Stall architecture influences horses' behaviour and the prevalence and type of stereotypies

Clémence Lesimple, Emmanuel Gautier, Haïfa Benhajali, Céline Rochais, Christophe Lunel, Samia Bensaïd, Adala Khalloufi, Séverine Henry, Martine Hausberger

▶ To cite this version:

Clémence Lesimple, Emmanuel Gautier, Haïfa Benhajali, Céline Rochais, Christophe Lunel, et al.. Stall architecture influences horses' behaviour and the prevalence and type of stereotypies. Applied Animal Behaviour Science, 2019, 219, pp.104833. 10.1016/j.applanim.2019.104833 . hal-02277005

HAL Id: hal-02277005

https://univ-rennes.hal.science/hal-02277005

Submitted on 31 Mar 2021

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Clémence Lesimple, Emmanuel Gautier, Haïfa Benhajali, Céline Rochais, Christophe Lunel, et al.. Stall architecture influences horses' behaviour and the prevalence and type of stereotypies. Applied Animal Behaviour Science, Elsevier, 2019, 219, pp.104833. ⟨10.1016/j.applanim.2019.104833⟩. ⟨hal-02277005⟩

Authors' post-print

Editor's version available at the following:

10.1016/j.applanim.2019.104833

BY NC ND

Authors' post-print

Stall architecture influences horses' behaviour and the prevalence and type of stereotypies

Clémence Lesimple[1], Emmanuel Gautier[2], Haïfa Benhajali[2¤], Céline Rochais[1], Christophe Lunel[2¤¤], Samia Bensaïd[3] Adala Khalloufi[3], Séverine Henry[1], Martine Hausberger[4]*

[1] Univ Rennes, Normandie Univ, CNRS, EthoS (Éthologie animale et humaine) - UMR 6552, F-35380 Paimpont, France

[2] Univ Rennes, Normandie Univ, CNRS, EthoS (Éthologie animale et humaine) - UMR 6552, F-35000 Rennes, France

3 Ecole Superieure d'Agriculture du Boulifa 7119, Le Kef, Tunisie

[4] CNRS, Univ Rennes, Normandie Univ, EthoS (Éthologie animale et humaine) - UMR 6552, F-35380 Paimpont, France

Corresponding Author :
Clémence Lesimple
UMR 6552 Ethologie animale et humaine
Station Biologique de Paimpont
35380 Paimpont – France
clemence.lesimple@univ-rennes1.fr,
tel. +33 2 99 61 81 58,

Authors' post-print

Current addresses:
¤: Department of Animal Breeding & Genetics, Interbull Centre, HGEN, Box 7023, 75007 Uppsala, Sweden
¤¤: UMR INRA 1349, IGEPP, Université de Rennes1, Rennes, France

ABSTRACT

Despite the spatial and social restrictions it causes, single stall housing still prevails in sport and riding school horses, leading to the emergence of abnormal behaviours such as stereotypic or abnormal repetitive behaviours (SB/ARB). In the present study, we investigated the impact of the type (visual/tactile) and amount of social information that could be exchanged (*i.e.* distance between the individuals) on the expression of welfare indicators, including, but not limited to, STB. Additional observations were made on the production of snorts, recently described as a potential indicator of positive emotions, according to the type of stall horses were housed in. Two complementary studies were performed. One observational study on 32 sport horses, all living in the same place, being of the same breed and sex, whose aim was to compare the behaviours of horses maintained for a long time in two types of stalls differing mostly in the possibilities of contact with close neighbours versus looking outdoors. The second, experimental study, consisted in moving purebred Arab broodmares from one condition to another randomly every day for 66 days, the two types of stalls differing only by the possibility or not to put the head outside above the open top half door. The results show clear statistical relations between stall architecture and horses' behaviour, especially STB, their prevalence and type differing according to the type of stall in both studies. Overall, the access to outdoor visibility and its degree (possibility to put the head out or not) had a major effect on the horses' behaviours, which was the same in both studies, despite the differences between populations in terms of breed, sex and type of work. The experimental study also reveals that changes in behaviours can be rapid after a change of housing.

Keywords: stereotypic / abnormal repetitive behaviours, time budget, housing, welfare, horse

Authors' post-print

1 - INTRODUCTION

Constant single stall housing (e.g. more than 20h/day) remains predominant in the global horse industry, and more particularly in sport and riding schools horses, and was related to the prevalence of stereotypic or abnormal repetitive behaviours (SB/ARB in the following manuscript) in questionnaire-based (e.g. McGreevy et al 1995) and observational (Lesimple et al 2016) epidemiological studies.

Beyond spatial, hence movement, restriction, this housing is also associated with a lack of social contact, one of the major sources of emergence of stereotypic behaviours in social captive/domestic species (*e.g.* Mason 1991). Parent-raised parrots, when separated, develop stereotypies when singly housed but not if they are housed in pairs (Meehan et al, 2003). Similarly, Visser et al (2008) found, in young horses stabled for the first time, that 67 % of young warmblood horses housed in single stalls developed stereotypic behaviours in the two first weeks after their first stall housing while pair housed animals did not. Moreover, the singly housed young horses were more agitated (increase of vigilance, neighing, pawing, nibbling) while paired horses spent more time eating. A study on adult mares also showed that broodmares with foals, thus having social interactions, expressed 5 times less stereotypic behaviours than their without-foal neighbours housed in the same conditions (Benhajali et al 2010). Singly housed horses and starlings are ready to "work" to obtain direct (Lee et al 2011), even if partial (Sondergaard et al 2011) or mimicked (picture: Perret et al 2015) social contact. In a variety of species (long tailed macaques: Crockett et al 1994; baboons: Kessel & Brent 2001), the increase of social opportunities also decreases the frequency of STB, even if social opportunities are slight (horses: naso-nasal/visual contact, Cooper et al 2000, Mills & Davenport 2002), or mimicked (horses: mirror: Kay & Hall 2009; Mills & Davenport 2002, conspecific picture: Mills & Riezebos 2005). In horses, this is also associated with a decrease of stress and excitation behaviours (vigilance, active locomotion) and an increase of behaviours reflecting calmness (resting, foraging), even in horses with a long history of stereotypic behaviours (e.g. weaving, Mills & Davenport 2002). It is well admitted that SB/ARB reflect chronic stress in captive and domestic animals (Mason 1991) and hence are reliable indicators of compromised welfare. In horses, the expression of SB/ARB is associated with lowered cognitive abilities (Hausberger et al 2007, Parker et al 2018) and fertility (Benhajali et al 2014). Thus, despite the

Authors' post-print

fact that STB may help horses cope (Fraser et al 1997), their efficiency in terms of coping remains to be demonstrated (e.g. Fureix et al 2013).

On the other hand, horses are also ready to work for access to a paddock even if alone as compared to being in a single stall, showing that movement restriction, and especially free movement (no motivation for constrained locomotion) is also a behavioural /physiological need (Lee et al 2011, Gorecka-Bruzda et al 2013). It has been proposed that captive laboratory animals, that experience high levels of spatial restriction, appear to develop motor STB related to flight attempts (mice: Lewis & Hurst 2004, Würbel et al 1996, 1998, starlings: Feenders 2012). Similarly in horses, it has been suggested that weaving, a well-known locomotor stereotypic behaviour, would particularly reflect the frustration of not being able to go out of the stall (Mills 2005).

Several authors stated that the nature and degree of frustration experienced might modulate the emergence, type and prevalence of STB. For example, Bergeron et al (2006) proposed that oral STB are mostly related to feeding frustration. In horses, beyond some potential genetic sensitivity (*e.g.* reviews in Houpt & Kusunose 2001, Hausberger & Richard-Yris 2005), large discrepancies have been found in terms of type and prevalence of stereotypies between studies or facilities (Lesimple & Hausberger 2014), that cannot be solely attributed to breed effects. Thus, different types of STB were found according to the type of work horses of a same sex and breed (all selected from show jumping bloodlines) living in a same site (with identical life conditions) performed. Dressage horses, that experience higher constraints at the head/mouth level, performed more STB, and especially more repetitive head movements (head shaking/tossing/nodding), potentially associated with nuchal ligament lesions (Cook 1999, 2003), and cribbing/windsucking, potentially related to teeth and gastric disorders (Mills 2005). However, vaulting, eventing and jumping horses performed less and “milder” forms of stereotypies (repetitive licking, tongue movement) (Hausberger et al 2009). Ödberg (1978) in particular, proposed that stereotypic behaviours emerge through the repetition of actions aiming at reducing the frustration/discomfort, leading to chronic repetition of particular behaviours. This could explain why different types of repetitive behaviours may emerge as a consequence of the type of restriction the individual experiences. Overall, these findings suggest that there is indeed flexibility in the expression of these behaviours and

Authors' post-print

that changes in the environment may be associated not only in changes in the frequency but also in the types of stereotypic behaviours.

Environmental “enrichments” are often proposed but in order to be efficient, they need to correspond to the animal’s needs (*e.g.* Mason 1993). Thus, increasing cage size did not prevent young gerbils from developing stereotyped sand digging, whereas providing an adequate burrow substitute, even in a small cage, did (Wiedenmayer, 1996a, 1996b). Raised resting platforms, added as environmental enrichment in the cages of shelter dogs and young silver foxes, were derived from their initial purpose and mostly used by the animals to obtain a visual access to the neighbours (dogs: Hubrecht 1993, silver fox: Monomen 1933 in Newberry 1995). Increasing visual horizons, and in particular providing a view of the outdoors, either real or as videos resulted in an increase of locomotor STB in starlings (Feenders et al 2012, Coulon et al 2014). In horses, providing a visual access to the outdoors -and potentially to unreachable congeners- led to an increase of vigilance (*i.e.* alarm posture, Kiley-Worthington 1976) (Cooper et al 2000), and appeared amongst the primary factors of STB emergence in an epidemiological observational study conducted on more than 300 horses (Lesimple et al 2016).

Only few experiments, often conducted on a small number of horses, investigated how stall architecture (visual horizon and type and amount of social opportunities) impacts horses’ behaviour. With the present study, we hypothesized that the visual horizon and the type of social contact (visual/tactile, distant/close) provided modulates horses’ behaviour and especially the expression of welfare indicators, in particular the type and frequency of STB. In order to test this hypothesis, we performed two main studies: (1) an observational study on 32 sport horses of same sex, breed and discipline living at a same facility (same management conditions) but housed in two different types of stalls: Open Stalls (OS, possibility to put their head out), or Grid Stalls (GS), enabling to see close neighbours but with no outside view); (2) an experimental study on 42 broodmares of same breed, living at a same facility (same management conditions), spending the day in paddocks and nights in single stalls. For the study, they were randomly assigned for the night in one out of two types of “external” stalls: Open Stalls (OS, possibility to put their head out) or Grid Stalls (GS, no possibility to put their head out). In addition, and given the recent discovery of a putative acoustic indicator of well-being

Authors' post-print

(Stomp et al 2018), we added a short later study on acoustic signals produced according to stall architecture on site 1.

2 – EXPERIMENT 1: observational study in sport horses

In order to detect a potential effect of stall architecture on horses' welfare, we first conducted observational studies in horses that had lived for at least 6 months in the same type of stall. All horses included in the two sessions were under the care of the veterinarian of the Ecole Nationale d'Equitation (Saumur, France) and were free from any health disorder.

2.1 – Material & Methods

2.1.1 – Session 1: Behavioural observations

2.1.1.1. Subjects and housing conditions

Thirty-two French Saddlebred geldings, aged 6-19 years ($\bar{X}$ ±*se*= 10.03 ± 0.12), all working in dressage, were observed at the "Ecole Nationale d'Equitation" (ENE) at Saumur in August 1994. Horses were kept in straw bedded single stalls, fed three daily concentrate meals, provided hay once a day (morning), with *ad-libitum* water access. All of them also had 1-hour riding exercise every day.

Thus, all horses shared the same environmental conditions, were of the same sex and breed with management condition differing only in terms of type of stalls they lived in, while the surfaces of the stalls were similar (9.75 m² for type 1 stalls, 9 m² for type 2 stalls). Open Stalls (OS, N=17 horses) (Fig.1a) had limited openings (3.35 m²) consisting of a small side window (0.49 m²) with grid that allowed horses to see one neighbour and mostly the open front half door (2.86 m²) enabling the horse to have its head outside. This opening gave a view over the outdoor riding arena and horses being led from their stall to the working areas and back. Grid Stalls (GS, N=15 horses) (Fig.1b) were located in an indoor barn with no outdoor openings, but half side walls replaced with grids, enabling sight and nose to nose contact with their two neighbours, as well as a grid above their door, enabling sight of neighbours across the corridor: they could see therefore more than 5 neighbours (1 on each side and 3 in front at least). This constituted a surface of 11.76 m2 openings. Thus, OS stalls favoured a vision of the outside world while GS stalls favoured social visual and olfactory (and some tactile) contacts at close range. All horses had been in this same stall for more than 6 months when the study started.

Authors' post-print

2.1.1.2 - Data collection

Each horse was observed during 10 to 11 5-minutes sessions distributed in the morning (08:00 to 11:00 a.m.), in the afternoon (01:00 to 04:00 p.m. and 05:00 to 07:00 p.m.) and before meals using the continuous focal sampling method (Altman 1974), yielding 50 to 55 minutes observation per horse (mean: 54.22 ± 1.84min/horse). The same observer (EG) recorded all the observations through a voice recorder while standing outside the stall (see also Fureix et al 2011). This same experimenter had been performing observations regularly in the previous months, horses were thus habituated to his presence. The time of observation of a given horse changed every day following a rotation schedule (thus if one horse was observed from 05:00 p.m. to 05:05 p.m. on day 1, it was observed between 05:05 p.m. to 05:10 p.m. on day 2, etc). All behaviours were noted (Table 1), and the frequency of observation was evaluated for each behaviour as the number of occurrences divided per the time of observation (giving a number of behaviour observed per minute). Stereotypic and abnormal repetitive behaviours (STB) were identified according to Mills (2005) and Lesimple & Hausberger (2014). Each behavioural sequence had to be repeted at least three times and observed at least five times independently of the period of observation (Table 1).

Table 1. List and description of the behaviours observed, during the two studies. STB were identified according to Mills (2005). * Waring (2003), ** Kiley-Worthington (1976)

Behaviours			Description
Calmness / Quietness	Feeding		Eating the straw or hay
	Resting*	*Standing*	Half closed eyes
		Lying	Sternal or Lateral
	Maintenance		Urination, Defecation, Scratching, Rolling, Rubbing
Excitation / Repetitive behaviours	Agitation / Stress	Vigilance**	Alarm posture, with fixed immobility, the head held high, ears pointed forwards, sometimes tail raised
	STB	*Weaving*	Lateral movement of the head, neck, forequarters and sometimes hindquarters
		Cribbing	The horse grasps a fixed object with its incisors, and pulls backwards
		Wind sucking	The horse grasps a fixed object with its incisors, pulls backwards and draws air into its oesophagus
		Head shaking	Head movement including head tossing and nodding : Repetitive and sudden vertical movements of the head and neck sometimes involving lateral components (circling)
		Compulsive licking	Repetitive licking of the same object of the environment
		Compulsive biting	Repetitive biting of the same object of the environment
		Tongue movements	Repetitive movements of the tongue inside or outside the mouth

Authors' post-print

2.1.2 – Session 2: Impact of stall architecture on the production of acoustic signals

2.1.2.1. Subjects and housing conditions

This additional study was performed after the discovery of a potential acoustic indicator of positive emotion, in order to test whether the stall architecture could also impact the expression of well-being. The observations were performed by a single experimenter (CR) between May 31st and June 10th 2016, at site 1.

Twenty-three horses living in this same facility, with the same management conditions (2 daily concentrate meals, provided hay once a day, 1h exercise/day, straw bedded single stalls) all performing dressage, were observed. Horses (6 mares and 17 geldings), aged 6 to 17 years ($\bar{X}$±se= 12.04 ± 0.71), mainly (60.9%) French Saddlebreds (N=14, for the other breeds: Hannoveraner, N=4; Anglo-Arabian, N=3; Rheinisches & Oldenburger, N=1 each), were observed in the OS and GS stalls (Fig 1a & 1b) where they had been housed for more than 6 months (see Table 2.).

Table 2. Horses' characteristics in the study performed at the ENE (study 1): distribution of the sex, breeds and age. Number and distribution (%) according to the stall architecture: OS= Open Stalls, GS=Grid Stalls.

		Open Stall (OS)		Grid Stall (GS)	
Sex	Gelgings	9	*75%*	8	*72.7%*
	Mares	3	*25%*	3	*27.3%*
Breeds	French Saddlebreds	7	*58.30%*	7	*63.60%*
	Hannoveraner	2	*16.70%*	2	*18.20%*
	Anglo-Arabian	1	*8.33%*	2	*18.20%*
	Rheinsches	1	*8.33%*	0	*0%*
	Oldenburger	1	*8.33%*	0	*0%*
Age	$\bar{X}$±se	11.41±0.99		12.72±1.02	

2.1.2.2 - Data collection

Horses were observed using a scan sampling method (Altman 1974), for three sessions of 30 minutes per day outside feeding time (at least 1h after the meal) leading to 214 ($\bar{X}$±se=214.37±17.7) scans per horse. During these three periods, both vocal and non-vocal acoustic signals were recorded. Since definitions of horses' acoustic repertoire differ somewhat between studies, the terms used follow the descriptions by Kiley (1972), Stomp et al (2018a,) and Waring (2003):

- snore: very short raspy inhalation sound, produced in a mild alert context (*i.e.* investigation of a novel object or obstacle);

Authors' post-print

-blow: short very intense non-pulsed exhalation through the nostrils, produced in high alert contexts, generally associated with vigilance/alarm postures;

- snort: more or less pulsed sound produced by nostril vibrations while expulsing the air, with a slightly longer duration in comparison to the blow, observed in calm relaxed contexts;

-nicker: modulated low intensity vocal sound produced during in particular at close social contact or food anticipation.

-whinny: loud vocalization produced mostly in response to social separation.

Stomp et al (2010b) described two categories of snorts that differed in the degree of pulsation and reflected different levels of positive emotions but given the important background noise in the site 1's environment (*i.e.* automatic system to remove manure), we could only determine here the presence/absence of snorts.

2.1.3 – Statistical analyses

In both session 1 and 2, data were not normally distributed, and the aim was to compare two distinct groups of horses. Thus, the same non-parametric statistical tests for independent data were used on each dataset independently.

To compare the number of horses performing given behaviours or activities between horses housed in Open Stalls and horses housed in Grid Stalls, we used Chi Square tests, classically used in the literature to compare unpaired discreet data (Siegel 1956). Mann-Whitney U tests (MW U test) were used to compare the frequency of occurrences of behaviours between OS and GS groups (see 2.1). The statistical tests were performed using Statistica® 13.

2.2 - Results

2.2.1- Session 1: Behavioural expressions of good/bad welfare

While stall architecture did not seem to affect activities such as eating (OS: $\bar{X}$±se=0.70 ± 0.276; GS: $\bar{X}$±se=0.73 ± 0.268; MW U test: U=133, p=0.85) or drinking (OS: $\bar{X}$±se=0.03±0.029; GS: $\bar{X}$±se=0.02±0.028; U=114, p=0.60), clear differences appeared for other behaviours. Thus, the time spent in vigilance (alert posture) (OS: $\bar{X}$±se=0.2±0.3; GS: $\bar{X}$±se=0.12±0.02; U=76.5, p=0.05) or

Authors' post-print

movements of the head with fixed stares towards the environment (OS: $\bar{X}$±se=0.71±0.08; GS: $\bar{X}$±se=0.46±0.05; U=68.5, p=0.03) was higher in the horses in OS (Fig.2a), while the horses living in GS spent more time sleeping (OS: $\bar{X}$±se=0.02±0.01; GS: $\bar{X}$±se=0.04±0.01;U=197, p=0.007) (Fig.2b).

All horses performed at least one type of STB during the observation period with frequencies of 0.18 to 2.13 STB per minute ($\bar{X}$±se: 0.49±0.07) (Table 3.). Three (9.4%) of them performed one type of STB, six (18.8%) performed two types of STB, ten (31.2%) performed three types of SB/ARB and thirteen (40.6%) performed four or more types of STB. There was overall no difference in the time spent in STBs according to stall architecture (OS: $\bar{X}$±se=0.047±0.046; GS: $\bar{X}$±se=0.037±0.025; U=116.5, p=0.692). However, there was a clear difference in the type of STB performed according to the type of stall. Almost half (41.2%) of the OS horses were observed weaving while it was seen in less than 10% of GS horses (Chi² test, N_{OS}=7/17, N_{GS}=2/15 p<0.005) (Fig.3). On the contrary, repetitive grid licking was performed in about 80 % of the GS stall horses and in less than 10% of the OS stall horses (Chi² test, N_{OS}=2/17, N_{GS}=11/15 p<0.001) (Fig.3). Moreover, the frequency of the different types of STBs expressed differed largely according to stall architecture: the horses living in OS spent more time weaving (OS: $\bar{X}$±se=0.042±0.072; GS: $\bar{X}$±se=0.011±0.0.034; U=91.5, p=0.091) and in tongue play (OS: $\bar{X}$±se=0.143±0.142; GS: $\bar{X}$±se=0.054±0.0.054; U=64, p=0.017) than the horses living in GS which spent more time repetitively licking the grids (OS: $\bar{X}$±se=0.002±0.006; GS: $\bar{X}$±se=0.087±0.0.102; U=215, p=0.0002).

Table 3. Prevalence and type of STB (number and % of horses) observed and their distribution according to stall architecture in the study at the ENE (study 1). The prevalence of SB/ARB, whatever their type, was higher in horses housed in Open Stalls.

	Total		**Open Stall (OS)**		**Grid Stall (GS)**	
	Nb	%	Nb	%	Nb	%
Weaving	9	*28.13*	7	*41.18*	2	*13.33*
Cribbing	4	*12.50*	2	*11.76*	2	*13.33*
Windsucking	4	*12.50*	2	*11.76*	2	*13.33*
Head shaking/tossing	24	*75.00*	12	*70.59*	12	*80.00*
Repetitive tongue movements	31	*96.88*	17	*100.00*	14	*93.33*
Repetitive licking of the wall	15	*46.88*	8	*47.06*	7	*46.67*
Repetitive licking of the grid	13	*40.63*	2	*11.76*	11	*73.33*
Repetitive biting of the grid	14	*43.75*	6	*35.29*	8	*53.33*

2.2.2 – Session 2: Acoustic indicators

Authors' post-print

During the three 30-minutes observation periods, horses produced whinnies, nickers, snorts, but no snores or blows. The analysis of the production of whinnies and nickers showed that neither the number of horses performing the behaviour (Chi² test, N_{OS}=2/12, N_{GS}=2/11 p>0.57 and N_{OS}=3/12, N_{GS}=1/11 p>0.81 respectively) nor the frequency of expression differed between OS and GS horses (Mann-Whitney U test, respectively OS: $\bar{X}$±se=0.12±0.06; GS: $\bar{X}$±se=0.05±0.03, and OS: $\bar{X}$±se=0.21±0.09; GS: $\bar{X}$±se=0.10±0.08, p>0.1 in both cases).

Interestingly though, when looking at the production of snorts, only 5 out of the 12 OS horses snorted at least once during the observation, whereas all (N=11) GS horses did (respectively 41. 7% and 100.0%, Chi-square tests, p=0.002) (Fig.4). In addition, the frequency of snorting was lower in OS horses (respectively 0.27 and 0.57 % of scans, MW U test, p=0.026).

2.3 - Conclusion

Horses that lived in outdoors stalls allowing a visual access to the outside but no close social contact expressed more “excitation” behaviours (vigilance and alert attention), while horses living indoors and having close social (at least visual and nose-to-nose) contacts expressed more quietness (resting) and snorts, potentially indicative of well-being. If all horses displayed STB, confirming that constant single stall housing (amongst other factors) is inappropriate, “more severe” forms (e.g. weaving) were predominant in horses with windows on outdoors. These observational studies show thus that the stall architecture has an impact on both the welfare state and the expression of positive emotions after long-term housing (at least 6 months). In the following steps, we tested therefore whether there could be short-term effects on the same behavioural measures, in particular when the access to a large outdoors visual horizon is or not restricted.

3- EXPERIMENT 2: experimental study in broodmares

The aim of the second study was to test the immediate impact of changes in housing conditions (stall architecture with or without large visual horizon) on the behaviour of horses, and especially the frequency and type of stereotypic behaviours.

3.1- Material & Methods

Authors' post-print

3.1.1 - Subjects and housing conditions

Forty-two purebred Arabian broodmares, aged 4 to 22 years ($\bar{X}$±se = 9.23 ± 0.83), were observed from March 21st to May 26th 2011 in the national breeding facility of Sidi Thabet in Tunisia (located 20km from Tunis). All mares were under the same management conditions, *i.e.* housed in individual straw bedded stalls (15m²), with barley grains (4 kg/day) and four kg of hay every evening, released every day from 09:00 a.m. to 03:00 p.m. in groups in a paddock with *ad libitum* access to water and limited shelter (5 trees). No food was available then but some freshly cut grass was left on the ground around 12:00 p.m. every day. None of the mares was pregnant at that time. The 42 mares came from 30 different breeding studs ($\bar{X}$±se = 1.36 ± 0, 1 mares/stud), which prevented a potential effect of their management history. They had been in the facility for 1 to 3 weeks before the start of observations. Thus, all the mares were under the same management conditions at the time of the observations.

Two types of stalls were available for housing at night: the Open Stall (OS, Fig.5a) with half front door open to the outside and thus the possibility to put the head outside and have a large visual horizon, or the Grid Stall (GS, Fig.5b) with a grid on the upper part of the front door, preventing the horse of having its head outside and thus leading to a limited visual horizon. For the experiment, every evening, each mare was randomly assigned to one or the other type of stall (OS: $\bar{X}$±se=51.46±1.15 times, GS: $\bar{X}$±se=44.44±1.15 times). Therefore, the behaviour of the same mares could be compared according to the stall type, the experiment being conducted over a period of 69 days.

3.1.2 - Data collection

Observations were made by two observers (AK & SB) every day from March 18th to May 26th 2011 (69 days) using instantaneous scan sampling (Altman 1974). Twice a day (once in the morning and once in the evening after feeding), each observer walked twice along the stalls and noted the behaviour of each of the mares at the instantaneous time of observation. A total of 11684 scans ($\bar{X}$±se 278.2 ± 12.2/mare, range 128-424) was recorded during the 69 days of observation. The time-budget for each behaviour was determined as the recorded number of scans of each behaviour divided by the total recorded number of scans for each horse.

Authors' post-print

3.1.3- Statistical analyses

As the data were not normally distributed, non-parametric statistics were used. The aim here being to compare the behaviour of the same horses placed in two different conditions, statistical tests for paired data were used.

To evaluate the impact of the type of housing (Open Stall and Grid Stall) on the expression of behaviours, we used McNemar tests, particularly adapted to experimental designs where each individual acts as its own control (Siegel 1956). Wilcoxon were used to compare the frequency of occurrences of behaviours between OS and GS groups (see 2.1). The statistical tests were performed using Statistica® 13.

3.2- Results

The stall architecture did not impact maintenance behaviours such as urination (% of scans, OS: $\bar{X}$±se=0.2±0.0005, GS: $\bar{X}$±se=0.2±0.0006, Wilcoxon test, Z=0.34, p=0.34), defecation (% of scans, OS: $\bar{X}$±se=0.6±0.001, GS: $\bar{X}$±se=1.00±0.002, Z=1.77, p=0.078) or scratching (% of scans, OS: $\bar{X}$±se=0.6±0.001, GS: $\bar{X}$±se=0.7±0.001, Z=0.41, p=0.68), but had an impact both on behaviours reflecting calmness (i.e. resting, foraging) or excitation/welfare impairment (*e.g.* STB, vigilance). Thus, when placed in GS (no opening to the outside), the mares spent significantly more time foraging (% of scans, OS: $\bar{X}$±se=35±0.02, GS: $\bar{X}$±se=47±0.01, Z=5.59, p<0.01) and resting, whether standing (% of scans, OS: $\bar{X}$±se=6.00±0.005, GS: $\bar{X}$±se=15.00±0.008, Z=5.38, p<0.01) or lying (% of scans, OS: $\bar{X}$±se=0.0±0.0, GS: $\bar{X}$±se=0.3±0.001, Z=2.02, p=0.04) whereas they expressed more vigilance (alert postures) when they were in OS (% of scans, OS: $\bar{X}$±se=26.00±0.01, GS: $\bar{X}$±se=9.00±0.007, Z=5.64, p<0.001) (Fig.6a).

Thirty-four of the forty-two mares (81%) performed a stereotypic behaviour at least once. Five types of abnormal or stereotypic behaviours (STB) were observed: weaving, cribbing, wind sucking, head tossing/nodding and repetitive pawing (see Table 3). The mares spent six times more time performing stereotypic behaviours, whatever the type of STB, when placed in the OS than in GS (% of scans, OS: $\bar{X}$±se=0.07±0.02, GS: $\bar{X}$±se=0.01±0.004, Z=3.48, p<0.01) or when considering only weaving (% of

Authors' post-print

scans, OS: $\bar{X}$±se=0.04±0.02, GS: $\bar{X}$±se=0.007±0.003, Z=3.41, p<0.01), cribbing (% of scans, OS: $\bar{X}$±se=0.03±0.007, GS: $\bar{X}$±se=0.006±0.002, Z=3.51, p<0.01) and head tossing/nodding (% of scans, OS: $\bar{X}$±se=0.002±0.0007, GS: $\bar{X}$±se=0.0007±0.0004, Z=2.06, p<0.01) (Fig.6b). Pawing and wind sucking were only performed when in OS, and their prevalence was too small to allow statistical comparisons (see Table 4.). Twenty mares expressed one type of STB, eight expressed two types of STB, five expressed three types of STB and one expressed more than four types of types of STB. The impact of stall architecture on these behaviours was further confirmed when looking at the number of mares performing them. Thus, fifteen mares (35.7%) performed stereotypic behaviours only when in the OS stalls and only two (4.8%) in GS (McNemar test, p=0.003). Overall, mares expressed all types of stereotypic behaviours when in OS, while repetitive pawing and windsucking were not observed in GS (Table 3).

Table 3. Prevalence (number and % of horses) of the different types of SB/ARB and their distribution according to the stall architecture in Study 2 (broodmares). SB/ARB, whatever their type, were more expressed when horses were in Open Stalls

	Total		**Open Stall (OS)**		**Grid Stall (GS)**	
	Nb	%	Nb	%	Nb	%
Weaving	15	*35.71*	15	*35.71*	8	*19.05*
Cribbing	25	*59.52*	22	*52.38*	13	*30.95*
Windsucking	1	*2.38*	1	*2.38*	0	*0.00*
Head tossing/nodding	11	*26.19*	9	*21.43*	3	*7.14*
Repetitive pawing	4	*9.52*	4	*9.52*	0	*0.00*

Conclusion

When placed in stalls allowing them to put their head outside and to access a larger visual horizon, the mares were more agitated (vigilance), while they spent more time in "quiet" activities (resting and foraging) in gridded stalls, preventing them from putting their head outside. Furthermore, the prevalence of STB was much higher in OS and a third of the mares performed STB only when in OS. This experimental study thus shows that even a short-term exposure to inappropriate stall architecture has a strong impact on the expression of welfare alteration.

4 - DISCUSSION

Authors' post-print

The results obtained here confirm the inappropriateness of constant single box housing for horses (*e.g.* Benhajali et al 2010, Lesimple et al 2016, Visser et al 2008), as indicated by the high prevalence of SB/ARB observed. However, they also reveal that, even in such restricted type of housing, some conditions, in particular in regards to the stall architecture, may be less appropriate than others. Thus, we show that both the frequency of occurrence and the type of stereotypies performed seem to be affected by at least two aspects of stall architecture: the presence of lateral grids allowing some social contacts and the presence of grids at the front door preventing the horse to put the head out. First, having close (visual/olfactory/ nose-to-nose) contact with neighbours diminishes the risk of stereotypic behaviours and vigilance while increasing the occurrence of behaviours reflecting quietness and positive emotions (e.g. resting, snorts). Second, it appears that changes in housing, *i.e.* stall architecture, induce immediate behavioural changes, with the major but intriguing finding that increasing the visual horizon by allowing horses to put their head outside is an aggravating factor for the production of stereotypic behaviours, and especially weaving considered as reflecting frustration of social contact (Cooper et al., 2000). In addition, it is worth noting that the second site had a lower prevalence of SB/ARB than the first one (where horses have no opportunity to go out for free movement) which may be due to differences in occupation, but overall to the mares being in paddocks half time (Heleski et al 2002; Lesimple et al 2016; Waters et al 2002).

Constant single housing is known to be detrimental for horses at any age (e.g. Heleski et al 2002; Lesimple et al 2016; Waters et al 2002) while pair housing may improve the situation (Visser et al 2008, Benhajali et al 2010). When given the choice, horses prefer to go to places where there are conspecifics (Lee et al 2011) and cows prefer a pen with a conspecific picture (compared to brushes or straw bedding) and spend more time ruminating when in presence of the picture than in the other conditions (Ninomiya & Sato 2009). The importance of close social contact has also been demonstrated by giving a visual access to neighbours through grids (Cooper et al 2000) or providing "substitutes" such as a horse picture or a mirror (Mills & Davenport 2002, McAfee et al 2002, Kay & Hall 2009). Videos of conspecifics (Shapiro & Bloomsmith 1995) and the presence of mirrors (Gallup & Suarez 1991) in single housed rhesus monkeys decrease the production of stress-related behaviours and a picture of a conspecific's face decreases heart rate and adrenaline concentration in sheep (Da Costa et al 2004). However, the

Authors' post-print

effects are not necessarily long-lasting and it is not always clear what is really perceived through a mirror (Galley & Suarez 1991, Baragli et al 2017). Therefore, care should be given to give access to a genuine close social contact with a preferred familiar congener, especially as it seems to increase positive emotions as shown here through the increased production of snorts in stalls allowing contact between neighbours (see also Stomp et al 2018a). Horses, like other species, are ready to work for even partial access to a conspecific (e.g. part of a real congener, like head and neck or through a fence or picture of a congener): in Sondergaard et al (2011)'s study, horses could push a lever up to 191 times in order to have access to a social stimulus while single housed starlings could put their beak up to 297 times per day to obtain each time the broadcast of a conspecific's picture (Perret et al 2015), showing how high is the motivation of social animals to interact with or at least have a visual access to conspecifics.

However, a rather more intriguing result of the present study is also that increasing the visual horizon, by allowing the horse to put their head outside was related to an increase of indicators of compromised welfare and agitation. Some studies had shown that there were more stereotypic behaviours in horses housed in conventional stalls with the front half door open and a view on the stable courtyard (Cooper 2000, Lesimple et al 2016). Here we demonstrate that even when there is a small possibility for close social contact, this outdoor view is a source of more agitation and chronic stress-related behaviours (study 1) and that the effect is immediate (study 2). This is especially remarkable in the broodmare population where this was the only difference between the two types of stalls: mares that had grids on the half door performed less stereotypic behaviours and spent more time foraging and resting, the latter behaviours known to occur more in calm and positive situations (Benhajali et al 2009, Greening et al 2013, Kwiatkowska-Stenzel et al 2016, Greening et al 2013, Pessoa et al 2016, Raabygmale et al 2005) than those who could have the head outside and watch out-of-reach conspecifics and humans walking around.

Another remarkable result is that the type of stereotypic behaviours performed varied according to stall architecture. Thus, in study 1, weaving was more frequent in the OS while repetitive grid licking predominated in the GS. In study 2, all stereotypic behaviours, whether locomotor or oral, increased when the mares could have their head outside, but some STB, mainly repetitive pawing, head movements and weaving, were particularly impacted. In other species, some types of stereotypic

Authors' post-print

behaviours are supposed to reflect escape attempts such as bar gnawing in rodents (Würbel et al 1996, 1998) or somersaulting in starlings (Feenders et al 2012). In starlings, an increase of the visual horizon, by broadcasting videos of landscape, was associated with an increase of somersaulting (Coulon et al 2014). It has been proposed in horses that weaving may result from social or movement frustration (Mills 2005). In our studies, it could be argued that weaving is more frequent in OS because the movement is easier with the head above the door. However, the study 2 shows that the mares could also perform it when the door was closed with a grid, thus this cannot be the sole explanation. It is also possible that the repetitive licking of the grids in the indoor horses of study 1 was related to a motivation to be closer to the neighbour.

It has been proposed that STB result from chronic frustration (Ödberg, 1978; Fureix et al., 2011), and it is quite possible that horses experience more frustration with an outdoor view, where they can see large spaces and/or other horses that they cannot reach, or see other horses given access to movement (ex in the riding arena or walking along). Monkeys are more frustrated to watch a conspecific eating an (unreachable) appetitive food than simply being denied access to the same visible food (Brosnan and de Waal, 2003). Thus, open front doors may induce more frustration leading to welfare impairment, due to either being unable to join the distant horses, or being unable to move out of the stall as do the other horses. Besides, the immediate influence of the type of housing on the mares' behaviour in study 2 shows in any case that stereotypic behaviours may be more flexible than often assumed as both their frequency and types could change rapidly for the same individuals as a result of a change in the environment. Finally, former studies conducted on Arabian broodmares in the same facility (site 2) showed that when released in paddocks in groups with congeners, they were never observed stereotyping (Benhajali 2008, 2009). In the same way, a recent study conducted in site 1 showed that sport horses that never went to paddock beforehand displayed a very fast decrease of SB/ARB expression in box during a period where they had 1h daily access to a paddock (Lesimple et al in prep). Thus, changes in management practices may have immediate and durable effects, even on such behaviours.

While constant single stall housing remains inappropriate for horses, housing has effects on horses' chronic stress levels and favouring close social contact, even partial (access to a limited part, *e.g.* head

Authors' post-print

and neck only, or through a fence or window), and less sources of frustration when building such housing systems remains important.

This study underlines once again the importance of animal-based criteria for identifying best practices (e.g. Blokhuis et al 2003) and that “only animals can tell”. Humans would tend to think that being able to watch outside and see activities would reduce boredom and hence stereotypies, while obviously this situation creates much more frustration as suggested also by Cooper et al (2000)’s earlier study.

5 - ACKNOWLEDGMENTS

This study could be performed thanks to the permission of Lieutenant Colonel d'Hérouville and the help of P. Galloux at the " Ecole Nationale d'Equitation de Saumur " in France and that of Dr M. Ezzaouia in Sidi Thabet We are most grateful to the staff of both sites for their help during the studies. Funding was provided by the Université de Rennes 1, the CNRS and the COST-IFCE. The authors also thank Katie Collier for the English corrections.

6 - REFERENCES

Altman, J., 1974. Observational study of behaviour : sampling methods. Behaviour 9, 227-265.

Baragli, P., Demuru, E., Scopa, C., Palagi, E. 2017. Are horses capable of mirror self-recognition ? A pilot study. PLoS ONE 12, e0176717. https://doi.org/10.1371/journal.pone.0176717.

Benhajali, H., Richard-yris, M.A., Leroux, M., Ezzaouia, M., Charfi, F., Hausberger, M. 2008. A note on time budget and social behaviour of densely housed horses A case study in Arab breeding mares. Appl. ANim. Behav. Sci. 196-200.

Benhajali, H., Richard-Yris, M.A., Ezzaouia, M., Charfi, F., Hausberger. M., 2009. Foraging opportunity: a crucial criterion for horse welfare? Animal 3, 1308-1312. doi:10.1017/S1751731109004820.

Authors' post-print

Benhajali, H., Richard-Yris, M.A., Ezzaouia, M., Charfi, F., Hausberger, M., 2010. Reproductive status and stereotypies in breeding mares: a brief report. Appl. Anim. Behav. Sci. 128, 64-68.

Bergeron, R., Badnell-Waters, A., Lambton, S., Mason, G. 2006. Stereotypic oral behaviour in captive ungulates: foraging, diet and gastrointestinal fuction. In: Mason, G., Rushen, J. (Eds.), Stereotypic Animal Behavior: Fundamentals and applications to welfare. CAB international, Wallingford, p.p20.

Blokhuis, H. J., Jones, R. B., Geers, R., Miele, M., & Veissier, I. 2003. Measuring and monitoring animal welfare: transparency in the food product quality chain. Animal Welfare, 12(4), 445-455.

Brosnan, S.F., de Waal, F.B.M., 2003. Monkeys reject unequal pay. Nature 425, 297-299.

Cook, W. R. 1999. Pathophysiology of bit control in the horse. J. Eq. Vet. Sci, 19, 196–204. doi: 10.1016/S0737-0806(99)80067-7

Cook, W. R. 2003. Bit induced pain: A cause a fear, flight and facial neuralgia in the horse. Pferdheilkunde, 19, 75–82.

Cooper, J.J., McDonald, L., Mills, D.S., 2000. The effect of increasing visual horizons on stereotypic weaving: implications for the social housing of stabled horses. Appl. Anim. Behav. Sci. 69, 67-83. e7625.doi:10.1371/journal.pone.0007625, 2009.

Coulon, M., Henry, L., Perret, A., Cousillas, H., Hausberger, M. George, I., 2014. Assessing video presentations as environmental enrichment for laboratory birds. PLoS ONE, doi.org/10.1371/journal.pone.0096949.

Crockett, C., Bowers, C., Bowden, D., Sackett, G., 1994. Sex differences in compatibility of pair-housed adult longtailed macaques. Am. J. Primato. doi.org/10.1002/ajp.1350320202

Da Costa, A.P., Leigh, A.E., Man, M.S., Kendrick, K.M., 2004. Face pictures reduce behavioural, autonomic, endocrine and neural indices of stress and fear in sheep. The Royal Soc. 271, 2077-2084.

Authors' post-print

Feenders, G. Bateson, M., 2012. The development of stereotypic behaviours in caged European starlings *Sturnus vulagris.* Dev.Psychobiol. 54, 773-784. doi.org/10.1002/dev.20623

Fraser, D., Weary, D.M., Pajor, E.A., Milligan, B.N. 1997. A scientific conception of animal welfare that reflects ethical concerns. Anim. Welf. 187-205.

Fureix, C., Gorecka-Bruzda, A., Gautier, E., Hausberger, M., 2011. Co-occurrence of yawning and stereotypic behaviour in horses *Equus caballus*. ISRN Zool. 98, 583–592.

Fureix, C., Benhajali, H., Henry, S., Bruchet, A., Prunier, A., Coste, C., Hausberger, M., Palme, R., Jego, P. 2013. Plasma cortisol and faecal cortisol metabolites concentrations in stereotypic and non-stereotypic horses : dos stereotypic horse scope better with poor environmental conditions ? BMV Vet.Res. doi:10.1186/1746-6148-9-3.

Gallup, G. G., Suarez, S. D., 1991. Social responding to mirrors in rhesus monkeys (*Maccaca mulatta*) : Effect of temporary mirror removal. J. Comp. Psychol. 105, 376-379.

Gorecka-Bruzda, A., Jastrzebska, E., Muszynska, A., Jedrezejewska,E., Jaworski, Z, Jezierski, T., Murphy, J., 2013. To jump or not to jump? Strategies employed by leisure and sport horses. J. Vet. Behav. 8, 253-260.

Greening, L., Shenton, V., Wilcockson, K., Swanson, J., 2013. Investigating duration of nocturnal ingestive and sleep behaviours of horses bedded on straw versus shavings. J. Vet. Behav. 8, 82-86. doi:10.1016/j.jveb.2012.05.003

Hausberger, M., Richard-Yris, M.A., 2005. Individual differences in the domestic horse, origins, development and stability, in: Mills, D.S., McDonnell, S.M. (Eds.), The Domestic Horse. Cambridge University Press, Cambridge, pp. 33-52.

Hausberger, M., Gautier, E., Müller, C., Jego, P. 2007. Lower learning abilities in stereotypic horses. Appl. Anim. Behav.Sci. 299-306.

Hausberger, M., Gautier, E., Biquand, V., Lunel, C., Jego, P., 2009. Could work be a source of behavioural disorders? A study in horses. PLoS ONE 4(10):

Authors' post-print

Hausberger, M., Fureix, C., Lesimple, C., 2016. Detecting horses' sickness : in search of visible signs. Appl. Anim. Behav. Sci. 175, 41-49.

Heleski, C., Shelle, A., Nielsen, B., Zanella, A., 2002. Influence of housing on weanling horse behavior and subsequent welfare. Appl. Anim. Behav. Sci. 78, 291-302.

Houpt, K.A., Kusunose, R., 2001. Genetics of behaviour. In: Bowling, A. T., & Ruvinsky, A. (Eds), The genetics of the Horse, MA: CABI Publishers, pp281-306.

Kay, R., Hall, C., 2009. The use of a mirror reduces isolation stress in horses being transported by trailer. Appl. Anim. Behav. Sci. 116, 237-243.

Kessel,A., Brent, L., 2001. The rehabilitation of captive baboons. J. Med. Primatol. 30, 71-80.

Kiley, M., 1972. The vocalization of ungulates, their causation and function. Z. Tierpsychol. 31, 171-222.

Kiley-Worthington, M. 1976. The tail movements of ungulates, canids and felids with particular reference to their causation and function as displays. Behaviour 56, 69-114.

Kwiatkowska-Stenzel, A., Sowinska, J., Witkiwska, D., 2016. The effect of different bedding materials used in stable on horses behavior. J. Eq. Vet. Sci. 42, 57-66.

Lee, J., Floyd, T., Erb, H., Houpt, K., 2011. Preference and demand for exercise in stabled horses. Appl. Anim. Behav. Sci. 130, 91-100.

Lesimple, C., .Hausberger, M., 2014. How accurate are we at assessing others' well-being? The example of welfare assessment in horses. Front. Psychol. https://doi.org/10.3389/fpsyg.2014.00021

Lesimple, C., Fureix, C., LeScolan, N., Richard-Yris, M.A., Hausberger, M., 2011. Housing conditions and breed are associated with emotionality and cognitive abilities in riding school horses. Appl. Anim. Behav. Sci. 129, 92-99.

Authors' post-print

Lesimple, C., Poissonnet, A., Hausberger, M., 2016. How to keep your horse safe ? An epidemiological study about management practices. Appl. Anim. Behav. Sci. 181, 105-114.

Lewis, R.S., Hurst, J.L., 2004. The assessment of bar chewing as an escape behavior in laboratory mice. Anim. Welf. 13, 19-25.

Mason, G., 1991. Stereotypies : a critical review. Anim. Behav. 41, 1015-1037.

Mason, G., 1993. Age and context affect the stereotypies of caged mink. Behaviour 127, doi: https://doi.org/10.1163/156853993X00029.

McAfee, L.M., Mills, D.S., Cooper, J.J., 2002. The use of mirrors for the control of stereotypic weaving behavior in the stabled horse. Appl. Anim. Behav. Sci. 78, 159-173.

McGreevy, P.D., Cripps, P.J., French, N.P., Green, L.E., Nicol, C.J., 1995. Management factors associated with stereotypic and redirected behaviour in the Thoroughbred horse. Eq. Vet. J. 27, 86–91.

Meehan, C.L., Garner, J.P., Mench, J.A., 2003. Isosexual pair housing improves the welfare of young Amazon parrots. Appl. Anim. Behav. Sci. 81, 73-88.

Mills, D.S., 2005. Repetitive movement problems in the horse, in: Mills, D.S., McDonnell, S.M. (Eds.), The Domestic Horse. Cambridge University Press, Cambridge, pp. 212-227.

Mills, D.S., Davenport, K., 2002. The effect of a neighbouring conspecific versus the use of a mirror for the control of stereotypic weaving behavior in the stabled horse. Anim. Sci. 74, 95-101.

Mills, D., Riezebos, M., 2005. The role of the image of a conspecific in the regulation of stereotypic head movements in the horse. Appl. Anim. Behav. Sci. 91, 155-165.

Newberry, R., 1995. Environmental enrichment: Increasing the biological relevance of captive environments. Appl. Anim. Behav. Sci. 44, 229-243.

Ninomiya, S., Sato, S., 2009. Display of a peer's face picture enhances the preference for a pen in preference testing in cows. Anim. Sci. J. 80, 605-610.

Authors' post-print

Ödberg, F. O., 1978. Abnormal behaviours: Atereotypies. Madrid: Proceedings of the 1st World Congress on Ethology as Applied to Zootechnies, 1, 475–480.

Parker, M., Goodwin, D., Redhead, E.S. 2008. Impaired instrumental choice in crib-biting horses (Equus caballus). Behav. Brain. Res.64, 81-90.

Perret, A., Henry, L. Coulon, M., Caudal, J.P., Richard, J.P., Cusillas, H., Hausberger, M. George, I., 2015. Social, visual contact, a primary "drive" for social animals? Anim. Cog. 18, 657-666.

Pessoa, G., Trigo, P., Mesquita Neto, F., Lacreta Junior, A. Sousa, T., Muniz, J., Moura, R. 2016. Comparative well-being of horses kept under total or partial confinement priori to employment for mounted patrols. Appl. Anim. Behav. Sci. 184, 51-58.

Raabygmale, P., Ladewig, J., 2005. Lying behavior in horses in relation to box size. J. Eq. Vet. Sci. 26, 11-17.

Shapiro, S.J., Bloomsmith, M.A., 1995. Behavioral effects of enrichment on singly-housed, yearling rhesus monkeys: An analysis including three enrichment conditions and a control group. Am.J. Primat. 35, 89-101.

Siegel, S. 1956. Nonparametric tests: for the behavioural sciences. McGraw-Hill Book Company, new York.

Sondergaard, E. Jensen, M.B., Nicol, C.J., 2011. Motivation for social contact in horses measured by operant conditioning. Appl. Anim. Behav. Sci. 132, 131-137.

Stomp, M., Leroux, M., Cellier, M., Henry, S., Lemasson, A., Hausberger, M., 2018a. An unexpected acoustic indicator of positive emotions in horses. PLoS ONE 13: e0197898. https://doi.org/ 10.1371/journal.pone.0197898

Stomp, M., Leroux, M., Cellier, M., Henry, S., Hausberger, M., Lemasson, A., 2018. Snort acoustic structure codes for positive emotions in horses. Sci. Nature 105, https://doi.org/10.1007/s00114-018-1582-9

Authors' post-print

Visser, E.K., Ellis, A.D., Van Reenen, C.G., 2008. The effect of two different housing conditions on the welfare of young horses stabled for the first time. Appl. Anim. Behav. Sci. 114, 521-533.

Waring, G.H. 2003. Horse behavior. Second ed. Noyes Publications William Andrew publishing, Norwich, New York.

Waters, A.J., Nicol, C.J., French, N.P., 2002. Factors influencing the development of stereotypic and redirected behaviours in young horses: findings of a four year prospective epidemiological study. Aq. Vet. J. 34, 572-579. doi.org/10.2746/042516402776180241.

Wiedenmayer, C. 1996a. Effect of cage size on the ontogeny of stereotyped behaviour in gerbils. Appl. Anim. Behav. Sci. 47, 225-233.

Wiedenmayer, C., 1996b. Causation of the ontogenic development of stereotypic digging in gerbils. Anim. Behav. 53, 461-470.

Würbel, H., Stauffacher, M., von Holst, D., 1996. Stereotypies in laboratory mice-Quantitative and qualitative description of the ontogeny of 'Wire-gnawing' and 'Jumping' in Zur:IC and Zur:ICR nu. Ethology 102, 371-385. doi.org/10.1111/j.1439-0310.1996.tb01133.x

Würbel, H., Chapman, R., Rutland, C. 1998. Effect of feed and environmental enrichment on development os stereotypic wire-gnawing in laboratory mice. Appl. Anim. Behav. Sci. 60, 69-81.

Authors' post-print

7 – Figures

Figure 1: Stall architecture in Study 1 (a) Open Stall (OS), (b) Grid Stall (GS)

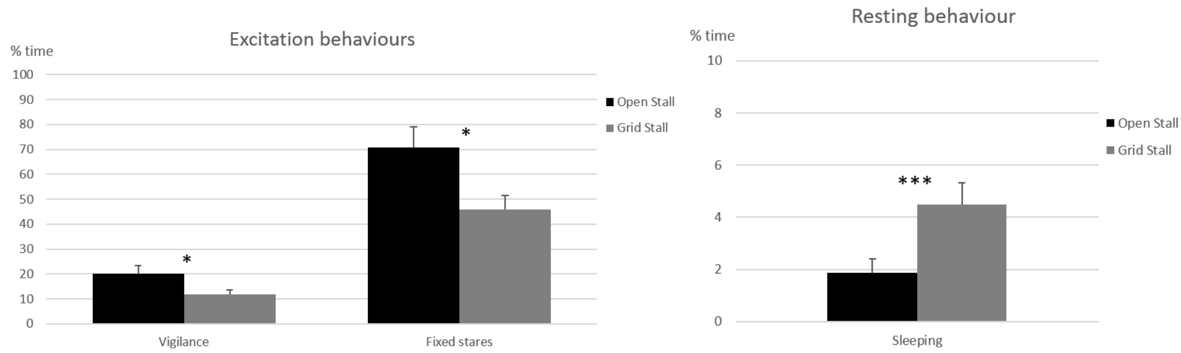

Figure 2: Impact of the type of stall on (a) the excitation behaviours, (b) resting behaviours performed in Study 1. Mann Whitney U test, *:p<0.05; **:p<0.01

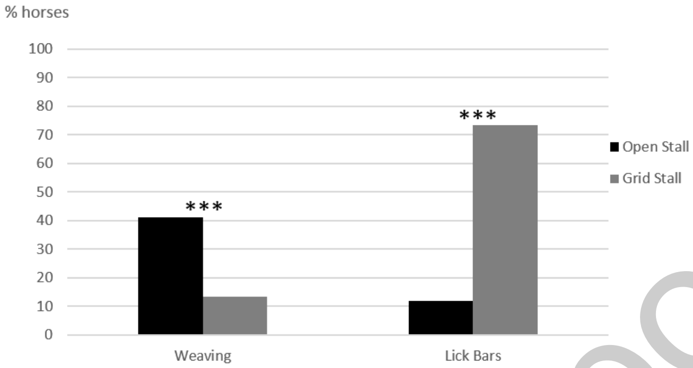

Figure 3: Expression of different types of SB/ARB according to the type of stall. Chi Square test, ***:p<0.005

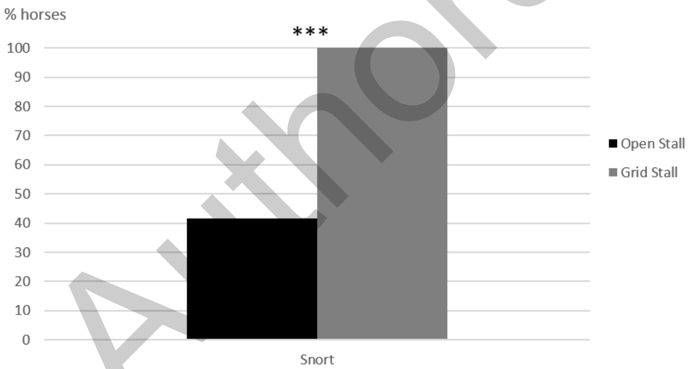

Figure 4: Proportion of horses performing snorts according to the type of stall in Study 1. All horses in GS snorted. Chi Square test (performed on real numbers), ***:p<0.005

Authors' post-print

Figure 5a: Stall architecture in Study 2 (a) Open Stall (OS), (b) Grid Stall (GS)

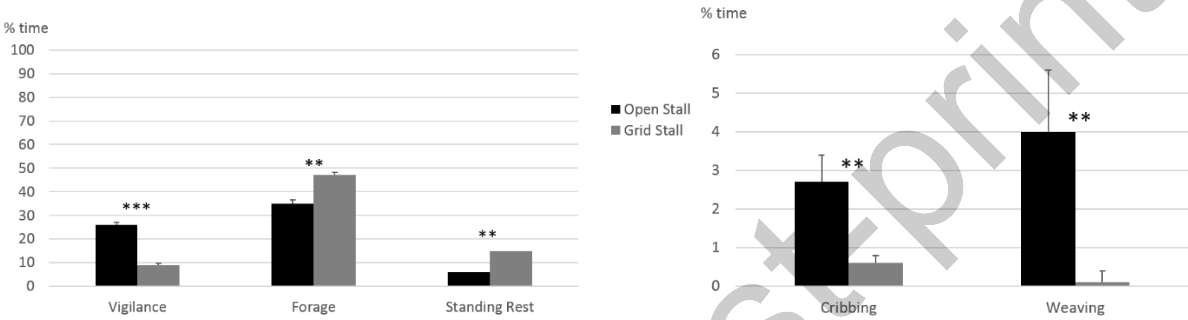

Figure 6: Impact of the type of stall on the time spent (a) in “quiet” behaviours and vigilance according and (b) in stereotypic / abnormal repetitive behaviour in the Study 2. When placed in GS, mares spent more time in quiet behaviours and less time in vigilance, and 2 to 4 time less stereotyping. Wilcoxon Test, **:p<0.01; ***:p<0.005

Authors' postprint