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Difficulty of cross-country obstacles for horses competing in Three Day Events

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ABSTRACT

The objective of the study was to determine which cross-country obstacles are more difficult for eventing horses. Jumping scores were considered in terms of the horse's reaction to novelty and to the fearfulness of novel objects which are the fences situated in novel terrain. The data concerned 11 classes of One to Four Star level (stars showing the difficulty of the class) held at the Olympic Games and three international Three Day Events. A total of 400 entries, in which 259 horses jumped 372 obstacles were considered. Scores of 11,341 jumps at particular fences were categorized either as faulty jumps or non-faulty jumps. Factors describing the fences versus the jumping scores were studied with least square analysis of variance, with respect to the interaction between the star level and the fence traits. The overall frequency of faults at the cross-country amounted to $4.33 \pm 0.57\%$. Among the effects analyzed, the difficulty of cross-country fences for the horses depends upon whether an obstacle is single or is an element of a combination, whether it is straight or requiring an effort in both height and spread, is broad or narrow, has a solid top or a brush, has an alternative or not and whether it is a water crossing or not. At One Star level, the less experienced horses react differently to certain fence traits compared to horses participating in Three or Four Star levels. It is concluded that the equine visionary system, being less developed towards identification of stationary objects than the human visionary system may be a key towards explaining the horse's behaviour while jumping the obstacle. The height-spread obstacles, those of the narrow front, with the brush and with the alternative seem to involve more faults because of the equine low-acuity vision. The same reason may justify the similar frequency of faults at the single obstacles and the first elements in combinations. Accurate methods of measuring equine vision would complement behavioural tests and should both be introduced into the selection of eventing horses.

1. Introduction

The way the horse reacts to different stimuli has a crucial importance for the human who deals with the horse. The humans aim at familiarity, confidence and obedience in horses for the reasons of safety, successful teaching, getting pleasure out of the contact with the animal and many others (e.g. Brisson, 2004; Hausberger et al., 2008; Visser et al., 2003a). The final goal of the breeding of sport horses is the high competition score. It results not only from technical abilities but also from the horse's personality traits, i.e. the propensity to behave in certain ways in certain situations (Erhardt and Schouten, 2001). Equestrians know how difficult it is to train a horse which gets frightened at the slightest stimulus. Many

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horses have to be excluded from leisure and sports because of fearfulness (Lansade et al., 2004). The possibility of predicting a substantial part of show-jumping performance on the basis of the horse's personality traits, as assessed earlier in life, was stated by Visser et al. (2003b). It seems that apart from the rider's effect on more emotionally reactive horses (Visser et al., 2008), vision in the horse is one of the most important factors which influence its behaviour (Murphy and Arkins, 2007).

Differences between breeds, as well as paternal effects in learning ability, show that equine behaviour is a heritable feature (Houpt and Kusunose, 2000). Although equine personality traits are widely studied in behavioural tests and determined in various measures (Hausberger et al., 2008), there are no commonly applied methods of judging them and thus they are not sufficiently regarded in the selection. The tests investigate the behaviour in experimental circumstances isolated from the entire environment. This allows observation of the horse's fundamental reactions. Visser et al. (2003b) studies go further and refer the behaviour to show-jumping training. However, scientific knowledge of how the horses behave during competitions and how they react to plural event circumstances, is lacking. Eventing horses' temperament or personality traits overall vary largely. Since the traits have a great impact on the eventing score, they should be considered in the selection. There is still a long way towards developing most objective methods of judging equine personality traits important in different disciplines. Such a tool would improve selection of the best horses for certain disciplines with respect to behaviour, and thus achieve breeding progress in the future. Cognition of which cross-country obstacle traits are more difficult for horses, the issue investigated in this study, may throw some light upon equine fearfulness and potential jumping willingness.

Three Day Eventing is one of the disciplines in which the horse's performance is assessed. The focus of the entire event is the cross-country test. According to the Rules for Eventing of Fédération Equestre Internationale (FEI, 2006), "the cross-country test is to prove the ability of the true cross-country horse". The cross-country obstacles, in turn, are integrated into the landscape and "must be fixed and imposing in shape and appearance". They are called "natural" since they should resemble natural obstacles such as stone walls, woodpiles, natural water bodies etc. Originally, eventing was designed to test military horses for any challenges that could occur in the terrain. Hence, the demands of this discipline are comparable to those encountered in a natural landscape of free-ranging horses. In the highest level of the cross-country, the maximum height of a fixed obstacle is 120 cm and of an obstacle with brush 145 cm; the distance is up to 6840 m, the speed is up to 570 mpm (metre per minute) and a maximum of 42–45 jumping efforts is allowed. As required by Regulations for Equestrian Events at the Olympic Games in Beijing (FEI, 2008), the distance in the cross-country test was 5700 m, the speed was 570 mpm and the maximum number of efforts equaled 45. The cross-country obstacles sometimes involve serious accidents (Murray et al., 2005). FEI aims at decreasing the danger of the cross-country, by analyzing detailed reports on the causes of the riders' and horses' falls, and by introducing several limits to the course design.

The scores for jumps at particular fences give information on the obstacle traits, which prove to be problematic for the horses not only because of technical difficulty but also because of the horses' fear. Assuming that the horses are physically well-prepared for the test, jumping scores may be considered in terms of the horse's reaction to novelty and fearfulness of novel objects (neophobia) such as the fences situated in novel terrain. The issue is whether or not the horses on the basis of similarities of the fences are able to generalize learning during training to a novel stimulus during the event (Flannery, 1997; Nicol, 2002).

The knowledge of which obstacles are more difficult for horses is important not only from a behavioural view but also for safety reasons and achievements in the sport: for riders, trainers, as well as course designers. The latter use mainly personal experience and common opinions in constructing the course, since the real difficulty of the cross-country obstacles has not been studied scientifically. In a previous study (Stachurska et al., 2002), we analysed which obstacles were problematic for horses in the show-jumping discipline. The purpose of the present study has been to determine which cross-country obstacles are more difficult for eventing horses in terms of the equine behaviour. An analysis of the effect of various obstacle traits on the frequency of faults in jumping the obstacles has been conducted.

2. Material and methods

2.1. Competitions and horses

According to the Rules for Eventing (FEI, 2006), "the level of events is indicated by stars, from one star to four star. The Four Star Three Day Events are those that require the highest level of training and experience from both horse and athlete." CCI (Concours Complet International) is the Three Day Event held on separate days, comprising one by one the dressage test, the cross-country test and jumping test. CIC (Concours International Complet) events include the same three tests, though the event may be carried out over one, two or three days at One, Two or Three Star level. In either case, the dressage test must be the first. Compared to CCI cross-country test, the CIC test is of a similar level of difficulty, according to the star system, but the course is shorter. Olympic Games are held as the CCI, at the Four Star level.

The data concerned the cross-country test in Three Day Events held in Hong Kong at the Olympic Games in Beijing 2008 and in three international Three Day Events which took place in Poland in 2008 (Biały Bór, Strzegom and Sopot). In total, 11 CCI and CIC classes of One to Four Star level were studied. In the study, four levels were distinguished, with both CCI and CIC classes of the same star level grouped together.

A total of 400 entries of 259 horses was considered. Horses competing at CCI*, CCI**, CIC*, CIC** or CIC*** levels are at least six years old, whereas horses competing at CCI*** and CCI**** levels must be a minimum of seven years old.

2.2. Obstacles

The cross-country courses studies consisted of 372 obstacles in total. The obstacles were measured, described and categorized with respect to variables, assumed for the purpose of the study, in most cases following the Rules for Eventing (FEI, 2006):

- a single fence or elements in a combination (single/first element/successive elements). In accordance with the Rules for Eventing (FEI, 2006), if two or more jumping efforts are situated close together, they are designed as elements of a single numbered obstacle. In the study, second, third and fourth elements of combinations were classified together as "successive elements".
- a straight fence or a fence of more than 100 cm spread which required an effort both in height and in spread or only in spread (straight/height-spread). The usual spread obstacles ("spread without height") were too rare to constitute a separate group, hence they were included in the height-spread group. According to the Rules for Eventing (FEI, 2006), a spread obstacle does not require an effort in height. It may include a guard rail or hedge in front, which facilitates jumping but does not exceed 50 cm in height.
- a narrow or broad front of the obstacle (narrow/broad). In the study, the front was considered as narrow if it measured up to 200 cm and broad when it had over 200 cm width.
- a solid top of the fence, or a brush (solid top/brush). The brush is made of flexible and deformable material, so that the limbs of the horse may rake through the fence top. The fixed element of the fence is situated 20 cm lower at One, Two and Three Star levels or 25 cm lower at Four Star level (FEI, 2006).
- a natural or artificial colour of the fence (natural colour/artificial colour). The colour of wood, greenery and water were rated among the natural colours.
- with or without an alternative obstacle (alternative/without alternative). According to the Rules for Eventing (FEI, 2006), the alternatives are judged as separate obstacles or elements, only one of which has to be jumped. Sometimes an obstacle may be jumped in one effort but has alternative options involving two or more efforts though in the study, alternative obstacles had options involving one effort. The alternatives usually differ in location, i.e. an option of more difficult conditions of taking off or landing simultaneously allows to shorten the way and in consequence the time of jumping an obstacle.
- a water crossing or an obstacle without water to cross (water/non-water). Water crossings which required jumps into the water, out of the water, both in and out of water or out of and into water, were classified together.

The obstacle height was not taken into account because of the low variability of the trait, which conforms to the star requirements, first of all.

2.3. Scores

The scores of 11,341 jumps at particular fences were collected from FEI detailed lists of results. Since faults related to jumping were rare, the scores were categorized generally either as faulty jumps or non-faulty jumps. The faulty jumps included refusals, run-outs, circles and falls. Simplifying the FEI definitions, a horse is considered to have refused if it stops in front of an obstacle to be jumped (FEI, 2006). A horse is considered to have run-out if, having been presented at an obstacle, it avoids it in such a way that the head and neck of the horse and the head of the athlete when mounted, fail to pass between the left and right boundaries of the obstacle. A circle is penalized if a horse passes around any element or circles between elements of a combined obstacle. A first refusal, run-out or circle is penalized with 20 penalties, a second refusal, run-out or circle at the same obstacle with 40 penalties and the third fault of this kind causes elimination. Likewise, a fall of the rider and/or the horse results in elimination. However, in the present study, all the faulty jumps were treated equally, whereas the FEI official total cross-country results (including time faults) were not considered at all.

2.4. Data analysis

The issue analyzed required an entirely different approach than other behavioural studies, since the main object of the analysis was the obstacle and not the horse. Therefore, the faults were not considered relative to particular horses but relative to the obstacles. After all, the same obstacles are destined equally for all the horses that compete in a class, e.g. for mares, stallions or geldings. Hence, variables defining horses by gender, age, size and breed, or by their riders, could not have been taken into account. Instead, the large data in consideration enabled to

Table 1
Faults (%) at various obstacles.

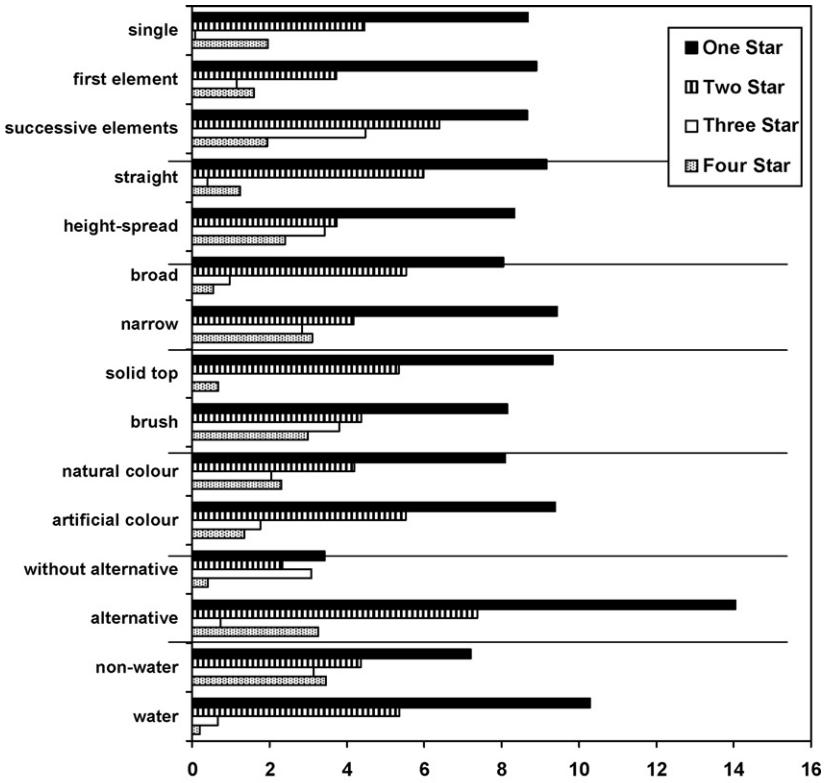
Obstacle	Number of jumps	LSM	SE
Single	5,404	3.50[a]	0.62
First element	2,457	3.99[b]	0.62
Successive elements	3,480	5.51[a,b]	0.58
Straight	6,426	4.19	0.58
Height-spread	4,915	4.47	0.60
Broad	8,953	3.78[c]	0.57
Narrow	2,388	4.89[c]	0.61
Solid top	9,507	3.84[d]	0.58
Brush	1,834	4.83[d]	0.60
Natural colour	8,229	4.16	0.57
Artificial colour	3,112	4.51	0.64
Without alternative	10,222	2.31[e]	0.32
Alternative	1,119	6.35[e]	1.06
Non-water	10,114	4.54	0.56
Water	1,227	4.13	0.67

[a,b,c,d,e]Values marked with same letters differ significantly at $P < 0.01$.

decrease these effects. To compare the data, least square analysis of variance was performed with the use of SAS programme (2003). The factors describing the fences (Section 2.2) versus scores for jumps at the fences were analyzed, with respect to the interaction between the star levels and the fence traits. The class of the event and the location of the competition were considered. The scores for individual jumps at obstacles were classified as 0: success (non-faulty jump) and 1: failure (faulty jump). Second presentation of the horse at an obstacle avoided previously, was considered as a next jump. The results are presented as the percentage of faults related to the number of jumps at particular fences in μ (overall mean), LSM (Least Square Mean) and SE (Standard Error).

3. Results

The overall frequency of faults at the cross-country amounted to $4.33 \pm 0.57\%$. Four factors turned out to be important when taking into account all star levels in total: whether an obstacle is single or is a part of a combination, the width of the front, the type of top and the presence or absence of an alternative (Table 1). The frequency of faults at single fences and first elements of combinations was similar, whereas faults at successive elements of combinations were more frequent than at single obstacles or first elements. Straight and height-spread fences were jumped with similar scores. Narrow obstacles resulted in a higher number of faults, as compared to broad ones. Likewise,



Obstacle	One Star	Two Star	Three Star	Four Star
single		ab	b	
first element		b	b	
successive elements		a	b	
straight	a	b	b	b
height-spread	a	b	b	b
broad	a		a	b
narrow	a		a	b
solid top	a		b	b
brush	a		b	b
natural colour				
artificial colour				
non-alternative	b		a	b
alternative	b		a	b
non-water	b		a	b
water	b		a	b

[ab] Obstacles marked with same letters differ significantly considering particular factors:[a] at $P<0.05$, [b] at $P<0.01$

Fig. 1. Faults (%) at various obstacles with regard to the star level, and significance of differences within groups of obstacles distinguished according to different factors.

Table 2
Faults (%) in various classes and at different star levels.

Class	Number of jumps	LSM	SE
One Star level			
CCI* Biały Bór	1390	7.81[a,b]	0.78
CCI* Sopot	170	10.15[a]	1.28
CIC* Sopot	489	8.99	0.96
CIC* Strzegom	1943	9.26[b]	0.74
Total	3992	8.74[e,f,g]	0.73
Two Star level			
CIC** Biały Bór	800	3.62[c]	2.26
CIC** Sopot	473	5.87[c,d]	2.24
CIC** Strzegom	1146	4.04[d]	2.28
Total	2419	4.86[e]	1.99
Three Star level			
CCI*** Biały Bór	805	1.01	0.86
CCI*** Strzegom	628	2.51	0.87
CIC*** Strzegom	843	2.13	0.83
Total	2276	1.90[f]	0.66
Four Star level			
CCI**** Hong Kong	2654	1.83[g]	0.47

[a,b,c,d,e,f,g]Values marked with same letters differ significantly: within a star level: [a,d] at $P < 0.05$, [b,c] at $P < 0.01$; between star levels in total: [e] at $P < 0.05$, [f,g] at $P < 0.01$.

more fault scores occurred at fences with a brush than fences with a solid top. The colour of the obstacle did not affect the score. Faults at obstacles with an alternative were 2.75 times more frequent than faults at fences without it. Similar scores were obtained at water crossings and non-water obstacles.

Considering particular star levels, in some cases the tendencies varied from the general results. At One Star level, the different relationships were as follows: single or combined obstacles did not influence the score, straight fences caused more faults than height-spread fences, solid tops were jumped with a higher number of faults than brush tops and more faults appeared at water crossings as compared to non-water obstacles (Fig. 1). At Two Star level, straight obstacles involved more faults than height-spread ones, whereas the width of the fence, the type of the top and the presence or absence of an alternative did not influence the score. Three Star level resulted in a higher number of faults at height-spread and non-water fences but the presence or absence of alternative did not affect the result. At Four Star level, in turn, single or combination obstacles were jumped with similar percentage of the scores, whereas faults at height-spread fences and non-water obstacles were more frequent.

The total number of faults was greater at One Star level than at higher levels (Table 2). The LSMs at Three and Four Star levels were less than at Two Star level, however the tendency was insignificant. Differences within One Star level and within Two Star level concerned classes which were held in different locations, i.e. in entirely different cross-country courses. In these classes, the lowest number of faults occurred at the Biały Bór course. At Three Star level, the faults in Biały Bór tended to be fewer, as well.

4. Discussion

Equine behaviour plays an essential role in mounted leisure or sport activities. Principles of behaviour are usually studied with novel objects, to which the horse could not have been accustomed (e.g. Flannery, 1997; Górecka et al., 2007). From a practical point of view, it is important how the horse accepts novel stimuli under normal conditions, when many factors influence the result, for instance previous training (Kusunose and Yamanobe, 2002; Visser et al., 2003b), company of horses of another gender (Jorgensen et al., 2009) and particularly the human interference (Hausberger et al., 2008). When studying equine behaviour during Three Day Events and defining it by the jumping score, the horse's skills, as well as the rider's effect are impossible to exclude. The obstacle design is another factor which has influence upon the jumping result. Many other variables may be important for the final competition results, such as the horse's gender, age, size and breed, as well as external conditions like weather, course surface etc. However, if large amounts of data are taken into account in analyses, the environmental bias can be diminished statistically and some principles of equine behaviour in terms of importance of various effects may be determined. In this study, we focused on traits which make the obstacle difficult. The cross-country fences are more differentiated, as compared to fences in show-jumping courses. A trait was taken into account in the analysis, on the condition that it appeared with sufficient frequency and it could have been measured. Therefore, some possibly important effects have had to be passed over, e.g. arrangement of fences on slopes, and sharp bends.

The low overall frequency of faults related to jumps in cross-country demonstrates that the horses were both physically and mentally well-prepared for the test. Hence, the cross-country scores do not decide the Three Day Event final results to the same extent as dressage and jumping scores do. On the other hand, the Rules for Eventing (FEI, 2006) in themselves limit the number of faults, since third refusal, run-out or circle at the same obstacle, as well as a fall, will cause elimination. The difficulty of cross-country courses varies according to the location of the competition. Presumably, it results from different terrain, as well as from different course builders' view.

Considering the obstacle traits, it comes out that faults at single obstacles occur with similar frequency to those at first elements of combinations, as formerly stated in show-jumping (Stachurska et al., 2002). The results strongly suggest that horses approaching a fence do not recognize which kind of obstacle they are to jump. They focus on the first element, being unable to comprehend other stationary objects from a distance. It is likely that such behaviour results from stress combined with the limited spatial acuity of the horse's vision (Timney and Macuda, 2001). The horse maintains the optimal horizontal eyeball position regardless of the head position relative to the ground. Thus, the rider will not interfere with its vision by not allowing the horse to raise the head when approaching an obstacle (Bartoš et al., 2008). However, equine vision system differs a lot from human vision (Saslow, 2002). It evolved more towards detection of predator approach

from any angle, and warning, than for accurate identification of stationary objects. Being prey animals, horses have the eyes rotated to sides of the head. This extends the total visual field but reduces a frontal overlapping binocular visual field. Equine vision in horses is not as differentiated human vision since horses rely more on their olfaction and hearing which, in turn, do not contribute to identify an obstacle.

The higher frequency of faults at the successive elements in combinations demonstrates that they are more difficult to jump. The phenomenon may result from surprise, special arrangement of elements and many other factors related to the horse's experience, technical abilities, suppleness and strength. Considering eventing levels in detail, the lack of differences between the fault number at single obstacles and elements of combinations at the One Star level suggests that course designers build easier combinations for less experienced horses. It can be suspected that at the Four Star level the combinations require a great effort. However, since they were jumped with a similar number of faults, compared to single obstacles, they were still not problematic. This confirms that the horses at the Olympic Games were very well-trained, obedient and confident.

Similar scores between straight and height-spread fences result from opposite tendencies at One and Two Star levels, as compared to Three and Four Star levels. At lower levels, the height-spread fences are easier, probably due to the course designers who facilitate other properties for the less experienced horses. At higher levels, the horses have distinctly more trouble with height-spread fences, which demand better skills and greater strength, in addition to being usually more imposing in appearance.

The narrow front of the fence is evidently more difficult, even if for statistic reasons the threshold between the narrow and broad front was assumed at quite a high level of 200 cm. Particularly at Three and Four Star levels, the narrow front often results in troubles. Both the height-spread fences and those of narrow front may be more frightening for the horses, because of the equine vision specificity.

Regarding the fence top, different tendencies in the fault frequency between the lower and higher eventing levels have also been found. At One Star level the generally younger or less experienced horses prefer to jump the brush although it is more impressive in height (130 cm) than an obstacle without brush. At Three and Four Star levels, the brush fences with a height of 140 and 145 cm, respectively, are evidently more difficult than the solid top of 120 cm. Presumably, this phenomenon also results from the horse's limited spatial acuity, not always allowing it to notice the lower fixed pole of the obstacle. Hence, the high brush fence is frightening. The Two Star level seems to be medium with regard to the difficulty.

Whether the obstacle is of natural or artificial colours is not important for the horse at any star level. It seems the eventing horses are being challenged to so many surprising stimuli that fence colour usually does not effect their behaviour. Conversely in show-jumping, the obstacles are less differentiated, so their colour was demonstrated to be an important factor (Stachurska et al., 2002). As it is known, horses have dichromatic vision, and are presumed able to discriminate yellow and blue but may have deficiencies in discriminating red and green (Blackmore et al., 2008).

Generally, an alternative involves more faults than an obstacle without alternative. It seems that in this case it is caused mainly by hesitation of the rider, and the subsequent choice of a variant exceeding the physical and mental skills of the horse. The higher difficulty of obstacles with an alternative is particularly visible at One Star level where not only the riders but also the horses are usually less experienced. On the other hand, it is likely that the horse feels the hesitation of its rider, notices two obstacles at a time and does not know which obstacle is to jump. If it is difficult with its vision system to judge one obstacle, it is hard the more to judge two obstacles simultaneously.

A phenomenon similar with respect to the horse experience concerns the water crossings. These obstacles are not an extra difficulty for experienced horses which participate in Three and Four Star level events, whereas at the One Star level they are difficult for the less accustomed horses. The Two Star level is medium with regard to the horses' reaction to such obstacles.

It should be underlined that whether the obstacle is straight or height-spread and whether it is a water crossing or not do influence the jumping score significantly, as most other variables studied do. However, the tendencies are opposite at One Star level versus Three and Four Star levels, resulting in an insignificant influence overall. Opposite tendencies also concern the type of the fence top, though generally a brush is more problematic than a solid top. At Two Star level, most factors do not influence the score significantly.

The decreasing number of faults at higher star levels suggests that the horses are more and more accustomed to the event circumstances, i.e. such stimuli have a lower effect upon their behaviour, likewise their skills improve with successive steps of their career. This occurs in spite of the rising height of obstacles and perhaps other difficult course design traits which could not have been analyzed in the study. The horse learning capacity should be highly appreciated in this aspect.

5. Conclusion

Among effects analyzed, the difficulty of cross-country fences for the horses depends upon whether an obstacle is single or is an element of a combination, whether it is straight or height-spread, broad or narrow, has a solid top or a brush, has an alternative or not and whether it is a water crossing or not. At One Star level, the less experienced horses react differently to certain fence traits, as compared to horses participating in Three or Four Star levels. The Two Star level is medium with regard to the horse's reaction to some obstacle traits.

Taking into account all the factors studied, it can be concluded that the equine visionary system, being less differentiated towards identification stationary objects than human vision, may be a key towards explaining

equine behaviour during jumping. At least the height-spread obstacles, those of the narrow front, with the brush and with the alternative seem to involve more faults because of the equine low-acuity vision. The same reason may justify the similar frequency of faults at the single obstacles and the first elements in combinations. In this context, we entirely agree with Murphy and Arkins (2007) who claim that investigations of the equine visual system will help to explain equine behaviour. Accurate methods of measuring equine vision would complement behavioural tests, and it is recommended to introduce both into the selection of eventing horses. Another question to study is whether vision has a similar impact on the horse's behaviour in other equestrian disciplines. It seems that for instance in free-style dressage not vision but hearing is more important.

References

Bartoš, L., Bartošova, J., Starostová, L., 2008. Position of the head is not associated with changes in horse vision. Equine Vet. J. 40 (6), 599–601.

Blackmore, T.L., Foster, T.M., Sumpter, C.E., Temple, W., 2008. An investigation of colour discrimination with horses (*Equus caballus*). Behav. Processes 78 (3), 387–396.

Brisson, J., 2004. Etude des dimensions du tempérament du cheval: évaluation expérimentale de différents traits de tempérament au moyen de tests comportementaux. Ecole Nationale Vétérinaire de Toulouse - ENVT. (in French).

Erhardt, H.W., Schouten, W.G.P., 2001. Individual differences and personality. In: Keeling, L., Gonyou, H.W. (Eds.), Social Behaviour in Farm Animals. pp. 333–352.

Flannery, B., 1997. Relational discrimination learning in horses. Appl. Anim. Behav. Sci. 54 (4), 267–280.

Górecka, A., Bakuniak, M., Chruszczewski, M.H., Jezierski, T., 2007. A note on the habituation to novelty in horses: handler effect. Anim. Sci. Papers Reports 25 (3), 143–152.

Hausberger, M., Roche, H., Henry, S., Visser, E.K., 2008. A review of the human–horse relationship. Appl. Anim. Behav. Sci. 109 (1), 1–24.

Houpt, K.A., Kusunose, R.R., 2000. Genetics of behaviour. In: Bowling, A.T., Ruvinsky, A. (Eds.), The Genetics of the Horse. CABI Publishing, Wallingford, pp. 281–307.

Jorgensen, G.H., Borsheim, L., Mejdell, C.M., Sondergaard, E., Boe, K.E., 2009. Grouping horses according to gender—effects on aggression, spacing and injuries. Appl. Anim. Behav. Sci. 120 (1–2), 94–99.

Kusunose, R., Yamanobe, A., 2002. The effect of training schedule on learned tasks in yearling horses. Appl. Anim. Behav. Sci. 78 (2-4), 225–233.

Lansade, L., Bertrand, M., Boivin, X., Bouissou, M.-F., 2004. Effects of handling at weaning on manageability and reactivity of foals. Appl. Anim. Behav. Sci. 87 (1–2), 131–149.

Murphy, J., Arkins, S., 2007. Equine learning behaviour. Behav. Processes 76 (1), 1–13.

Murray, J.K., Singer, E.R., Morgan, K.L., Proudman, C.J., French, N.P., 2005. Risk factors for cross-country horse falls at one-day events and two-/three-day events. Vet. J. 170 (3), 318–324.

Nicol, C.J., 2002. Equine learning: progress and suggestions for future research. Appl. Anim. Behav. Sci. 78 (2–4), 193–208.

Regulations for Equestrian Events at the Olympic Games of the Fédération Equestre Internationale, 2008. 22nd Edition, effective for the 2008 Beijing Olympic Games. (Hong Kong).

Rules for Eventing of the Fédération Equestre Internationale, 2006. 22nd Edition, effective 1st January 2006.

SAS Institute Inc., 2003. C.N.U. SAS User's Guide Statistics: Version 9.1.3. SAS Institute Inc., Cary, NC.

Saslow, C.A., 2002. Understanding the perceptual world of horses. Appl. Anim. Behav. Sci. 78, 209–224.

Stachurska, A., Pięta, M., Nesteruk, E., 2002. Which obstacles are most problematic for jumping horses? Appl. Anim. Behav. Sci. 77 (3), 197–207.

Timney, B., Macuda, T., 2001. Vision and hearing in horses. J. Am. Vet. Med. Assoc. 218, 1567–1574.

Visser, E.K., VanReenen, C.G., Schilder, M.B.H., Barneveld, A., Blokhuis, H.J., 2003a. Learning performances in young horses using two different learning tests. Appl. Anim. Behav. Sci. 80 (4), 311–326.

Visser, E.K., VanReenen, C.G., Engel, B., Schilder, M.B.H., Barneveld, A., Blokhuis, H.J., 2003b. The association between performance in show-jumping and personality traits earlier in life. Appl. Anim. Behav. Sci. 82 (4), 279–295.

Visser, E.K., VanReenen, C.G., Zetterqvist Blokhuis, M., Morgan, E.K.M., Hassmén, P., Rundgren, T.M.M., Blokhuis, H.J., 2008. Does horse temperament influence horse-rider cooperation? J. Appl. Anim. Welfare Sci. 11 (3), 267–284.