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1 Detecting horses' sickness: in search of visible signs

2

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17

18 **Abstract**

19 Assessing sickness in animals, by which we refer to non-specific states involving both
20 physical discomfort and negative emotional states, is a real challenge. In this review, we
21 demonstrate the need for clear and simple indicators of sickness in horses, a species in
22 which suffering is largely underestimated. We provide a critical review of existing tools
23 available to assess sickness in equids, which include composite pain scales and scores and
24 welfare assessment scoring. Many such scales and scoring systems involve subjective
25 assessments and lack of clear definitions. We discuss possible objective, visible indicators
26 (qualitative and quantitative behavioural modifications and some postures) associated
27 with sickness in horses, highlighting the two predominant modalities of expression
28 (becoming unresponsive to environmental stimuli and “lethargic”, or becoming
29 aggressive and hostile). Much work is still needed before an agreement can be achieved
30 on the indicators of sickness in horses; there are however signs that, even if non-specific,
31 should attract the owners’ attention on the horses’ welfare states.

32

33 Keywords: Horses; Illness; indicators; sickness assessment; welfare; pain.

34

35 **1. Introduction**

36 According to the Oxford Guide of the English Language (1984), sickness corresponds to a
37 state of being sick, *i.e.* unwell, but also distressed or disgusted, bad, harmful, hostile.
38 Several points deserve attention here: 1) sickness is non- specific; 2) the definitions refer
39 to both physical discomfort (“unwell”) and emotions (distress, hostility); 3) these last
40 aspects indicate the interrelations between physical sensations and self-deprecation or
41 anger. In fact, there is a complex relationship between sickness and stress, distress and
42 pain (Ashley et al., 2005). Therefore the present review will also include aspects related to
43 pain and chronic stress.

44 Sickness induces aversive experiences that range from mild discomfort to acute pain.
45 Sickness is often accompanied by pain (Dantzer, 2004), an “unpleasant sensory and
46 emotional experience associated with actual or potential tissue damage or described in
47 terms of such damage” (International Association for the Study of Pain IASP, 1979).
48 Discomfort or pain are ways of protecting the organism by prompting the avoidance of
49 harm, promoting healing by inhibiting other activities that might cause further tissue
50 damage (Bateson, 1991). “Suffering offers the best protection for survival” (Damasio,
51 1994). Pain grabs attention, interrupts associated behaviour: the more intensive and
52 threatening the pain, the more disruptive of attention to anything else it is (Williams,
53 2002). Sick individuals may become lethargic, unresponsive to their environment and stop
54 eating and drinking (Dantzer, 2004).

55 In humans, although clear pain scales exist, especially for non-verbal subjects (*i.e.* infants,
56 elderly), underestimation of pain is widespread amongst health professionals whether in
57 elderly (*e.g.* Forrest et al., 1989; Grossman et al., 1991) or in intensive care (Marquié et al.,

58 2003) units. Overexposure may raise the threshold of detection (Prkachin, 2002) as does
59 the suspicion of overstatement of pain expression by the patient (Williams, 2002).
60 Repeated exposure is one likely explanation as the phenomenon is observed more in
61 more experienced staff (Prkachin, 2002; Prkachin et al., 2001, 2004). Another reason is
62 that discomfort and pain are highly subjective experiences and that there is not
63 necessarily a direct relation between the degree of expression of pain and the actual
64 damage to the tissues.

65 While it is difficult to evaluate the degree of sickness in another human being, especially
66 from another social community, it is still more so when trying to assess it in non-humans.
67 Experience does not necessarily help: cats' emotional states are best evaluated by people
68 who identify with them (*i.e.* thinking "pets are like us") whether or not they are cat
69 owners (Thibault et al., 2006). Human beings also tend to look at other species as they
70 would to conspecifics, with much emphasis on faces and much less on other body parts.
71 This may be misleading in species where sickness expression may be through whole body
72 or other body regions' postures (Leach et al., 2011).

73 Assessing sickness in animals is therefore a real challenge and requires the identification
74 of reliable visual indicators of sickness, including discomfort or pain. As the idea is that
75 practitioners, caretakers or owners detect at first sight a sick animal, visible indicators,
76 especially behavioural and postural signals, are clearly needed.

77 But then, what is a reliable indicator? Referring to the Oxford guide to the English
78 Language (1984), an indicator is "a thing that indicates something" (*i.e.* point out, be a
79 sign of, show the need of), but also a "device on a vehicle showing when the direction is
80 going to be altered". This last aspect makes an interesting parallel as sickness indicators
81 are supposed to indicate changes from an homeostatic state of well-being/good health.

82 Sickness indicators should indicate the changes in behaviour and postures that
83 correspond to changes in the internal state. The question arises on the reference taken to
84 make comparisons: a healthy population? The individual itself? What is the reference for a
85 health practitioner surrounded by unhealthy persons? What if the individual has never
86 been seen in good health?

87 The question of the “reference” in domestic animals is complex, as life conditions have
88 put such pressure on their abilities to adapt that whole populations may be in states of
89 altered welfare and thus at risk of becoming sick. Although it is regularly argued that
90 domestication/selection may have promoted an adaptation to the domestic constraints,
91 domestic animals exhibit health and behavioural problems that show that they do not
92 cope that well (e.g. Duncan, 1998; Fraser and Broom, 1990; Mason, 2010; Mason and
93 Latham, 2004).

94 In the present review, we demonstrate the need for clear and simple indicators of
95 sickness in horses, a species that experiences both the environmental constraints of farm
96 animals and a working and affective relationship with humans. Suffering is largely
97 underestimated in this species, mostly because the recognition of signs of discomfort is
98 weak. We concentrate on sickness indicators, related to health problems and not on
99 overall welfare assessments (psychological alterations), although, as mentioned earlier
100 they are interrelated.

101

102 **2. Issues in detecting changes due to sickness in horses**

103 Sickness has, to our knowledge, not been a major focus of interest for scientists working
104 on horse behaviour in natural conditions. There are anecdotal reports of infected
105 wounds, lameness, loss of condition, dehydration and aging that may induce discomfort

106 but mortality rates are low and are mostly due to early foals' deaths (Berger, 1983, 1986;
107 Feist and Mc Cullough, 1975; Waring, 2003). In addition feral horses exhibit little signs of
108 sickness: colic (sign of gastrointestinal pain), laminitis (foot inflammation) postures and
109 stereotypic behaviours seem to be absent. Interestingly though, Przewalski horses kept
110 in enclosures may develop laminitis (Budras et al., 2001). The precise causes of acute
111 laminitis in the horse are not yet fully understood, but certain types of carbohydrate
112 appear to trigger changes in the hindgut precipitating this disease (Mills, 2005).
113 According to Bailey et al., (2004), "studies suggest that a large proportion of cases in the
114 UK are linked to diet, thus laminitis may be considered a disease of domestication", and
115 indeed the domestic situation can be very different from a naturalistic situation.

116 Most domestic horses experience social and spatial restriction, a high energy diet and
117 demanding work. Some diseases are clearly characterized (e.g. Waring, 2003): tetanus is
118 associated with a rigid, spread leg stance; laminitis with an arched body posture that
119 takes the weight off the forefeet. The very well known "colic" includes frequent rolling,
120 lying down - getting up, pawing, staring at flanks. Limb problems are detected when they
121 induce lameness. All these symptoms are regularly encountered in the domestic situation
122 to the point that riding centre owners may consider it normal that several horses exhibit
123 colic at least once per year (Hausberger, pers. obs.). More problematic is the observation
124 that some health problems are highly prevalent and remain undetected, hence worsened
125 by the persistence of causal factors. Two clear examples are gastric ulcerations, that,
126 according to Bell et al. (2007) affect 88.3 % of the ridden horse population, and vertebral
127 disorders that affect at least 70 % of the ridden horse population (Fonseca et al., 2006;
128 Jeffcott, 1979). In the absence of clear indicators, gastric ulcerations rely upon endoscopy
129 in order to be detected, which also requires that the owner and practitioner are aware

130 that this is a possible source of the problem encountered. Vertebral disorders that may
131 be sources of chronic discomfort or pain (see Lesimple et al., This issue), are not easy to
132 detect and most often are only detected when at an advanced stage where gait
133 abnormalities or reactions to back touch are clearly visible. Moreover, radiographic
134 imaging does not work easily in field situations as the horses' muscular mass is an
135 obstacle to obtain clear images of the spine. Thus, vertebral disorders, even when
136 suspected, remain difficult to diagnose (see Lesimple et al., This issue).

137 In any of the above mentioned cases, it is probable that before reaching such acute
138 stages, horses have experienced some discomfort that, if detected, may have been
139 alleviated. However, early signs may remain undetected because they are non-specific to
140 a given pathology. Much attention will be given here to general expressions of sickness
141 that may be common to preliminary stages of a whole range of health problems.

142 This is difficult even when the signals are very visible as shown in a recent study looking at
143 stereotypic behaviours. Lesimple and Hausberger (2014) compared the responses to
144 questionnaires of caretakers and owners asked whether their horses were performing
145 any kind of abnormal repetitive behaviour (predefined with them) to ethological
146 observations of the same 373 horses. The results show a huge discrepancy (5% reported
147 versus 37% observed abnormal repetitive behaviours), even when only major well-known
148 stereotypic behaviours (e.g. crib-biting) were considered. This underestimation may
149 result from different factors (negation of a problem in their stables, attentional problems,
150 lack of training, etc.) but overexposure to these behaviours is likely to be a major aspect:
151 there was a correlation between the level of discrepancy and the proportion of
152 stereotypic horses in the stable. In another study performed on 59 adult horses living in
153 riding schools where ethological observations, blood sampling, spine assessment by

154 practitioners and health questionnaires were performed, 34 % of the horses had a chronic
155 health problem (e.g. lameness, respiratory problem), 73 % had back problems, 18% had
156 anaemia while 66% of them performed abnormal repetitive behaviours (see also Fureix et
157 al., 2010, 2013). Similar findings were obtained in a larger riding school population (N =
158 373, Lesimple et al., subm). In studies performed in developing countries, 89 % of the
159 horses had limb abnormalities (Pritchard et al., 2005), and many (~10%) seemed to have
160 anemia as evaluated through mucus membrane (Burn et al., 2010). When the majority of a
161 population is showing similar behaviours and postures even if due to an altered internal
162 state, it is certainly difficult to imagine that this majority is not the norm.

163 What is then a healthy horse? Horses living in the wild or in naturalistic situations may
164 encounter stress but overall show little evidence of illness. Their time budget is spent
165 predominantly eating and resting; locomotion is regular but mostly consists of slow
166 walking; social interactions are rare but so is social isolation and social bonds are
167 characterized mostly by quiet proximity; horses regularly scan the environment and
168 remain attentive and ready to react to unusual stimuli (e.g. Waring, 2003). Ear and tail
169 postures (Kiley-Worthington, 1976) and neck height are informative (to conspecifics) of
170 the internal state of the animal (Waring, 2003; Wolff et al., 1997).

171 Despite rarely referring to the naturalistic situation, most sickness (including pain and
172 welfare alteration) assessments in horses base their evaluation on changes in these
173 parameters. But maybe precisely because these measures are taken without clear
174 reference to a “norm”, there is little consensus and a lack of reliability to the diverse
175 scales and scores proposed. Detecting the first signs of discomfort may then induce a
176 search for the cause of the discomfort and help identify sickness before it reaches

177 advanced stages. However, in order to ensure validity, the search for indicators must be
178 multidimensional, involving behavioural, health and physiological parameters.

179

180 **3. Assessing sickness in horses: are there reliable visible indicators?**

181 *3.1. Sickness assessment: the example of pain and welfare scales and scores*

182 3.1.1. The composite pain scales

183 According to Zimmermann (1984), pain in animals is “an aversive sensory experience that
184 elicits protective motor actions, results in learned avoidance and may modify species-
185 specific traits of behavior including social behavior”. According to Robertson (2006), pain
186 has been largely underestimated in animals, and in particular chronic pain should be
187 looked at as a disease in itself. Several pain scales were developed for horses, most or all
188 of them referring to behaviours and postures of head, neck, ears, tail, often in association
189 with physiological parameters (Ashley et al., 2005). All were developed in a hospital
190 context where animals were being operated for arthroscopy (Price et al., 2003),
191 celiotomy (Pritchett et al., 2003), or abdominal repair (Graubner et al., 2011); were
192 submitted to an orthopaedic-inducing pain (Bussi eres et al., 2008) or were suffering
193 laminitis (Vinuela-Fernandez et al., 2011). Different pain-relieving drugs were administered
194 and their effects used for testing the reliability of the chosen variables. Horses were
195 generally assessed in their individual stalls, often with videorecordings. Scores of severity
196 were given to each predetermined variable (e.g. no sweating = 0, excessive sweating= 3).
197 Some indicators were developed taking into account the specificity of the variable, that is
198 its degree of characterization of a particular type of pain (heart rate is not specific of a
199 particular problem, while responses to palpation are indicative of the location and
200 potentially the type of pain, hence are specific) and the sensitivity, which is indicative of

201 the degree of pain (Bussières et al., 2008). Thus, in a study based on analgesic
202 administration, the score obtained for the variable considered follows the same gradient
203 as the level of analgesia given, which indicates the level of pain. In their study, pawing for
204 example is very sensitive.

205 Ashley et al. (2005) produced the first review on the behavioural assessment of pain in
206 horses and donkeys. Since then, more studies and new scales have been proposed. Most
207 scales converge on the categories of items they take into consideration but in most if not
208 all cases they rely upon subjective assessment, especially where behaviour is concerned
209 (e.g. general subjective assessment of behavioural signs of pain in Graubner et al., 2011's
210 scale). For example, in the Bussières et al., (2008) composite pain scale, it is unclear how
211 an "exaggerated response to auditory stimulus" (score 1) differs from an "excessive to
212 aggressive response to auditory stimulus" (score 2) and what "being bright" means
213 (behavioural criterion). In that same scale, stupor and prostration have the maximum
214 score in interactive behaviour (score 3 of pain) while in the behaviour ("appearance")
215 category, restlessness and excitation have the highest scores compared to "being
216 bright". While these proposals for scoring are probably based on clinical experience, a
217 prior evaluation of the validity of the concerned variable would have strengthened its
218 integration into a composite scale.

219 Most scales include physiological measures such as heart rate, respiratory rate, rectal
220 temperature and sometimes cortisol. However heart and respiratory rates have poor
221 reliability in terms of reflecting the severity of pain while temperature and cortisol
222 reliability varies according to the type of pain (Graubner et al., 2011; Holton et al., 1998;
223 Molony and Kent, 1997; Mormède et al., 2007; Pritchett et al., 2003; Price et al., 2003).
224 Bussières et al. (2008) found that heart and respiratory rates were moderately specific

225 and sensitive while rectal temperature was neither. This is especially interesting as heart
226 rate is the first criterion mentioned by practitioners in evaluating the severity of pain in
227 horses (Price et al., 2002).

228 In the Bussières et al. (2008) study, four out of the 15 elements measured appeared
229 crucial: response to palpation in the sensitive zone, kicking at abdomen, interactive
230 behaviour and posture (from normal walk to prostration). Despite the variety of the pain
231 inducing situations involved in these different studies, some convergences are worth
232 mentioning: restlessness and agitation as indicators of severe acute pain; rigid stance and
233 reluctance to move, often associated with facing away, as a general indicator; a lower
234 head carriage as an indicator of “depressive” state due to chronic unrelenting pain;
235 aggression towards handlers or objects as an indicator of pain (Ashley et al., 2005).

236 While these scales do give some assessment of pain (van Loon et al., 2010), their validity is
237 still undetermined. There is a need to test each variable involved and remove measures
238 that did not prove reliable (e.g. heart rate, Graubner et al., 2011). There is also a need for
239 clarification of variables. While Bussières et al. (2008) were very precise in evaluating
240 pawing or kicking at abdomen by giving an objective measure of the number per five
241 minutes, interactive behaviour is evaluated based on imprecise terms such as “pays
242 attention to people”, appearance is a mix of different postural elements and behaviours,
243 and resistance to palpation is described as mild, resistant or violent, which may be
244 perceived quite differently by different practitioners. Another evaluation of reaction to
245 palpation determines only the presence/absence of reactions, while postural changes
246 combine ears position and head level (Graubner et al., 2011). Most studies also include
247 “appetite” as an indicator which reflects the horses’ interest/disinterest in the available
248 food; however no attempt is done to quantify it.

249 Specific behavioural or obvious postural alterations and subtle changes in time budget
250 activities may be more representative of pain type and severity (Ashley et al., 2005).
251 Pritchett et al. (2003) mentions that bouts of immobility and lack of responsiveness to
252 positive stimuli occur more often than the generally accepted signs of visceral pain
253 (restlessness, pawing, staring at flanks) in cases of gastrointestinal pain.
254 Horses in pain exhibit significant changes as compared to the healthy “naturalistic
255 behavioural profile”: they lose mobility, eating and social motivation as well as alertness.
256 More emphasis should be placed on the development of quantitative evaluations of the
257 postural and behavioural associated measures. Clear, measurable criteria would help
258 limiting the effects of subjective perception. Using a clinical grading system, Vinuela-
259 Fernandez et al. (2011) have shown that students from veterinary schools agreed more on
260 elevated scores, while experienced practitioners agreed more on what a healthy horse is
261 and not on the most severe cases.

262

263 3.1.2. A horse pain grimace scale?

264 One recent study (Dalla Costa et al., 2014) attempted to apply to horses the grimace
265 scales already developed in rats (Sotocinal et al., 2011) and mice (Langford et al., 2010), by
266 taking pictures of horses undergoing surgical castration, receiving analgesic either i)
267 immediately before anaesthesia or ii) immediately before anaesthesia and then again
268 post-surgery, and iii) of anaesthetised control horses (receiving analgesic immediately
269 before anaesthesia but experiencing non-invasive, indolent procedures). They evaluated
270 the pain level measuring six Facial Action units: stiffly backwards ears, orbital tightening,
271 tension above eye area, prominent chewing muscles, mouth strained, strained nostrils
272 and flattening of the profile. In parallel, behavioural observations were performed. They

273 found an average accuracy of 73 %, which is less than in rodent studies, but the image
274 qualities, with different angles and interference of the horses' eye blinks made definite
275 conclusions difficult. Interestingly though, behavioural observations confirmed some of
276 the above-mentioned findings that horses displayed a lowered level of alertness after
277 operation. Postures with head lower than withers were not rare at that moment (Taylor
278 et al., 2002). It would be interesting to test each facial feature separately in order to
279 determine if accuracy could be improved. It is difficult to distinguish a "pain grimace"
280 from an overall tension of the whole body (Salzen, 2002), which would mean that this
281 "grimace", as in humans, could be found also in other high emotional contexts. Further
282 studies are clearly needed here.

283

284 3.1.3. Sickness and welfare assessment scoring

285 In order to be able to assess the working equids in developing countries, the Brooke
286 Foundation developed welfare assessments that were rapid, simple and useable by
287 different (or even large numbers of) observers, and that could be performed in the field
288 situation without disturbing the working activities (e.g. Pritchard et al., 2005; Burn et al.,
289 2010). Forty-one measures of sickness were noted (eyes, teeth, body condition score,
290 limb abnormalities, skin lesions, lameness, diarrhoea, etc.) and behaviour (reactions to
291 human approach and presence) was scored in terms of presence or absence (e.g. alert
292 versus apathetic) (Burn et al., 2010). This approach, developed with more than 2000
293 horses, revealed that lack of responsiveness was correlated with low body condition
294 score, lesions of skin and deeper tissues and abnormal gait and that ridden horses,
295 although more alert, tended to be more aggressive than draught horses. However this
296 promising approach also lacks clearly defined parameters and scales. General attitude

297 was not clearly defined and the horses had to be classified as either alert or apathetic
298 (amongst which 8 % would be severely depressed). Despite training with the same
299 guidance notes and pictures leading to 80% agreement with their trainers, there was only
300 poor reliability between observers on aspect like “the apathetic general attitude” (Burn
301 et al., 2010). The authors acknowledged that “assessment of alertness/apathy should be
302 refined”, which would allow a greater discrimination between stances relating to apathy
303 and severe depression. They suggested that “a rigid stance, inattentive to the external
304 environment, is often associated with chronic pain, and thus might be distinguishable
305 from the more ‘slumped’ stance associated with depression/exhaustion” (Burn et al.,
306 2010). Swann (2006) mentioned that the apathetic state, defined as non-responsiveness
307 to external events, was observed only in working settings at the beginning of the
308 working season in donkeys carrying bricks in hot temperatures, while it became
309 permanent and associated with social withdrawal at the end of the season. Such donkeys
310 simply appeared “lazy” to the owners. Further work on 715 Romanian horses by Popescu
311 and Duigan (2013), led to the same conclusions that alertness and reactions to humans
312 are major elements of expression of welfare states. Similar conclusions were reached by
313 Fureix et al. (2012a)’s study on depressive-like horses.

314 Young et al. (2012) developed behavioural scoring associated with physiological measures
315 (heart rate and cortisol) while testing horses with different stimuli (sound of electric coat
316 clippers or fireworks) during grooming or social isolation. Using Principal Components
317 Analysis they classified the horses in 4 categories from no stress to high stress (on the
318 basis of the cortisol data and time spent in activities) to which were added the
319 descriptions from the panel. Curiously, the “no stress” horses were performing repetitive
320 oral behaviours, and the authors interpreted this finding by suggesting that stereotypic

321 behaviours may have helped the horses reduce stress. It is unclear whether and to what
322 extent acute reactions to stimuli, as observed here, are reflecting the welfare state of the
323 animal. When a horse reacts strongly to a firework sound, does it mean it is experiencing
324 a bad welfare? Is it reactivity stress or the expression of temperament traits? The fact that
325 the high stress horses showed agitation, anxiousness and aggressiveness is precisely the
326 opposite of the apathetic/depressed profile described in many above-mentioned studies.
327 Further investigation is needed in order to more clearly establish the potential link
328 between reactivity and chronic stress, although some studies argue that welfare
329 alterations may lead to more excited personality profiles (Hausberger et al., 2011).

330

331 3.1.4. Can we assess sickness through scales and scores: conclusions

332 Despite very different and independent approaches, pain scale studies and behaviour
333 scorings revealed the same general non-specific trends: extreme and durable pain or
334 distress leads to apathetic (depressed-like?) states where the animals become indifferent
335 to the environment. Several studies suggested that aggressiveness (or indifference)
336 reflects pain (Ashley et al., 2005; Burn et al., 2010; Fureix et al., 2010; Popescu and Diugan,
337 2013; Pritchard et al., 2005). Loss of interest in food is mentioned in several studies on
338 pain and novel behaviours (e.g. staring at flanks) have been associated with
339 gastrointestinal pain (Ashley et al., 2005; Pritchett et al., 2003). However, all scales and
340 scoring systems thus far involve subjective assessments and lack of clear definitions. The
341 lack of precise definitions of behaviours and postures leaves a large part to individual
342 interpretations, and only the extremes are really discriminant.

343

344 *3.2. Can we rely upon behavioural or postural changes to detect sickness in horses?*

345 Variables related to sickness (*i.e.* health disruption) will be considered here but vertebral
346 disorders, given their prevalence and importance, will be considered in a joined paper
347 (see Lesimple et al., This issue).

348

349 3.2.1. Changes in the behavioural repertoire

350 Novel behaviours typical of sick horses are mentioned in pain scales, such as staring at
351 flank in cases of colic, but there is little clear evidence of changes in the behavioural
352 repertoire *per se*. In a study on Arab broodmares housed in high density and without
353 roughage available in the paddock, Benhajali et al. (2008) observed that the behavioural
354 repertoire was restricted, lacking social behaviours, resting behaviours and rolling. When
355 hay was made available, these behaviours reappeared and the horses had improved body
356 condition and fertility (Benhajali et al., 2009, 2013). Although it is not certain that these
357 mares were actually “sick”, the fact that they proved healthier after the management
358 change suggests it.

359 The lack of roughage, restricted time for feeding and inappropriate diet are common in
360 domestic settings and can lead to potential gastric ulcerations, or at least digestive
361 disorders that may lead to the expression of “abnormal behaviours” such as stereotypic
362 behaviours (e.g. McGreevy et al., 1995, Nicol et al., 2002). As mentioned earlier, gastric
363 ulcerations are present in most of the riding horse adult population. Horses have adapted
364 to a diet rich in fibre (and poor in energy) and their digestive tract requires a quasi-
365 continuous “filling”. This is reflected by the huge part of the time budget devoted to
366 feeding activities in natural conditions (e.g. Waring 2003). Commonly, domestic horses
367 are fed in one to three meals of commercial pellets that are consumed in less than half an
368 hour each, and no or restricted amounts of hay (e.g. 6-7kgs daily). When the litter is made

369 of straw, this can add fibre, but many horses are on bedding made from wood-shaving or
370 other substrates. Therefore horses may experience an empty stomach for many hours,
371 while it seems, given the physiology of the digestive tract, that one hour with an empty
372 stomach may already be a source of discomfort (Harris, 2005). Ponies fed only
373 concentrates will eat their wood-shaving bedding (Haupt et al., 1988). Concentrates also
374 reduce saliva production and increase gastric acidity, perhaps through the secretion of
375 gastrin (Elia et al., 2010; Nicol et al., 2002; Wickens and Heleski, 2010). It has been
376 proposed that oral stereotypies, such as crib-biting, may substitute for chewing hay in
377 stimulating the production of saliva (Nicol, 1999). Gastric ulceration or inflammation is
378 present in 60% of crib-biting foals compared to a prevalence of 20% in the non-stereotypic
379 foals and its severity is higher, as revealed by endoscopy (Nicol et al., 2002). A
380 relationship between gastric inflammation and oral stereotypies has also been found in
381 adults (Mc Greevy et al., 1995). Crib-biting increases during and after meal consumption
382 while antacids or naloxone reduce post-feeding crib-biting (Mc Bride and Cuddeford,
383 2001; Mills and Mcleod, 2002), up to 6-8 hours post-feeding suggesting that gastric pain is
384 not the sole source of visceral discomfort. Clegg et al. (2008) suggest that there could be
385 fermentative acidosis in the hindgut, as this time period corresponds to the arrival of
386 food ingested in the caecum. According to Hemmings et al. (2007), visceral discomfort
387 may play a role in the establishment of oral stereotypies through alteration of basal
388 ganglia programming. Although feeding may not be the only factor involved in the
389 emergence of oral stereotypies, these behaviours obviously reflect a potential state of
390 sickness. Therefore their appearance has to be considered as an important indicator that
391 the horse may be experiencing discomfort. Other behaviours such as vacuum chewing
392 (Hausberger et al., pers. obs.) or yawning (Baenninger, 1987) may also be indicators of

393 sickness that deserve further investigation. Stereotypic broodmares exhibit a lower
394 fertility, which suggests that their health is altered (Benhajali et al., 2014).

395

396 3.2.2. Changes in time budget

397 In the above mentioned example of the Arab broodmares, in the absence of foraging
398 opportunities, the horses increased time spent active walking while the usual locomotion,
399 the slow exploratory walk, was reduced (Benhajali et al., 2008, 2009). Hence, the empty
400 stomach and the associated discomfort may lead to some restlessness. Restlessness and
401 agitation could be more characteristic of severe and acute pain (Ashley et al., 2005).
402 Moreover the few social interactions exhibited were agonistic. Restlessness is mentioned
403 in many clinical evaluations, especially in cases of digestive disorders, where horses tend
404 to alternate lying down, standing up and rolling repetitively (e.g. Pritchett et al., 2003). Of
405 course, the presence of abnormal behaviour and abnormal repetitive behaviours (which
406 may reflect sickness) modifies the time budget. Thus, it has been shown that adult
407 stereotypic horses living in stalls spent less time lying down and sleeping than non
408 stereotypic horses living at the same place (Hausberger et al., 2007).

409 Although included in many pain scales, loss of appetite as an indicator is poorly defined.
410 Since foraging is a behavioural priority for horses, lack of foraging behaviour when
411 resources are available may be a good indicator of discomfort or pain. However, to date
412 there has been no research to indicate this.

413 The time spent in certain orientations or postures as well as the time spent immobile may
414 be good indicators of sickness, as these are features characteristic of the “apathetic,
415 lethargic, depressed” horses observed both in hospital settings and in working conditions

416 (Burn et al., 2010; Fureix et al., 2012, 2015; Popescu and Diugan, 2013; Pritchard et al.,
417 2005) but this is rarely measured (see further).

418

419 3.2.3. Alertness as an indicator of sickness

420 Most pain and welfare scales include “attitudes”, “alertness” or other similar wordings
421 meaning responsiveness to environmental stimuli, including humans. Could this be a
422 general sickness indicator?

423

424 3.2.3.1. Towards depression-like states

425 Sick horses are often described through words like “apathy”, “lethargy”, “depression”
426 (Burn et al., 2010; Popescu and Diugan, 2013; Pritchard et al., 2005). As mentioned earlier,
427 “apathetic” and “depressed” horses are often considered different in general attitude,
428 but without reference to their differences. There is no standard measurement, although
429 there is agreement that they are characterized by prolonged times of immobility
430 associated with a rather “slumped” posture (weight on the forehead), head at or under
431 withers level and a lowered interest for the environment (Burn et al., 2010, Fureix et al.,
432 2012). According to Ashley et al. (2005), apathy is associated with fixed stare, dilated
433 nostrils and a clenched jaw; depression and dullness are characterized by reduced
434 alertness, self-isolation, facing away, lowered head carriage. These elements are included
435 in different scales but mostly on the basis of subjective assessment and it is unknown if
436 they are reflective of a state of sickness. Popescu and Diugan (2013) found that the 2.65 %
437 of horses they considered as being in a “depressed mental state” (*i.e.* lower
438 responsiveness towards environmental stimuli), were also those more prone to have
439 body lesions.

440 We tried, as suggested by Burn et al. (2010) to characterize this condition and find out to
441 which extent it can be analogous to human depression. In one study we labelled 24% of
442 the horses (out of 59 horses living in three riding centres) ‘withdrawn’ as they exhibited
443 bouts of inactivity while displaying a stationary, atypical, flat-necked posture, wide-open,
444 unblinking eyes with a fixed gaze and no ears nor head movements (Fureix et al., 2012a)
445 (**Fig. 1**). Even when not in this unusual posture, ‘withdrawn’ horses differed from control
446 (“non-withdrawn”) horses living in the same stables in several ways, they showed
447 reduced responsiveness to standardized tactile stimulation using Von Frey filaments, less
448 reaction to a human’s sudden appearance at the stall door (Hausberger and Muller,
449 2002); less exploration and more behavioural signs of arousal (fear) when exposed to a
450 novel object, and lower baseline levels of plasma cortisol (Fureix et al., 2012a). Due to
451 analogies with some symptoms of human clinical depression, we hypothesised that
452 withdrawn horses exhibit a depression-like condition, and tested this hypothesis by
453 assessing anhedonia (the loss of pleasure), one of the most important symptoms of
454 human depression (American Psychiatric Association APA, 2013), which has been
455 successfully modelled in biomedical studies of rodents, particularly *via* inducing and
456 recording reductions in sucrose intake (e.g. Papp et al., 1991; Willner et al., 1992). As
457 predicted, the most withdrawn horses consumed the least sucrose, suggesting further
458 depression-like conditions in these animals (Fureix et al., 2015). Like anhedonia,
459 diminished ability to concentrate can also be part of clinical diagnosis of clinical
460 depression in humans (Diagnostic and Statistical Manual of Mental Disorders, Fifth
461 Edition, APA, 2013) and our recent additional observations revealed that withdrawn
462 horses paid a lower attention to auditory stimuli than controls (Rochais et al., *subm.*).
463 Withdrawn horses also maintained withdrawn posture while at work (*pers. obs.*),

464 supporting Swann's (2006) suggestion that in donkeys this syndrome may become
465 chronic, thus independent of context.

466

467 3.2.3.2. A non-specific reliable indicator of internal state: the ears' position

468 All pain scales include ear positions as a variable, but they use different definitions.

469 Overall though, ears pricked forward are considered signs of alertness and positive

470 interactions, while ears pinned backwards appear as signs of sickness (discomfort or pain;

471 Ashley et al., 2005; Dalla Costa et al., 2014; Graubner et al., 2011). Ear position is also an

472 intrinsic part of identification of the horse's interactive state (e.g. Waring, 2003). However

473 there is no clear definition of the different ears' positions, nor do the different scales and

474 scores indicate the conditions in which ear positions have a reliable significance, nor how

475 to evaluate it as part of the time budget. Ears are mobile and they can be backwards for

476 various reasons including noises, negative interactions, discomfort and possibly sickness.

477 In order to use this component as a reliable indicator of sickness, it is necessary to have

478 established a standardized protocol and to have clear definitions. In a study performed

479 on several hundred horses living either in natural or domestic conditions, we found that

480 ear positions can be a useful tool in welfare assessment. For instance, horses that spend

481 most of their time with the ears backwards in calm, non-interacting contexts were more

482 prone to be sick (Fureix et al., 2010; Hausberger et al., *subm.*).

483 Ears held backward in a sustained way may indicate physiological disorders, hence

484 sickness (Hausberger et al., *subm.*).

485

486 3.2.3.3. Testing orientation in the stall as a source of information

487 Positioning in the stall is one of the key parameters in Price et al. (2003) pain scale where
488 being in the front is considered a positive sign, interpreted as a wish to interact. Overall,
489 position and orientation within the stall may indicate that the horse is interested in its
490 external environment and possibly ready to interact (Young et al., 2012). However, is the
491 reverse true? Is staying at the back a sign of sickness? In a study performed on riding
492 school horses (Fureix et al., 2009), we studied the orientation of the horses in their
493 individual stalls. Fifty-five horses from three riding schools were observed in 2007 and
494 2008. Each horse was kept singly in a 3 m x 3 m individual straw-bedded stall in a barn,
495 allowing auditory, visual, and limited tactile contact with conspecifics. Observations using
496 Instantaneous scan sampling (N=90 scans per horse; Altman 1974) were used to assess
497 horses' orientation in their stall: facing a wall, facing external cues (head towards a stall
498 aperture), head out (through a window or in the stable corridor).

499 These behavioural observations revealed that while all horses could be seen at least once
500 facing the wall, the time spent in this position varied greatly between individuals (3 to 91
501 % of the time budget, \bar{X} = 42.5 % +/- 21.5).

502 In parallel, we collected conventional haematological data. These analyses allowed us to
503 identify horses with unusual levels of haematological parameters, for instance anaemic
504 animals. Thus, 18% of the horses suffered from anaemia (see also Burn et al., 2010).

505 The time horses spent facing the wall and their haemoglobin level were negatively
506 correlated: the more time they spent facing the wall, the lower their haemoglobin level
507 was (Spearman correlation, N = 55, r_s = -0.51, p < 0.01). Facing the wall could be another
508 way of “switching off” and avoiding contact with the environment or people. Ashley et
509 al. (2005) mentioned that horses in pain tend to face away from handlers. Sickness may
510 make horses “introverted” and hostile to external stimulations. As mentioned earlier,

511 pain grabs attention, and the more intensive it is, the more disruptive of attention to
512 anything else it is (Williams, 2002).

513

514 3.2.3.4. Interacting with others: aggressiveness as an indicator of sickness

515 According to Ashley et al. (2005), aggressiveness emerges from pain. Humans and pigs
516 also become aggressive when unwell (e.g. Anderson et al., 2002; Day et al., 2008). Horses
517 submitted to heavy work have negative behavioural responses to humans (Popescu and
518 Diugan, 2013) and riding horses seem to be more aggressive than pack or draught horses
519 (Pritchard et al., 2005). To our knowledge, the only proof that aggressiveness may reflect
520 chronic discomfort/pain is that of Fureix et al. (2010) showing that horses presenting
521 vertebral disorders were more prone to be aggressive towards humans. Following Ashley
522 et al. (2005) suggestion that aggressiveness may reflect a state of general hostility, we
523 studied whether aggressiveness towards humans could be associated with
524 aggressiveness towards conspecifics as well.

525 Fifty-nine horses from three riding centres were observed in their individual stall for all
526 occurrences of behaviours. Aggressive reactions could vary from simple threats (i.e.
527 looking with ears laid back), threats to bite (i.e. showing the teeth in addition to simple
528 threats) to threatening approaches (stretching the neck or approaching with ears laid
529 back, sometimes with an attempt to bite, mouth open and teeth visible) (e.g. Hausberger
530 and Muller, 2002; Waring, 2003). They were measured in two contexts: opportunistic
531 recordings during 30 min focal observations where they could be directed towards the
532 observer, another human or a conspecific walking in the corridor, and during specific
533 human-horse relationship tests. Human-horse relationship tests were five standardized
534 behavioural tests, routinely used in different studies on human – horse relationship

535 (Hausberger et al., 2008; Fureix et al., 2009, 2010). Aggressive reactions towards the
536 experimenter were defined similarly to the above-mentioned reactions towards
537 conspecific, and were summed across the five tests, yielding a total “aggression score”.
538 Fifty-nine percent of the horses displayed at least one aggressive reaction towards a
539 conspecific during focal observations; 27% threatened humans present in front of the stall
540 with one to 17 threats per horse and 71% threatened the experimenter at least once
541 during the tests. Aggression towards conspecifics tended to be positively correlated with
542 both the total aggression score test situation ($N = 59$, $r_s = 0.24$, two-tail $P = 0.072$) and the
543 number of times horses threatened humans walking in the corridor during the focal
544 observation periods ($N = 59$, $r_s = 0.22$, two-tail $P = 0.09$).

545 Further observations of a subset of horses ($N=29$) at paddock revealed that the horses
546 that threatened the experimenter at least once during the tests were also the most
547 aggressive when in group ($N_1=19$, $N_2=10$, $U=30$, $P<0.05$) as were the horses that had
548 threatened at least once humans during the observations in the box ($N_1=22$, $N_2=7$, $U=20$,
549 $P<0.02$)

550 Increased aggressiveness towards humans (Ashley et al., 2005) and conspecifics
551 (Benhajali et al., 2008) has been observed in a variety of negative contexts. In natural
552 settings, aggressiveness is low in stable groups and increases when there are
553 disturbances or restriction of resources (Fureix et al., 2012b). Przewalski horses that
554 suffer foot pain have more agonistic interactions with conspecifics (Budras et al., 2011).
555 Aggressiveness in domestic settings may be a non-specific indicator of sickness, triggered
556 by discomfort and pain. It also shows more persistence across situations than friendly
557 behaviours, suggesting that negative behaviours may be more reliable as a sign of poor
558 well-being than positive behaviours as a sign of good well-being (Fureix et al., 2009). This

559 generalization of aggressive behaviours between humans and conspecifics (and objects?,
560 cf. Ashley et al., 2005) suggests that aggressiveness may reflect a “negatively biased
561 mood” more than a real negative perception of the interlocutor. Indeed, sick horses
562 tested in a cognitive bias task showed negative biases that may explain that all stimuli are
563 perceived aversively (Henry et al., unpublished).

564

565 3.2.3.5. Conclusion:

566 Sickness alters the way horses “see the world”: could alertness and interactive
567 behaviours be non-specific but major indicators of sickness? Alertness is a term used in
568 most scales to indicate the animal’s responsiveness to environmental stimuli (e.g. Ashley
569 et al., 2005; Popescu and Diugan, 2013). Although few studies have based their
570 assessments on a clear quantitative approach, all observations converge to indicate that
571 sickness modifies the way horses perceive and react to environmental stimuli. There are
572 two predominant ways horses express their poor well-being: they may, especially in cases
573 of chronic repeated pain, become unresponsive to environmental stimuli, motionless and
574 lethargic or become aggressive and hostile. Sickness associated with pain and discomfort
575 can lead to horses’ self-attention and thus withdrawal from the environment with all
576 senses: auditory (ears back, lowered reaction to sounds), visual (facing the wall, “empty
577 gaze”), and tactile. Gustatory and olfactory responses have not been tested. Sick horses
578 show fewer reactions towards positive stimuli (Pritchett et al., 2003), including sucrose
579 (Fureix et al., 2015). Mobility (of body, ears, etc.) remains to be investigated as a potential
580 indicator of non-sickness.

581 Healthy horses are regularly observed to be attentive to the environment, ready to react
582 to stimuli and to be positive towards other living beings. Therefore the lack of responses

583 may indicate a possible discomfort that, if untreated may transform into pain. However,
584 definitions, thresholds and contexts still need to be determined.

585

586 3.2.4. Beliefs and « false friends » as obstacles to the detection of sickness in horse

587 Because the above mentioned indicators are non-specific, they are easily misinterpreted
588 by owners and caretakers: apathetic equids can be considered “lazy”, that is “unwilling”
589 to perform their work (Swann, 2006), while aggressive horses are “badly behaved” and
590 get punished or culled for this reason, especially as it is believed that it is a temperament
591 trait. Knowing “laziness” and increased aggressiveness to be early signals of sickness
592 would aid the detection of problems before they have transformed into more severe
593 situations. Ear position is rarely considered outside an interactive context and as
594 mentioned earlier, even visible abnormal behaviours may remain undetected. Long bouts
595 of immobility in the stall (or paddock) are often interpreted as resting, probably because
596 of the absence of awareness of the associated body posture (quite different between
597 resting and being inactive, Fureix et al., 2012a).

598 On the other hand, some behaviours may be mistakenly considered as indicators of
599 health. Thus, in folk psychology but also in many scientific reports, play behaviour is
600 considered as a clear indicator of well-being. And indeed in young horses, play behaviour
601 is a normal part of the behavioural development, and is impaired in cases of disease (e.g.
602 Waring, 2003; Henry et al., 2009, 2012). However, adult play is almost absent from the
603 repertoire of horses living in natural conditions as well as in domestic naturalistic settings,
604 while being regularly reported by owners. We performed a study on 29 riding school
605 horses living in individual stalls, fed concentrates and hay, and working every day for one
606 to three hours where horses were observed when released in bare paddocks once a week

607 in groups and independently were observed in their stall and had blood taken. The horses
608 that played the most were those with the highest oxidative stress (a measure of
609 susceptibility to diseases), the highest score of poor welfare and a highest aggressiveness
610 towards humans. Players also had more vertebral disorders, were more often seen facing
611 the wall and had a lower tactile reactivity when in their stall (Hausberger et al., 2012).
612 Interestingly, similar findings have been obtained in primate species, and following Carr
613 (1902), we propose that play behaviour in adults may serve as a way of “evacuating
614 stress, hence toxins and getting oxygenation” (Blois-Heulin et al., 2015). Adult play is
615 therefore an ambiguous behaviour that indicates that the animals are temporarily in a
616 better situation, while being a potential signal of sickness.

617 Another ambiguous behaviour is yawning, which is generally considered to be associated
618 with relaxed states, possibly leading to sleep. Opportunistic observations of high
619 frequencies of yawning in frustrating or stress-inducing situations led us to investigate
620 the potential link between yawning and stereotypic behaviours in horses (Fureix et al.,
621 2011). One hundred and forty horses were observed in their individual stalls. Yawning and
622 stereotypic behaviour frequencies both increased in the period prior to the meal when all
623 horses did not get fed at the same time (frustrating situation). Yawners were also more
624 prone to be stereotypic than non-yawners. High frequencies of yawning outside of a
625 sleep/rest context may therefore be a potential signal that the horse is experiencing
626 some discomfort, and in any case, does not appear to be a reliable indicator of good
627 health.

628

629 **4. General conclusion**

630 Much work is still needed before an agreement can be achieved on the indicators of
631 sickness in horses. However, there are signs that should attract the attention on the
632 horses' wellbeing. Flattened backs and immobile postures have been described as a
633 despair state when persistent. It may also result from learned helplessness where animals
634 learn that they have no chance of escaping the pain or the repeated painful actions of
635 riders (e.g. Hall et al., 2008). Ears' postures (when measured in an appropriate calm
636 context) may reveal a range of sickness including back disorders (Hausberger et al.,
637 *subm.*). Aggressiveness and restlessness may be other ways of expressing discomfort and
638 pain. It is important that reliable indicators are discriminated from "false friends" such as
639 play or yawning and to get out the belief that aggressive horses are just nasty animals.
640 Also, seeking indicators requires us to rely upon on clearly healthy populations while
641 recognizing that the "norm" is not necessarily healthy.

642

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649

650 **6. Ethical note**

651 Reported studies performed by the authors were all complied with the French laws
652 related to animal experimentation and the European directive 86/609/CEE and were
653 approved by the University of Rennes 1 local Animal Care Committee any time approval

654 was needed. Horse husbandry and care were under management of the riding schools:
655 the horses used in this experiment were not research animals.

656

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904

905 **Figure Captions**

906

907 **Fig. 1 The posture of “withdrawn” horses.** Pictures of a horse a) in a withdrawn posture,
908 b) standing observing and c) standing resting. The withdrawn state is characterized by a
909 stretched neck (obtuse jaw-neck angle) and a similar height between the horse’s neck
910 and back (a nape–withers–back angle of $\approx 180^\circ$). This posture is different from those
911 associated with observation of the environment (for which the neck is higher), and
912 resting, when eyes are at least partly closed and the horse’s neck is rounder (Waring,
913 2003; Fureix et al., 2011). Note that the restricted size of the stall (3 m x 3 m) prevented
914 the authors from taking a picture of the whole horse displaying the withdrawn posture,
915 as we chose to use the same lens to limit shape distortion between images. From Fureix
916 et al., 2012.