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1 How to keep your horse safe? An epidemiological study about management practices

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14 **Abstract**

15 As animal welfare has become a major societal concern since the last decades, identifying the
16 factors affecting it, is of first importance. Many studies have been conducted, mostly centred
17 on one particular environmental factor. However, animal welfare is multifactorial, and
18 evaluating the management as a whole seems more appropriate. In this particular study, we
19 aimed to identify environmental parameters impacting riding school horses' welfare. We
20 focused here on four reliable welfare indicators (presence of wounds, stereotypic/abnormal
21 repetitive behaviours, ear position and depressed-like posture) and recorded sixteen intrinsic
22 (e.g. sex, age, type) and extrinsic (housing, feeding, social and working conditions) factors of
23 impact. Using logistic regression models, we could identify and classify the management
24 parameter according to their impact on the different welfare indicators and we were able to
25 identify characteristics of good and bad management practices. Besides confirming the
26 importance of feeding and housing conditions, our study is the very first to show that working
27 conditions in developed countries have a crucial impact on several aspects of equines'
28 welfare, and that horses might be less resilient to inappropriate living conditions than ponies.
29 This study leads to the identification of characteristics of "good" and "bad" management
30 practices as a whole, based on scientific evidences on a large sample of horses.

31 Key words: equids, welfare, management, work, equid type

33 **1. Introduction**

34 Assessing the factors influencing animal welfare has been the core of many scientific studies
35 in the last decades. Most of them have been centered on one particular potential factor of
36 influence (*i.e.* housing : *e.g.* Casamassima *et al* 2001, Meunier-Salaun *et al* 1987;
37 social conditions: *e.g.* Grignard *et al* 2000, van Reenen *et al* 2000, Bouissou *et al* 2001,
38 Wechsler *et al* 1997; feeding: *e.g.* Freire *et al* 2009), whereas only a multifactorial approach,
39 including a maximum of management parameters, could allow an overview of the real
40 consequences on animal welfare. The welfare state of an individual results from a
41 combination of influences and there is a strong need to develop systemic and hence large
42 scale “field” studies (Main *et al.*, 2003; Whay *et al.*, 2003) in order to reliably evaluate (and
43 thus improve) the animals’ welfare. The relative weight of the different factors and their
44 potential interactions are of prime interest if improvements are to be proposed in management
45 practices.

46 Some attempts have been made in horses (Mc Greevy *et al.*, 1995), but because assessing
47 animal welfare through a large scale is energy and time consuming, most of these studies rely
48 upon questionnaire surveys of caretakers or owners’ opinions (Napolitano *et al.*, 2008; Parker
49 *et al.*, 2008; Upjohn *et al.*, 2012). These studies have emphasized the impact of some crucial
50 factors such as food availability and composition, early experience, social possibilities or
51 stabling, on the prevalence of chronic behavioural problems such as stereotypic behaviours
52 (Hockenhull and Creighton, 2010; McBride and Long, 2001; Mc Greevy *et al.*, 1995;
53 Normando *et al.*, 2002; Parker *et al.* 2008; Visser *et al* 2008; Waters *et al.*, 2002). More
54 recently, a study including equitation factors (riding style, *e.g.* western or english and number
55 of working hours per week) showed that riding style has a major impact on the prevalence of
56 chronic behavioural problems (Normando *et al.*, 2011), confirming observational studies
57 (Hausberger *et al.*, 2009, 2011).

58 Although these surveys have proved very useful in identifying factors of influence, they often
59 focus on one particular welfare indicator (*e.g.* stereotypic behaviour), rely upon subjective
60 assessment of caretakers or owners and depend on the respondents’ “ability” to assess the
61 target welfare indicator and / or on their willingness to admit their horses’ behavioural
62 problems (Mills *et al.*, 2002; Lesimple and Hausberger, 2014). If in one study, experimenter’s
63 observations and responses of owners did converge on the prevalence of stereotypic
64 behaviours (Normando *et al.*, 2011), discrepancy between the actual prevalence and the

65 owners' / caretakers' evaluations may be huge (Lesimple and Hausberger 2014). This is
66 especially true in stables highly "at risk" (70-100% of stereotypic horses) where overexposure
67 of owners/caretakers to abnormal behaviour or signs of poor welfare prevents proper
68 evaluation (Lesimple and Hausberger 2014). This may explain why estimates of the
69 prevalence of stereotypic and abnormal repetitive behaviours are between 1 and 10%
70 according to questionnaire surveys (McGreevy et al., 1995; Mills et al., 2002; Normando al.,
71 2011; Parker et al., 2008) and between 22 and 96.6% in observational studies (Benhajali et al.,
72 2010, 2014; Fureix et al., 2011; Hausberger et al. 2007, 2009; Lesimple and Hausberger 2014;
73 Visser et al., 2008). In the same way, effects of the rider-based parameters (e.g. the rider's
74 position) can only be explored using observational studies (Hockenhull and Creighton, 2012).
75 Some large scale observational studies have been performed: Pritchard et al. (2005) and Burn
76 et al. (2010a, 2010b) analysed data from several thousand of equids from different countries.
77 Welfare assessment was performed by trained observers on the basis of 3 types of measures:
78 physical health, alertness and response to human actions. This approach appeared to be very
79 promising, revealing for example that apathetic horses were overall in poor health and
80 presented more body lesions. Because these studies require that assessment be quick, non-
81 invasive and easy to apply in "field" conditions (no disturbance in the facilities' routines), the
82 parameters used need to be both simple and rapid to assess.

83 In the present study, we carried out an epidemiological study on a large sample of riding
84 school horses living in facilities distributed all over France. We chose, as most of the above-
85 mentioned studies, animal-based measures previously shown to be reliable welfare indicators,
86 obtained through direct observations in the horses' home environment. The welfare
87 assessment was based on clearly defined indicators and measures: body lesions, abnormal
88 behaviours, alertness and postures (see also Hausberger et al., 2016). They were chosen
89 because the evaluation needed to be easily and rapidly performed in the facilities (3
90 days/facility). The aim was to evaluate the relative weight of different parameters, either
91 intrinsic (age, breed, sex) or extrinsic (housing, feeding or social related) on horses' welfare
92 state (this study), but also to be able to compare facilities' management as whole systems, and
93 not parameter by parameter.

94

95 **2. Material and methods**

96 The present study was divided into two parts: a first part on 306 horses from 20 riding schools
97 for which "classical" management parameters (housing, feeding and social conditions) were
98 examined and a second part on a subset of 276 horses for which we also had information on

99 the riding techniques used in the facility. The second part includes therefore elements that
100 were proven to be crucial for the horses' back health in earlier studies (Lesimple et al., 2010,
101 subm). Logistic regressions provided multivariate models that allowed a ranking of the factors
102 of influence (e.g. Benhajali et al., 2010; Normando et al., 2011, Visser et al., 2014).

103 The study was performed between October 2010 and May 2011. The observations were
104 conducted in 20 riding schools (N=306 horses, 2 stallions, 177 geldings and 127 mares) all
105 over France. Detailed information on the specific population studied in each part of the
106 studies is given below.

107 *2.1. Animal based measures and data sampling*

108 2.1.1. Physical/health indicator

109 Several studies conducted in developing countries measured the animals' body score in order
110 to have an evaluation of their physical state (Pritchard et al., 2005; Burn et al., 2010b,
111 Popescu and Diugan 2013). However, in our population of French riding school horses, all the
112 animals scored in a pilot study were "optimal" to "fat" and the measurement of body
113 condition was not discriminant (Fureix in prep). Therefore we did not include body scoring in
114 our welfare measures.

115 • Body lesions related to the equipment: in horses working under extreme
116 environmental conditions (e.g. high heat, dehydration), the presence of wounds related to bad
117 equipment's fitting is associated with reveals a more general poor welfare state and is related
118 to the development of strong apathetic states (e.g. Burn et al 2010a). Each equid involved in
119 the study was thoroughly examined and an exhaustive list of the wounds or marks of former
120 wounds (white hair areas) and their relative location compared to the equipment (place of the
121 saddle, girth, bit/bridle, spurs) was noted (Burn et al 2010a, 2010b, Popescu & Diugan 2013,
122 Pritchard et al 2005). Horses presented only minor flesh wounds, mostly hairs removed and
123 sometimes some slight skin irritation. Horses were then binary classified: 1 if they presented
124 at least one lesion (or mark of former lesion) and 0 otherwise.

125

126 2.1.2. Behavioural measures

127 • Stereotypic / Abnormal Repetitive Behaviours
128 Stereotypic and abnormal repetitive behaviours are repetitive, invariant and (apparently)
129 functionless behaviours (Mason, 1991; Ödberg, 1978), that are never seen in animals under
130 natural conditions and are known to appear in captivity under sub-optimal conditions (Mason,
131 1991). In most species, the presence of such behaviours is associated with chronic stress
132 (Bashaw et al., 2001; Keiper, 1969; Meehan et al., 2004) and their emergence is linked to

133 repeated contexts of frustration (e.g. Fureix et al., 2011; Benhajali et al., 2014).
134 Environmental restrictions, including feeding (e.g. McGreevy et al., 1995; Nicol, 2000),
135 social (e.g. Cooper et al., 2000; Mills and Riezebos, 2005), spatial (e.g. McGreevy et al.,
136 1995; Parker et al., 2008) and working (Hausberger et al 2009) conditions appear as
137 facilitating factors, as is genetic influence (e.g. Vecchiotti and Galanti, 1986). Some horses
138 persist in performing these behaviours even after the conditions have improved, which means
139 that if one horse performs them in a stable, this does not mean the management practices are
140 inappropriate. However, the large number of horses involved here prevent the influence of
141 such particular cases on the statistically significant management practices. Their presence in
142 horses is associated with a decrease of learning abilities (Hausberger et al., 2007; Parker et al.,
143 2008) and fertility (Benhajali et al., 2014).

144 To facilitate the reading, we will define here the terms used in the following manuscript. We
145 call here “stereotypic behaviours” (SB) the sequences well-known in the horse industry (e.g.
146 weaving, cribbing) and “abnormal repetitive behaviours” (ARB) the sequences less (not)
147 described or recognized (Mills 2005, Mills et al, 2002). As they share the same definition
148 (repetitive and apparently functionless behaviours) and appear under sub-optimal conditions,
149 they were grouped in the subsequent analyses (SB/ARB). The 5 SB and the 9 ARB observed
150 or reported in this study are described below.

151 SB (from Mills, 2005; Lesimple and Hausberger, 2014):

- 152 - weaving: obvious lateral movement of head, neck, forequarters and sometimes hindquarters,
- 153 - cribbing / windsucking: the horse grasps a fixed object with its incisors, pulls backwards and
154 draws air into its oesophagus,
- 155 - head tossing / nodding: vertical movements of head and neck,
- 156 - striking with forelimb: the horse hits the door or wall with one of its forelegs,
- 157 - box walking: repetitive tracing a route within the stable.

158 ARB

- 159 - compulsive licking: licking of the same object in its environment (except the trough),
- 160 - compulsive biting: biting of the same object in its environment (except the trough),
- 161 - head movements (other than head tossing / nodding): movement of the head,
- 162 - Vacuum threats: the horse express threat sequences (kicking, biting) alone in its box,
- 163 - mouth open: the horse keeps its mouth open with a lateral movement of its neck,
- 164 - teeth rubbing: rubbing teeth on the upper part of the door,
- 165 - teeth chattering: mouth movement with teeth chattering,
- 166 - lips movements: clapping of lips,

167 - tongue movements: movements of tongue, inside or outside the mouth
168 In the present study, the observer (C.L) stood motionless at one end or in the middle of lines
169 of boxes so that she could see all horses. In many cases, the stables were disposed along
170 corridors with a row of stalls on each side. When positioned at the midline of the corridor, it
171 was therefore possible to easily see 4 stalls at a time. When the stables were so that the stalls
172 had an opening outside, it was generally possible to see 6 horses in a row. The sampling was
173 *ad libitum* (Altman 1974, Benhajali et al 2008, Lesimple & Hausberger 2014) which means
174 that the behaviours concerned were scored (in terms of presence/absence) everytime they
175 occurred together with the horse identity. For a behaviour to be considered as SB/ARB, the
176 behavioural sequence had to be repeated at least 3 times successively and observed 5 times,
177 independently of the period of observation. Most observations were performed at quiet times
178 (outside teaching activities) with little disturbance by the routine procedures. In any case, the
179 proportion of quiet and disturbed time periods was balanced between stables so that they
180 remained comparable. In total, each horse was observed for 18 hours. At the end of the
181 procedure, horses were binary scored: 1 if they performed at least one SB/ARB, 0 otherwise.

182

183 2.1.3. Postural measures

184 • Depressed-like posture (AbnPost) with or without wall orientation: Apathetic animals,
185 showing a strong decrease of reactions towards their environment, were described in several
186 situations when welfare was altered (Burn et al 2010a, 2010b, Popescu and Diugan 2013)
187 particularly in cases of proven pain (Hausberger et al 2016). Fureix et al (2012) were the first
188 to truly characterize this “depressive-like” state in riding school horses: the animals stand
189 immobile, eyes wide opened with a stretched neck (back and neck on the same line), an
190 unusual gaze, head and ears fixity, mostly backwards ears and a global indifference towards
191 environmental stimuli (visual, tactile and auditory, Fureix et al., 2012; Rochais et al. 2015,
192 subm) in their home environment. Such horses also show signs of anhedonia (Fureix et al
193 2015).

194 The prevalence of “depressed like posture” was evaluated at the same time as SB/ARB and
195 following the exact same procedure. At the end of the observation time (18h/horse, see
196 above), horses were binary classified: 1 if they presented at least once the “depressed-like”
197 posture” during the observation time, 0 otherwise.

198 • Ears position: Backwards ears position is reported in all cases of acute pain or
199 discomfort (Hausberger et al 2016 for a review, Waring, 2003) and has been shown to
200 indicate welfare impairment in horses (Fureix et al 2010, in prep). In these studies, a

201 predominant backwards ears position (>50% time) was related to an increased prevalence of
202 stereotypic behaviours and chronic health problems, while forwards ears indicated either a
203 positive human-horse relationship, an increased attentional state towards the environment and
204 overall a better welfare (Hausberger and Müller, 2002; Rochais et al., 2016, Waring, 2003).
205 Ears positions were defined by referring to studies on other species (Reefmann et al 2009):
206 axial ear (perpendicular to the head – rump axis), forward ear (tip of the ear towards the front
207 at an angle of more than 30° from the perpendicular) or backward ear (tip of the ear towards
208 the back at more than 30° from the perpendicular).
209 Ear positions were recorded whilst horses were foraging on the ground (hay/straw) only, as it
210 has been shown to be the most reliable context (Fureix et al 2010, in prep.). Observations
211 were performed when the stables were quiet, outside feeding and working time. The
212 experimenter walked slowly and regularly (1 step/sec) in the middle of the corridor, or 2m
213 away from the boxes in stables with one line of boxes. She approached slowly towards each
214 box in order to be able to see the ear positions through the trough opening or box's door,
215 remaining at a distance. This quiet approach did not elicit the strong reactions observed when
216 approaching suddenly at the box's door (Hausberger and Muller 2002). The instantaneous ear
217 position of the feeding horse was silently noted (only if the horse kept feeding and paid no
218 attention to the observer). The observer then resumed her walk along the midline up to the
219 next stall. These samplings were made every day for 3 consecutive days and distributed all
220 along the day until 10 ear positions were obtained per horse. The percentage of scans in each
221 position was calculated for each horse. For further analyses horses were binary categorized
222 according to their “favourite” ($\geq 60\%$) posture: mostly forwards ears / mostly backwards ears.
223 Asymmetric or side positions were considered as “neutral” and were in any case observed
224 much less often.
225 Based on these observations, each animal was binary classified for each of the welfare
226 impairment signal.

227

228 *2.3. Management parameters (Tables 1 and 2)*

229 All the horses involved in the study were under the responsibility of the riding schools and
230 subjected to the standard living conditions of the facilities. For the needs of the analyses, the
231 management parameters had to be categorical. All these management parameters are detailed
232 below.

233 2.3.1. Choice of horses: type of equids present

234 The **sex**, **age** and breed were recorded from the animals' official identification documents.
235 However, since most animals were unregistered, the 'breed' parameter could not be used as
236 such. Differences have been observed between types of equids (e.g. pony / horses,
237 "warmbloods"/ "coldbloods") in other studies (e.g. Wallin et al., 2000), meaning that above
238 breed, several types of equids may exist, that differ in different traits. Therefore, we
239 investigated two features: the equid's overall morphology, and its size. Using the parameters
240 described in Chabchoub et al (2004), we classified the animals into 3 categories, based on
241 their **proportion**: dolichomorphic (length>height, ex: thoroughbred, Arab purebred),
242 mesomorphic (length=height, ex: French saddlebred) and brachymorphic (length<height:
243 Merens horses). The animals were also divided into "classical" official **type**: pony (<1.48m
244 high at the withers, International Federation for Equestrian Sport) or horse (>1.48m high at
245 the withers) in the analyses. The impact of the animal's age was also investigated ([3-10], [11-
246 15], [16+] y.o.).

247 2.3.2. Housing conditions

248 The spatial restriction being an important aspect in horse welfare (Raabygmagle and Ladewig,
249 2006; Rivera et al., 2002; Parker et al., 2008) the **size of the boxes** and the **percentage of**
250 **time spent in paddock** were recorded for each individual. In France, standard boxes are 9, 12
251 or 16m² wide. As in this study, most boxes measured 9m², two categories were made: small
252 ($\leq 9\text{m}^2$) and big ($> 9\text{m}^2$). Depending of the facility, equids spent 0 to 83.3% ($\bar{X} \pm \text{es} = 19.5 \pm 1.3$)
253 of their time in paddocks. According to the data distribution, two profiles appeared: horses
254 went in paddock either less than 17% or more than 25% of their time. These values were used
255 to make the categories. The **bedding** (straw or shaving) (Pedersen et al., 2004), as well as the
256 box architecture and in particular the visual horizon of the horses (Benhajali et al., subm;
257 Cooper et al., 2000; Hausberger et al., subm), were recorded: thus it was noted whether equids
258 could **put the head outside the box** (entirely: open doors, limited: V shape doors, or not:
259 grids) and if the box was **open** to the outside or **inside** a building.

260 2.3.3. Social conditions

261 All the animals in this study could at least hear one congener. For each individual, we
262 recorded whether or not they could have **tactile contact** with one of their neighbours when in
263 the box, and we also recorded the **number of visible congeners** from inside the box (e.g.
264 Mills & Riezebos 2005). The number of visible neighbours was divided into 3 categories ([0-
265 1], [2-4], [5+]) according to the distribution of the data. When the animals had access to a
266 paddock, we also recorded whether they went **alone or in group**.

267 2.3.4. Feeding conditions

268 For each individual, the quantity and number of meals of roughage and concentrates was
269 recorded from the instruction documents of the facilities (*e.g.* Nicol, 2000). As in both cases,
270 the two parameters were strongly correlated (Spearman correlation test, $p < 0.0001$), only the
271 **number of meals**, giving information on the temporal distribution of feeding (Benhajali et al.,
272 2009, 2013; Fureix et al., 2011) were kept in the analysis. Based on the data distribution,
273 roughage availability was divided into 4 categories ([0]: no roughage, [1]: once/day, [2]:
274 twice/day, [3-10]: almost continuous) and concentrate availability into 3 categories ([0]: no
275 concentrates, [1-2]: few concentrates, [3-6]: large amount of concentrates).

276 2.3.5. Working conditions

277 First, we extracted the **time spent working/ week** for each equid from the official working
278 document of the schools. Based on the data distribution, 3 categories were made: [5-7], [8-
279 10], [11-14] h/week.

280 *2.4 Statistical analyses*

281 Logistic regressions models were used to assess the impact of the management factors on
282 each of the welfare indicators. The first step was the selection of the management factors that
283 would integrate the model, using univariate logistic regressions. Thus, each of the 15
284 management factors was tested on each of the 5 welfare indicators. For each welfare
285 indicator, all the factors with a p value < 0.2 were kept to build the logistic models. The
286 second step was to integrate the selected management factors in multivariate logistic
287 regression models with a stepwise function to settle the most explicative factor combination.
288 A F test was conducted to assess the significance of the management factors kept in the
289 model. The F value was used to assess the importance of the management factor in the model.
290 All the modalities of each management factor were defined by a coefficient (coef) and an Odd
291 Ratio (OR). The OR for the modality of reference (used as base in the analyses) is 1. The
292 other modalities are compared to this reference. The OR. was used to determine the
293 “direction” of action (increasing or decreasing the prevalence of the indicator) and the coeff
294 was used to assess the impact of the different modalities. To assess the relative importance
295 (RI) of each of the modalities of all management factors involved in the model, we used the
296 exponential function of the coefficient. Each OR was accompanied with a 95% Confidence
297 Interval (IC). If 1 was comprised in the IC, the modality could not be considered as
298 significant.

299 In a first step, we did simple models without taking into account interactions. Then, as ponies
300 are traditionally kept under less constraining conditions, we included the interactions between

301 the type of equine (pony/horse) and the other management practices. All the interactions with
302 a p value <0.2 were kept in the models.

303 Chi square post hoc tests were used to assess further differences between several modalities of
304 the same management factor.

305 All the statistical analyses were made using R 3.1.1. software.

306

307 **4. Results**

308 To facilitate the reading, when describing the logistic regression models, only the significant
309 parameters will be presented.

310 *4.1. Study 1: Impact of life conditions and choice of equids*

311 4.1.1. Population

312 For the first part of this study, 306 horses (2 stallions, 177 geldings and 127 mares) of various
313 ages (3-34y.o, $\bar{X} \pm se = 12.2 \pm 0.28$) and breeds (N=23, mostly unregistered horses: 36.6% and
314 French Saddlebreds: 26% with smaller proportions of other breeds) in 20 riding schools all
315 over France ($\bar{X} \pm se = 15.3 \pm 0.48$ horse/school) were observed. Most of the animals were horses
316 (>1.48m at withers, N=191, 62.4%) and 115 (37.6%) were ponies (<1.48m at withers)
317 Amongst these 306 horses, 67.6% (N=207) presented equipment-related wounds, 35%
318 (N=107) expressed at least one STB/ARB, 38% (N=116) had mostly backwards ears (>60%
319 time) (36% (N=110) had mostly forwards ears) and 41.5% (N=127) presented a “depressed-
320 like” posture in the box.

321

322 4.1.2. Presence of equipment-related wounds

323 Three main management parameters appeared to have a significant impact on the prevalence
324 of equipment-related wounds: the time spent in paddock (F=7.77, p=0.003), the type of
325 equine (F=4.59, p=0.02) and the number of hay meals (F=3.75, p=0.01).

326 Thus, animals that spent less time in paddock (Odd Ratio [Interval of Confidence] = 2.37
327 [1.35-4.18]), were of horse type (OR [IC] = 1.87 [1.1-3.2]) and received few (0: OR [IC] =
328 2.44 [1.03-5.80], or 1: OR [IC] = 2.29 [1.26-4.16]) hay meals were more prone to have
329 wounds. On the contrary, there were less such wounds in animals that spent more than 25% of
330 time in paddock (reference modality, OR=1), being a pony (OR=1) and having 2 hay meals
331 (OR=1) (Table 1.).

332 The most important parameter appeared to be the time spent in paddock (RI=2.36), followed
333 by the number of hay meals (RI=2.29) and the type of equid (RI=1.88).

334 When interactions were included in the model, it appeared that horses were more prone than
335 ponies to have wounds if they spent less than 25% time in paddocks (F=3.97, p=0.05, OR
336 [IC]=3.27 [1.1-9.69]).

337

338 4.1.3. Presence of SB/ARB

339 Four parameters appeared to impact the prevalence of SB/ ARB: the time spent in paddock
340 (F=14.12, p=0.0002), the type of equine (F=8.6, p=0.004), the possibility to put the head
341 outside the box (F=4.31, p=0.01) and the number of concentrate meals (F=3.25, p=0.04).

342 The animals that spent less time in paddock (OR [IC] =3.69 [1.88-7.22]), were of horse type
343 (OR [IC] = 2.56 [1.39-4.69]), could put the head outside the box (OR=1) and had more
344 concentrate meals (OR=1) were more prone to develop SB/ARB. On the contrary, spending at
345 least 25% time in paddock (OR=1), being a pony (OR=1), having limited (OR [IC] = 0.44
346 [0.22-0.85]) or no (OR [IC] = 0.38 [0.15-0.96]) possibilities to put the head outside the box
347 and having no concentrate meals (OR [IC] = 0.12 [0.01-0.95]) reduced the risk of developing
348 SB/ARB.

349 The most important parameter appeared to be the number of concentrate meals (RI=8.67),
350 followed the time spent in paddock (RI=3.71), the possibility to put the head outside the box
351 (RI=2.66), and the type of equid (RI=2.56).

352 When integrating interactions in the model, it appeared that being released alone in paddock
353 increased more the risk of presenting SB/ARB for horses than for ponies (F=4.37, p=0.01, OR
354 [IC] = 5.30 [1.34-20.99]).

355

356 4.1.4. Ear positions

357 As the ear positions were recorded only when horses ate roughage or straw, the parameter
358 related to roughage (number of hay meals), was not included in the following analyses.

359 *Prevalence of backward ears*

360 Only one management parameter appeared to be significant concerning the backward ears
361 position: the number of visible neighbours (F=5.38, p=0.005). Horses that were allowed
362 limited visual contacts with congeners ([0-1] visible neighbours: OR [IC] = 3.68 [1.76-7.71];
363 [2-4] visible neighbours: OR [IC] = 2.08 [1.01-4.30]) presented more backwards ears. On the
364 contrary, horses that could see more than 5 congeners (OR=1) had less backward ears position
365 (Table 1.).

366 Seeing [0-1] neighbours appeared to be more important (RI=3.67) than seeing [2-4]
367 neighbours (RI=2.08).

368 The exact opposite results appeared for predominant forwards ears.

369 No interaction emerged for these models.

370

371 4.1.5. Presence of “depressed-like” posture in the box

372 No clear management parameter emerged as being especially influential here ($p > 0.05$ in all
373 cases). It may be because this “syndrome” results from a combination of varied factors or
374 because an important management factor was not examined here.

375

376 *4.2. Study 2: Integrating working conditions*

377 4.2.1. Population

378 A subset of 276 horses out of the 306 animals mentioned above, coming from 17 of the 20
379 riding schools ($\bar{X} \pm se = 16.2 \pm 2.1$ horse/school) could be observed during beginners’ riding
380 lessons. This second group was constituted of 118 mares, 158 geldings, aged 3-30 y.o. ($\bar{X} \pm se$
381 $= 11.8 \pm 0.3$) from 23 breeds (39% unregistered, 27% French Saddlebreds and smaller
382 proportions of other breeds). Most of the animals were horses (N=163, 59%) and 113 (41%)
383 were ponies. The riding lessons were recorded using a Sony HDR-XR105® camera with the
384 protocol developed in Lesimple et al. (2010). Each time the horse-rider couple crossed
385 perpendicularly the camera’s field of vision, we recorded the rider’s hands’ height and reins
386 length, shown as reliable predictors of vertebral disorders in Lesimple et al. (2010)’s study.
387 From these observations, we calculated the time horses were ridden with **high hands** and
388 **short reins**. Based on the data distribution, 3 categories were made for each of the parameters
389 (Table 1).

390 On the 276 horses observed in this part of the study, 35.9% (N=99) expressed at least one
391 SB/ARB, 71.4% (N=197) presented wounds linked to bad fitted equipment, 40.2% (N=111)
392 had mostly (>60% time) backwards ears, 34% (N=94) had mostly (>60% time) forwards ears
393 and 41.3% (N=114) presented a “depressed-like” posture in the box. This subset was
394 therefore representative of the whole population.

395

396 4.2.2. Presence of equipment-related wounds

397 Five of the investigated management parameters appeared as significant on the prevalence of
398 equipment-related wounds: the type of equine (F=9.05, $p=0.003$), the time ridden with short
399 reins (F=6.11, $p=0.003$), being released alone or in group (F=5.26, $p=0.023$), the number of
400 visible congeners (F=3.47, $p=0.033$) and the number of concentrate meals (F=5.13, $p=0.007$).

401 Animals ridden more than 40% of time with short reins were more at risk to develop
402 equipment-related wounds ([40-65] %: (OR [IC] = 4.97 [1.66-14.89]) or [73-93] % : (OR [IC]
403 = 6.93 [2.36-20.38]), than those ridden [33-39] % time with short reins (Table 1.) (Fig. 2).
404 The animals ridden more than 70% with short reins (OR [IC] =6.93 [2.36-20.38]), fed [3-6]
405 meals (OR [IC] =5.69 [1.79-18.08]), released alone in paddock (OR[IC]=3.34[1.18-9.39]),
406 and horse type (OR[IC]= 2.82[1.45-5.46]) were more prone to develop equipment related
407 wounds.

408 Being ridden more than 70% of the time with short reins appeared as the most important
409 factor (RI: 6.96), followed by the number of concentrate meals (RI: 5.70), being ridden more
410 than 40% time with short reins (RI: 4.95), the number of visible neighbours (RI: 3.63) and
411 being a horse (RI: 2.83).

412

413 4.2.3. Presence of SB/ARB

414 Seven management parameters appeared to significantly impact the prevalence of SB/ARB:
415 the type of equine (F=17.32, p<0.0001) (Fig. 3.), the time ridden with short reins (F=12.49,
416 p<0.0001), the box size (F=10.5, p=0.001), the litter (F=4.16, p= 0.04), the possibility of
417 putting the head outside (F=3.13, p=0.045) and the number of hay meals (F=3.11, p=0.027).

418 Animals ridden [40-65] % of the time with short reins were more prone to develop SB/ARB
419 than those ridden [33-39] % of the time with short reins (Table 2.).

420 The animals ridden [40-65] % time with short reins (OR [IC] =6.5 [1.66-25.27]), with shaving
421 litter (OR [IC] =6.33 [1.11-36.2]), fed only 1 hay meal (OR[IC]= 4.47[1.05-18.99]), o f horse
422 type (OR[IC]= 4.19[2.08-8.46]), and released alone in paddocks (OR[IC]=3.63[1.47-8.97])
423 were more prone to develop stereotypic behaviours..

424 The number of hay meals appeared as the most important parameter (RI: 5.99), followed by
425 the possibility of putting the head outside the box (RI: 5.31), the type of equine (RI: 4.62), the
426 box size (RI: 4.18), the modality of paddock release and the litter (RI: 3.63 for each) and the
427 time ridden with short reins (RI: 2.69).

428

429 4.2.4. “Depressed-like” posture in the box

430 Although riding parameters had no direct influence, when they were included in the analysis,
431 the proportion of animals presenting them tended to change according to these parameters
432 (F=2.33, p=0.09). However, as this factor is not statistically significant, it was not possible to
433 go further in the statistics and to determine the impact, positive or negative, of each modality

434 (dolichomorphic, mesomorphic, brachymorphic) on the prevalence of the depressed-like”
435 posture.

436

437 **5. Discussion**

438 This study is, to our knowledge, the very first to investigate in details the relative impact of
439 several management parameters, including working conditions, type of equines and detailed
440 housing, feeding and social conditions on different expressions of welfare alteration in the
441 same population of horses. The prevalence of equipment related wound was very high,
442 compared to other studies (Burn et al., 2010a: 2-53%; Pritchard et al., 2005: 13.2-31.9% of
443 the horses, depending on the location of the lesions), whilst the welfare indicators recorded
444 were in accordance with previous studies (SB/ARB, observational studies: Benhajali et al.,
445 2010; Hausberger et al., 2007, 2009; Lesimple and Hausberger, 2014; Visser et al., 2008;
446 Waters et al., 2002: 22-96.6%; “depressed-like posture”: Burn et al., 2010a: 2-63%; Fureix et
447 al., 2012: 24%).

448 Amongst the 17 management parameters investigated, 13 influenced significantly at least one
449 of the welfare indicators recorded. When the riding parameters were not taken into account,
450 our results confirmed the importance of feeding (Benhajali et al., 2008; Cooper et al., 2005;
451 Jonsson and Egenval, 2006; Murray et al., 1996; Nicol et al., 2005; Tinker et al 1997),
452 paddock release (Christensen et al., 2002; Heleski et al., 2002; Visser et al., 2008) and social
453 opportunities (Christensen et al., 2002; McAfee et al., 2002; Mills and Riezebos, 2005), and
454 highlighted the emergence of often under-estimated parameters such as the type of equid and
455 the possibility to put the head outside the box. The relative importance of each management
456 parameter varied according to the welfare indicators concerned: the time spent in paddock,
457 type of equids and feeding conditions appear as particularly relevant concerning the
458 prevalence of SB/ARB and equipment-related wounds, whereas visual social opportunities
459 was the only criterion emerging for the ear position when feeding, and no particular parameter
460 emerged to explain the “depressed-like” posture. When including the riding parameters, they
461 appeared as the second most influential parameter, just after the type of equid, and before the
462 paddock release, the feeding and social parameters. It is thus very important to include riding
463 parameters when investigating welfare in riding horses. Previous epidemiological surveys
464 investigating the impact of management parameters were mainly focused on the prevalence of
465 SB/ARB and based upon questionnaires. However, despite the methodological differences, a
466 roughage based diet with regular meals, less constraining working methods, and an increased
467 time spent in paddock were consensually identified as protecting from SB/ARB emergence

468 (Normando et al., 2011; McGreevy et al., 1995). In addition, in McGreevy et al. (2005)'s
469 study, when there were grilles or bars between the stalls, horses were less prone to develop
470 any SB/ARB.

471 In general, our population presented a high prevalence of welfare impairment signals
472 (wounds, SB/ARB, “depressed-like” posture and backwards ears). The proportion of horses
473 suffering equipment-related wounds was higher than those observed in horses working in
474 developing countries (Burn et al., 2010a, 2010b). In these studies, only “severe” lesions were
475 recorded, i.e. involving more or less deep incision of the skin. In our study, no severe lesion
476 was seen, but all the minor flesh lesions including hairs used but skin not incised were
477 recorded, which could explain the differences between the evaluations.

478 Trying to give the horse a living environment the more alike natural conditions is part of
479 welfare improvement. Thus, it is commonly recognised that a roughage based diet has a
480 positive impact on horses' welfare, both from a behavioural (Benhajali et al., 2008; Cooper et
481 al., 2005; Tinker et al., 1997; Jonsson and Egenvall, 2006) and physiological (e.g. Harris,
482 2007; Nicol, 2000; Nicol et al., 2002) point of view. The dietary physiology of horses is
483 adapted to a high fibre / low energetic intake (Harris, 2007; Martin-Rosset, 2008) and
484 according to most authors, the high prevalence of concentrates and the lack of roughage (i.e.
485 fibres) in the diet of domestic horses is related to a high occurrence of colic, gastric
486 ulcerations, laminitis (Tinker et al., 1997; Jeffcott et al., 1986; Murray et al., 1996; Jonsson
487 and Egenvall, 2006) and SB/ARB (Bachmann et al., 2003; McGreevy et al., 1995; Nicol
488 1999). In our study, horses that received more roughage meals were less prone to develop
489 SB/ARB, and those that received more concentrates were more prone to have equipment-
490 related wounds. This second relation is less intuitive. Two reasons however may explain this
491 relation: firstly concentrates are highly energetic (Martin Rosset 2008; Tinker et al 1997), and
492 secondly being stuck in a 9m² space increases the risk of active locomotion patterns when
493 outside the box (Lesimple et al., 2011). Thus, both the overflow of energy due to concentrates
494 and motion restriction related to box housing might increase the undesired behaviours and
495 unwillingness to slow down at work, leading the riders to have stronger actions on the bit,
496 through the reins. The possibility also exist that overfed horses become fat, and develop
497 wounds at the level of the girth. The opportunity to move freely is an important feature of
498 horses' life: under natural conditions and when allowed to, horses spend in average 90% of
499 their time grazing (Waring 2003), which means eating while walking (Haupt, 2005). Most of
500 the authors agree that living in a paddock or pasture is more appropriate than living in a box:
501 horses housed in paddocks are less aggressive towards humans (Rivera et al., 2002) and

502 develop less SB/ARB (Chaya, 2006; Christensen et al., 2002) than those housed in boxes. This
503 is in accordance with our study: the more horses spent time in a paddock, the less they were
504 prone to develop SB/ARB. The ability to move freely when in paddocks might also explain
505 the lower prevalence of equipment-related wounds: horses having the opportunity to move
506 freely most of the day, they may be less impacted by the working constraints. On the other
507 hand, horses housed in single box, whose only opportunity to move is when ridden could be
508 more reluctant to obey when at work. Increasing social inputs was also shown as improving
509 horse welfare (McAfee et al., 2002; Mills & Riezebos, 2005). Thus, horses housed with
510 congeners are less prone to develop SB/ARB (Christensen et al., 2002; Visser et al., 2008)
511 and increasing the possibility of visual contact (Mills and Riezebos, 2005; McGreevy et al.,
512 1995) has been shown to have, to a lesser extent, the same positive effect. This is in
513 accordance with our findings, that horses released in paddock with congeners are less prone to
514 develop SB/ARB and wounds, and that increasing visual contacts favours forward ear
515 position. However, increasing visual horizon towards moving congeners or inaccessible space
516 might increase horses' frustration, whereas close contact to the neighbours (through grids for
517 example) might be more positive (Benhajali et al., 2014; Hausberger et al., in prep; Mills and
518 Riezebos, 2004), which could explain the lowest risks for stereotypic behaviours when horses
519 could not put the head outside (those that did were in general in indoor barns where they faced
520 several congeners at close distance). Working conditions are known to impact horses' welfare
521 (Burn et al., 2010a; Hausberger et al., 2009, 2011; Lesimple et al., 2010; 2012; Fonseca et al.,
522 2006; Visser et al., 2014), but, apart from veterinarian studies, rarely taken into account as
523 part of the management parameters. If the effect of the discipline has already been
524 investigated (Fonseca et al., 2006; Hausberger et al., 2007, 2011), the impact of restrictive
525 riding techniques (short reins and high hands leading to an increased pressure in the horse's
526 mouth and on its neck, Lesimple et al 2010, subm.) has recently been shown as crucial for the
527 prevalence of back disorders (Lesimple et al., 2010, 2012). Here the data confirm earlier
528 findings showing that beginners in riding lessons may alter the spine of the horse (and its
529 mouth) by in particular riding with high hands and tensed short reins (Lesimple et al., 2010,
530 subm). It is crucial that riding teachers be made aware of this as they can thus put more
531 emphasis on riders' positions during lessons (Lesimple et al 2010, in prep). This study
532 highlights that restrictive riding appears amongst the two most important parameters in the
533 emergence of SB/ARB and equipment-related wounds. More interesting still is the fact that
534 when adding the working conditions, not only the models are strengthened but also, the type
535 of equine and the riding techniques (time riders spend with short reins) appear as the two most

536 important factors involved in welfare impairment, and interactions emerged between these
537 two parameters. Thus, in addition of being more prone to develop stereotypic behaviours and
538 wounds than ponies, horses are also more sensitive to harmful riding techniques and
539 constraining life conditions. Finally, this study confirms the low impact of sex (Fureix et al.,
540 2010, 2011; Hausberger et al., 2004; Lesimple et al., 2010, 2011, 2012) and age (Cooper et
541 al., 2000; Fonseca et al., 2006; Fureix et al., 2010, 2011; Hausberger et al., 2004; Haussler et
542 al., 1999; Lesimple et al., 2010, 2011, 2012) on horse welfare. However, even if it was not
543 possible to test a potential breed effect here despite its interest (Hausberger et al 2004;
544 Lesimple et al 2011), we show for the first time that in these domestic situations, horses are
545 more at risk to develop stereotypic behaviours and wounds than ponies, which may reflect
546 more difficulties dealing with sub optimal conditions.

547 These results highlight the multifactorial nature of welfare, both in terms of causes and of
548 consequences on the animals. It is thus of primary importance to take into account the whole
549 management (not in a parameter by parameter approach) and several modalities of welfare
550 expression when trying to investigate the quality of a system. This study allows the
551 classification of management parameters leading to potential “positive” management
552 strategies and enabling to identify “at risk” management strategies in terms of welfare, based
553 on scientific evidence on a large population of horses, and highlights the key points
554 professionals should take care of to improve their horses’ welfare.

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561 **7. Ethical note**

562 This study complies with the French laws related to animal experimentation and the European
563 directive 86/609/CEE and were approved by the University of Rennes 1 local Animal Care
564 Committee any time approval was needed. Horse husbandry and care were under management
565 of the riding schools: the horses used in this experiment were not research animals.

566

567

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784

785 **Tables**

786

787 Table 1. F values and Odd Ratio of the management parameters and their different modalities
 788 included in the logistic regression model of each welfare indicator. The welfare indicators are
 789 presented in column and the management parameters in lines. To read the logistic regression
 790 model for each indicator, the table has to be read in columns.

791

		SB/ARB F OR [IC]	Wounds F OR [IC]	Backw. Ears F OR [IC] ^b	Forw. Ears F OR [IC] ^b
Individual informations	Type	8.60 **	4.59*		
	Horse pony	2.56 [1.39-4.69] 1	1.87 [1.1-3.2] 1		
Housing conditions	Type of door	4.31*			
	Yes	1			
	Lim	0.44 [0.22-0.85]			
	No	0.38 [0.15-0.96]			
Feeding conditions	Time in paddock	14.12***	7.77***		
	[0-16.14]	3.69 [1.88-7.22]	2.37 [1.35-4.18]		
	[25-83]	1	1		
Social possibilities	Visual contact			3.36 *	3.38*
	[0-1]			3.68 [1.76-7.71]	0.42 [0.21-0.86]
	[2-4]			2.08 [1.01-4.30]	0.4 [0.2-0.77]
	[5-more]			1	1
Feeding conditions	No hay meals		3.75**		
	[0]		2.44 [1.03-5.80]		
	[1]		2.29 [1.26-4.16]		
	[2]		1		
	[3-10]		0.45 [0.14-1.45]		
	No concentrate meals	3.25*			
[0]	0.12 [0.01-0.95]				
	[1-2]	1			
	(3-6)	0.64 [0.34-1.2]			

792

793 F: F value. * p<0.05, **p<0.01, ***p<0.005

794 OR IC[]: Odd Ratio and Confidence Interval.

795 For the presence of SB/ARB, Wounds, Abn Post, and Backw. Ears modalities with OR<1 are increasing horses' welfare

796 For the Forw. Ears, modalities with OR>1 are increasing horses' welfare

797

798

800 Table 2. F values and Odd Ratio of the management parameters, including riding parameters
 801 on the presence of SB/ARB, wounds and abnormal postures. The welfare indicators are
 802 presented in column and the management parameters in lines. To read the logistic regression
 803 model for each indicator, the table has to be read in columns.

		SB/ARB F OR [IC]	Wounds F OR [IC]	Abn Post F OR [IC]
	Proportion			2.33 °
	Dolicho.			
	Meso.			
	Brachy.			
	Type	17.32 ***	9.05 ***	
	Horse	4.19 [2,08-8,46]	2.82 [1.45-5.46]	
	Pony	1	1	
	Box's size	10.47 **		
	Large	1		
	Small	0.18 [0,07-0,5]		
	Litter	4.16 *		
	Straw	1		
	Shaving	6.33 [1.11-36.2]		
	Type of door	3.13 *		
	Yes	1		
	Lim	0.38 [0.16-0.86]		
	No	0.37 [0.12-1.17]		
	Tactile contact			
	Yes			
	No			
	Visual contact		3.47 *	
	[0-1]		0.27 [0.1-0.75]	
	[2-4]		0.50 [0,17-1,41]	
	[5-more]		1	
	Paddock release	8.29 ***	5.26 *	
	Alone	3.63 [1.47-8.97]	3.34 [1.18-9.39]	
	Group	1	1	
	No hay meals	3.11 *		
	[0]	4.04 [1.57-23.22]		
	[1]	4.47 [1.05-18.99]		
	[2]	1		
	[3-10]	0.22 [0.01-2.85]		
	No concentrate meals		5.13 **	
	[0]		3.60 [0.52-24.65]	
	[1-2]		1	
	[3-6]		5.69 [1.79-18.08]	
	Short reins	12.49 ***	6.11 ***	
	[33.64-38.33]	1	1	
	[40-64.60]	6.47 [1.66-25.27]	4.97 [1.66-14.89]	
	[73.13-93.54]	0.98 [0.21-4.48]	6.93 [2.36-20.38]	

804

805 F: F value. * p<0.05, **p<0.01, ***p<0.005

806 OR IC[]: Odd Ratio and Confidence Interval.

807 For the presence of SB/ARB, Wounds, Abn Post, and Backw. Ears modalities with OR<1 are increasing horses'
 808 welfare

809 For the Forw. Ears, modalities with OR>1 are increasing horses' welfare

810

811 **Figure captions**

812 Fig. 1. Distribution of the number of hay meals amongst our population of horses: example of
813 categories. The points in black represent the number of horses for each number of meals. The
814 circles in grey represent the categories built on the basis of the data distribution.

815 Fig. 2. Proportion of horses with and without equipment-related wounds according to the time
816 ridden with short reins. The proportion of horses presenting wounds equipment-related
817 increases with the time ridden with short reins.

818 Fig. 3. Proportion of horses with and without SB/ARB according to the number of hay meals.
819 The proportion of horses with SB/ARB decreases when the number of hay meals increases.

820