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Risk factors associated with behavioural disorders of crib-biting, weaving and box-walking in Swiss horses

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Summary

Reasons for performing study: **Studies on the prevalence of behavioural disorders in horses and on associated risk factors have revealed inconsistent results. There are many studies on the neuropharmacological, surgical ormechanical therapy of stereotypies, but little is known about their causation.**

Objectives: **To explore risk factors associated with the occurrence of behavioural disorders in horses.**

Methods: **A sample of horse owners, selected randomly and representative for Switzerland, was contacted in a postal survey. Answers were provided for 622 stables (response rate 35.2%). Individual data of 2341 horses were examined with path analysis (multivariable linear and logistic regression), and adjustment made for possible confounding effects due to age and breed.**

Results: **Out of 60 possible risk factors, 11 were associated with the outcome at the univariable level (null-hypothesis path model) and 3 factors remained after the backward logistic regression procedure. Mature Warmbloods and Thoroughbreds, assessed by the owners to be reactive, fed 4 times a day and without daily pasture, had increased odds of displaying crib-biting, weaving and box-walking. Furthermore, indirect associations of 5 factors with the outcome were identified.**

Conclusions: **The final logistic regression model of risk factors leads to the hypotheses that causal prevention of stereotypic behaviours should be based upon housing and management conditions which allow tactile contact with other horses (e.g. mutual grooming), daily free movement (paddock or pasture), as well as the provision of high amounts of roughage but of little or no concentrates.**

Potential clinical relevance: **It is one of the aims of population medicine to prevent the development of behavioural disorders. Further research is needed to test the concluding hypotheses in experimental studies or to verify them in the context of similar observational studies.**

Introduction

Studies on the prevalence of behavioural disorders in horses have revealed inconsistent results. Two and a half percent of examined Italian Thoroughbreds (Vecchiotti and Galanti 1986), 15% of Canadian horses (Luescher *et al.* 1991) and 1–4% of English Thoroughbreds (Prince 1987) displayed stereotypies, whereas McGreevy *et al.* (1995a) described 13.7% of horses of different breeds performing crib-biting, weaving, box-walking or wood-chewing. Other studies investigated neuropharmalogical (Dodman *et al.* 1987; McDonnell 1998), surgical (Frauenfelder 1981; Turner *et al.* 1984) or mechanical (McGreevy and Nicol 1998a) therapy of stereotypies, but little is known about their causation. Behavioural disorders may be caused by a variety of factors (e.g. genetics, rearing conditions, housing, feeding) which may be linked with each other (Stauffacher 1992) and, therefore, cannot be regarded as statistically independent in their effects.

Only recently, epidemiological methods and multivariable analyses have been used to investigate the association of behavioural disorders to environmental or horse-specific factors. McGreevy *et al.* (1995a,b) found behavioural disorders of Thoroughbreds to be most strongly associated with factors relevant during the time horses are in the stable; for example, daily amount of forage (less than 6.8 kg), bedding (other than straw) and social contact (isolation from other horses with no visual contact). On the other hand, in a cross-sectional Canadian study, Luescher *et al.* (1998) claimed characteristics of the individual horse (breed, age, sex) to be most important, with highest prevalence of crib-biting for Thoroughbreds and for stallions, increasing with age.

The aim of this study was to explore possible risk factors associated with the occurrence of the stereotypies crib-biting, weaving and box-walking, particularly a sample of all breed types, types of use, housing and management systems, representative for Switzerland. With respect to the complex network of potential interactions between the variables collected, data were analysed with path analysis, a commonly used multivariable statistical technique in veterinary epidemiology.

Materials and methods

Data collection

A postal survey of horse yards was conducted all over Switzerland from December 1996 to February 1997. Out of

*Author to whom correspondence should be addressed. ‡The questionnaire (in German or French) can be obtained from the last author upon request.

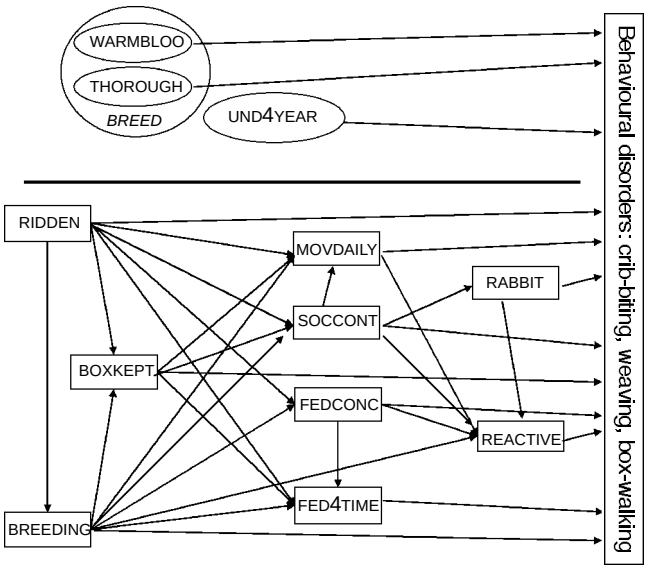

Fig 1: Null-hypothesis model of factors which may influence the occurrence of the behavioural disorders crib-biting, weaving and/or box-walking in horses.

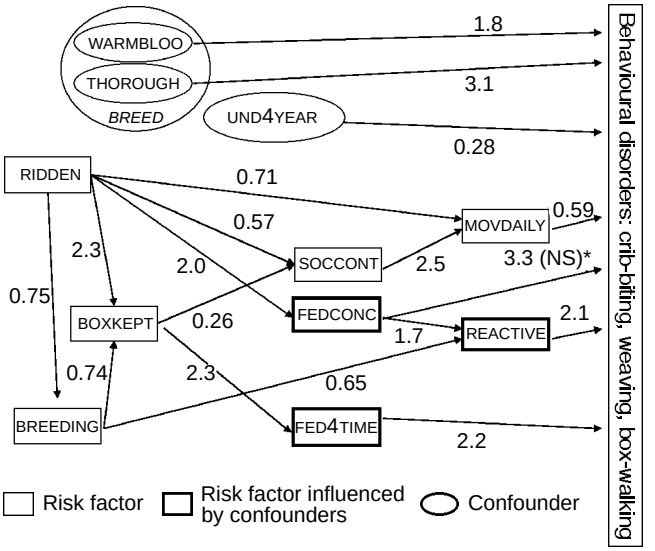

*Fig 2: Final model of risk factors for the occurrence of the behavioural disorders crib-biting, weaving and/or box-walking in horses. *Although FEDCONC had an OR of 3.3, it lost significance after confounders were included into the model. This was due to a very low proportion of horses performing behavioural disorders but not fed concentrates (2 out of 88 horses), resulting in a high 95% confidence interval (1.4, 22.8).*

21,313 officially registered yards with at least one horse (Anon 1994), 1768 were selected randomly, stratified by canton (according to the number of stables) and by stock sizes, and a project-specific 12-page questionnaire‡ was sent out. Detailed questions included general farm characteristics (e.g. farm size, number of horses in yard, education/training of persons taking care of the horses), characteristics of the horse (breed, age, sex, temperament, descendants), housing conditions (e.g. type of housing system, air supply, light, bedding type), social contact (auditory, olfactory, tactile or free; with conspecifics or other animals), feeding (e.g. forage type, frequency of food provision, type and amount of concentrates), use of the horses (e.g. type and extent), free movement (e.g. paddock or pasture, frequency and duration, in groups or individually) and conspicuous behaviours. Most questions had to be answered individually for every horse. The validity of the responses was evaluated by a cross-check with known measures from the officially registered yards (yard size, number of horses, age classes). Furthermore, data reliability was tested in 2 instances, by asking the same questions twice in slightly different forms and in different context.

Statistical analysis

Questionnaire data were managed using Access97[1] and statistical analyses carried out on individual horse variables using STATA 5.0[2]. The outcome variable was dichotomous; stating whether or not an individual horse was known to display one or several of the following stereotypic behavioural disorders: crib-biting, weaving or box-walking.

First, a data-quality check was carried out, using descriptive statistics. Some variables, likely to be subject to a recording bias, were excluded from further investigation. Variables with a frequency of more than 15% of missing values were excluded. The remaining factors were classified as being recorded on either a continuous, ordinal or categorical scale.

Selection of potential risk factors for the outcome variable was based on their known or suspected causal relationship, supported by literature or by biological reasoning. In total, 60 potential risk factors were analysed, describing farming management in general (11 factors), feeding (13), housing system (22) and use of the horse (9), or covering individual characteristics of the horse (5).

Path analysis was used to understand the interrelationships between the factors studied and their contribution to the outcome (Pedhazur 1982). As multivariate techniques are mathematically complex, the following description of the analytical procedure can provide only a rough outline; for detailed information, see Keil *et al.* (2000, 2001) and Audigé *et al.* (1999).

The potential risk factors were screened for association with the outcome using univariable statistical methods. Variables not showing a statistically significant association with the outcome variable with $P>0.15$ were excluded from subsequent multivariable analysis. This also applied for horses with missing data for one of the remaining factors. Differences between selected and excluded horses were checked by χ^2 test of independence, using the independent measures of the screened and selected variables.

With the remaining potential risk factors, a null-hypothesis path diagram (Burridge *et al*. 1977; Goldsmith 1977; Curtis *et al.* 1988) was drawn. In the following step, regression analyses were applied to assess statistically whether an arrow in the null-hypothesis path diagram would remain into the final diagram. Only statistically significant paths were part of the final diagram. Dichotomous variables (the outcome variable and all other factors with arrows leading to them) were analysed with multivariable logistic regression analyses, using a stepwise backward procedure. The exponentials of β-coefficients presented on significant paths between dichotomous variables were interpreted as odds ratios (Curtis *et al.* 1988). Odds ratios (OR) are a multiplicative measure of risk that range from 0 to infinity. An OR >1 is predisposing and implies a positive association between independent and dependent variables, while an OR <1 is preventive and implies an inverse association.

Because several horses were often housed in the same stable, a cluster effect due to stable was considered. A model adjustment for

TABLE 1: Descriptive statistics for potential confounding and for dichotomous risk factors associated with crib-biting, weaving and box-walking (χ^2 test Pvalue ≤0.15) included in the null-hypothesis path diagram and unadjusted odds ratios (OR)

Factor	Description	Categories	Behavioural disorders Yes	Behavioural disorders No	OR	95% confidence interval
Use of the horse						
RIDDEN	Use of the horse for riding and/or driving	Yes	79	1776	2.4	1.2, 4.7
		No	9	477		
BREEDING	Use of the horse for breeding	Yes	11	429	0.61	0.32, 1.1
		No	77	1824		
Housing system						
BOXKEPT	Horse kept in individual loose box (closed,	Yes	67	1430	1.8	1.1, 3.0
	open-fronted or with paddock)	No	21	823		
Feeding management						
FEDCONC*†	Horse is fed regularly with concentrates	Yes	86	1994	5.6	1.4, 22.8
		No	2	259		
FED4TIME	Horse is fed 4 times/day	Yes	9	99	2.5	1.2, 5.0
		No	79	2154		
Social contact possibilities between horses						
SOCCONT	Physical contact with other horse possible	Yes	34	1145	0.61	0.39, 0.94
		No	54	1108		
RABBIT*†	Rabbit as a companion animal	Yes	2	17	3.1	0.70, 13.5
		No	86	2236		
Free movement possibilities						
MOVDAILY	Free movement on pasture/paddock daily	Yes	38	1371	0.49	0.32, 0.75
		No	50	882		
Animal characteristics						
REACTIVE	Horse is assessed to be reactive (instead	Yes	24	316	2.3	1.4, 3.7
	of normal or calm) by the owner	No	64	1937		
Confounding factors						
UND4YEAR*†	Horse age <4 years	Yes	5	466	0.23	0.09, 0.57
		No	83	1787		
BREED†	Warmblood, Thoroughbred (English or	2 = WARMBLOO	53	944	2.5	1.6, 3.9
	Arabian) or other breed	1 = THOROUGH	7	77	4	1.7, 9.5
		0 = OTHER	28	1232		

*Pvalue calculated with Fischer exact test; †OR and 95% confidence interval calculated with logistic regression.

stable-effect was implemented with variables selected after the stepwise selection procedure by specifying the 'cluster' option with STATA 5.0[2]. The goodness-of-fit of the final model was estimated using the Hosmer-Lemeshow test with a P value >5% being considered a good fit (Hosmer and Lemeshow 1989). When there was only one explanatory factor, however (only dichotomous factors were used in this study), the χ^2 test of independence was used.

For analysis, breed and age were treated as potential confounders, because they were known to be associated with stereotyped behaviours (e.g. Kiley-Worthington 1983; Luescher *et al*. 1998); furthermore, a relationship to many other factors under study was assumed. Cross-tabulations and logistic regression analyses were used to explore differences in occurrence of stereotypies between horse breeds. Breeds were combined when no significant differences were observed between them or when numbers of horses were too small to conduct appropriate statistics. By combining breed-type categories, the variable BREED was subdivided into 3 categories; Thoroughbred (English or Arabian Thoroughbreds), Warmblood, or other breeds (other horse breeds, ponies, donkeys, crosses). The other potential confounder, UND4YEAR (age <4 years), resulted from a cut-off value of the continuous variable AGE, that best distinguished the horses with or without stereotypies. These 2 factors, BREED and UND4YEAR, were excluded during the model-building procedure and then forced back into the final model. A change of more than 10% of at least one regression coefficient was considered to be an indicator of a significant confounding effect (Greenland and Rothman 1998).

Results

Response rate and survey quality

Of the 1768 questionnaires sent out, 622 (35.2%) were answered, providing data on 2536 individual horses. Because of missing values for variables included in the null-hypothesis model, 195 horses had to be excluded from multivariable regression analysis. For 9 out of 12 variables checked, there were significant differences between the 2341 remaining and the 195 excluded horses. Horses with missing values were more often young, fewer Warmbloods or Thoroughbreds and, therefore, less reactive and tended to be kept in the following way; no concentrates, more free movement on pasture, more often kept in loose boxes, with more possibilities of social contact, and not used for breeding.

In comparison to the official Swiss horse census, there were fewer yards with 1 or 2 horses (52.7%) and more yards with over 2 horses (47.3%) in the survey than in the official registers (63.7 and 36.3%, respectively). In the survey, there were fewer foals (3.8%) and more horses age >3 years (79.0%) than in the official data (8.6 and 72.8%, respectively). For descriptive analysis of the questionnaire, see Bachmann and Stauffacher (2002a).

With respect to data reliability, the rates of inconsistent answers to the questionnaire were 5.6% for the combination 'type of housing system' and 'possibility for tactile contact to other horse(s)' and 2.8% for 'type of housing system' and 'free movement on paddock or pasture daily'. These answers were rechecked and corrected during a telephone interview.

TABLE 2: Odds ratio (OR) and 95% confidence interval (95% CI) of risk factors for the behavioural disorders crib-biting, weaving and box-walking included in the final model [a]

	OR	95% CI
Factor		
MOVDAILY	0.59*	0.37, 0.93
REACTIVE	2.1**	1.2, 3.6
FED4TIME	2.2*	1.1, 4.6
FEDCONC	3.3 (P = 0.10)	0.80, 13.8
Confounders		
WARMBLOO	1.8*	1.2, 3.0
THOROUGH	3.1*	1.3, 7.8
UND4YEAR	0.28*	0.10, 0.78

Goodness-of-fit (Hosmer-Lemeshow) P = 0.99. [a]Risk factor codes are described in Table 1; *P<0.05, **P<0.01.

Prevalence of behavioural disorders

Most behaviours described to be 'conspicuous'by the horse owner had no biological relevance (e.g. pawing, rubbing, easily frightened) (Bachmann and Stauffacher 2002b). Eighty-nine horses (3.5%, n = 2536) displayed crib-biting, weaving or box walking, or a combination thereof.

Screening and null-hypothesis path diagram

Eleven out of 60 potential risk factors were associated with the outcome variable at a P≤0.15. These factors were composed into the null-hypothesis diagram (Fig 1), with descriptive statistics presented in Table 1.

Multivariable analysis

After the backward logistic regression procedure, 3 factors remained in the final model with a direct association to the outcome (Fig 2). Horses which were assessed to be reactive (instead of normal or calm) by their owners had about doubled odds of being cribbers, weavers or box-walkers. If food was provided 4 times/day, the odds of performing stereotyped behaviours was increased by a factor of 2.2, compared to horses fed otherwise. On the other hand, free movement daily on paddock or pasture decreased the odds of stereotypies (OR = 0.59). Indirect associations of 5 factors with the outcome were identified: When a horse was used for riding or driving, odds ratios for free movement daily (OR = 0.71), physical contact to other horses (OR = 0.57) and use for breeding (OR = 0.75) were below 1, whereas ORs for fed with concentrates (OR = 2.0) and stabled in loose boxes (OR = 2.3) were above 1. Being a breeding horse was associated with reduced odds of being stabled in a loose box (OR = 0.74) and being assessed to be a reactive horse (OR = 0.65). Horses kept in loose boxes had 4 times decreased odds of having physical contact with other horses (OR = 0.26), but higher odds of being fed 4 times/day (2.3). Horses with physical contact with others had significantly more daily access to pasture (OR = 2.5) and, finally, horses fed concentrates were reported as reactive more often than other horses (OR = 1.7; this association was marginally nonsignificant).

The statistical details for risk factors included in the final model with the outcome crib-biting, weaving, box-walking are presented in Table 2. Regression models related to indirect significant paths within the final diagram are presented in Table 3. After considering a cluster effect due to stable, 5 factors of the indirect path diagram did not remain significant (Table 3). With one exception, FED4TIME (P<0.001, Table 3), the models fitted well or almost well to the data (Goodness of fit [Hosmer-Lemeshow or χ^2 test of independence], requested P≥0.05).

TABLE 3: Odds ratio (OR) and 95% confidence interval (95% CI) of the final model related to indirect path diagram*

Outcome	Factor	OR	P value	95% CI
REACTIVE[†]	FEDCONC	1.7	0.051[‡]	1.00, 2.7
	BREEDING	0.65	<0.01	0.46, 0.90
	Goodness-of-fit (Hosmer-Lemeshow):		0.98	
FEDCONC	RIDDEN	2.0	<0.01	1.2, 3.3
	UND4YEAR	1.0	0.841	0.65, 1.7
	WARMBLOO	8.6	<0.001	5.0, 14.6
	THOROUGH	8.6	<0.01	2.2, 34.7
	Goodness-of-fit (Hosmer-Lemeshow):		0.88	
FED4TIME[†]	BOXKEPT	2.3	0.056[‡]	0.98, 5.30
	χ^2 test:		<0.001	
MOVDAILY	RIDDEN	0.71	0.173[‡]	0.43, 1.2
	SOCCONT	2.5	<0.001	1.6, 3.8
	Goodness-of-fit (Hosmer-Lemeshow):		0.04	
SOCCONT	RIDDEN	0.57	<0.05	0.36, 0.88
	BOXKEPT	0.26	<0.001	0.17, 0.40
	Goodness-of-fit (Hosmer-Lemeshow):		0.002	
BOXKEPT	RIDDEN	2.3	<0.001	1.5, 3. 5
	BREEDING	0.74	0.162[‡]	0.48, 1.1
	Goodness-of-fit (Hosmer-Lemeshow):		0.045	
BREEDING	RIDDEN	0.75	0.341[‡]	0.42, 1.4
	χ^2 test:		<0.05	

*Risk factor codes are described in Table 1; [†]Confounding factors not considered in this model, because they were not significant. [‡]Selection was done without considering farm effect. Final results are presented with farm effect, even if some factors did not remain significant.

Confounding effects

The factors BREED and UND4YEAR were confirmed as confounders. Both categories, WARMBLOO and THOROUGH, were associated positively with outcome, indicating that being a Warmblood or Thoroughbred was associated with a 1.8- and 3.1-fold increased odds of being a crib-biter, weaver or box-walker, respectively, compared to all other breed types. In comparison to mature horses, those age younger than 4 years had almost 4 times lower odds (OR = 0.28) of performing stereotypies. BREED and UND4YEAR had a confounding effect on FEDCONC, REACTIVE and FED4TIME. The factor FEDCONC became nonsignificant after the confounders had been forced into the final model.

Discussion

Data management and analytical method

In this study, risk factors associated with the occurrence of the stereotypic behavioural disorders crib-biting, weaving and box-walking were investigated. To cover a wide range of suspected factors representative for Switzerland, and to identify enough cases of affected horses in a cost-effective way, a postal questionnaire survey was administered to a large sample of stables. The response rate of 35.2% was relatively high, taking into account the length and complexity of the questionnaire. The time-consuming process

of answering could have influenced the validity of the results in favour of well-managed stables. Also, there is no guarantee that all horses performing behavioural disorders were known and indicated by their owners. Furthermore, the comparison of the analysed sample with the official Swiss census 1993 revealed some slight differences in age composition and stock size. Such potential under- and overestimates are typical for epidemiological surveys based on questionnaires, but it is very likely that the representativity of this study, as well as the analytical procedure, were not affected to a major extent. All efforts were made to ensure that data provided by the horse owners were valid and reliable. Although the rates of inconsistency of 5.6% and 2.8% were considered acceptable, all inconsistencies identified were rechecked and corrected whenever possible.

Path models provide a comprehensive view of the causal web under study, with visual representation of the complex interrelationships (Pfeiffer and Morris 1994). So far, path analysis has rarely been used in ethological studies and never with horses. Keil *et al.* (2000, 2001) studied factors associated with the occurrence of intersucking in Swiss dairy heifers. They have shown that path analysis is an appropriate tool for understanding the interrelationships between risk factors and their contribution to the occurrence of behavioural disorders. A limitation of path analysis lies in the drawing of the null-hypothesis diagram after univariable analysis, as it is based on the current (potentially biased) knowledge of the biological process under investigation. This potentially subjective judgement, however, was limited by a thorough literature review and by extensive contacts with horse owners and experts. It is emphasised that this method only leads to hypotheses about the causation and the development of disturbed behavioural patterns. Such hypotheses may later be tested in experimental studies or, due to the very complex nature of the outcome, verified in additional observational studies.

Prevalence of behavioural disorders

Compared with the 1–15% prevalence of behavioural disorders reported in other studies (Vecchiotti and Galanti 1986; Prince 1987; Luescher *et al.* 1991; McGreevy *et al.* 1995a), the 3.5% of Swiss horses performing crib-biting, weaving or box-walking appears to be rather low. This may be due to different sample composition (e.g. selected breeds vs. all breeds of a national population) and to the types of behavioural disorders taken into account (e.g. many different 'behavioural problems' vs. selected stereotypies). Although occasional owners of crib-biters might not have participated in the survey, the proportion seems accurate for Swiss horses (including ponies; Bachmann and Stauffacher *et al.* 2002b).

Risk factors for the behavioural disorders crib-biting, weaving and box-walking

The factor BREED subdivided the horses into 3 categories; Warmblood, Thoroughbred and other breeds. For analysis, BREED was selected as a potential confounder, because horses of different breed-types may also differ in temperament, use, feeding and housing. Warmblood and Thoroughbred are known to display stereotypies more often than other breeds (Kiley-Worthington 1983; Vecchiotti and Galanti 1986; Luescher *et al.* 1998), possibly due to genetic differences. The probability of performing stereotypic behaviour increases with age. Furthermore, horses younger than age 3 or 4 years are housed, managed, used and fed differently from mature horses. As hypothesised, BREED and UND4YEARS had a significant impact on several factors in the final path model.

There are more suggestions than proper scientific studies about the causation of stereotypic behaviours in horses. Besides of genetics, supposed risks are associated with weaning, social contact, crowding, restriction, feeding, housing, exposure to a stereotyping neighbour, as well as to type or intensity of training (Kiley-Worthington 1983; Luescher *et al.* 1991). In UK Thoroughbred yards, the risk of behavioural disorders was increased when visual contact with a neighbouring horse was impossible, bedding other than straw was provided, less than 6.8 kg forage was fed daily, roughage was offered 3 times a day and was hay instead of hay alternatives and when no paddock was available (McGreevy *et al.* 1995a,b).

Horses assessed to be reactive instead of normal or calm by their owners had odds of exhibiting stereotypies twice as high as those of quieter horses. Vivacious breeds, such as Thoroughbreds, are known to have a higher prevalence of behavioural disorders than others (Kiley-Worthington 1983; McGreevy *et al.* 1995a; Luescher *et al.* 1998). In this study, Thoroughbreds and Warmbloods had 3.1- and 1.8-fold higher odds of being a crib-biter, weaver or box-walker than other breed types, respectively.

Although often emphasised in the literature, type and amount of exercise did not influence the occurrence of behavioural disorders. Indeed, the factor RIDDEN is associated with all but 2 factors of the final path model, but there is no direct path to the outcome. This suggests that riding or driving *per se* is not a direct cause of stereotypies, but using horses for riding or driving may be linked with specific housing and management variables. On average, horses were used 4.5 h/week (Bachmann and Stauffacher 2002a). Although the short duration of exercise is not linked to the outcome in the final model, it may well increase the influence of factors related to time spent in the stable.

Activities outside the stable allow expression of specific behaviours that are denied when stabled. Daily free movement (paddock and/or pasture) reduced the risk of behavioural disorders. Wild horses spend 9% of their day with locomotor activities, especially walking (Duncan 1980). At pasture, horses also have the chance to perform natural feeding behaviour, i.e. grazing. Furthermore, MOVDAILY was associated positively with the factor SOCCONT (tactile contact to another horse allowed). Social isolation is often assumed to cause stereotypies in horses (Kiley-Worthington 1983) and horses in visual and tactile contact with others have a reduced risk of abnormal behaviours (McGreevy *et al.* 1995b). In one study (Cooper *et al.* 2000), weaving was no longer recorded when box design of weavers increased opportunities for interactions with neighbouring horses.

Two factors related to the feeding management remained in the final model. This supports the study of McGreevy *et al.* (1995b) in which 3 out of 8 management factors associated to behavioural disorders were within feeding context. Feeding grain was found to cause a significant increase in the crib-biting frequency of crib-biting horses, whereas pelleted alfalfa hay was without effect (Gillham *et al.* 1994). This is consistent with the OR higher than unity for regular concentrate feeding (FEDCONC), although the factor lost statistical significance after confounders were forced into the final model. Crib-biters prevented from crib-biting and food intake responded with a significant increase in plasma cortisol and with a reduction in orocaecal motility (McGreevy and Nicol 1998b). This did not occur when only feeding or crib-biting, respectively, was prevented. The authors suggested that food intake

and crib-biting might be partial substitutes for each other.

Unfortunately, the variables 'daily time spent feeding' and 'daily amount of forage' had to be excluded from this study due to unreliable answers. Nevertheless, it is obvious that horses which were fed concentrates received less forage and therefore spent less time feeding, which again is consistent with the results of other studies. If food was provided 4 times a day, the odds of performing stereotypies was increased by a factor of 2.2 compared to horses fed more or less frequently. McGreevy *et al.* (1995b) found an increased risk when forage was offered 3 times a day. Therefore, an increase in stereotypic behaviour could be related to food anticipation. Waiting for food delivery 4 times a day may produce more emotional stress than waiting once or twice. On the other hand, delivering food more than 4 times/day may be equivalent to feeding *ad libitum* and therefore not trigger anticipation behaviour at all.

In accordance with McGreevy *et al.* (1995b), but not fully consistent with survey results of Luescher *et al.* (1998), the path model presented emphasises the importance of stable-related factors for the causation of behavioural disorders. However, the influence of breed type and age was also very strong. McGreevy *et al.* (1995b) collected data on young racehorses only and, therefore, breed and age were not considered as variables. In the present study, breed and age were treated as confounders and excluded from the model building process. Therefore, stable-related factors were not lost when entering into the final logistic regression analysis, as might have been the case in the study of Luescher *et al.* (1998). In conclusion, this study supports the hypothesis that some horse breeds have higher predispositions to develop sterotypic behaviours. These are often reactive horses, such as Thoroughbreds or some Warmblood breeds. However, the study also leads to the hypothesis that development and expression of stereotypies can be prevented or reduced by adjusting various stable-related and environmental factors. It is suggested that prevention should be based upon husbandry conditions which allow tactile contact to other horses, free movement at least daily and feeding with a high amount of roughage and little or no concentrates, as well as on a feeding management preventing situations causing food anticipation behaviour. Further research is needed to test these hypotheses in experimental studies or to verify them in the context of similar observational studies.

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Manufacturers'addresses

[1]Microsoft Corporation, Redmond, Washington, USA.
[2]Stata Corporation, College Station, Texas, USA.

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