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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 an evidence base 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 set 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 was considerably lower than between video clips, indicating a high reliability of behavioral scoring. This remained the case even when only considering the three most commented on behaviors (turn, jump, buck). 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. This preliminary descriptive ethogram for horses in domestic contexts merits further development and additional scholarly activity to add behaviors and improve definitions. Such endeavor will deliver a robust tool for researchers and practitioners and help to distinguish the most effective and humane training methods that advance both rider safety and horse welfare.

Keywords	Ethogram; equine; equitation science; applied ethology
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Submission Files Included in this PDF

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cover letter Reliability Reference Ethogram Marc Pierard.docx [Cover Letter]

Highlights Reliability Reference Ethogram Marc Pierard.docx [Highlights]

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10 March 2018

Dr. Karen Overall

Editor-in-Chief

Journal of Veterinary Behavior: Clinical Applications and Research

Dear Dr. Overall,

We wish to submit an original research paper, entitled "Reliability of a descriptive reference ethogram for equitation science", requesting you would consider it for publication in the upcoming special issue on equitation science of the *Journal of Veterinary Behavior: Clinical Applications and Research*.

This paper aims to advance the development of a descriptive reference ethogram for domestic horses. A first draft of such an ethogram was compiled and tested for reliability. It is not a final document, but a first step that can lead to further discussions and improved versions of the ethogram. This topic was the central work in my PhD, which I recently defended successfully. It was also presented at the latest conference of the International Society for Equitation Science.

We believe that this manuscript is appropriate for publication in the special issue on equitation science of the *Journal of Veterinary Behavior: Clinical Applications and Research* because it addresses a practical way to optimize a fundamental instrument in applied ethology of horses, the ethogram. The *Journal of Veterinary Behavior: Clinical Applications and Research* has also emphasized the value of more standardized ethograms and this study is an effort in that respect.

We confirm that this work has not been published elsewhere and has not been submitted for publication anywhere else. There is no conflict of interest for professor McGreevy, professor Geers or myself. I hope you will consider this manuscript for publication.

Sincerely,

A handwritten signature in blue ink, appearing to read 'Pierard'.

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Highlights:

- A reference ethogram with structural definitions is valuable for equitation science
- No such ethogram for horses is currently available
- Structural definitions can be used reliably
- No difference between researchers and practitioners

1 Reliability of a descriptive reference ethogram for equitation science

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6 Abstract

7 An ethogram and its components, correctly defined behavior units, are the fundamental
8 measuring tools for (applied) ethology and, therefore, also for equitation science, the
9 nascent discipline that gathers an evidence base on horse training, handling and riding.
10 However, there is currently no consensus on names and definitions of equine behaviors and
11 no purely descriptive ethogram for horses is available. As structural descriptions of
12 behavioral units are a starting point for experimental enquiries into their function, cause or
13 ontogeny, this project set out to draft and test the reliability of a descriptive reference
14 ethogram for domestic horses (*Equus caballus*). Classification, names and definitions of
15 behaviors were descriptive and assigned to categories according to structural similarities. An
16 international panel of participants (n=23) was established to represent both researchers in
17 equitation science and practitioners, including trainers, riders, coaches and veterinarians. A
18 part of the ethogram was tested by asking the panel to score 30 short video clips for 20
19 different behaviors and requesting feedback on the ethogram. Statistical analyses with
20 logistic mixed models showed that variability between observers was considerably lower
21 than between video clips, indicating a high reliability of behavioral scoring. This remained
22 the case even when only considering the three most commented on behaviors (turn, jump,
23 buck). There was no significant difference between researchers and practitioners, but the
24 variability of scores for simple video clips (one or two behaviors) differed significantly from
25 more complex ones. This preliminary descriptive ethogram for horses in domestic contexts
26 merits further development and additional scholarly activity to add behaviors and improve
27 definitions. Such endeavor will deliver a robust tool for researchers and practitioners and
28 help to distinguish the most effective and humane training methods that advance both rider
29 safety and horse welfare.

31 **Keywords:** Ethogram; equine; equitation science; applied ethology

32

33 **Introduction**

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

45

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

53

54 Attempts have been made to devise standardized methods to describe behavior (for
55 example: Schleidt and Crawley, 1980; Schleidt et al., 1984), but, so far, none has been widely
56 applied. Behavioral units can be defined to reflect its structural, functional and causal
57 attributes, depending on the focus of the particular research project. The basic definition is
58 structural and focuses on spatio-temporal patterns of muscular actions, resulting in
59 descriptions of postures, movements and vocalizations (Hinde, 1966; Martin and Bateson,

60 2007). In contrast to a structural definition, a functional definition acknowledges the
61 consequences of behaviors and their effects on the animal or its environment, including
62 other animals (Hinde, 1966; Martin and Bateson, 2007). Causal definitions are based on
63 physiological or environmental triggers for behaviors (Hinde, 1966). Some ethograms
64 contain elements of different definition types, either in the ethographic definitions
65 themselves or in the classification of behaviors. Such a mix should be implemented carefully
66 and explained clearly to avoid potential issues, such as the same structurally defined
67 movements representing more than one function simultaneously or different functions
68 under varying contexts (Purton, 1978).

69

70 The importance of ethograms for equitation science has been recognized (Hall and Heleski,
71 2017; Pierard et al., 2015). Several valuable sources containing definitions of horse behavior
72 are available (for example: Glatthaar, 2012; McDonnell, 2003; McGreevy, 2012; Waring,
73 2003) and many scientific articles contain custom-made ethograms of specific behaviors, but
74 ethographic definitions within these inventories are highly variable and not always
75 compatible with each other. Existing ethograms represent different types of definitions or
76 classifications, often mixed within a single ethogram. They range from structural, only
77 describing what the horse does, to more functional or causal, focusing on effects or triggers
78 of the behaviors. However, it is crucial to know the range and structure of behaviors an
79 animal executes before the function, cause or ontogeny of those behaviors can be
80 thoroughly examined (Lorenz, 1960; Lorenz, 1973; Purton, 1978; Tinbergen, 1963).

81

82 The aim of the current study was primarily to develop a first draft of a reference ethogram
83 for domestic horses, using only structural descriptions and classifications. To this end, a
84 number of existing equine ethograms, used by equitation scientists, were compared.
85 Behavioral units were defined and grouped according to their structural similarities. A test
86 panel was established to determine the reliability of the draft ethogram via a survey and
87 members of the test panel also provided feedback.

88

89 **Material and methods**

90 *Survey ethogram*

91 A first draft of the reference ethogram was compiled. It comprised 65 behavior categories.
92 The first draft reflected existing definitions and classifications . The most influential sources
93 were existing ethograms (Glatthaar, 2012; McDonnell, 2003), general textbooks on equine
94 behavior (McGreevy, 2012; Waring, 2003) and a textbook on equine locomotion (Back and
95 Clayton, 2013). To keep it manageable for the test panelists (n=23; details below), both in
96 terms of time and complexity, 21 behaviors were selected for the survey. Table 5.1 contains
97 the ethogram used in the survey.

98

I. Whole body

A. Locomotion

Locomotion literally means moving from a certain place. In this document the term locomotion is used in the largest 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 hind limb) 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 hind limb. 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 hind limbs in the next stride, or it can be executed during the suspension phase (in which case it starts with the hind limbs). 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 hind limb ipsilateral to leading front limb) and a transverse (leading hind limb 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 hind limbs). 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 hind limb 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 in 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 hind limbs, 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 hind limbs or on one or two hind limbs. 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.

8. Buck

The horse pushes both hind limbs 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 hind limbs, 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 hind limbs, 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 hind limb closest to the ground and the ventrolateral part of the torso. The legs are more or less flexed and the head can be held up 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 hind limbs are adjusted.

b. Back

The hind limbs 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 hind limbs, 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 done 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 hind limbs 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 hind limbs, 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.

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 hind limbs 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 hind limbs 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 hind limbs.

99 Table 5.1: Ethogram of 21 behavioral units provided to the survey panel of 23 experts to
100 score behaviors present in 30 video clips.

101

102

103 *Survey protocol and participants*

104 The survey was based on 35 video-clips of horses running loose in an arena, being worked in-
105 hand, or being ridden. The panelists received a document explaining how to score the
106 videos, including explanations of potential scores for the first five video-clips (walk;
107 rear/turn; walk/turn; canter/buck/kick; lie down/roll/get up). They were asked to score the
108 remaining 30 video-clips, naming any behaviors from the provided ethogram that they
109 observed in the clip. Video-clips ranged from very simple behaviors to more complex
110 combinations of fast movements, lasting from 1 to 9s. An Excel-file was provided as a
111 standard score sheet. Video-clips and documents were uploaded to Dropbox and
112 participants received a link to access the material.

113

114 Participants (n=23), representing both researchers and practitioners, were personally invited
115 by email, This closed format, allowing only invited experts to participate, was chosen to
116 control the quality of the participants' responses, their independence and their diversity. All
117 participants were highly experienced. They were classified as researchers if they were
118 involved in original research and had at least 5 peer-reviewed publications on any aspect of
119 equitation science. Practitioners included international judges, trainers and riders, but also
120 veterinarians and staff members of horse welfare organizations. To avoid linguistic issues,
121 native English speakers were selected preferentially, with only 3 researchers not being
122 native speakers but having very good English skills. Of the 20 researchers and 24
123 practitioners contacted, 13 and 10 participated, respectively. Among these, technical issues
124 blocking access to the videos prevented 1 researcher and 2 practitioners from participation.

125

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

129

130 *Statistics*

131 Data from the survey were analyzed with logistic mixed models, which are a form of
132 generalized linear mixed models, using SAS 9.3 (www.sas.com). All behaviors were scored as
133 present or absent for every panelist in each clip. The models were run with two random
134 variables, clip and panelist. If the model did not converge with both random variables
135 simultaneously, they were run for each random variable separately. The models provided
136 covariance parameter estimates which are measures for the variability of the covariates clip
137 and panelist. The analyses were performed on 20 behaviors, as “swim” was not possible
138 because no horse was near or in water in any of the video-clips, and transitions from one
139 behavior to another and combinations of more than one behavior were not counted as
140 separate categories. The analyses were repeated after excluding paw, roll and sit, behaviors
141 that were never scored by any of the observers and therefore did not contribute at all to the
142 variability. The three behaviors that panelists most often commented on (jump, buck, turn)
143 were also analyzed separately. Clips differed in the number of behaviors they presented,
144 from the most simple (one behavior per clip) to the most complex (6 behaviors per clip). The
145 impact of this complexity on the behavioral scoring was tested. A distinction was made
146 between the simpler clips and the more complex ones. Clips were categorized as complex if
147 at least 6 of the 23 observers scored three or more behaviors from the ethogram for that
148 clip. The simple clips were those in which at least 18 panelists observed no more than two
149 behaviors. Categories of complexity were decided after data collection and allowed all clips
150 to be assigned.

151

152 *Draft reference ethogram*

153 After the survey, a more comprehensive first draft was written of a descriptive reference
154 ethogram for horses. This was based on the feedback from the panelists combined with an
155 extensive search of existing equine behavioral definitions. In this phase, the focus was on

156 structural definitions with a minimum of interpretation by the observer. Lumping rather
157 than splitting categories allowed to emphasize similarities.

158

159 **Results**

160 *Comparing existing ethograms*

161 The most extensive sources on equine behavior were consulted in preparation of the first
162 version of the reference ethogram. None were found to be purely descriptive or to use only
163 structural definitions and classifications. Two of them are equine ethograms. The ethogram
164 by McDonnell (2003) is the most extensive and is intended for both researchers and
165 practitioners. The definitions contain general structural elements but often also functional
166 aspects, while the classification also contains functional distinctions. Glatthaar (2012)
167 contains an ethogram in three languages. The definitions are mostly structural, but each
168 behavior is also defined by the context in which it occurs and this is mostly referring to
169 function or cause. The definition for gallop only mentions rotary gallop, but not transverse
170 gallop.

171

172 Two textbooks on equine behavior are often cited and also provide extensive information on
173 structure, function, cause and ontogeny of individual behaviors. Waring (2003) contains a
174 table with 143 elements of the equine ethogram. Details are provided in functionally
175 organized chapters. It includes several figures with drawings showing sequential stages of
176 behavioral responses as indications of function or emotional state. Behaviors are described
177 by a combination of structural, causal and functional elements. McGreevy (2012) provides
178 detailed information of many behaviors, dispersed over the different chapters. Behavioral
179 definitions contain structural, causal and functional aspects. A third textbook, on equine
180 locomotion, by Back and Clayton (2013) contains extensive information on biomechanics. Its
181 fifth chapter, on gaits and interlimb coordination, provides detailed information and figures
182 on structural aspects of gaits.

183

184 *Survey results*

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

189

190 Applying logistic mixed models to the data for all 20 behaviors (no horse was swimming in
191 any video-clip), resulted in a variability for the clips of 0.1498 (standard error 0.04639) and a
192 variability for panelists that was too small to quantify. After excluding the three behaviors
193 that showed no variation in scoring as they were never scored, the variability for the video
194 clips was 0.1561 (standard error 0.04819) and the variability for panelists was still too small
195 to register.

196

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

202

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

207

208 Analyzing only buck, jump and turn, resulted in a model that did not converge with both
209 random variables simultaneously. Models with only one random variable did converge,
210 showing a variability of 2.7243 (standard error 0.8644) for clip and a variability of 0.01139
211 (standard error 0.01954) for panelist. There was no significant difference between
212 researchers and practitioners, for either random variable. The difference between simple

213 and complex clips was significant, both with clip ($p=0.0002$) and observer ($p<0.0001$) as the
214 random variable.

215

216 *Feedback ethogram*

217 Panelists were asked for free-text feedback on the ethogram and its definitions, and several
218 provided comments. None of them questioned the usefulness of a reference ethogram.

219 Most remarks were questions about or suggestions for definitions or inclusion of additional
220 behaviors. Several panelists reported difficulties applying definitions for turn, buck and
221 jump. The definition provided for turn seemed too broad for multiple panelists. Some

222 panelists proposed the introduction of distinctions between changing direction, such as on a
223 circle or in a corner, and movements where the horse travels at an angle to its longitudinal
224 axis, such as half-pass. Some participants had different views on what bucking entails. Most
225 comments also mentioned that scoring would have been easier if they could have watched
226 the video-clips in slow motion, especially those clips with fast and complex movements.

227

228 *Draft descriptive reference ethogram*

229 The ethogram was adapted after the survey, taking into account comments by panelists and
230 an extensive literature review. Table 5.2 contains the revised version of the descriptive
231 reference ethogram.

232

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 fore and 1 hind limb) 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 fore limbs.

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 fore limb. 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 fore limbs or it can be executed during the suspension phase (in which case it starts with the hind limbs).

5. Gallop

The gallop is a faster version of the canter, with the diagonal pair dissociated, resulting in a 4-beat gait. The leading hind limb can differ, which accounts for the difference between a rotary (leading hind limb contralateral to leading fore limb) and a transverse (leading hind limb ipsilateral to leading fore limb) 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 fore limbs or it can be executed during the suspension phase (in which case it starts with the hind limbs). Typically, the gallop has only one suspension phase after the leading fore limb begins its swing phase. At higher speeds, the gallop may contain 2 suspension phases, with a second added between either the last hind limb taking off and the first fore limb landing, or between the trailing fore limb and the leading fore limb. A gallop with 3 suspension phases is seen if both additional suspension phases are present.

6. Back-up

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 fore limbs and raises them, then pushes off the ground and forward by extending both hind limbs, followed by a suspension phase and landing. The landing can vary: it can be on one or both fore limbs, on fore limbs and one or two hind limbs 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 hind limbs 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.

9. Rear

The horse raises both fore limbs off the ground, without forward movement. It can sometimes be combined with bipedal walk of the hind limbs, while the fore limbs 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 fore limbs further until one shoulder touches the ground. It will continue by further flexing its hind limbs,

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 fore and hind limb 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 fore limbs.

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 fore limbs 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 fore limbs 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 hind limbs are adjusted.

b. Back

The hind limbs 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 hind limbs, the fore limbs are adjusted.

c. Both

The horse can also move both its fore and hind limbs sideways in the same movement. This can be done 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 (for example, 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 fore leg is not used, the horse will move both hind limbs and then move the front end by pushing off with the weight bearing fore limb.

15. Sit

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

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 hind limbs will move very little or not at all and are often partially flexed. The fore limbs 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 anti-parallel 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 done 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 hind legs. 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 (for example up/down, left/right).

22. Bump or push other individual

The horse moves towards 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 hind legs, 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 fore limbs 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 backwards or sideward before putting his fore limbs 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.

II. Vocalization

The names and structural parts of the definitions in 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 upon forceful quick exhalation of less than 1 second duration, with an audible flutter pulsation.

32. Blow

Non-pulsated sound produced upon strong, sharp exhalation.

33. Sigh

Audible prolonged loud exhalation following 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.

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 or 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 fore limb, often scraping the floor during retraction, but also possible without contact with the floor.

49. Flexion/extension fore limb

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

50. Flexion/extension hind limb

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

51. Adduction/abduction fore limb

The fore limb is adducted (moved towards the midline) or abducted (moved away from the midline).

52. Adduction/abduction hind limb

The hind limb is adducted (moved towards the midline) or abducted (moved away from the midline).

53. Strike

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

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 fore limbs being in a different plane from the hind limbs. An example is seen during getting up from a recumbent position, when the fore legs rotate before the hind legs.

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 hind limbs 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 hind limb 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 fore limb) 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 done once or repeatedly.

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 fore limbs and even the hind limbs.

b. Pacing

This 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 fore 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.

c. Jump + buck + kick

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

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 fore limbs by leaning backwards, which means the hind limbs are slightly flexed and the thoracic vertebrae are extended.

f. Combined fore limb movement

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

g. Combined hind limb movement

The hind limb 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.

233 Table 5.2: The descriptive reference ethogram after integrating feedback from survey
234 participants and literature review.

235

236 Discussion

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

257

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

266

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

274

275 Depending on the needs of any study or application, more or less detailed ethographic
276 definitions are required. Several members of the current panel suggested providing more
277 detail, for example by including terms commonly used in dressage. However, at this point, it
278 would be unnecessarily complicated to describe structural differences between different
279 forms of gaits (such as extended, collected, medium or others) that are applicable for all
280 horses under all circumstances, as individual horses differ in stride length, tempo and other
281 variables. The broadest category in the current ethogram was turn and this attracted
282 comments from several panelists. Moving on a circle and half-pass are indeed very different,
283 but are both a form of turn in the current definition, in combination with the gait. This will
284 require further attention to write correct and practical definitions for different components
285 of turn but, at this stage, the current definition was intended to emphasize the similarity of
286 showing abduction and adduction of the horse's limbs. Turn is not defined in both existing

287 ethograms (Glatthaar, 2012; McDonnell, 2003), but was included in the current study
288 because it is widely referred to in equitation and represents different muscular action from
289 when the horse moves along its longitudinal axis.

290

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

298

299 Not only the definitions, but also the names of the behavior units should initially be only
300 structural and not reflect any assumption about function or cause (Martin and Bateson,
301 2007). Behavioral scoring is susceptible to different forms of observer bias and researchers
302 should actively try to minimize their impact (Tuytens et al., 2014; Tuytens et al., 2016). In
303 the current version of the ethogram, functional names for behaviors and categories were
304 avoided . For example, threat bite is an often used name that was replaced with partial bite
305 because threat is a functional term that creates expectations about context and
306 consequences. However, in a few cases, a purely structural term was elusive and existing
307 terms were well established. Allogroom, autogroom and mare presenting are functional
308 terms, but they were defined in a structural manner. Stereotypies were included as
309 “behaviors not seen in free-ranging horses” since stereotypy is arguably a functional term.
310 This category was included because these behaviors are part of the repertoire of many
311 domestic horses and, therefore, should be present in a reference ethogram.

312

313 When testing the scoring of a part of the ethogram by an expert panel, variabilities for
314 observers were much lower than those for video clips, indicating a high reliability. This was
315 the case even when analyzing only the three behaviors that participants identified as most
316 difficult to score (buck, turn, jump). The relatively low variability for video clips could

317 indicate that they were not very diverse. A future test with more diverse behaviors in the
318 video clips would be useful to evaluate if additional diversity affects the variability of
319 panelists' responses.

320

321 In the current test, there were no significant differences between scoring by researchers and
322 practitioners. Visser et al. (2012) did find differences between researchers and practitioners,
323 but the ethogram differed and participants were asked to score intensity of each behavior.
324 The number of participants in the current study was too low to test for differences between
325 different subcategories within the two groups. It would be useful to compare different
326 categories of researchers or practitioners, because Hall et al. (2014) reported differences in
327 subjective scoring between three categories of practitioners (veterinarians, riders and riding
328 instructors). However, we did find a significant difference between scoring of simple versus
329 complex video clips, which is compatible with feedback from participants who found it hard
330 to score video clips with combinations of fast and short movements. This findings concurs
331 with reported issues in lameness evaluation, especially if deviations are small (Hammarberg
332 et al., 2016).

333

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

346

347

348 **Conclusions**

349 Exploration of existing ethograms revealed there is actually no purely descriptive ethogram
350 for horses that uses only structural definitions and classifications. Equine behaviors are
351 named and defined in many different ways, which are often not compatible. The current
352 study began with the draft of a descriptive reference ethogram for domestic horses. A panel
353 of 23 international experts was asked to deploy the core of this ethogram. This revealed that
354 the current draft can be applied reliably, without significant differences between researchers
355 and practitioners. The complexity of the video clips did have an influence on behavioral
356 scoring. This report confirms that there is merit in the further development of a reference
357 ethogram suitable for use by researchers in equitation science and by practitioners
358 throughout the equine industry.

359

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367 were only videoed during routine manipulations and panelists participated voluntarily and
368 were given the explicit option to withdraw at any stage. The practices did respect the ethical
369 guidelines of the International Society for Applied Ethology.

370

371 **Conflict of interest statement**

372 None of the authors declared a conflict of interest.

373

374 **Authorship statement**

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

378

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