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1 **Investigating duration of nocturnal ingestive and sleep behaviors of horses bedded**
2 **on straw versus shavings**

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8

9 **Abstract**

10 Horses are stabled overnight for a number of practical reasons however there is little research
11 quantifying nocturnal equine behavioral patterns or the extent to which different environments
12 influence nocturnal behavior. The aim of this study was to establish whether differences in duration
13 of sleep and ingestive behaviors were apparent for horses bedded on straw (group one) or shavings
14 (group two). Ten geldings of mixed breed (mean age 7.3 ± 3.53 years) bedded on either shavings (N=5)
15 or straw (N=5) were observed between 1900 and 0700 hours. Duration of behaviors according to a
16 predefined ethogram were recorded in minutes using a video recorder and continuous focal
17 sampling. Mann-Whitney U tests were used to identify whether any significant differences in duration
18 of ingestion and sleep behaviors occurred for horses bedded on straw compared with shavings. Out
19 of the total observation period, group one spent on average 29.3% of their time budget engaged in
20 recumbent behaviors, compared with 12.2% for group two. However, no significant differences in
21 duration were established between horses bedded on straw or shavings for standing sleep, sternal
22 recumbency and lateral recumbency behaviors ($P > 0.05$). Ingestive behaviors occupied approximately
23 a third of the time budget with no significant difference ($P > 0.05$) observed between groups. On
24 average, group one spent a longer proportion of the observation period ingesting bedding (8.1%)
25 compared with group two (1%). Duration of bedding ingestion appeared to peak between 0100 and
26 0700 for both groups. Although not quantified, general observations revealed horses were motivated
27 to alternate between eating hay and bedding in both groups, due to the prevalence of bedding
28 ingestion. The results indicate that straw bedding facilitates the display of ingestive and sleep
29 behaviors, whilst horses bedded on shavings spent a greater proportion of their nocturnal time
30 budget engaged in 'other' behaviors. Further research is required to investigate the extent to which
31 different types of bedding material enrich the environment of horses that are stabled overnight.

32 **Keywords:** equine, nocturnal, recumbent, ingestion, behavior, bedding.

33

34 **Introduction**

35 The domestic environment within which the horse is kept and managed can present challenges to
36 instinctive and innate behavioral patterns. Research indicates that within this environment, stabling
37 and associated practices are often the most challenging aspects that the horse is expected to cope
38 with (for example: [McGreevy et al., 1995](#); [Henderson & Waran, 2001](#); [Piccione et al., 2008](#)). Intense
39 stabling practices, involving long periods of confinement with very little access to (free) exercise, have
40 been associated with increased restlessness and aggression ([Werhahn et al., 2011](#)). Extended periods
41 of confinement can also be associated with increased risk of abnormal behavior development
42 ([McGreevy et al., 1995](#)). Barriers within traditional and conventional stabling systems therefore
43 appear to reduce the opportunity for the horse to display normal behavior and increase the likelihood
44 of abnormal behavior display ([Cooper and Albentosa, 2005](#); [Rose-Meirhofer et al., 2010](#)). The role of
45 the horse in modern society however seems to necessitate stabling ([Henderson, 2007](#)) and as a result
46 research exists to investigate methods to enrich the stable environment using; feed-balls ([Henderson
47 and Waran, 1998](#)), increased opportunities to forage ([Thorne et al., 2005](#)), and; increased visual
48 horizons, such as mirrors ([Cooper et al., 2000](#); [Mills and Davenport, 2002](#)). The use of bedding in the
49 stable is a traditional practice that is receiving increased attention as a stimulus which is reported to
50 exert variable positive and negative influences ([Werhahn et al., 2010](#)). However previous studies
51 investigating bedding report contradictory evidence, maybe due to non-comparable sample
52 populations or aspects of the study design. For example some studies employed female populations
53 exclusively ([Haupt et al., 2003](#); [Werhahn et al., 2010](#)), used relatively small stalls ([Pedersen et al.,
54 2004](#)) and cross over designs employing different bedding materials ([Werhahn et al., 2010](#)). During
55 preference tests, horses have been observed to choose straw bedding when given the choice ([Mills et
56 al., 2000](#)), but have also demonstrated no significant preference ([Hunter and Haupt, 1986](#)). Some of
57 the negative conclusions from bedding research suggest that bedding material has little significant
58 influence on behavior ([Thompson, 1995](#)) and is linked with colic ([Greet and Rossdale, 1987](#)). More
59 recently, research has shown that straw bedding encourages more bedding-directed behaviors, less
60 standing behavior and longer duration recumbent behavior ([Pedersen et al., 2004](#); [Werhahn et al.,
61 2010](#)). The current study therefore aimed to establish whether significant differences existed for a
62 sample population of mixed breed/age geldings, bedded on either straw or shavings, looking at the
63 duration of nocturnal ingestive and sleep behaviors.

64

65 **Methods and materials**

66 **Materials**

67 Ten geldings of mixed breed and age (average 7.3 ± 3.53 years; range 4-13 years) were allocated to
68 either group one; wood shavings (N=5), or group two; straw (N=5) based on the bedding material that

69 appeared in their stable. Each horse had been bedded on the material for at least five months
70 previously. Each stable measured 12feet by 12feet, the design of which prevented physical contact
71 between neighboring horses due to solid walls separating each horse; they were able to see each
72 other from the stable door. No deep litter systems or rubber matting were present in any of the
73 stables. The bedding that appeared in the stable was either wheat straw or pine wood shavings that
74 were not entirely new, and varied in depth according to owner preference (minimum 10cm). Each
75 horse was provided with access to pasture for between six and ten hours during the day and given its
76 normal feed and/or individual ration of hay at 1830. All horses were individually stabled on the same
77 yard and underwent light to medium work but were privately owned and therefore subject to
78 different daily regimens.

79

80 **Experimental design**

81 Each horse was filmed once for a period of twelve hours between 1900 and 0700. The light was left
82 on during the study and horses were habituated to this for a period of two nights prior to data
83 collection. A Sony Handycam DCR-SX15E with a NP-FV100 battery was secured in the stable rafters in
84 the top corner above the stable door and set on a wide-angle lens so that the entire stable was visible
85 to facilitate data collection. Duration of ingestion and recumbent behaviors (table 1) were recorded
86 using continuous focal sampling. Sleep was recorded where the behavior lasted for longer than one
87 minute. Ethical approval was granted by Hartpury College.

88

89 Table 1: Ethogram of ingestive and sleeping/recumbent behaviors (Adapted from Dierendonck et al.,
90 1996; Winkill et al., 1996; Flannigan & Stookey, 2002; Souris, 2007)

Category	Description of activities
Ingest hay	Masticating, prehending or swallowing hay
Ingest concentrates	Masticating, prehending or swallowing concentrates
Ingest bedding substrate	Masticating, prehending or swallowing bedding substrate
Sleep whilst standing	Standing immobile, no or limited ear movement, relaxed tail, limited leg movement, eyes closed or half shut
Sternal recumbency	Recumbent, with sternum in contact with the ground, legs folded beneath the body, no or limited ear movement
Lateral recumbency	Recumbent, either lateral thoracic area parallel to and in contact with the ground, head immobile and in contact with the ground, legs extended

91

92 **Statistical analysis**

93 In order to establish whether differences in frequency or duration of ingestive and recumbent
94 behaviors existed for horses bedded on straw or shavings, Mann Whitney-U tests were used

95 ($N_1=N_2=5$). Significance levels were set at $P<0.05$. Total mean duration of individual behaviors was
 96 calculated from the sum of the total time spent engaging in that behavior by each horse, divided by
 97 the size of the sample population in each group. Mean duration data was also used to calculate the
 98 proportion of the total observation period (720 minutes) that each behavior was displayed for.

99 Results

100 Sleep behavior

101 No significant differences between group one or two were observed for median total duration sleep
 102 standing ($Z=-0.104$; $P>0.05$), sternal recumbency ($Z=0.301$; $P>0.05$) and lateral recumbency ($Z=1.985$;
 103 $P>0.05$) (table 2). During the total observation period, horses bedded on straw spent on average
 104 29.3% of their time budget engaged in recumbent behaviors, compared with 12.2% for those bedded
 105 on shavings. Overall horses bedded on straw spent 56.9% engaged in sleep behaviors compared with
 106 49.2% for horses bedded on shavings.

107

108 Table 2. Average duration (minutes) of sleep and sternal behaviors, also showing total duration as a
 109 proportion of the total observation period (%)

	Sleep standing		Sternal recumbency		Lateral recumbency	
	Shavings	Straw	Shavings	Straw	Shavings	Straw
Median duration (minutes)	263	273	113	148	6	45
Mean duration (minutes)	266	199	83.40	162.20	5	49
Proportion of total observation period (%)	36.9	27.6	11.6	22.5	0.7	6.8

110

111 Ingestion behaviors

112 Only one horse bedded on shavings was observed not to display any type of bedding ingestion
 113 behavior. No significant differences were observed for median total duration of hay ingestion ($Z=-$
 114 0.940 ; $P>0.05$) or bedding ingestion ($Z=1.776$; $P>0.05$) (table 3). Out of the total observation period
 115 horses bedded on straw spent on average 36.2% of their time engaged in ingestion behaviors,
 116 compared with 33.1% displayed by horses bedded on shavings.

117

118 Table 3. Average duration (minutes) of ingestion behaviors, also showing total duration as a
 119 proportion of the total observation period (%)

	Ingestion of hay		Ingestion of bedding	
	Shavings	Straw	Shavings	Straw
Median duration (minutes)	248	228	8	17
Mean duration (minutes)	231.20	202	7.20	58.20
Proportion of total observation period (%)	32.1	28.1	1	8.1

120

121 Although not statistically tested as part of the aims of the study, general observations recorded peak
 122 duration of hay ingestion occurring between 1900 and 2200, followed by a general decrease until the
 123 hours of 0400 and 0700. Around this time bedding ingestion was seen to increase. Additionally horses
 124 with hay nets were observed to have some hay left in the morning which may be explained in some
 125 cases by the prevalence of bedding ingestion.

126

127 **Nocturnal time budget**

128 Distinct differences were observed in nocturnal time budgets for lateral recumbency and ingesting
129 bedding behaviors, when comparing the shavings (figure 1) and straw (figure 2) bedding groups.
130 Overall the average proportion of time spent on other activities was greater for horses bedded on
131 shavings (17.7%) compared with straw (7%). This equates to 127.44 minutes and 50.40 minutes
132 respectively, where horses were not engaged in sleep, recumbent or ingestive behaviors.

133

134 Figure 1.

135

136 Figure 2.

137

138 **Discussion**

139 The results of the current study, although non-significant, reinforce previous research findings that
140 straw bedding encourages increased bedding ingestion and recumbent behaviors, and reduced
141 standing related behaviors (Pedersen et al., 2004; Werhahn et al., 2010). No standardization of bed
142 size or condition was made, therefore representing 'normal' bedding conditions observed in the
143 general population. Motivation to engage in bedding ingestion behaviors may have been influenced
144 by bedding condition, where horses have been observed to display anti-parasite strategies when
145 grazing at pasture (Fleurance et al., 2007). Further exploration of this theory in the stable may be
146 useful to establish whether bedding condition influences nocturnal behavior.

147

148 On average the horses bedded on straw were observed to ingest their bed for longer than those
149 bedded on shavings, although it is important to note that the latter still engaged in bedding ingestion
150 behaviors to some extent. Research has shown that horses provided with multiple forage
151 opportunities were observed to perform foraging behavior more frequently and for longer (Thorne et
152 al., 2005). In the current study however there was very little difference in total average duration of
153 ingestion behavior between shavings and straw beds, suggesting that whilst straw offers variation in
154 palatability it does not significantly influence the amount of time that horses spend eating in the
155 stable overnight. Although not quantified, general observations noted that horses moved between
156 ingestion of hay to bedding ingestion, supporting the idea that some motivation exists to introduce
157 variation into the diet. The ethogram used in the current study however incorporated prehension of
158 bedding under the heading 'bedding ingestion' which may have included hay that was mixed in with
159 the bed although the observer attempted to discern between the two.

160

161 Interestingly when the researcher asked the owners about each horse prior to the start of data
162 collection whether their horse had colicked in the last five months, all owners replied no. Although
163 straw ingestion has been linked with colic in the past (Greet and Rossdale, 1987) the anecdotal

164 reports from owners in the current study do not support this. Some horses engaged in bedding
165 ingestion more than others, suggesting different individual motivation to do so. Increasing access to
166 different types of forage within the stable has also been shown to decrease straw bed forage
167 behavior (Thorne et al., 2005), which may offer a practical solution for owners of horses who have
168 experienced colic associated with the use of a straw bed.

169
170 Straw beds have been reported to facilitate more sternal recumbency (Werhahn et al., 2010) and
171 lateral recumbency (Pedersen et al., 2004). In the current study a straw bed appeared to encourage
172 horses to spend a greater proportion of the observation period engaged in both lateral and sternal
173 recumbency compared with horses bedded on shavings, suggesting that straw facilitates sleep, and
174 more importantly paradoxical sleep, highlighting the potential for improved welfare. However it is
175 recognized that the exact amount of exercise each horse undertook was not standardized which may
176 have influenced the amount of rest that individual horses were motivated to undertake during the
177 study (Caanitz et al, 1991). Similarly the study could afford to be conducted over a longer period of
178 time to gain more data for each individual, and the size of the horse relative to the dimensions of the
179 stable should also be considered in future as horses have been found to engage in more recumbent
180 behavior in large boxes (Raabymagle & Ladewig, 2006)

181
182 Overall the average proportion of time spent on other activities was greater for horses bedded on
183 shavings (17.7%) compared with straw (7%). Further research may help to verify the following
184 suppositions; that this time may have been spent standing alert, moving, rolling, engaging in
185 stereotypic behavior, or defecation. Generally it is accepted that environmental enrichment aims to
186 improve the biological functioning of an animal by making adjustments to the artificial environment,
187 although measuring the success of such improvements quantitatively has proven to be challenging
188 (Newbury, 1995). Where it is possible to account for biologically relevant behaviors within time
189 budgets, it could be suggested that a straw bed encourages the display of more beneficial or
190 functional behaviors from horses compared with shavings, although further research would be
191 required to account specifically for the type and prevalence of these.

192

193 **Conclusion**

194 No statistically significant differences were observed for time spent engaged in ingestion or sleep
195 behaviors where horses were bedded on shavings compared with straw. The proportion of time not
196 spent engaged in sleep or ingestion related behaviors was greater for horses bedded on shavings,
197 suggesting straw enables more functional behavior to be displayed in the stable overnight. Although
198 no episodes of colic were recorded during or prior to the study, owners are recommended to
199 approach the requirements of individual horses with care. Future research should focus on
200 quantifying the occurrence of other nocturnal behaviors, whilst a greater understanding of individual
201 horse bedding preferences, including factors affecting motivation behind bedding directed and

202 recumbent behaviors, is still required.

203

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205

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