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RESEARCH ARTICLE

Weaving horses. Etiological, clinical and paraclinical investigation

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Abstract

The stronger dissociation of animals from their natural habitat, the increasing role of the anthropogenic factor in animal biology and the utilisation of animals for different purposes (often uncommon for them) by men are responsible for the increased prevalence of stereotypic (psychic) disorders in a number of animal species. One of frequently seen unwanted stereotypes in horses is weaving.

Over a 2-year period, etiological, clinical and paraclinical investigations on 7 weaving horses have been carried out and the obtained results were compared to the same number of healthy subjects.

In our opinion, the main cause for weaving is the state of expectation of various stimuli – feeding, walking, training etc. from the part of horses. On the basis of our etiological investigations we assumed that frustration was the main triggering factor of the weaving horse vice as the animals were motivated (willing) to perform certain activities but they were not allowed to.

Weaving in horses represents abnormal repetitive swaying of the head and the neck of various duration, accompanied by swaying of the body from side to side with the front extremities. Most often, this behaviour could be observed about an hour before feeding or walking (training).

Blood samples were collected from all horses twice at 10-day intervals from v. jugularis for analysis of calcium, inorganic phosphorus, magnesium, plasma total protein, blood glucose, urea, creatinine, aspartate amino-transferase, alanine amino-transferase, alkaline phosphatase, thyroid stimulating hormone, free thyroxine, adrenaline, noradrenaline, adrenocorticotropic hormone, growth hormone (somatotropin), cortisol, insulin, dopamine, serotonin and melatonin.

In weaving horses, blood magnesium, adrenocorticotropic hormone, thyroid stimulating hormone and melatonin were decreased while the level of serotonin was higher vs control horses.

These data suggest that during the demonstration of the abnormal behaviour, the horses "felt happy"; furthermore, repetitive weaving was a means for increasing serotonin levels and thus, the personal feeling of comfort.

INTRODUCTION

Weaving is an abnormal behaviour in horses, characterised by repetitive swinging of the head, neck and swaying of the body with the front legs and sometimes, hind quarters. Among horse owners, this vice is often called "bear step" or "bear paw". According to Nicol (1999a,b) locomotor stereotypic behavioural disorders could affect as much as 3% of adult horses, while the incidence as per McBride (1996) varied about 7-9%.

Weaving, a common locomotor stereotypy, has been associated with social isolation in stabled horses. Weaving is most commonly seen when the animals are deprived from walking or their locomotion within the box is very restricted by the insufficient space (McGreevy et al., 1995a,b; Cooper and Albentosa, 2005; McMillan, 2005; Christie et al. 2006). Some researchers (Nicol, 1999; Ninomiya, 2007) believe that a probable cause for this abnormal behaviour is the frustration from the lack of social contacts of animals with other horses. This hypothesis is supported by the fact that the reinstatement of social contacts reduced stereotypic behaviour at a considerable extent (Binev et al., 2012). Increasing number of opinions about weaving being an obsessive compulsive disorder have emerged as this vice is characterised with repetitive, stable unusual behavioural activity beyond the normal locomotor activity of horses (Mason et al., 2006a,b). Also, it is outlined that weaving in horses occurs on the basis of conflict with environmental factors (Cooper et al., 2000; Cooper and Albentosa, 2005; Ninomiya, 2007) and that it is directly related to the specific rearing conditions and selection (Mason and Latham, 2004; Clegg et al., 2008). At the background of high extent of repetition and continuous conflict or frustration, this stereotypic behaviour could evolve into "emancipated" (free from dependence, prejudices and limitations) (Korff et al., 2008), as compared to the normal behaviour of the animal species and could be exaggerated, repetitive and stable (Mason et al., 2006a). A specific trait of psychic disorders is that they are manifested in different situations at a decreasing level of excitement (McMillan, 2005).

So far, the opinions about the causes for the weaving horse disorder remain controversial. The etiological factors are various and multiple, but according to most authors, (Mills et al., 2000; Bachmann et al., 2003; Mason and Latham, 2004; Mason et al., 2006b; Murphy and Arkins, 2007) stress is the primary triggering mechanism of compulsive disorders. In line with the theory for stereotypic behaviour in animals, the obsessive behaviour is assumed to result from conflict with the environment and consequently, frustration and stress (Nagy et al., 2009; Hemmann et al., 2012).

According to most researchers, the pathophysiology of obsessive compulsive disorders in animals is similar to that in humans – changes in the level of serotonin, dopamine, beta-endorphin systems etc. (Beerda et al., 1999; McMillan, 2005; Lim and Young, 2006; Gillham et al., 2007; Korff et al., 2008; Hemmann et al., 2012).

A lot of other factors are thought to be involved as causes for the onset and development of stereotypic behaviours in horses. These include confinement isolation from other horses (Nicol, 1999; Cooper et al., 2000; McAfee et al., 2002; Mills and Davenport, 2002), an over-abundance of environmental activity (Cooper et al., 2000), provision of small concentrated feeds (McGreevy et al., 1995a; Nicol, 1999), increasing meal frequency (Cooper et al., 2005) and both a lack of stimulation (Waran and Henderson, 1998; McBride and Cuddeford, 2001).

Due to the belief that weaving is a psychic disorder and data for chronic traumatism resulting from exerted locomotor activities, various techniques have been tested to distract and engage the horses (Henderson and Waran, 2001). The effect from using mirror, balls and other means for distraction is disputable and not satisfactory (Mills et al., 2000, Mills and Davenport, 2002). Other recommendations include rearing in a larger box, more frequent training and walking (Nicol, 1999b; McBride and Cuddeford, 2001; Waters et al., 2002; McGreevy, 2004; Ninomiya, 2007).

The aim of the present study was to establish the possible causes for the occurrence of this stereotypic disorder and to elucidate some neurophysiologic events in weaving horses on the basis of results from blood laboratory assays. Our hope is to throw some light on the neurophysiologic basis of the disorder and to evaluate the adequacy of measures used for limitation of this abnormal behaviour.

Material and methods

The investigations were conducted over a 2-year period, in 7 horses: 3 of them owned by the Experimental Equine Base at the Trakia University, Stara Zagora and 4 owned by private horse farms from different regions in the country.

A thorough history including a detailed neurological exam was taken from all animals. Four of patients were provided with rubber balls, and mirrors were placed in their boxes.

Horses were divided into 2 groups – group I (control; n=7) – horses that did not demonstrated weaving and group II (n=7) – horses exhibiting this stereotypic behaviour. All animals were from the same gender and housed under equal conditions and activity schedule with regard to training, walking, feeding, drinking, cleaning etc. The signalment data of the control group of horses were as close as possible with horses from group II (Table 1).

Blood was sampled from v. jugularis of all horses twice at 10-day interval for analysis of: calcium (Ca, mmol/L), phosphorus (P, mmol/L), magnesium (Mg, mmol/L), plasma total protein (TP, mmol/L), blood glucose (Glu, mmol/L), urea (mmol/L), creatinine (μmol/L), aspartate amino-transferase (AST, U/L), alanine amino-transferase (ALT, U/L) and alkaline phosphatase (ALP, U/L) (an automatic biochemical analyzer Mindray BS-120, China), tiroideastimulating hormone (TSH, mlU/L), free thyroxine (FT_4, pmol/L), adrenaline (ng/L), noradrenaline

(ng/L), growth hormone (somatotropin) (GH, ng/ml), cortisol (nmol/L) and insulin (μU/ml) (by electrochemiluminescence an apparatus Elecsys 2010, Roch-Hitachi, Japan), adrenocorticotropic hormone (ACTH, pg/ml) (via electrochemiluminescence apparatus Imulite 2000, Siemens, Germany), dopamine (ng/L), serotonin (μg/L) and melatonin (ng/L) (by high-performance liquid chromatography an apparatus Hitachi, Japan).

Табл. 1. Formation of horses (weaving and control) in pairs as stable, sex, age and breed.

Pair	Stable	Weaving (sex, age, breed)	Control (sex, age, breed)
1	School horse base	Stallion, 14 years, East Bulgarian horse	Stallion, 13 years, East Bulgarian horse
2	School horse base	Stallion, 17 years, Danube horse	Stallion, 16 years, Danube horse
3	School horse base	Gelding, 19 years, Haflinger horse	Gelding, 15 years, Haflinger horse
4	Private stable	Stallion, 11 years, East Bulgarian horse	Stallion, 8 years, East Bulgarian horse
5	Private stable	Gelding, 17 years, half-bred	Gelding, 14 years, half-bred
6	Private stable	Stallion, 18 years, East Bulgarian horse	Stallion, 19 years, East Bulgarian horse
7	Private stable	Mare, 12 years, half-bred	Mare, 9 years, half-bred

Blood samples from control horses were collected in the morning (8.00 AM) before feeding, and samples from weaving horses – at the time of its manifestation.

All results were processed with statistical software (Statistica 6.0 for Windows, StatSoft Inc. USA, 1993). The significance of differences between weaving horses groups and controls were evaluated by ANOVA. The level of statistical significance was $P<0.05$.

Results

Our observations showed that all horses demonstrated weaving at the time of expecting food, as well as before getting out of the box for walk, training or drinking. In about 70% of cases, this abnormal behaviour appears half an hour to one hour before the morning feeing and relatively rarely (≈30%) before the evening feeding. In about 60% of weaving horses, the stereotypic behaviour was observed before leaving the box for walk, training and drinking water. In the other horses, the same rate of abnormal behaviour episodes was registered during leaving the box.

All weaving horses exhibited swaying of the head and neck, and body movements from side to side with front quarters, very rarely with hind quarters. This combination of movements with head and extremities occurred at the same time and was of various duration, most commonly between 5 and 15 min. Weaving was usually interrupted by pauses during which the animals exhibited their normal physiological activity. After the pauses, the stereotypic behaviour was repetitively resumed.

Three of animals reared in boxes fenced with metal bars exhibited multiple excoriations in the region of the head with specific localisation on the prominent parts of the skull (Fig. 1 and 2).

Fig. 1 and **2.** Excoriations on the prominent parts of the head and the lower part of the neck (right). Weaving horses.

Due to the specific nature of the head movements, the skin lesions in these regions occurred as a result from constant rubbing against the metal bars (self mutilation). In some instances, skin lesions were localised on the lower neck as a result from rubbing against the concrete bed where feed was offered (Fig. 2).

In 3 (43%) от weaving horses, improper conformation of front legs was present. Damage of muscles, joints, tendons and bones of hooves and front legs consequently to continuous repetitive movements was observed. The horses were excluded from training because of intermittent or constant lameness. In one case (14%), laminitis was diagnosed.

The analysis of blood parameters (Table 2) revealed statistically significant changes in magnesium, thyroid stimulating hormone (TSH), adrenocorticotropic hormone (ACTH), serotonin and melatonin between the groups. In weaving horses the respective average values were 0.87±0.24 mmol/L, 0.36±0.21 mlU/L, 7.41±1.68 pg/ml, 364.3±48.2 μg/L and 2.12±0.62 ng/L, vs 1.28±0.35 mmol/L ($p<0.05$), 5.28±1.75 mlU/L ($p<0.01$), 18.63±5.42 pg/ml ($p<0.01$), 107.3±31.3 μg/L ($p<0.01$) and 4.15±0.88 ng/L ($p<0.01$) in controls.

Tabl. 2. Change in some blood parameters in weaving horses

Groups	Ca (mmol/L)	P (mmol/L)	Mg (mmol/L)	TP (mmol/L)	Glucose (mmol/L)	Urea (mmol/L)
I	3.04±0.42	1.08±0.17	1.28±0.35	62.8±7.2	4.86±0.73	5.73±0.88
II	2.89±0.38^{ns}	0.93±0.11^{ns}	0.87±0.24*	70.4±8.8^{ns}	5.22±1.03^{ns}	5.12±1.12^{ns}
	Creatinine (μmol/L)	AST (U/L)	ALT (U/L)	ALP (U/L)	TSH (mlU/L)	FT_4 (pmol/L)
I	137.4±18.9	263.0±30.7	9.11±1.14	216.0±28.7	5.28±1.75	11.8±2.5
II	121.8±16.4^{ns}	237.3±33.6^{ns}	8.85±1.14^{ns}	194.1±25.2^{ns}	0.36±0.21**	15.4±3.8^{ns}
	Adrenaline (ng/L)	Noradrenaline (ng/L)	ACTH (pg/ml)	GH (ng/ml)	Cortizol (nmol/L)	Insulin (μU/ml)
I	48.7±11.2	210.4±54.2	18.63±5.42	4.78±2.12	166.1±32.9	12.82±3.42
II	37.6±13.4^{ns}	164.2±38.4^{ns}	7.41±1.68**	3.16±1.64^{ns}	138.8±29.4^{ns}	14.61±4.12^{ns}
	Dopamine (ng/L)	Serotonin (μg/L)	Melatonin (ng/L)			
I	52.3±9.6	107.3±31.3	4.15±0.88			
II	41.7±11.1^{ns}	364.3±48.2**	2.12±0.62**			

Difference from control group**;** n.s. – non significant; $^{*}p<0.05$; $^{**}p<0.01$.

Legend: Ca – calcium; P – inorganic phosphorus; Mg – magnesium; TP – plasma total protein; AST – aspartate amino-transferase; ALT – alanine amino-transferase; ALP – alkaline phosphatase; TSH – tiroideastimulating hormone; FT_4 – free thyroxine; ACTH – adrenocorticotropic hormone; GH – growth hormone (somatotropin).

Discussion

The observed abnormal behavioural activities characterised with frequent swaying of head, neck and front quarters of variable duration were probably due to frustration from failure of affected horse to perform social contacts with other animals. This thesis was supported by the fact, that after restoration of social contacts with horses outside the stable, weaving was not observed. In described cases, the main reason for weaving in our opinion was the expectation of different stimuli – feeding, walking, training etc. On the basis of our investigations we suggest that frustration was the main triggering factor of the weaving horse vice as the animals are motivated (willing) to perform certain activities but they were restrained from doing them. This way, our data about the etiology of the weaving behaviour in horses agree with those already reported by other researchers (Christie et al., 2006; Hothersall and Nicol, 2009; Geor et al., 2013).

Our data allowed affirming (Christie et al., 2006; Mason et al., 2006b; Heather et al., 2008), that this stereotypic behaviour in the horses is a kind of obsessive compulsive disorder, as it is repetitive, stable unusual behaviour not consistent with the normal locomotor activity of horses. Also, this psychic pathology emerges on the basis of conflict with housing environment factors.

Our observations confirmed the data of McGreevy et al. (1995b), McGreevy and Nicol (1998a), Cooper et al. (2005) and Clegg et al. (2008), namely that the weaving behaviour occurs most commonly an hour before feeding. This supports the opinion that weaving is rather a consequence of frustration caused by the excitement of anticipation of a given event and at a significantly lesser extent, response to dietetic factors or deficiency of stimuli.

From published discussions (McGreevy et al., 1995a,b; McGreevy and Nicol, 1998a; Cooper et al., 2005; Gillham et al., 2007), we hypothesised that weaving peaks during periods of high activity such as prior to feeding and turnout.

In the view of some authors, (Nicol, 1999; Heather et al., 2008) the deprivation of horses from walking or severely limited locomotion within a small box are other possible reasons for occurrence of weaving. Our observations did not show such cause-and-effect relationship, as the horses were regularly walked and the area of their boxes was about 15 m^2.

Six (86%) of horses in this study demonstrating weaving were male and only 1 (14%) mare was affected. This fact agrees with reported data, but there is not a common agreement on the cause for the predisposition of males. It is acknowledged that in men, serotonin levels are almost twice lower than in females. Probably, males need more numerous and variable stimuli and response activities for maintaining the optimum sense of comfort.

The analysis of blood laboratory analyses showed statistically significantly increased levels of serotonin, and lower blood magnesium, thyroid stimulating hormone, adrenocorticotropic hormone and melatonin.

The available literature data showed that blood mineral concentrations in horses are directly associated with their dietary content and endocrine regulation (Hothersall and Nicol, 2009; Christie et al., 2006; McBride and Hemmings, 2005; McBride and Hemmings, 2009). Some of them (calcium, potassium, sodium, lithium, chlorides etc.) are essential for the onset of psycho-neurological disturbances in animals and men (Nicol, 1999; Freire et al., 2009; Frape, 2010). Magnesium is one of most important macro minerals responsible for maintaining the equilibrium of neurological processes at cellular level. (Secombe et al., 2012; Geor et al., 2013). Our studies showed that the blood level of this parameter was lower in weaving horses than in healthy controls.. Levels of the calcium and inorganic phosphorus ranged around the controls determinations. The registered hypomagnesaemia was in line with reported data about lower magnesium levels in hyperkinesia because this ion prevented both the development of hyperkinesia and impairments of learned behaviour (Yakimovskii and Varshavskaya, 2007). Weaving horses exhibited numerous episodes of hyperkinesia of extremities, head and neck.

The existing opinions that (McBride and Hemmings, 2005; Hemmann et al., 2012) the different types of stress could trigger weaving in horses provided incentive for analysis of several blood parameters as adrenocorticotropic hormone, growth hormone (somatotropin), cortisol, adrenaline, noradrenaline, dopamine, insulin, blood glucose, cholesterol and catecholamines (adrenaline, noradrenaline and dopamine. Multiple studies conducted for establishing the changes in these blood laboratory indices together with thyroid gland parameters (thyroid stimulating hormone and free thyroxine) demonstrated that they were related to psychic processes in animals and men (Breuhaus, 2002; McBride and Hemmings, 2005; Haritou et al., 2008). It is found out that some stereotypic behavioural disorders in horses were not accompanied by substantial deviations in blood concentrations of these parameters or existing changes were not consistent (Gillham et al., 2007; Haritou et al., 2008; Hemmann et al., 2012). Our results also confirmed the tendencies and we also assert the conviction of Medica et al. (2011) about the need for thorough and critical interpretation of data from blood hormonal analysis in clinical psychology.

In our study, blood adrenocorticotropic hormone was lowered, while other studied analytes (growth hormone, cortisol, adrenaline, noradrenaline, dopamine, insulin, blood glucose, cholesterol) did not exhibit any significant changes. We support the thesis that stress is the triggering factor of abnormal activities, but according to present results, when animals exhibit the stereotypic behaviour, specific blood markers of stress (cortisol, dopamine, adrenaline and noradrenaline) were not altered and moreover, adrenocorticotropic hormone was lower than respective control levels. Our results are thus comparable to those of McBride (1996), McGreevy and Nicol (1998a), Pell and McGreevy (1999), McBride and Cuddeford (2001) and Clegg et al. (2008). We agree with the hypotheses of Clegg et al. (2008) and Freire et al. (2009), that possibly, the long-term demonstration of stereotypic behaviour could exert a stress-reducing effect in animals. The history of weaving horses in our experiment showed that the stereotypic behaviour was exhibited for more than a year. This fact fully correlates to data of Clegg et al. (2008) and provide support to the thesis that changes in blood markers of stress are more likely to be found in young horses or at the beginning of weaving. On the basis of results, it could be assumed that during the hyperkinetic activity, weaving horses were not in stress.

This thesis of ours was also supported by blood serotonin and melatonin concentrations. Investigations on blood levels of these parameters showed that in most cases they changed significantly regardless of the type of the psychic disorders in both animals and men (Gillham et al., 2007; Haritou et al., 2008).

Our experiment revealed twofold reduction in blood melatonin in weaving horses vs control animals. In our view, the lower melatonin was associated with the continuous state of enhanced anxiety (demonstrated with hyperkinesia in weaving horses) and resulting fatigue (Haritou et al., 2008). Possibly, melatonin decline could be attributed also to circadian fluctuations (melatonin concentrations in blood are lower during the light part of the day) or age-related factors (aging reduces melatonin secretion) (Haritou et al., 2008; Murphy et al., 2011). During the

present study however, both groups of horses (control and weaving) were at a similar age, and blood samples were obtained during the same part of the day (in the morning).

The results from blood serotonin analysis showed that in weaving horses its concentrations increased more than 3 times vs controls. It is acknowledged that serotonin is the "hormone of happiness" ("pleasure") (Hemmann et al., 2012), and physical exercise increases the levels of this neurotransmitter in men (Jacobs and Fornal, 1997). Considering the scarce available information in animals as well as the low number of studied horses (n=7), it could be supposed with great caution that during the demonstration of the stereotypic disorder, the horses are "happy" and that the repetitive swaying in weaving horses was a means for increasing blood serotonin levels and thus, the feeling of comfort.

The analysis of some hormones related to thyroid gland function (thyroid stimulating hormone and free thyroxine), showed lower TSH concentrations in weaving horses than in healthy ones. As the role of thyroid hormonal disbalance in the onset of psychic disorders in animals is disputable and not studied in detail, it could be only implied that low blood TSH correlated inversely (Breuhaus, 2002) with increased fT_4 in horses exhibiting the stereotypic disorder, although not statistically significantly.

The clinical observations showed that consequently to continuous identical movements, 3 3 (43%) of weaving horses had muscle, joint, tendon and bone injuries in the region of hooves and front legs.

These findings are a curious phenomenon, when "happy" weaving horses cause themselves physical injuries with important adverse effect on their health and physical fitness.

Management of weaving stereotypic behaviour.

In boxes of all weaving horses, originating from private stable, mirrors and a rubber ball were placed with the purpose to distract them and engage their attention. During the first 2-3 weeks after introduction of the new stimuli, a substantial reduction in the frequency and duration of stereotypic disorder were noticed. After about a month after placement of mirrors and balls, the animals "lost" interest to them and weaving was resumed with the usual traits of this behavioural disorder.

In our opinion, the practice of introducing new stimuli interferes with the will of the animal to choose by itself how to feel "happy" or "satisfied". This results in a kind of conflict between the purpose of rearing set by the owner, and the psychic health of the animal, suffering from the abnormal behaviour.

In general, we agree with theses that imitation could be a possible mechanism for occurrence of psychic disorders in animals (McGreevy, 1999; McAfee et al., 2002; Mills and Davenport, 2002; Waters et al., 2002; Nagy et al., 2008). Our observations did not allow us making categorical conclusions as 4 (57%) of weaving horses were housed in close vicinity with optimum visual contact, whereas the other 3 (43%) have never been inn contact with other horses exhibiting the studied abnormal behaviour. This fact supports the assumptions of McGreevy (2004) that horses do not learn this stereotypic behaviour through "imitation".

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