Session: S19
Abstract number: 4828
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Inherited disorders and their management in European warmblood sport horse breeds

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Abstract
The main aim of this study was to determine the current strategies employed to manage inherited disorders in European warmblood sport horses. An online survey was sent to 37 breeding organisations in 29 countries, from which 11 countries replied. The breeding associations played major roles in selection, management and recording of inherited disorders. Recording of disorders in both breeding stallions and young horses was practiced in five countries; usually at official events or prior to sale. When disorders of breeding stallions and young horses were recorded during private veterinary visits, there was little obligation to report them. There was a trend for countries with smaller warmblood populations to monitor the fertility of breeding stallions and record disorders in foals. Furthermore, they were more likely to summarise and evaluate records of disorders in breeding stallions and young horses. Evaluation of collected records could be used by both breeding associations and breeders in the selection of breeding stallions. Involvement of all interested parties in the collection and evaluation of these records should be encouraged. However, international comparisons may not always be easy due to differing classification and diagnoses of disorders or varied scoring systems. This was reflected by the varied consideration of specific disorders in selection of breeding stallions between countries. Regarding management of disorders in breeding stallions, skeletal and joint disorders were screened for the most and muscular disorders the least. Reproductive, respiratory and degenerative joint disorders usually resulted in exclusion from breeding. Most conformational deviations were considered only when severe, or could be compensated for with good performance. These deviations were considered at the same level within countries although research implies that deviations predisposing to injury vary across breeds and sport types. There appears to be a great need for more research into which deviations are most detrimental for riding horses.

Background
Warmblood horses are used extensively for sport and pleasure riding. There is therefore a strong need for good conformation and healthy constitution within the breed. Within Europe, most of the breeding organisations of warmblood horses have strong selection and breeding programs for sport horses, and horses with unfavourable conformation or known genetic disorders are excluded from breeding. This selection mostly only applies to stallions while the use of mares in breeding is less rigorously controlled. Due to the large size of the warmblood

population and its diverse origins (Hamann & Distl, 2008), inbreeding is generally not a problem if matings are carefully planned. The open borders policy and free trade within Europe implemented by the European Union (EU) has increased the ease of extensive exchange of genetic material across the continent. Therefore, the main aim of this study was to determine what strategies different European countries currently have for managing inherited disorders in their breeding plans. Such information could be used to improve the health and welfare of the warmblood breed and may strengthen trading ties between European countries. An additional aim of this study was to carry out a literature review on 11 common skeletal disorders found in the sport horse.

Genetic disorders

Genetic disorders in the horse can be broadly defined as defects of structure or function caused by a negative mutation of one or multiple genes (Trommershausen-Smith, 1980). The identification of genetic disorders in the horse has been aided by the presence of well-kept studbooks, information on stallions collected from numerous numbers of their progeny as well as improved molecular techniques. Conversely, long gestation periods, single births, incomplete recording and frequent changes of ownership of horses have adversely affected the collection of data regarding genetic disorders. Additionally, characteristics of the disorders themselves, such as delayed clinical onset of symptoms, incomplete penetrance and varied expressivity between individuals means that studies on the inheritance of genetic disorders are often difficult, lengthy and expensive (Finno *et al*., 2008).

Skeletal disorders

Skeletal disorders include abnormal bone and cartilage growth, mainly found in the limbs and vertebrae of the horse. Many musculoskeletal problems are localized in the lower limbs, although the exact location tends to vary on the activity of the horse, i.e. its use for dressage, racing, jumping or eventing. Lameness and its causative factors were found to be the biggest health problems in the warmblood horse population, with respiratory problems being the second biggest (Wallin *et al*., 2000; Stock & Distl, 2005). Skeletal disorders may often be difficult to categorise due to confusion in definitions and terminology of the disorders. Many different terms are often used to describe the same disorder, interfering with the quantification of the heritable nature of the disorder (Marks, 2000). Although skeletal disorders may not be severe or lethal, they may significantly disturb locomotion such that health and performance of the horse are affected (Knottenbelt & Pascoe, 1994). Many studies relating common conformational deviations and performance in racehorses have found that certain deviations are more likely do predispose to injury than others (Dolvik & Klemetsdal, 1994; Dolvik & Klemetsdal, 1999; McIlwraith et al., 2003; Anderson et al., 2004). Certain breeds and populations used for similar activities tend to share conformational deviations. This could be due to use-related adaptations in the skeleton in response to the activity the horse performs or direct or indirect selection for such conformation. Relationships between conformation and performance need to be investigated across breeds and sport types, in order to determine which deviations are most detrimental.

Methods and materials

In November 2008 an online survey was sent to 37 breeding organisations in 29 European countries. The survey consisted of two sections. The first section dealt with the monitoring and management of inherited disorders in breeding stallions, young horses (1-4 years) and foals. The main questions asked were when disorders were recorded, where the records were kept, who was responsible for reporting disorders to record keeping organisations, how data on inherited disorders was summarised and evaluated and if such data was subsequently published. The monitoring of fertility in stallions was also considered in this context. The countries were further asked to comment on any health- or conformation-related restrictions on the registration and breeding of mares. The second section dealt with the management of 29 disorders with known or suspected inheritance patterns in the selection of breeding stallions. The 29 disorders consisted of skeletal and joint, hoof, muscular, respiratory, skin, reproductive and other disorders. The countries were asked if they scanned or examined for (screened for) the disorders and to what level the disorders were considered in the selection of breeding stallions. There were four levels of consideration given as options:

(1) not considered at all
(2) exclusion from breeding only occurs if phenotype severe and affects performance
(3) can be compensated with good performance
(4) stallion automatically excluded from breeding

Results and discussion

The results were based on replies from associations in 11 European countries, resulting in a reply rate of 38%. Although the reply rate was not very high, the associations that answered did represent a considerable proportion of warmblood horses in Europe, producing approximately 31 000 foals per year (Table 1).

Table 1: The countries studied and the number of foals born in 2007

Country	Abbreviation	Association	Foals
Belgium	BLG	Belgian Warmblood	3747
Denmark	DK	Danish Warmblood	2742
Finland	FIN	Finnish Warmblood	352
France	FR	Les Haras Nationaux	8352
Ireland	IRE	Irish Sport Horse	8281
Norway	NOR	Norwegian Warmblood	84
Poland	POL	Polish Horse Breeders	3895
Scotland	SCOT	Scottish Sports Horse	70
Slovenia	SLO	University of Ljubljana, Veterinary Faculty	73
Sweden	SE	Swedish Warmblood	2900
Switzerland	SWI	Swiss Sporthorse Breeding	850
Total			**31 353**

The breeding associations were shown to play major roles in the formulation of restrictions for inherited disorders. Additionally, they were also responsible for the keeping of records, mainly in the case of breeding stallions and young horses, as well as for the summarising and evaluation of these records, which may then be available for use in selection.

Table 2: The number of countries that record disorders in breeding stallions, young horses and foals; that have restrictions for the breeding of mares and that monitor fertility in stallions.

	Stallions	**Young horses**	**Foals**	**Mares**	**Stallion fertility**
Country	*Recorded*	*Recorded*	*Recorded*	*Restrictions*	*Monitored*
BLG	Yes	No	No	Yes[1]	No
DK	Yes	Yes (Y)	Yes	No	Yes
FIN	Yes	Yes	No	No	Yes
FR	Yes (Y)	No (Y)	No	No	No
IRE	Yes	No	No	No	No
NOR	Yes	No	No	No	Yes
POL	No	No	No	Yes	No
SCOT	Yes (Y)	Yes (Y)	Yes	Yes	Yes
SLO	No	No	Yes	Yes	Yes
SE	Yes (Y)	Yes (Y)	Yes	No	Yes
SWI	Yes	Yes	No	Yes	No

[1] – optional registration of mares

(Y) – recording of disorders that occurs during private veterinary visits

Disorders in stallions were recorded by nine countries (82%) (Table 2) and this was usually done at events compulsory for the registration of stallions for breeding e.g. stallion shows or stallion performance tests. Only five countries (45%) recorded disorders in young horses, at the age of 1-4 years (Table 2). This was mostly done at young horse events, such as young horse performance tests, young horse shows or prior to sale of the horse. Two countries (Poland and Slovenia) replied that disorders were recorded neither in stallions nor their young progeny (Table 2), although some type of screening procedures for breeding stallions were mentioned. Considerably less countries recorded disorders in stallions and young horses during private veterinary visits (Table 2). It was usually the responsibility of the owner or veterinarian to report disorders at such occasions, although this was not obligatory. Accordingly, doubts were expressed as to how many of these cases are actually reported.

Not all stallions and young horses would attend stallion and young horse events and thus studies of frequencies and heritablities of disorders would miss these individuals. If veterinarians were encouraged to record disorders observed in horses during private veterinary visits, it would increase the statistical accuracy of estimated parameters relating to disorders. Additionally, encouraging breeders and owners to report disorders of horses that do not attend events where recordings takes place should be encouraged. The risk here however, is that reporting by breeders/owners would be subjective as for example, some would not report a disorder if they did not consider it to be a real problem.

Less than half the countries in the study (4) recorded disorders in foals (Table 2). It was usually the responsibility of the owner and/or veterinarian to report disorders to the record keeping organisations. Once again, recording of disorders in foals and collection of such data would allow more accurate estimates of the frequency of disorders to be obtained. This is because foals born with certain disorders are unlikely to attend young horse or stallion events and thus these individuals would be excluded from data collections. The best way to collect foal data may be to involve veterinarians to a greater extent. Routine veterinary visits, for example for vaccination, then provide opportunities to increase the knowledge about the occurrence of certain disorders.

Only five countries had some kind of restrictions on the selection of mares for breeding. In Belgium, an optional registration of mares has been introduced to increase the breeding status of mares having been screened for certain disorders. Such a health label, called a G label in Belgium, may be considered as an appropriate measure to increase availability of health data on a voluntary basis. Only a few countries had strict requirements for the selection of breeding mares. This may be explained by there being many more mares than breeding stallions on average in every country. Furthermore, mares often belong to many different owners whereas breeding stallions are usually concentrated within a much smaller number of facilities. It is therefore more difficult to implement and control restrictions on the breeding of mares. It may be beneficial for disorders that are highly heritable to more intensely select against them in both mares and stallions. For disorders with lower heritabilities, it may at first be sufficient to only select against them in stallions. This is because individual stallions can be used much more extensively in their lifetimes and can sire many more offspring than an individual mare. The contribution of the stallion to the next generation is therefore on average larger that that of a mare.

Just over half of the countries in this study (6) monitored fertility in stallions (Table 2). Fertility does not generally seem to be viewed as a trait of high importance. This is in agreement with a study by Koenen et al. (2004) where it was found that only 10 out of 19 breeding organisations attached a high relative importance to fertility while only 3 breeding organisations included fertility as a trait in their verbally expressed breeding objectives. Most of the countries used statistical data concerning foaling and pregnancy rates to monitor fertility of stallions; one country used only a semen test (counting numbers of healthy and motile sperm) and one country used both methods. It is important to consider what kind of methods is used to monitor the fertility of a stallion. According to Amann (2005), shortcomings of reports on stallion fertility include that the estimation of a stallion's fertility is usually imprecise when based on information consisting of pregnancy and foaling rates of mares alone. This is because pregnancy/foaling rates are influenced by many factors, not the fertility of the stallion alone. These other factors, which may contribute five times more to the outcome of a successful pregnancy than does the fertility of the stallion alone, include the fertility and health of the mare, the management strategies of the facility where the mare is kept, timing of insemination as well as whether or not a mare changes stallions between inseminations (Amann, 2005).

Among the five countries that summarised and evaluated the records of inherited disorders in breeding stallions and young horses (Table 2), only four countries published the data, which was then available for breeders either directly or indirectly. However, the format in which this information was published was not specified. In most cases, the breeding association was involved in the evaluation of the collected records and in two countries the Veterinary Faculties of the local universities were also involved. Collecting, summarising and evaluating records of disorders, and subsequent publishing, would assist the breeding associations and breeders when it comes to selecting breeding stallions. Additionally, a possible option would be to create a central database of disorders where all this information is stored, starting at a national level as international data collection may not be easy to achieve due to differing classification and diagnoses of disorders or varied scoring systems.

Management of disorders in breeding stallions

Out of the 29 disorders that breeding stallions were screened for, skeletal and joint disorders (such as OC/OCD, bone spavin, over/underbite and conformational deviations) were screened for the most. This may reflect the fact that lameness caused by musculoskeletal disorders is a major problem in warmblood sport horses. However, very few countries examined for rhabdomyolysis and only one country excluded stallions from breeding if they had the disorder. Rhabdomyolysis or tying-up syndrome, is caused by the dysfunction and breakdown of muscle cells due to inadequate blood flow to the muscles, causing them to work anaerobically. Inflammation results from cell damage and painful muscles spasms. Indications of a very closely related disorder called polysaccharide storage myopathy (PSSM) that is thought to indirectly or directly cause episodes of exertional rhabdomyolysis, have been found in 50% of muscle biopsies from warmblood horses presenting neuromuscular symptoms. Additionally, very high heritabilities of about 0.40 have been estimated by Oki *et al*. (2005) for extertional rhabdomyolysis in Thoroughbred horses, and an autosomal dominant inheritance has been suggested by Dranchak *et al*. (2005). The very high percentage of warmblood horses with signs of PSSM may be more susceptible to mild forms of rhabdomyolysis which may impair performance and possibly result in higher rates of musculoskeletal injuries. Thus in the light of riding horses as athletes, it may be beneficial to devote in depth studies to the occurrence and frequency of muscular disorders, which could be a group of emerging disorders in riding horses.

There was great variation in how disorders were considered with regards to selection of breeding stallions. There was a general trend for degenerative joint, reproductive and respiratory disorders to result in the automatic exclusion of the stallion from breeding. This is reflected by the fact that degenerative disorders that affect limb joints are shown to be major health problems in warmblood horses (disorders such as OC/OCD, bone spavin and navicular disease). Reproductive disorders (such as cryptorchidism, hernia scrotalis and disorders of the testes), although screened for to a high degree, did not include problems such as general fertility disturbance and dysfunction. This reflects that fertility disturbance and dysfunction have little weight when selecting stallions for breeding, although they do have important economic meaning in the horse industry. Respiratory disorders seem to be an emerging problem in riding horses, especially disorders such as COPD (chronic obstructive pulmonary

disease), and may reflect the unnatural housing conditions that most horses are exposed to. Prolonged enclosure in stalls, especially during the winter period, results in increased inhalation of irritants such as dust and fungal spores. Respiratory disorders ranked second among the main reasons for premature culling of Swedish warmblood horses (Wallin *et al*., 2000). In a study on Hanoverian warmblood horses, it was found that one third of the horses were reported to have respiratory problems (Stock & Distl, 2005). Within countries, there was consensus on the management of common conformational deviations (bench/offset knees, calf knees, bucked knees, toe-out, toe-in, abnormal formations in the hock and outward rotation of the limbs). This is interesting as studies have shown that certain conformational deviations in racing horses are very detrimental and predispose to injuries more than others. Unfortunately, very few studies on the relationship between conformation and performance have been conducted in warmblood horses. Most studies and literature in this area have been conducted in racehorses (either trotters or gallopers). This indicates that considering all conformational deviations at the same level in riding horses is inaccurate and more research is needed to determine which conformations are most likely to result in injuries when specific riding activities are performed.

Conclusion

The following suggestions for improving the current strategies for the management of disorders in the warmblood horse could be derived from this study. Horse breeding would benefit from coordinated action of all parties involved in the collection, recording and evaluation of disorders in warmblood horse populations (veterinarians, researchers, stud officials, breeding association members, etc.). This should make it possible to increase knowledge on the frequencies, the genetic variation and heritabilities of certain disorders. If such data was collected and evaluated, it could be used within the breeding associations for the approval or exclusion of stallions for breeding. Furthermore, publication of health data may allow breeders to make more informed decisions about matching their mares to the approved stallions. Perhaps an option would be to create a central database for disorders, where all this information could be stored and published, at a national level (as some countries are in the process of doing). Furthermore, international standardisation in classification, diagnoses and scoring of inherited disorders would be desirable. Although much needed, this standardization may not be easy to achieve. It should be ensured that health data collected is as objective as possible and an accurate representation of the horse population in question. Pre-selection of horses often poses a serious risk; both in considering average prevalence of disorders in a population, and in considering prevalence in progeny groups of breeding stallions for which this data would be used to estimate their breeding values. Additionally, further studies on the role of conformational deviations in relation to performance in warmblood horses should be conducted. This would collectively serve to ensure that the most viable breeding plans, in terms of health, longevity, performance and welfare of horses can be constructed from this information.

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