

The identification of abnormal behaviour and behavioural problems in stabled horses and their relationship to horse welfare: a comparative review

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Summary

Many behaviours in domestic animals, such as the 'stable vices' of horses, are treated because they are considered undesirable for economic or cultural reasons, and not because the activity affects the horse's quality of life. The impact of a behaviour on the human reporter is not a function of its impact on the animal performer, and an understanding of the causes and effects of the particular activity is necessary to assess the costs and benefits of treatment. Where the behaviour is a sign of poor welfare, such as an inadequate environment, treatment can best be achieved by removing these underlying causal factors. Pharmacological or physical prevention of a behaviour can be justified only if the behaviour causes harm to the performer or to others. In these cases, prevention of the behaviour without addressing its causes is no cure and may result in its perseverance in a modified form or the disruption of the animal's ability to adapt to its environment. Where the behavioural 'problem' causes no harm and is not related to poor housing, then the education of the reporter, rather than treatment of the performer, may be the best solution.

Introduction

The behaviour of captive animals is commonly described as abnormal (Fox 1968; Fraser and Broom 1990). This term is applied to a variety of behaviours including: feather-pecking by laying hens (Blokhuys 1986); tail-biting by fattening pigs (Dougherty 1976); and pacing by polar bears in zoos (Meyer-Hopzapfel 1968). In horses, weaving, box-walking, pawing, kicking, self mutilation, cribbing, wind-sucking and wood-chewing are all described as abnormal (Waring 1983; Kiley-Worthington 1987; McBane 1994).

Abnormal behaviour elicits considerable controversy in animal husbandry. Many activities are described as abnormal because they are a problem for the human reporter, who may find the behaviour inconvenient, offensive, unsightly, incomprehensible, or may believe it to be indicative of suffering. An abnormal behavioural response can, however, also be a real

problem for the animal, where it causes physical harm or where it is associated with an inadequate environment (Dawkins 1980; Mason 1991). In horses, certain activities such as self mutilation overtly reduce the performer's well being, but the majority of behaviour is referred for treatment because it is a problem for the owner. Both the occurrence and the prevention of behavioural responses the stable environment can reduce the horse's quality of life. Consequently, it is important to determine the extent to which an activity is a problem both for the horse and for the observer, before attempting behavioural modification.

The use of the terms abnormal and problem to describe animal behaviour

There are a number of difficulties with the careless use of terms like 'abnormal behaviour' and 'behavioural problem' in the description and treatment of animal behaviour. Both are descriptive concepts that cover a range of diverse activities with superficial similarities which can nevertheless vary widely in their causes and in their effects. They are also ambiguous terms which have several scientific and popular meanings, are applied inconsistently and can depend as much on the subjective perspective of the reporter as on the behaviour itself (Dawkins 1980). Below, we consider some of the ways these terms are used.

In ethology, abnormal behaviour means responses that are literally 'away from the norm' as in statistically rare in their context or different from a given normal population (Mason 1991). Conventionally the normal response is taken to be that of free living animals (Hediger 1950) or that of animals in conditions that allow a full range of behaviour (Fraser and Broom 1990). In clinical veterinary medicine and psychology, abnormal behaviour is used in a different sense, as a diagnostic tool to help identify pathological illness or damage (Rosenhan and Seligman 1989; Gershon and Rieder 1992). Abnormal levels of activity, abnormal posture or abnormal responses can be indicative of illness, pain or discomfort (Morton and Griffiths 1985; Hart 1988).

For ethologists, behavioural problems are described from the perspective of the animal in terms of how the behaviour affects quality of life. Some abnormal responses may be harmful, maladaptive, or related to a poor environment, but there is no implication that an abnormal response is necessarily a problem for the animal. For practising veterinarians and behavioural

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consultants, who work with the general public, behavioural problems are considered to be activities that are undesirable to the reporter (O'Farrell 1990; McBane 1994). Animals are referred for treatment because their behaviour is offensive (coprophagia by dogs), inconvenient (destructiveness in home-alone dogs), distressing or incomprehensible (stereotypic pacing by polar bears in zoos). Alternatively, animals may be treated because their behaviour appears to reduce quality of life (self mutilation) or reduce the value of the animal (wind-sucking in horses).

Clearly, the impact of the behaviour on the human observer is not a function of its significance to the animal performer. Nevertheless, simple descriptive terms, such as abnormal behaviour and behavioural problem, often take on inferential and emotionally loaded meaning for the general public (Dawkins 1980). On the one hand, abnormal responses can be considered behavioural vices, as if the animal is in some way at fault, or maliciously causing trouble. On the other, abnormality and behavioural problems can be implicitly related to well being, such that animals that perform an abnormal response must in some way be suffering. The terms 'abnormal behaviour' and 'behavioural problem' may, therefore, have some use in the description of animal behaviour, but they are too ambiguous, inconsistently applied, and subjective to help with the modification of behaviour. A better approach is to focus on the behaviour itself and to avoid arbitrary distinctions, such as that between abnormal and normal behaviour. Investigations of each behavioural response, whether or not it seems to be abnormal or a problem, make it easier to understand the response in terms of its causes and effects and, consequently, its implications for animal welfare and, if required, the best approach to treatment.

Abnormal behaviour, behavioural problems and suffering

An animal's behaviour can relate to welfare in 4 ways (Dawkins 1980; Mench and Mason 1997): an indicator of poor welfare; a means of adapting to the captive environment; its performance can itself be harmful; or it can have little direct impact on the performer's quality of life.

A pattern of behaviour can be a response to an inadequate or noxious environment and, as such, an indicator of low quality of life. Good evidence for apparently abnormal behaviours indicating poor welfare has been found in both motivational and physiological studies. Hens that are experimentally frustrated by placing a glass barrier over their food dish pace to and fro (Duncan and Wood-Gush 1972). These pacing activities are also found in caged hens particularly prior to laying when they have had little opportunity to perform nesting behaviour (Cooper and Appleby 1996). Similarly, stereotypic bar-biting in pigs has been related to hunger (Terlouw *et al.* 1991a) and to physiological measures of stress (Dantzer 1991; Schouten *et al.* 1991; Terlouw *et al.* 1991b).

There is some evidence that an animal's behavioural response to captivity is an adaptive mechanism which reduces the impact of a poor environment (Cooper and Nicol 1993). Stereotypic voles become less choosy in their environment preference (Cooper and Nicol 1991) and rats that are surgically prevented from stereotyping show a prolonged rise in blood corticosteroids following administration of pharmacological stressors such as amphetamine (Jones *et al.* 1989). On the whole, however, evidence that so-called abnormal responses help animals to cope with captivity is sparse and difficult to interpret (Mason 1991; Cooper and Nicol 1993; Rushen 1993). Bar-biting in pigs and cribbing in horses have been associated

with reduced heart rates (Schouten 1991; Lebelt *et al.* 1996) or reduced blood corticosteroids (Terlouw *et al.* 1991b), but is not clear whether these activities directly affect physiological correlates of stress, or if their effect is co-incidental (Dantzer 1991; Terlouw *et al.* 1991b).

While some of the behaviour of captive animals may be beneficial, many activities found in captive animals can be harmful either to the performer or to other animals. Caged monkeys, for example, can bit themselves so hard they scream (Morris 1964). Anal massaging and tail-biting in pigs and feather-pecking in hens can wound and lead to trampling and suffocation (Dougherty 1976; Fraser and Broom 1990). The behaviour of captive animals is not, however, unique in causing physical injury. Male lions, for example, usually kill the young cubs on taking over a pride. Infanticide is not only harmful, but appears at first glance to be maladaptive. The removal of the previous males offspring, however, increases the incoming males fitness because the female lions become sexually receptive sooner than if they were suckling cubs (Dawkins 1989).

In horses, a number of responses to the stable environment are believed to be harmful. For example, wind-sucking and cribbing are irregularly associated with teeth wear and potentially life threatening colic (McGreevy 1995). It is, however, unclear as to whether there is a causal or correlational relationship between wind-sucking and colic, particularly as the wind-sucking action does not actually involve aerophagia (McGreevy *et al.* 1995a). Weaving and box-walking in stabled horses are also said to have harmful consequences such as muscle damage and fatigue (McGreevy 1995), but again their prevalence is unclear (McGreevy *et al.* 1995b). It may be that the deleterious consequences of these activities are genuinely rare within the horse population but colic or muscle damage are more likely to be reported when they affect athletic performance. Consequently, weaving or cribbing are more likely to be labelled as problems and referred for treatment in elite horses, than in less valuable horses where athletic performance is less critical.

Finally, many behaviours that are unique to captivity, such as circling by dogs before settling and wheel-running by hamsters, do not appear to be directly related to welfare (Mench and Mason 1997). In general, unless a behaviour is overtly causing injury, the animal's behaviour in captivity is only a rough indicator of well being (Dawkins 1980). Unusual or incomprehensible responses may develop as the bastardised expression of naturally motivated responses in restricted or unusual conditions, but the extent to which they are adequate substitutes is unclear.

The modification of animal behaviour

There is strong case for preventing overtly harmful behaviour. It is, however, dangerous to apply this reasoning to all behaviour that we find undesirable, especially if they cause the animal little harm, or have some benefit in captivity. If prevention is to be achieved without the risk of devaluing the animal's environment, then it is best to address the underlying causes. For example, gerbils perform stereotypic digging in cages with sawdust as litter (Wiedenmeyer 1996). In the wild, gerbils would naturally dig burrows, but this is not possible in sand or sawdust. Removing the digging substrate reduces the digging stereotypy but does not solve the motivational problem and gerbils shift to scabbling or wire-gnawing stereotypes. In contrast, providing a long burrow or substrates that allows the construction of a burrow extinguishes the digging stereotypy without an increase

in other stereotypies. Similarly, bank voles readily perform jumping and somersaulting stereotypies, when housed in small, barren cages. These appear to develop from escape attempts and can be prevented in young voles by providing natural cover in the form of hay or straw (Ödberg 1987; Cooper *et al.* 1996).

Horses are naturally free-ranging, social, grazing herbivores. In stables, horses are provided with food, water and shelter, but their choice of feed, social interactions and movement are limited. Under these conditions a number of behaviours can develop that are considered undesirable, such as weaving, crib-biting and wind-sucking. An understanding of the horse's behavioural organisation and how this will be affected by the stable environment and management is a logical first step to understanding why these behaviours arise and how to treat them.

Locomotor stereotypies, such as weaving and box-walking, may be related to exercise, so turning out or frequent exercise can reduce their incidence (Houpt and McDonnell 1993). Alternatively, they may be intentional movements which can be reduced by increasing opportunities to forage or socialise. Conditioning may reverse the development of such behaviour by rewarding nonperformance of the intentional movement (Houpt and McDonnell 1993). This may, however, be difficult to achieve given the biological and psychological constraints on acquiring alternative responses (Roper 1983; Shettleworth 1994).

Oral stereotypies, such as wind-sucking, cribbing and wood-chewing have been associated with feeds with high digestibility but little dietary fibre (McGreevy *et al.* 1995b). Providing a high fibre alternative, such as hay, reduces stereotypy (Kiley-Worthington 1987; Houpt and McDonnell 1993). This may occur because there is an increase time spent feeding and processing food and, consequently, less time available to stereotype. High fibre feeds may also reduce oral stereotypies by reducing the motivation to forage through increased gut-fill or other feed back mechanisms associated with eating. An alternative approach, where the feeding of high fibre diets is deemed inappropriate, to mimic natural feeding patterns, for example, by increasing the time and work required for a meal. This can be achieved using a foraging device, such as the football developed by Young *et al.* (1994) for pigs, which delivers food randomly as the ball-shaped device is pushed around the stall. In trials using horses, however, a similar foraging device, reduced the incidence of weaving, but did not reduce cribbing (Henderson 1995; Winkill *et al.* 1996).

Treatment by general modifications to the horse's environment, such as housing in social groups or in large outdoor enclosures is not always successful in reducing undesirable behaviour. This can be for 2 reasons. Firstly, the environmental change may not have actually solved the motivational problem. Dry sows, for example, are restrictively fed to prevent obesity and perform sham rooting, vacuum chewing and bar-biting when individually housed in stalls. Hunger primarily motivates these behaviours, as sows continue to stereotype in loose group housing (Terlouw *et al.* 1991a) and perform stereotypic stone-chewing behaviour in outdoor systems if they are restrictively fed (Edwards *et al.* 1993). Secondly, the behaviour may have become independent from its original causes. In voles, the effect of providing natural cover on stereotypic behaviour is age dependant. Voles, age 6 months and older, that have developed jumping stereotypies continue to stereotype in large enclosures with plentiful cover (Cooper *et al.* 1996). This persistence of stereotypies and similar behaviours is commonly found in zoo animals (Meyer-Hopzapfel 1968) where, for example, animals that pace out a route in one cage

will persist with the same route even when moved to a larger, more varied cage. This may account for the resistance of activities, such as weaving and wind-sucking, to modification, because, by the time the behaviour is obvious, it may be an established part of the horse's behavioural repertoire.

Where the behaviour is causing obvious harm, there may be justification for attempting to curb the behaviour by pharmacological means. The development of many stereotypies, for example, depend on intact opioid and dopaminergic pathways. Opioid antagonists, such as naloxone and dopamine antagonists, such as haloperidol reduce the incidence of jumping stereotypy in voles (Kennes *et al.* 1988), oral stereotypies in pigs (Cronin 1985) and crib-biting in horses (Dodman *et al.* 1987), although opioid blockers are less effective in older animals (Cronin 1985; Kennes *et al.* 1988; McBride 1996) where the behaviour has become established.

Pharmacological intervention is not, however, without its risks. The physiological control of behaviour is complex and it is unlikely that pharmacological intervention can be limited to undesirable behaviours. The opioid and dopamine pathways are involved in multiple behavioural and physiological systems (Cabib 1993), including modulation of stress (Dantzer 1991), integration of behavioural responses and the perception of the rewarding consequences of behaviour (Robbins and Everitt 1996); and the imprecise use of antagonists can therefore cause more harm than good.

Physical prevention of behaviour can also cause distress. Jumping stereotypies in bank voles, for example, can be prevented by lowering the roof of their cage. This, however, produces the same changes in adrenal activity and white blood cells as repeated foot-shock (Kennes and de Rycke 1988). Prevention of behavioural problems in horses can be achieved with a variety of techniques including: physical barriers, such as weaving bars above stable doors or harnesses that restrict movement; punishment, such as nails hammered into cribbed wooden surfaces; and surgical intervention, such as cutting the muscles involved in cribbing or wind-sucking (Forsell 1926). These, however, do not address the primary causes of the behaviours and the horse may, therefore, persevere with the response in a reduced or redirected form. Weaving bars, for example, may reduce heat-out-of-the-door weaving, but horses can continue to weave out-of-sight in the stable (McBride 1996), while preventing crib-biting the removal of all horizontal surfaces raises blood corticosteroid concentration, except where horses have access to hay (McGreevy 1995).

Conclusions

The label abnormal is ambiguous and value-laden and does not help to interpret the behaviour of captive animals. Behavioural problems are undesirable as if they are harmful or if they are a sign of a poor environment, but at present they will generally only be treated if they are undesirable to people. An understanding of the causes and effects of the behaviour itself is needed to identify: why behaviours arise; their costs and benefits; if they truly are undesirable and to whom; and how best to treat them without reducing the animal's quality of life.

Stereotypies and redirected behaviour in horses do not consistently cause direct harm to the horse and they are conventionally perceived as undesirable vices on aesthetic, convenience and economic grounds. On the evidence available, there is little justification for curbing the majority of stable vices by pharmacological or physical means, because the potential

benefits to the horse do not outweigh the potential costs of frustrating an established behaviour, taking away the horse's means of adapting to an unfavourable environment, or even disabling its stress modulatory mechanisms.

When a behaviour causes harm, or if it is a clinical sign of an inadequate environment, then it can best be treated by removing its underlying causes in the horse's environment. Addressing the root cause of the problem, rather than suppressing its behavioural signs, not only carries a lower risk of adversely affecting the horse's quality of life, but also reduces the tendency to persevere with the behaviour or its redirection to a modified form.

Finally, a radically different approach to the treatment of behavioural problems is to focus on the reporter, rather than on the animal performer. Where the behaviour is causing no harm to the animal and there is a risk of reducing its welfare using preventative measures, then it would be better to educate the owner as to the costs and benefits of treatment, particularly where the behaviour appears to be a problem solely for cultural reasons.

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References

- Blokhuys, H.J. (1986) Feather pecking in poultry: its relation with ground pecking. *Appl. anim. Behav. Sci.* **16**, 63-67.
- Cabib, S. (1993) Neurobiological basis of stereotypies. In: *Stereotypic Animal Behaviour: Fundamentals and Applications to Welfare*. Eds: A.B. Lawrence and J.F. Rushen. Chapman and Hall, London. pp 119-146.
- Cooper, J.J. and Nicol, C.J. (1991) Stereotypic behaviour affects environmental preference in bank voles. *Anim. Behav.* **41**, 971-977.
- Cooper, J.J. and Nicol, C.J. (1993) The "coping" hypothesis of stereotypic behaviour: a reply to Rushen. *Anim. Behav.* **45**, 616-618.
- Cooper, J.J. and Appleby, M.C. (1996) Individual variation in prelaying behaviour in laying hens with nest sites. *Br. Poult. Sci.* **37**, 245-253.
- Cooper, J.J., Ödberg, F.O. and Nicol, C.J. (1996) Limitations on the effectiveness of environmental improvement on reducing stereotypic behaviour in bank voles. *Appl. anim. Behav. Sci.* **48**, 237-248.
- Cronin, G.M. (1985) *The Development and Significance of Abnormal Stereotyped Behaviours in Tethered Sows*. PhD Thesis, Agricultural University Wageningen.
- Dantzer, R. (1991) Stress, stereotypies and welfare. *Behav. Procl.* **25**, 95-102.
- Dawkins, M.S. (1980) *Animal Suffering; the Science of Animal Welfare*. Chapman and Hall, London.
- Dawkins, R. (1989) *The Selfish Gene*. Oxford University Press, Oxford, UK.
- Dodman, N.H., Shuster, L., Court, M.H. and Dixon, R. (1987) Investigation into the use of narcotic antagonists in the treatment of a stereotypic behaviour pattern (crib-biting) in the horse. *Am. J. vet. Res.* **48**, 311-318.
- Dougherty, R.W. (1976) Problems associated with feeding farm livestock under intensive systems. *World Rev. Nutr. Diet* **25**, 249-275.
- Duncan, I.J.H. and Wood-Gush, D.G.M. (1972) Thwarting of feeding behaviour in the domestic fowl. *Anim. Behav.* **20**, 444-451.
- Edwards, S.A., Atkinson, K.A. and Lawrence, A.B. (1993) The effect of food level and type on behaviour of outdoor sows. In: *Proceedings of International Congress on Applied Ethology*. Eds: M. Nichelmann, H.K. Wierenga, and S. Braun. Humbolt University Press, Berlin. pp 501-503.
- Forsell, G. (1926) The new surgical treatment against crib-biting. *Vet. J.* **82**, 538-548.
- Fox, M.W. (1968) *Abnormal Behaviour in Animals*. W.B. Saunders, Philadelphia.
- Fraser, A.F. and Broom, D.M. (1990) *Farm Animal Behaviour and Welfare*. Balliere Tindall, London.
- Gershon, E.S. and Rieder, R.O. (1992) Major disorders of mind and brain. *Sci. Am.* **267**, 89-103.
- Hart, B.L. (1988) Biological basis of the behaviour of sick animals. *Neurosci. Biobehav. Rev.* **12**, 123-133.
- Hediger, H. (1950) *Wild Animals in Captivity*. Butterworth, London.
- Henderson, J.V. (1995) *The Effect of an Operant Feeding Device on Stereotypic Behaviour in the Stabled Horse*. MSc Thesis. University of Edinburgh.
- Houpt, K.A. and McDonnell, S.M. (1993) Equine stereotypies. *Comp. cont. Educ. pract. Vet.* **15**, 1265-1271.
- Jones, G.H., Mittleman, G. and Robbins, T.W. (1989) Attenuation of amphetamine-stereotypy by mesostriatal dopamine depletion enhances plasma corticosterone: implications for stereotypy as a coping response. *Behav. and Neural Biol.* **51**, 80-91.
- Kennes, D. and de Rycke, P.H. (1988) Influence of performance of stereotypies on plasma corticosterone and leukocyte levels in bank voles. In: *Proceedings of the International Conference on Applied Ethology in Farm Animals*. Eds: J. Unshelm, G. van Patten, K. Zeeb and K. Eskesbo. KTBL, Damstadt. pp 238-240.
- Kennes, D., Ödberg, F.O., Bouquet, Y. and de Rycke, P.H. (1988) Changes in naloxone and haloperidol effects during the development of captivity-induced jumping stereotypy in bank voles. *Eur. J. Pharmacol.* **153**, 19-24.
- Kiley-Worthington, M. (1987) *The Behaviour of Horses in Relation to Management and Training*. J.A. Allen, London.
- Lebel, D., Zanella, A.J. and Unshelm, J. (1996) Changes in thermal threshold, heart rate, and plasma β -endorphin associated with cribbing behaviour in horses. In: *Proceedings 30th International Congress of the International Society of Applied Ethology*. Eds: I.J.H. Duncan, T.M. Widowski and D.B. Haley. CSAW, Guelph, Canada. p 28.
- McBane, S. (1994) *Behaviour Problems in Horses*. David and Charles, Birmingham.
- McBride, S.D. (1996) A comparison of physical and pharmacological treatments for stereotyped behaviour in the horse. In: *Proceedings of the 30th International Congress of the International Society of Applied Ethology*. Eds: I.J.H. Duncan, T.M. Widowski and D.B. Haley. CSAW, Guelph, Canada. p 26.
- McGreevy, P.D. (1995) *The Functional Significance of Stereotypes in Stabled Horses*. PhD Thesis, University of Bristol.
- McGreevy, P.D., Richardson, J.D., Nicol, C.J. and Lane, J.G. (1995a) A radiographic and endoscopic study of horses performing oral stereotypy. *Equine vet. J.* **27**, 92-95.
- McGreevy, P.D., Cripps, P.J., French, N.D., Green, L.E. and Nicol, C.J. (1995b) Management factors associated with stereotypic and redirected behaviour in the Thoroughbred horse. *Equine vet. J.* **27**, 86-91.
- Mason, G.J. (1991) Stereotypy: a critical review. *Anim. Behav.* **41**, 1015-1038.
- Mench, J.A. and Mason, G.J. (1997) Behaviour. In: *Animal Welfare*. Eds: M.C. Appleby and B.O. Hughes. CAB International, Wallingford.
- Meyer-Hopzapfel, M. (1968) Abnormal behaviour in zoo animals. In: *Abnormal Behaviour in Animals*. Ed: M.W. Fox. W.B. Saunders Co., Philadelphia. pp 476-503.
- Morris, D. (1964) The response of animals to a restricted environment. *Symp. Zoo. Soc. London* **13**, 99-111.
- Morton, D.B. and Griffiths, P.H.M. (1985) Guidelines on the recognition of pain, distress, and discomfort in experimental animals and an hypothesis for assessment. *Vet. Rec.* **116**, 431-436.
- O'Farrell, V. (1990) Behavioural problems in companion animals. In: *Managing the Behaviour of Animals*. Eds: P. Monaghan and D.G.M. Wood-Gush. Chapman and Hall, London. pp 233-252.
- Ödberg, F.O. (1987) The influence of cage size and environmental enrichment on the development of stereotypies in bank voles. *Behav. Proc.* **14**, 155-173.
- Robbins, T.W. and Everitt, B.J. (1996) Neurobehavioural mechanisms of reward and motivation. *Current Opinion in Neurobiology* **6**, 228-236.
- Roper, T.J. (1983) Learning as a biological phenomenon. In: *Animal Behaviour, Genes, Development and Learning*. Eds: T.R. Halliday and P.J.B. Slater. Blackwell, Oxford.
- Rosenhan, D.L. and Seligman, M.E.P. (1989) *Abnormal Psychology*. Norton, New York.
- Rushen, J. (1993) The 'coping' hypothesis of stereotypic behaviour. *Anim. Behav.* **45**, 613-615.
- Shettleworth, S.J. (1994) Biological approaches to the study of learning. In: *Animal Learning and Cognition*. Ed: N.J. Macintosh. Academic Press, San Diego.
- Schouten, W., Rushen, J. and de Passille, A.M. (1991) Stereotypic behaviour and heart rate in pigs. *Physiol. Behav.* **21**, 617-624.
- Terlouw, E.M.C., Lareence, A.B. and Illius, A.W. (1991a) Influences of feeding level and physical restriction on development of stereotypies in sows. *Anim. Behav.* **42**, 981-991.
- Terlouw, E.M.C., Lawrence, A.B., Ladewig, J., de Passille, A.M., Rushen, J. and Schouten, W. (1991b) Relationship between plasma cortisol and stereotypic

- activity in pigs. *Behav. Proc.* **25**, 133-153.
- Waring, G.H. (1983) *Horse Behaviour: the Behavioural Traits and Adaptations of Domestic and Wild Horses including Ponies*. Noyes, New Jersey.
- Wiedenmeyer, C. (1996) Effect of cage size on the ontogeny of stereotyped behaviour in gerbils. *Appl. anim. Behav. Sci.* **47**, 225-233.
- Winskill, L.C., Waran, N.K. and Young, R.J. (1996) The effect of a foraging device (a modified Edinburgh football) on the behaviour of the stabled horse. *Appl. anim. Behav. Sci.* **48**, 25-35.
- Young, R.J., Carruthers, J. and Lawrence, A.B. (1994) The effect of a foraging device on the behaviour of pigs. *Appl. anim. Behav. Sci.* **39**, 237-247.