone with the ground until it lies down. All legs are on one side of the body. There are 2 ways a horse can remain lying down:

a. Sternal recumbency

The horse is lying on the lateral side of the front and hindlimb closest to the ground and the ventrolateral part of the torso. The legs are more or less flexed and the head can be held upright or resting on the ground or its front legs.

b. Lateral recumbency

The horse is lying on one lateral side of its entire body, usually including head and neck. The head can briefly be held up by lateral flexion of the neck. Limbs can be held in different positions.

11. Get up

A horse in lateral recumbency will first "roll" (rotate around its longitudinal axis) until it reaches sternal recumbency. This can include an abduction of the limbs furthest of the ground, followed by an adduction combined with a "roll" of the entire body. From a sternal recumbent position, the front limbs are extended cranially, lifting the sternum off the ground by retracting them. Subsequently the hind legs push the pelvis off the ground until the body reaches a standing position.

12. Roll

Starting from a position of lateral recumbency, the horse rotates along its longitudinal axis. The horse can also show rotation, dorsoventral flexion/extension and lateral flexion of the spine. The rotation around the longitudinal axis can be minimal, up to a maximum of about 180°.

13. Turn

The horse shows "yaw" (rotation around vertical axis) or the horse does not move along its longitudinal axis.

a. Front

In its simplest form, the front limbs move sideways by abduction and adduction. This mostly includes some degree of lateral flexion of the spine. Once the horse takes multiple steps, the hindlimbs are adjusted.

b. Back

The hindlimbs are moved sideways by adduction and abduction. This mostly includes some degree of lateral flexion of the spine. If the horse takes multiple steps with the hindlimbs, the front limbs are adjusted.

c. Both

The horse can also move both its front and hind limbs sideways in the same movement. This can be carried out to opposing sides or to the same side.

14. Hop

When the horse does not put any weight on one limb or has 2 limbs tied together, it will have to change the normal 4-beat walk into a 3-beat walk. For example, if one front leg is not used, the horse will move both the hindlimbs and then push the front end by pushing off with the weight bearing front limb and landing cranially.

15. Sit

A horse can put the weight on the posterior sides of its hindlimbs, while the front limbs are in standing position. This is an intermediate position while getting up, but it can be maintained for longer. It can also be a taught behavior.

16. Shake

The horse rolls (rotates around longitudinal axis) parts of its body repeatedly. It can be only head and neck. If it shakes all the way down its spine, the rotation moves like a wave along the length of the spine.

(*continued on next page*)

Table 1 (*continued*)

17. Swim

When moving in water that is too deep to reach the bottom, horses will swim. They extend head and neck to keep the head just above the water level. They move their limbs like in a trot, with more or less coordination between diagonal pairs of limbs.

18. Slide

A horse can move forward without moving all of its limbs, for example, when sliding down a steep slope or executing a sliding stop in reining. The hindlimbs will move very little or not at all and are partially flexed. The front limbs show more variability and will often continue to show a walk-like movement, as is required for a correct sliding stop in reining.

II. Limbs

Movement of the limbs is part of many other behaviors. In this section, the possible movements of the limbs are the only focus, either as separate movements or as part of a more complex behavior.

19. Paw

Protraction of one front limb, scraping the floor during retraction.

20. Strike

One or both front limbs show a fast movement. This can be in different directions and with different degrees of flexion or extension in the articulations of the front limbs. It can be directed at another horse, human, or animal or its own body. The horse may or may not make contact with itself or another organism involved.

21. Kick

One or both hindlimbs show a fast movement. This can be in different directions and with different degrees of flexion or extension in the articulations of the hind limbs. It can be directed at another horse, human, or animal or its own body. The horse may or may not make contact with itself or another organism involved.

III. Other

22. Transitions

Transitions between different behaviors can mean the coordination of different body parts needs temporary adjustment. Such intermediate movement patterns can, for example, be seen in transitions between different gaits (trot to canter, walk to halt).

IV. Combinations of behaviors

Horses can show overlap between behaviors, which means one behavior can be executed while performing another. An exhaustive list of these combinations is not feasible. At this point, it seems more practical to simply describe this by the basic movements that are being combined. A few examples of combinations that are seen regularly are included to clarify the concept.

a. Turn + other movement

A horse can turn while moving (walk, trot, canter) and can do this in different ways. It can also turn while rearing, meaning it will land with its front limbs in another place than where they originally took off.

b. Jump + buck

A horse can include a buck in a jump. It will push off with the hind limbs and lift the pelvis higher during or at the end of the jump, with an extra muscular action to surpass the regular pattern of the jump.

c. Jump + buck + kick

A horse can jump and, during this movement, lift the pelvis higher and extend one or both hindlimbs.

English speakers were selected preferentially, with only 3 researchers not being native speakers but having very good English skills. Of the 20 researchers and 24 practitioners contacted, 13 and 10 participated, respectively. Among these, technical issues blocking access to the videos prevented 1 researcher and 2 practitioners from participation.

Video clips were only from footage for which explicit consent was obtained for this particular use. Panelists were assured anonymous processing of data and explicitly given the option to withdraw from the study at any point.

Statistics

Data from the survey were analyzed with logistic mixed models, which are a form of generalized linear mixed models, using SAS 9.3 (www.sas.com). All behaviors were scored as present or absent for every panelist in each clip. The models were run with two random variables, clip and panelist. If the model did not converge with both random variables simultaneously, they were run for each random variable separately. The models provided covariance parameter estimates which are measures for the variability of the covariates clip and panelist. Comparison of the variability among panelists with variability among clips permitted an evaluation of the reliability of behavioral scoring by panelists. If the variability of the observers' scores was considerably lower than that of the clips, the observers were revealed to be scoring the behaviors more reliably than they would by chance.

The analyses were performed on 20 behaviors, as "swim" was not possible because no horse was near or in water in any of the video clips, and transitions from one behavior to another and combinations of more than one behavior were not counted as separate categories. The analyses were repeated after excluding paw, roll, and sit, behaviors that were never scored by any of the observers and therefore did not contribute at all to the variability. The three behaviors that panelists most often commented on (jump, buck, and turn) were also analyzed separately. Clips differed in the number of behaviors they presented, from the most simple (one behavior per clip) to the most complex (6 behaviors per clip). The effect of this complexity on the behavioral scoring was tested. A distinction was made between the simpler clips and the more complex ones. Clips were categorized as complex if at least 6 of the 23 observers scored three or more behaviors from the ethogram for that clip. The simple clips were those in which at least 18 panelists observed no more than two behaviors. Categories of complexity were decided after data collection and allowed all clips to be assigned.

Draft reference ethogram

After the survey, a more comprehensive first draft was written of a descriptive reference ethogram for horses. This was based on the feedback from the panelists combined with an extensive search of existing equine behavioral definitions. An extensive literature review was critical in the preparation of the study ethogram. To ensure no valuable sources had been missed, the search for new information was extensive. All collated information was used as a framework to revise the reference ethogram, in light of the comments from the panelists and the evolving insights after discussing the ethogram with colleagues. In this phase, the focus was on structural definitions with a minimum of interpretation by the observer. Lumping rather than splitting categories allowed to emphasize similarities.

Results

Survey results

Panelists were asked to only score behaviors from the provided ethogram that were observed in each video clip, but responses included additional names for behaviors they had observed, including terms not present in the test ethogram. Behaviors outside the scope of the test ethogram that panelists reported were not included in the analysis.

Applying logistic mixed models to the data for all 20 behaviors (no horse was swimming in any video clip), resulted in a variability for the clips of 0.15 (standard error 0.05) and a variability for

panelists that was too small to quantify. After excluding the three behaviors that showed no variation in scoring as they were never scored, the variability for the video clips was 0.16 (standard error 0.05) and the variability for panelists was still too small to register.

When comparing researchers and practitioners, the model could not be fitted with both random variables (clip and observer) for 20 or 17 behaviors. Models did converge with only one random variable and this did not show any significant differences between researchers and practitioners, for neither random variable clip nor panelist and for neither 20 nor 17 behaviors.

When comparing simple (n = 16) and complex (n = 14) clips for the 17 behaviors, the model with both random variables did not converge, whereas models with one random variable did fit. This revealed a significant difference between simple and complex clips, both with the random variable clips ($P < 0.0001$) and panelists ($P < 0.0001$).

Analyzing only buck, jump, and turn resulted in a model that did not converge with both random variables simultaneously. Models with only one random variable did converge, showing a variability of 2.72 (standard error 0.86) for clip and a variability of 0.01 (standard error 0.02) for panelist. There was no significant difference between researchers and practitioners, for either random variable. The difference between simple and complex clips was significant, both with clip ($P = 0.0002$) and observer ($P < 0.0001$) as the random variable.

Feedback ethogram

Panelists were asked for free-text feedback on the ethogram and its definitions, and several provided comments. The feedback was voluntary and not all panelists provided comments or did so in the same way. This was not meant as a quantitative measure, but as a qualitative source of information. Some panelists gave some general remarks in an email, whereas others wrote more detailed comments in a separate document. A systematic questionnaire to gather structured feedback on each definition would be a useful addition, but was deemed too time-consuming for panelists at this stage.

None of the panelists questioned the usefulness of a reference ethogram. Most remarks were questions about or suggestions for definitions or inclusion of additional behaviors. Several panelists reported difficulties applying definitions for turn, buck, and jump. The definition provided for turn seemed too broad for multiple panelists. Some panelists proposed the introduction of distinctions between changing direction, such as on a circle or in a corner, and movements where the horse travels at an angle to its longitudinal axis, such as half-pass. Some participants had different views on what bucking entails. Most comments also mentioned that scoring would have been easier if they could have watched the video clips in slow motion, especially those clips with fast and complex movements.

Draft descriptive reference ethogram

The ethogram was adapted after the survey, taking into account comments by the panelists and an extensive literature review. Table 2 contains the revised version of the descriptive reference ethogram.

Discussion

The aim of this study was to compile a first draft of a descriptive reference ethogram for horses, using only structural definitions, and to establish if different potential users could apply it with high consistency. Despite the need to first describe and define behaviors before researching their cause, function, or ontogeny (Lehner, 1998; Lorenz, 1973; Martin and Bateson, 2007; Purton, 1978; Tinbergen, 1963), very few purely descriptive ethograms are available, for horses or any other animals. While evidence-based functional or causal ethograms are valuable tools to evaluate health, welfare, or performance of horses (Hall and Heleski, 2017), there is currently no agreement on nomenclature and structural definitions of equine behavior units as basic measurements for experimental research. A widely accepted descriptive reference ethogram would improve communication among all stakeholders and enhance comparability of studies (Miller, 1988). Defining behavior units always entails arbitrary choices on which elements to include and which similarities to prioritize (Drummond, 1981; Hinde, 1966). Therefore, a reference ethogram would form only a starting point for researchers when developing a protocol for a particular study. They would still need to choose which behaviors to include, the level of detail, and the classification of behaviors in groups, which can include splitting or lumping behaviors. A well-established reference ethogram could act as a benchmark, allowing researchers to use the provided names and definitions, or to explain how and why they deviated from them. A descriptive reference ethogram would also provide a neutral vocabulary for discussions among stakeholders, diminishing emotional responses and misunderstandings.

Facial Action Coding Systems provide a purely descriptive tool for behavior units caused by actions of facial muscles. This has been applied to horses (Wathan et al., 2015) and resulted in the definition of 17 Action Units that could be scored with high reliability. This could be integrated in a descriptive reference ethogram to define facial expressions. A similar approach for the entire horse would become complicated, given that there are 245 types of muscles in the body overall (Changizi, 2003), compared with the 15 types of facial muscles (Wathan et al., 2015). However, it could be feasible for the movements of isolated body parts, for example, limbs, when they are the focus of a study or an application.

For the initial phase of the development of a reference ethogram, categories were created according to structural similarities, with the emphasis more on lumping than on splitting behavior units. This first draft of the ethogram aimed to draw attention to the probable need to optimize the equine ethogram continuously and to provide a discussion document for ensuing phases of ethogram development. The definitions were not written in purely scientific terms but are a compromise to make them more accessible to practitioners so that there would only be one ethogram for all stakeholders.

The fundamental approach at this stage of the development of the reference ethogram was to avoid interpretations of behaviors as much as possible. So, no evaluations of quality (good/bad) or normality (normal/abnormal) were included. The sole aim was to describe the range of behaviors domestic horses can show, with an emphasis on similarities and, therefore, broader behavioral categories that will demand additional details at later stages. Piaffe was mentioned in the full ethogram and the loss of suspension included. If discussion with relevant stakeholders leads to a consensus on separating piaffe from trot, this could certainly be included in a more advanced version of the reference ethogram. In the gaits, as in all the other behaviors, similarities were emphasized. Variations in, for example, walk were not named individually but referred to in general and in relation to stance phases of feet. Ingestive behaviors, such as grazing and browsing, could be added in a more detailed version of the ethogram. Definitions of behavioral units are never absolutely complete, but are a selection of characteristics that allow observers to identify them and separate them from other defined entities.

The selection of behaviors for the reliability study was intentionally restricted to keep the ethogram manageable for the

Table 2
The descriptive reference ethogram after integrating feedback from survey participants and literature review

I. Whole body

A. Locomotion

Locomotion literally means moving from one place to another. In this ethogram, the term locomotion is used in the broadest sense, indicating movements of the body as a whole in any direction. Standing and lying are included in this section as they represent coordinated actions of the whole body.

1. Stand

The horse is standing on 3 or 4 limbs without moving in any direction. The head and neck can move without movement of the limbs. Depending on the focus of the research question for a given study, this can include the horse slightly repositioning one or more limbs, while remaining at or very close to the original position.

2. Walk

The horse moves its 4 feet individually with each stride showing a 4-beat rhythm. The feet move in a sequence: left fore, right hind, right fore, left hind. Most of the time, horses will have 2 or 3 limbs in stance phase (weight-bearing). Some horses can show variations on the walk, but the gait is always 4 beat. Some faster variations can include only 1 foot in stance phase at some stages of the stride.

3. Trot

The horse moves in a 2-beat gait with pairs of limbs (1 forelimb and 1 hindlimb) moving simultaneously, with a short suspension phase between stance phases of both pairs of limbs. The most common form of trot is characterized by diagonal pairs of limbs moving together, while a lateral variation (often called pace) also exists. The synchrony between paired limbs is not always perfect. The forward movement of the horse can vary up to not going forward at all (piaffe), which can result in loss of suspension, especially in the forelimbs.

4. Canter

The horse moves in an asymmetrical 3-beat gait. Horses are described as being on the left or right lead, according to the leading forelimb. The canter on the right lead shows the following sequence: left hind, diagonal pair of right hind and left fore, right fore, followed by a suspension phase. The diagonal pair is not always perfectly synchronized. A lead change is the transition from right lead to left, or vice versa. This can start with a change of the forelimbs or it can be executed during the suspension phase (in which case it starts with the hindlimbs).

5. Gallop

The gallop is a faster version of the canter, with the diagonal pair dissociated, resulting in a 4-beat gait. The leading hindlimb can differ, which accounts for the difference between a rotary (leading hindlimb contralateral to leading forelimb) and a transverse (leading hindlimb ipsilateral to leading forelimb) gallop. A rotary gallop with right lead has the following sequence of footfalls: right hind, left hind, left fore, right fore. A transverse gallop on the right lead has this sequence of footfalls: left hind, right hind, left fore, right fore. The rotary gallop is not typical for horses, but is sometimes temporarily seen. A lead change is the transition from right lead to left, or vice versa. This can start with a change of the forelimbs or it can be executed during the suspension phase (in which case it starts with the hindlimbs). Typically, the gallop has only one suspension phase after the leading forelimb begins its swing phase. At higher speeds, the gallop may contain 2 suspension phases, with a second added between either the last hindlimb taking off and the first forelimb landing, or between the trailing forelimb and the leading forelimb. A gallop with 3 suspension phases is seen if both additional suspension phases are present.

6. Backup

The horse moves backward. This can be a 4-beat gait, with each limb moving separately, or a 2-beat movement, with diagonal or lateral pairs moving simultaneously, without a suspension phase.

7. Jump

The horse flexes the forelimbs and raises them, then pushes off the ground and forward by extending both hindlimbs, followed by a suspension phase and landing. The landing can vary: it can be on one or both forelimbs, on forelimbs and one or two hindlimbs, or on one or two hind limbs. Sometimes a horse can take off with all 4 limbs simultaneously ("crow hopping").

8. Buck

The horse pushes both hindlimbs off the ground at the same time, resulting in the pelvis being higher than the withers. This can be achieved while standing or while moving.

(continued on next column)

Table 2 (*continued*)

9. Rear

The horse raises both forelimbs off the ground, without forward movement. It can sometimes be combined with bipedal walk of the hindlimbs, while the forelimbs are still up in the air.

10. Lie down

This behavior begins with a controlled transition from an upright position to a recumbent position. The horse will first slightly flex all 4 limbs. Then it will flex its forelimbs further until one shoulder touches the ground. It will continue by further flexing its hindlimbs, gradually increasing the contact zone with the ground until it lies down. All limbs are on one side of the body. There are 2 ways a horse can remain lying down:

a. Sternal recumbency

The horse is lying on the lateral side of the forelimb and hindlimb closest to the ground and the ventrolateral part of the torso. The limbs are more or less flexed and the head can be held upright or resting on the ground or its forelimbs.

b. Lateral recumbency

The horse is lying on one lateral side of its entire body, usually including head and neck. The head can briefly be held up by lateral flexion of the neck. Limbs can be held in different gradations of flexion.

11. Get up

A horse in lateral recumbency can first roll until it reaches sternal recumbency. This can include an abduction of the limbs furthest of the ground, followed by an adduction combined with a roll of the entire body. From a sternal recumbent position, the forelimbs are extended cranially, lifting the sternum off the ground by extending and retracting them. Subsequently, the hind limbs push the pelvis off the ground until the body reaches a standing position.

12. Roll

Starting from a position of lateral recumbency, the horse rotates along its longitudinal axis. The horse can also show rotation, dorsoventral flexion/extension, and lateral flexion of the vertebral column. The rotation around the longitudinal axis can be small, up to a maximum of 180°.

13. Turn

Starting from a standing or moving situation, the horse shows rotation around a vertical axis or it moves at an angle to its longitudinal axis.

a. Front

The forelimbs move sideways by abduction and adduction. This mostly includes some degree of lateral flexion of the vertebral column. Once the horse takes multiple steps, the hindlimbs are adjusted.

b. Back

The hindlimbs move sideways by adduction and abduction. This mostly includes some degree of lateral flexion of the vertebral column. If the horse takes multiple steps with the hindlimbs, the forelimbs are adjusted.

c. Both

The horse can also move both its forelimbs and hindlimbs sideways in the same movement. This can be carried out to opposing sides or to the same side.

14. Hop

When the horse does not put any weight on one limb or has 2 limbs strapped together (e.g., when hobbled), it will have to change the normal 4-beat walk into a 3-beat version. The exact movement will depend on the limb that is incapacitated. For example, if one foreleg is not used, the horse will move both hindlimbs and then move the front end by pushing off with the weight bearing forelimb.

15. Sit

The horse puts its weight on the posterior sides of its hindlimbs, while the forelimbs are in standing position. This is an intermediate position while getting up, but it can be maintained for longer.

(continued on next page)

Table 2 (*continued*)

16. Shake

The horse rotates several degrees to the left and right around its longitudinal axis repeatedly. This movement can involve only the head and neck, or increasing extensions caudally up to the entire length of the body. If it shakes all the way along its body, the rotation moves as a wave along the length of the vertebral column.

17. Swim

When moving in water that is deep enough for them to float, horses will swim. They extend head and neck to keep the nostrils, eyes, and ears just above the water level. They move their limbs like in a trot, with more or less coordination between diagonal or lateral pairs of limbs.

18 Slide

A horse can move forward without moving all of its limbs, for example, when sliding down a steep slope or executing a sliding stop in reining. The hindlimbs will move very little or not at all and are often partially flexed. The forelimbs show more variability and will often continue to show a walk-like movement, as in a correct sliding stop in reining.

B. Social behavior

Behaviors are categorized as social if another animal is involved in a direct interaction. Social behavior can be intraspecific, when another horse is involved, or interspecific, when interacting with any other species, including humans.

19. Allogroom

This is almost always a mutual event between two horses, with one horse initiating and the other reciprocating within seconds. The horses will usually stand antiparallel and they can change sides within one bout. The horses will move their muzzle, lips, or incisors along the skin of the other horse. This will mostly be carried out on the dorsal part of the body, from the cranial part of the neck to the base of the tail. In horses with feathering (longer hairs at the posterior side of the fetlock), allogrooming may include attention to the feathering of the hindlegs. Humans can imitate this by scratching the horse with their hands or an object.

20. Lick other individual

The horse opens its mouth, extends the tongue beyond the lips, and rubs the tongue against a human, another horse, or another animal. This can be executed once or repeatedly.

21. Rub against other individual

The horse moves part of its body against a human, another horse, or another animal. This can be one movement or a series of movements (e.g., up/down, left/right).

22. Bump or push other individual

The horse moves toward a human, another horse, or another animal until it touches it with a part of its body. It continues to move and the other individual involved either loses contact after the initial contact (bump) or moves along for some time after initial contact (push).

23. Sniff other individual

The horse moves its nose close to another individual, dilates its nostrils while inhaling. Contact with the sniffed individual is possible, but the interaction can also be achieved at a short distance.

24. Sexual behavior

In this document sexual behavior refers to behaviors that directly involve the external sexual organs.

a. Sniff genital region

A horse sniffs the sexual organs of another horse.

b. Mare presenting

A mare abducts both her hindlegs, moves her tail with a combination of lateral flexion and dorsoventral extension up to the point where her vulva is visible. This can be accompanied by repeated movements of the labia, exposing the clitoris (clitoral winking).

c. Mount/dismount

The stallion lifts his forelimbs off the ground, walks slightly forward until his sternum rests on the back of the mare. For dismounting, he will lift his body up from the back of the mare and either he will move backward or sideward before putting his forelimbs back down, or the mare will move forward.

d. Intromission

After mounting, the stallion will insert his erected penis into the mare's vagina. He will thrust several times by flexing and extending his lumbar and coccygeal vertebrae.

(*continued on next column*)

Table 2 (*continued*)

II. Vocalization

The names and structural parts of the definitions in the ethogram by McDonnell (2003) were used, with additions from Waring (2003) for snort and blow.

25. Whinny

A loud, prolonged call, typically of 1 to 3 seconds, beginning high pitched and ending lower pitched. Also called neigh.

26. Squeal

A high-pitched vocalization of variable loudness and typically of less than 1 second.

27. Scream

Of similar high pitch, but louder and longer than the squeal.

28. Nicker

A low-pitched, gutturally pulsated vocalization.

29. Grunt

Low-pitched vocalization of about 0.5 seconds.

30. Groan

Monotonous, hum-like sound produced during exhalation, typically lasting up to 2 seconds.

31. Snort

Sound produced on forceful quick exhalation of less than 1 second duration, with an audible flutter pulsation.

32. Blow

Nonpulsated sound produced on strong, sharp exhalation.

33. Sigh

Audible prolonged loud exhalation after quick deep inhalation.

III. Facial expression

Facial expressions are the result of actions of the facial muscles. The different contributing features are briefly introduced. A complete facial expression is a combination of these features.

34. Ears

The pinnae of the ears can move independently of each other. Each pinna can rotate several degrees in either direction around its longitudinal axis and along its transverse axis or a combination of both. The extremes are both ears turned forward pointing upward and, on the other hand, both ears pinned flat against its neck.

35. Nostrils

The nostrils can be narrow or dilated. The horse can also draw the nostrils cranially, creating one or more wrinkles above the nostril.

36. Chin

Through muscular action, the chin of the horse can be more or less pronounced.

37. Lips

The lips of the horse can be extended or tight against its incisors. They can be open or closed (lower lip touching upper lip from one commissure to the other).

38 Eyes

The eyes can rotate in the orbit, but the movements of both eyes are not independent. The eye lids can cover a variable portion of the cornea and the sclera of the eyes. Muscular action can cause wrinkles above the orbit, with a varying number of wrinkles at variable angles.

39. Cheeks

The muscles on the cheek can be tightened or loose.

40. Mandible

The position of the mandible in relation to the maxilla can vary in three dimensions. Distance between mandible and maxilla can vary when the horse opens or closes its mouth. The mandible can move dorsoventrally, laterally, rostrocranially, or a combination of these.

41. Tongue

The horse can move its tongue internally and externally of the oral cavity. It can extend the tongue so its distal part passes the lips. This can be forward, laterally, or a combination of both. The shape of the tongue can be altered by muscular action.

(*continued on next page*)

Table 2 (*continued*)

IV. Head-neck

This section addresses postures and movements of the head and of the cervical part of the vertebral column.

42. Bite

The horse brings its head to the position of a human, another horse, or another animal. It opens its mouth, puts its incisors on the other individual and brings its lower and upper incisors closer together. A horse can also show the same sequence without actually touching the other individual, who may have moved out of the way. A horse can also bite an object.

43. Partial bite

The horse moves its head in the direction of a human, another horse, or another animal. It opens its mouth but does not reach the original position of the other individual. It can close its mouth again at any time during the behavior. The horse can also show this behavior without the presence of another animal.

44. Extension/flexion neck

The cervical part of the vertebral column can show dorsoventral flexion and extension and lateral flexion to both sides. This is the part of the vertebral column with the greatest range of motion. Both cranial and caudal parts of the vertebral column can move, either separately or simultaneously.

45. Rotation of the neck

The cervical part of the vertebral column is rotated along its longitudinal axis.

46. Extension/flexion head

The cranium of the horse is extended or flexed at the poll by movement in the first cervical vertebrae. This can be dorsoventral flexion/extension or lateral flexion. A combination of both directions is also possible.

47. Rotation of the head

The cranium of the horse is rotated around the longitudinal axis of the first cervical vertebrae.

V. Limbs

Movement of the limbs is part of many other behaviors. In this section, the possible movements of the limbs are the only focus, either as separate movements or as part of a more complex behavior.

48. Paw

Protraction of one forelimb, often scraping the floor during retraction, but also possible without contact with the floor.

49. Flexion/extension forelimb

A forelimb is extended or flexed at one or more articulation(s).

50. Flexion/extension hindlimb

A hindlimb is extended or flexed at one or more articulation(s).

51. Adduction/abduction forelimb

The forelimb is adducted (moved toward the midline) or abducted (moved away from the midline).

52. Adduction/abduction hindlimb

The hindlimb is adducted (moved toward the midline) or abducted (moved away from the midline).

53. Strike

One or both forelimbs show a fast movement. This can be in different directions and with different degrees of flexion or extension in the articulations of the forelimbs. It can be directed at another horse, human, or animal, its own body, or an object. The horse may or may not make contact with the animal or object involved.

54. Kick

One or both hindlimbs show a fast movement. This can be in different directions and with different degrees of flexion or extension in the articulations of the hindlimbs. It can be directed at another horse, human, or animal, its own body, or an object. The horse may or may not make contact with the animal or object involved.

(*continued on next column*)

Table 2 (*continued*)

VI. Torso

55. Dorsoventral flexion/extension of the vertebral column

The horse moves the thoracolumbar vertebral column in the sagittal plane, flexing and extending the vertebral column dorsoventrally. This results in a more convex or concave shape of the dorsal midline of the torso.

56. Lateral flexion/extension of the vertebral column

The horse moves the thoracolumbar vertebral column in the dorsal plane, flexing and extending the vertebral column laterally. As a result, the vertebral column is bend to the left or the right.

57. Rotation of the vertebral column

The thoracolumbar vertebral column can have a limited internal rotation, meaning different parts of the vertebral column rotate in different directions. This results in the forelimbs being in a different plane from the hindlimbs. An example is seen during getting up from a recumbent position, when the forelegs rotate before the hindlegs.

VII Tail

58. Dorsoventral flexion/extension of the tail

The tail can be moved in the sagittal plane, resulting in a dorsoventral movement of the tail.

59. Lateral flexion of the tail

The tail can be moved in the dorsal plane, resulting in a movement from side to side.

VIII. Other

60. Urinate

The horse extends its tail dorsally. Its hindlimbs are both abducted and extended posteriorly. This posture will be maintained until no more urine is excreted.

61. Defecate

The horse extends its tail dorsally and flexes it slightly laterally. It pushes out the excrements and brings its tail back into a more neutral position at the end.

62 Eat

The horse grabs a food item with its lips. If it is grazing or the food item is too big, it will bring its lower and upper incisors closer together to cut the vegetation or food item. With its lips and tongue, it will move the food item higher into its oral cavity. The mandible will move in a combination of lateral, rostrocranial, and dorsoventral directions while masticating.

63. Drink

The horse puts its lips just below the surface of the water. The lips are slightly extended and minimally opened. Caudal and cranial movement of the pharynx can often be appreciated from a lateral aspect.

64. Autogroom

These activities relate to ways in which a horse manipulates its own skin.

a. Lick

The horse opens its mouth, extends the tongue beyond the lips, and rubs the tongue against a part of its own body. This can be executed once or repeatedly.

b. Scratch

The horse brings one hindlimb to its head or cranial part of the vertebral column and scratches its head or neck with its hoof. This can be once or repeatedly.

c. Rub

The horse moves one part of its body against another body part (for example rubbing his head against its forelimb) or against an object. This can be one movement or a series of opposite movements (for example, up/down, left/right).

d. Nibble

The horse opens its mouth slightly, puts its incisors against its own skin, brings upper and lower incisors closer together, and slightly moves its head so the skin is pulled in some direction. This can be carried out once or repeatedly.

(*continued on next column*)

Table 2 (*continued*)

65. Behaviors not reported in free-ranging horses

Some behaviors of domestic horses have so far not been reported in free-ranging or feral horses. They are not part of the ethogram of feral horses and are classified in a separate category.

a. Weaving

This is characterized by rhythmical and repeated lateral movements to alternating sides. It can be a movement of the head, or it can progressively involve the neck, the forelimbs, and even the hindlimbs.

b. Pacing

This is a repetitive movement along a fixed path, often inside its box (also called box-walking) but also possible in a paddock or pasture, for example, near a fence. In the box, it is usually executed at the walk, but in larger areas, it can be at the trot or even the canter.

c. Crib-biting

The horse opens its mouth, puts its upper incisors on an object and partially flexes its head and neck, while producing a grunting noise.

d. Wind-sucking

A horse opens its mouth, partially flexes head and neck, and makes a grunting noise. This is basically crib-biting without the object.

e. Self-mutilation

A horse can bite itself repeatedly, usually on the lateral side of the torso. This can cause severe wounds.

66. Transitions

Transitions between different behaviors can mean the coordination of different body parts needs temporary adjustment. Such intermediate movement patterns can, for example, be seen in transitions between different gaits (e.g., trot-to-canter, walk-to-stand) or before and after jumping.

IX. Combinations of behaviors

Horses can show overlap between behaviors, which means one behavior can be executed while performing another. An exhaustive list of these combinations would be very long. For this ethogram it seems more practical to describe this by the basic movements that are being combined. A few examples of combinations that are seen regularly are included to clarify the concept.

a. Turn + other movement

A horse can turn while moving (walk, trot, canter) and can do this in different ways. It can also turn while rearing, meaning it will land with its forelimbs in another place than where they originally took off.

b. Jump + buck

A horse can include a buck in a jump. It will push off with the hindlimbs and lift the pelvis higher during or at the end of the jump.

c. Jump + buck + kick

A horse can jump and, during this movement, lift the pelvis higher and extend the hindlimbs.

d. Chase (move + bite)

This is a social behavior with a horse moving behind another individual, often while trying to bite it.

e. Stretch

This is a combination of flexion and extension of different body parts. At least one body part will show clear extension. For example, a horse can extend its forelimbs by leaning backward, which means the hindlimbs are slightly flexed and the thoracic vertebrae are extended.

f. Combined forelimb movement

The forelimb moves in a combination of flexion/extension and adduction/abduction.

g. Combined hindlimb movement

The hindlimb moves in a combination of flexion/extension and adduction/abduction.

h. Combined vertebral column movement

The thoracolumbar vertebrae can move in a combination of dorsoventral flexion/extension, lateral flexion, and rotation.

i. Combined tail movement

Most often, the movements of the tail are a combination of dorsoventral flexion/extension and lateral flexion.

participants and for the statistical analysis. Since the overall ethogram comprises behaviors of the entire body (mainly locomotion) and behaviors of distinct body parts, the current selection was made to explore the fundamental locomotory behaviors in a general sense.

Depending on the needs of any study or application, more or less detailed ethographic definitions are required. Several members of the current panel suggested providing more detail, for example, by including terms commonly used in dressage. However, at this point, it would be unnecessarily complicated to describe structural differences among different forms of gaits (such as extended, collected, medium, or others) that are applicable for all horses under all circumstances, as individual horses differ in stride length, tempo, and other variables. The broadest category in the current ethogram was turn and this attracted comments from several panelists. Moving on a circle and half-pass are indeed very different, but are both a form of turn in the current definition, in combination with the gait. This will require further attention to write correct and practical definitions for different components of turn but, at this stage, the current definition was intended to emphasize the similarity of showing abduction and adduction of the horse's limbs. Turn is not defined in both existing ethograms (Glatthaar, 2012; McDonnell, 2003), but was included in the present study because it is widely referred to in equitation and represents different muscular action from when the horse moves along its longitudinal axis.

Lazzeri (2014) argues that involuntary physical actions, such as casting a shadow or falling, are not included in the definition of behavior. For actions such as falling or stumbling, the role of volition is debatable as there is often an interaction between simple physical actions, for example, caused by gravity, and more or less coordinated muscular reactions from the animal to mitigate the consequences of the physical forces. Because actions that compensate for external physical forces are highly variable and very difficult to define, they were not included in the current version of the reference ethogram.

Not only the definitions, but also the names of the behavior units should initially be only structural and not reflect any assumption about function or cause (Martin and Bateson, 2007). Behavioral scoring is susceptible to different forms of observer bias, and researchers should actively try to minimize their effect (Tuyttens et al., 2014; Tuyttens et al., 2016). In the current version of the ethogram, functional names for behaviors and categories were avoided. For example, threat bite is an often used name that was replaced with partial bite because threat is a functional term that creates expectations about context and consequences. However, in a few cases, a purely structural term was elusive and existing terms were well established. Allogroom, autogroom, and mare presenting are functional terms, but they were defined in a structural manner. Stereotypies were included as "behaviors not seen in free-ranging horses" because stereotypy is arguably a functional term. This category was included because these behaviors are part of the repertoire of many domestic horses and, therefore, should be present in a reference ethogram.

When testing the scoring of a part of the ethogram by an expert panel, variabilities for observers were much lower than those for video clips, indicating a high reliability. This was the case even when analyzing only the three behaviors that participants identified as most difficult to score (buck, turn, and jump). The relatively low variability for video clips could indicate that they were not very diverse. A future test with more diverse behaviors in the video clips would be useful to evaluate if additional diversity affects the variability of panelists' responses.

In the current test, there were no significant differences between scoring by researchers and practitioners. Visser et al. (2012)

did find differences between researchers and practitioners, but the ethogram differed and participants were asked to score intensity of each behavior. The number of participants in the present study was too low to test for differences among different subcategories within the two groups. It would be useful to compare different categories of researchers or practitioners, because Hall et al. (2014) reported differences in subjective scoring among three categories of practitioners (veterinarians, riders, and riding instructors). However, we did find a significant difference between scoring of simple versus complex video clips, which is compatible with feedback from participants who found it hard to score video clips with combinations of fast and short movements. This finding concurs with reported issues in lameness evaluation, especially if deviations are small (Hammarberg et al., 2016).

Besides clear definitions allowing identification of and distinction among behaviors, proper training in the application of the ethogram helps to ensure that it is used correctly and reliably (Lehner, 1998; Martin and Bateson, 2007). Extensive training in the use of a large ethogram has been shown to result in high reliability (Coelho and Bramblett, 1981). In our study, real training was not possible and the participants were provided only a document on scoring and five exemplar video clips. A further complication was that all the panelists had many years of experience with horses and their personal experience and preferences could influence their scoring. That said, the very low variability for observers and the lack of significant differences between researchers and practitioners suggest that fairly simple descriptive definitions can be reliably applied without extensive training. However, it would be useful to determine how the extent and content of training in the use of the ethogram influences the validity and reliability of behavioral scoring.

Conclusions

This study addressed two central research questions. First, whether generally accepted structural definitions for horse behaviors are available or can be developed? Second, can such definitions be used reliably by researchers and practitioners? Exploration of existing ethograms revealed there is actually no purely descriptive ethogram for horses that uses only structural definitions and classifications. Equine behaviors are named and defined in many different ways, which are often not compatible. The present study began with the draft of a descriptive reference ethogram for domestic horses. A panel of 23 international experts was asked to deploy the core of this ethogram. This revealed that the current draft can be applied reliably, without significant differences between researchers and practitioners. The complexity of the video clips did have an influence on behavioral scoring. This report confirms that there is merit in the further development of a reference ethogram suitable for use by researchers in equitation science and by practitioners throughout the equine industry.

Acknowledgments

This study was inspired by two workshops linked to conferences of the International Society for Equitation Science, held in 2009 and 2012, in which the equine ethogram was discussed. The authors are also grateful for the participation and constructive feedback of all members of the survey panel. They thank the people allowing them to video dedicated footage and to use it in the survey. Statistical advice was provided by Professor Geert Verbeke. The feedback by two anonymous reviewers was helpful and greatly appreciated.

This research did not receive any funding. No formal ethical approval was obtained as horses were only videoed during routine manipulations and panelists participated voluntarily and were given the explicit option to withdraw at any stage. The practices respected the ethical guidelines of the International Society for Applied Ethology.

Authors' contributions: This article was written by all authors, who have approved the final version. Marc Pierard designed the protocol and gathered all data. All authors contributed to the analysis and interpretation of the data.

Conflict of interest

None of the authors declared a conflict of interest.

References

Back, W., Clayton, H., 2013. Equine Locomotion, second edition. Elsevier Health Sciences.
Changizi, M.A., 2003. Relationship between number of muscles, behavioral repertoire size, and encephalization in mammals. J. Theor. Biol. 220, 157–168.
Coelho, A.M., Bramblett, C.A., 1981. Interobserver agreement on a molecular ethogram of the genus Papio. Anim. Behav. 29, 443–448.
Drummond, H., 1981. The Nature and Description of Behavior Patterns. In: Bateson, P.P.G., Klopfer, P.H. (Eds.), Perspectives in Ethology: Volume 4 Advantages of Diversity. Springer, US, pp. 1–33.
Glatthaar, A., 2012. Pferde unter Sich: Verhalten und Verständigung. Wu Wei Verlag, Schondorf.
Hall, C., Heleski, C., 2017. The role of the ethogram in equitation science. Appl. Anim. Behav. Sci. 190, 102–110.
Hall, C., Kay, R., Yarnell, K., 2014. Assessing ridden horse behavior: Professional judgment and physiological measures. J. Vet. Behav.: Clin. Appl. Res. 9, 22–29.
Hammarberg, M., Egenvall, A., Pfau, T., Rhodin, M., 2016. Rater agreement of visual lameness assessment in horses during lungeing. Equine Vet. J. 48, 78–82.
Hinde, R.A., 1966. Animal Behavior: A Synthesis of Ethology and Comparative Psychology. McGraw-Hill, New York.
Hogan, J.A., 2015. A framework for the study of behavior. Behav. Processes 117, 105–113.
Lazzeri, F., 2014. On defining behavior: some notes. Behav. Philos. 42, 65–82.
Lehner, P.N., 1998. Handbook of Ethological Methods, second edition. Cambridge University Press, Cambridge.
Levitis, D.A., Lidicker, W.Z., Freund, G., 2009. Behavioural biologists do not agree on what constitutes behaviour. Anim. Behav. 78, 103–110.
Lorenz, K., 1960. Methods of Approach to the Problems of Behavior. Harvey Lect, New York, pp. 60–103.
Lorenz, K.Z., 1973. The fasionable fallacy of dispensing with description. Naturwissenschaften 60, 1–9.
Martin, P., Bateson, P., 2007. Measuring Behaviour: An Introductory Guide, third edition. Cambridge University Press, Cambridge.
McDonnell, S.M., 2003. The Equid Ethogram: A Practical Field Guide to Horse Behavior. Eclipse Press, Lexington.
McGreevy, P., 2012. Equine Behavior: A Guide for Veterinarians and Equine Scientists, second. Saunders, London.
McGreevy, P.D., 2007. The advent of equitation science. Vet. J. 174, 492–500.
Miller, E.H., 1988. Description of bird behavior for comparative purposes. Curr. Ornithol., 347–394.
Pierard, M., Hall, C., König von Borstel, U., Averis, A., Hawson, L., McLean, A., Nevison, C., Visser, K., McGreevy, P., 2015. Evolving protocols for research in equitation science. J. Vet. Behav.: Clin. Appl. Res. 10, 255–266.
Purton, A.C., 1978. Ethological categories of behaviour and some consequences of their conflation. Anim. Behav. 26, 653–670.
Schleidt, W.M., Crawley, J.N., 1980. Patterns in the behaviours of organisms. J. Soc. Biol. Struct. 3, 1–15.
Schleidt, W.M., Yakalis, G., Donnelly, M., McGarry, J., 1984. A proposal for a standard ethogram, exemplified by an ethogram of the bluebreasted quail (coturnix chinensis). Z. Tierpsychol. 64, 193–220.
Tinbergen, N., 1963. On aims and methods of ethology. Z. Tierpsychol. 20, 410–433.
Tuyttens, F.A.M., de Graaf, S., Heerkens, J.L.T., Jacobs, L., Nalon, E., Ott, S., Stadig, L., Van Laer, E., Ampe, B., 2014. Observer bias in animal behaviour research: can we believe what we score, if we score what we believe? Anim. Behav. 90, 273–280.
Tuyttens, F.A.M., Stadig, L., Heerkens, J.L.T., Van laer, E., Buijs, S., Ampe, B., 2016. Opinion of applied ethologists on expectation bias, blinding observers and other debiasing techniques. Appl. Anim. Behav. Sci. 181, 27–33.
Visser, K., Munsters, C., Roost, L., McGreevy, P., Heleski, C., 2012. Trainers and scientists differ when scoring stress-related behaviours in ridden horses. In: Randle, H., Waran, N., Williams, J. (Eds.), The Road Ahead: Proceedings of the 8th International Equitation Science Conference, p. 121.
Waring, G.H., 2003. Horse Behavior, second edition. Noyes Publications/William Andrew Publishing, New York.
Wathan, J., Burrows, A.M., Waller, B.M., McComb, K., 2015. EquiFACS: The equine facial action coding system. PLoS One 10, 1–35.