Description of the Friesian Horse population of South Africa and Namibia

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Abstract

Data obtained from the Friesian Horse Studbook of Southern Africa and Friesian Horse Breeders' Society of South Africa were analyzed to describe and evaluate the population regarding inbreeding and morphological body measurements. Eight different body measurements (height at withers, height of back, height of croup, body length, length of cannon forelimb and hind limb, circumference of cannon bone fore- and hind limb) recorded on 232 horses were included for analyses. The pedigrees of 696 horses were used for estimation of inbreeding coefficients. A total of 25% of the horses included in the data was inbred, with inbreeding coefficients ranging from 0.07% to 27.8%. A positive trend in the average inbreeding per year was observed, but the rate of inbreeding was relatively low. Recording of pedigree information will be essential for long-term evaluation of inbreeding in the Friesian Horse and the recording of objective body measurements is recommended for inclusion in selection programs.

Keywords: Body measurements, linear scoring, heritability, inbreeding
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Introduction

The Friesian Horse breed originated from Friesland in the Netherlands. The first record of these horses referred to as Friesians, was during mediaeval times, when the knights in armour mostly used Friesian Horses (Douma, 1994). Since then Friesian Horses were subjected to selection for several conformational features suited to the requirements of the moment in time, varying from a horse used in warfare, to sport and agriculture (Douma, 1994). The first herd book for Friesians, namely "Het Friesch Paarden Stamboek" (FPS), was established in 1879 in Roordahuizum, Friesland, with the aim to improve the breed through pedigree recording and implementation of stud registers (Douma, 1994). During 1906 two Friesian stallions were imported to South Africa, followed by several imports of mares and stallions from the Netherlands. In 1980 the Friesian Horse Breeders' Society of South Africa was established consisting of 12 members (Campher *et al*., 1998) and an additional breeders organization was formed in 1989, namely the Friesian Horse Studbook of Southern Africa (FPSSA). The main differences between the two organizations are that the South African government and South African Studbook recognize the Friesian Horse Breeders' Society of South Africa, while the Friesian Horse Studbook of Southern Africa is affiliated with the FPS and the World Friesian Horse Organization. The organizations further differ in their approach to judging and evaluation of their horses. Only international judges from The Netherlands are recognized by the FPSSA for the evaluation of their horses, while local judges are responsible for the judging Friesian Horses of the Friesian Horse Breeders' Society of South Africa (Dr B.F. Smit, 2001, Personal communication, P.O. Box 4, Piketberg, 7320).

Friesian horses became popular in South Africa for recreation, but were also used in crossbreeding programs with Hackneys, Boerperde and other breeds in an effort to improve draught horses (Campher *et al*., 1998). In South Africa, Friesian Horses are currently selected mostly on the grounds of their aesthetical value rather than for functional efficiency. Breeders make substantial financial investments and, therefore, there is sufficient reason to evaluate the genetic potential as well as traits for inclusion in selection programs.

Performance and pedigree data of the South African Friesian Horses are limited, as indicated in this study. The aim of this paper was to provide a morphological description (body measurements) of Friesian Horses in South Africa and Namibia and to evaluate inbreeding in the current Southern African population, using the available data.

Material and Methods

Body measurements were obtained from 232 horses four years of age and older, belonging to 21 stud breeders and 16 horse owners in South Africa and Namibia, representing both breeders' societies (FPSSA and the Friesian Horse Breeders' Society of South Africa). Eight body measurements were taken, namely wither height, back height, croup height, body length, cannon bone length of the front and hind limbs and cannon bone circumference of the front and hind limbs (Table 1). All horses were measured on a level, hard surface. Measurements were taken on the left side of the horse and the horses were held by the personnel of the stud or by the horse owners. If horses were not calm enough, a twitch was used. Animals were not sedated. If the measuring process was disturbed, it was repeated. Only in very few cases could some of the measurements not be taken. The method of taking the measurements were similar to that used by Zechner *et al*. (2001). All measurements were taken by the same person in order to minimize human error. Approximately 20% of the horses in each stud was measured twice on the same day for data validation.

Table 1 Procedures for obtaining body measurements

Measurement	Measuring device	Anatomical description
1. Height at withers	Measuring stick (cm)	Distance from the highest point of the processus spinali of the second to the sixth thoracic vertebra to the floor
2. Height of back	Measuring stick (cm)	Distance from the deepest point of the back to the floor
3. Height of croup	Measuring stick (cm)	Distance from the rump (ileum) to the floor
4. Body length	Metal measuring tape (cm)	Distance from the most cranial point of the sternum to the most caudal point of the pin bone
5. Length of cannon - forelimb	Metal measuring tape (cm)	Distance from the lateral tuberculum of the os metacarpal IV to the middle of the fetlock joint
6. Length of cannon - hind limb	Metal measuring tape (cm)	Distance from the lateral tuberculum of the os metatarsal IV to the middle of the fetlock joint
7. Circumference of cannon bone - forelimb	Plastic measuring tape (cm)	Smallest circumference of the cannon bone of the forelimb
8. Circumference of cannon bone - hind limb	Plastic measuring tape (cm)	Smallest circumference of the cannon bone of the hind limb

The pedigree information for the study was obtained from both the Friesian Horse Studbook of Southern Africa (FPSSA) and the Friesian Horse Breeders' Society of South Africa. The FPSSA had approximately 540 horses registered with their association at the time of the study, while the Friesian Horse Breeders' Society of South Africa had 192 horses registered with their association on 1 July 2001 (Campher *et al*., 1989). The pedigree file was compiled from the records provided by the FPSSA, consisting of registration certificates of the FPS, the FPSSA, the South African Stud Book Association or the Friesian Horse Breeders' Society of South Africa, birth notifications of any of the above-mentioned associations, judging sheets and even change of ownership notifications.

Statistical analyses were performed using the statistical programs of the SAS (2001) and inbreeding coefficients were estimated using the Animal Breeder's Tool Kit ® (Golden *et al*., 1992). Rate of inbreeding had been estimated as the regression of average inbreeding on year of birth. Heritability was estimated for the different body measurements using a sire model. Due to limited pedigree information available on Friesian Horses measured in this study, only 80 animals were included in the sire model. These animals originated from 29 sires. For the purpose of fitting the model, the horses were grouped together according to the location of measurement for compiling contemporary groups of reasonable size. Location was defined as the specific farm or Friesian Horse show where horses were measured on the same day from different studs and owners. The use of the animal was defined as a fixed effect as Friesian Horses are mainly used in two categories by breeders and owners, namely recreation and sport. The following sire model was fit to the data, using SAS (2001):

$$\mathbf{Y_{ijkl} = \mu + L_i + U_j + G_k + S_l + e_{ijklm}}$$

Where
$\mathbf{Y_{ijklm}}$ = observation of the *m* th animal (*l* = 1,2,…80)
μ = the population mean
$\mathbf{L_i}$ = fixed effect of of the *i*th location of measurement (*i* = 1,2,…13)
$\mathbf{U_j}$ = fixed effect of the *j*th use of the animal (*j* = 1,2)
$\mathbf{G_k}$ = fixed effect of the *k*th gender (*k* = 1,2,3)
$\mathbf{S_l}$ = random effect of the *l*th sire (*l* = 1,2,…29)
$\mathbf{e_{ijkl}}$ = random residual error

Results and Discussion

In this study, eight different body measurements of 232 horses were measured as described in Table 1. The means, minimums and maximums of all the measurements are shown in Table 2.

Table 2 Descriptive statistics for eight body measurements (cm) for each of the three genders

Variable Label	N	Mean	Std Dev	Std Error	Var	Min	Max	Skewness
Stallions								
Wither-height	33	160.3	6.09	1.06	37.08	151	169	-0.02
Back-height	33	148.9	4.95	0.86	24.5	140	158	0.04
Croup-height	33	158.4	4.74	0.82	22.43	148	167	-0.12
Body-length	33	165.7	6.53	1.14	42.66	153	179	0.22
CC-FL	33	24.4	1.37	0.24	1.87	21.5	28.5	0.66
CC-HL	32	26.6	1.35	0.24	1.81	24	29.5	0.28
CL-FL	33	31.5	1.99	0.35	3.94	25	35	-1.32
CL-HL	32	36.9	2.24	0.4	5.02	32	41	-0.29
Mares								
Variable Label	**N**	**Mean**	**Std Dev**	**Std Error**	**Var**	**Min**	**Max**	**Skewness**
Wither-height	176	157.4	4.81	0.36	23.13	147	171	0.28
Back-height	176	146.2	4.45	0.34	19.83	136	161	0.45
Croup-height	176	155.3	4.22	0.32	17.81	146	167	0.21
Body-length	176	166.5	6.72	0.51	45.22	150	182	-0.11
CC-FL	175	21.8	1.04	0.08	1.09	19	24	-0.06
CC-HL	173	24.1	1.16	0.09	1.35	21	27	0.17
CL-FL	175	29.2	1.85	0.14	3.42	24	33	-0.15
CL-HL	174	34.6	2.12	0.16	4.5	29	41	0.54
Geldings								
Variable Label	**N**	**Mean**	**Std Dev**	**Std Error**	**Var**	**Min**	**Max**	**Skewness**
Wither-height	23	158.6	4.93	1.03	24.35	149	168	0.01
Back-height	23	148.3	3.99	0.83	15.95	142	156	0.29
Croup-height	23	158	4.06	0.85	16.5	151	169	0.85
Body-length	23	163.7	6.04	1.26	36.47	149	173	0.43
CC-FL	23	22.9	1.18	0.25	1.39	21	25	0.21
CC-HL	23	25.1	1.03	0.21	1.05	23	27	-0.4
CL-FL	23	30.7	1.61	0.34	2.6	28	34	0.2
CL-HL	23	36.3	2.26	0.47	5.11	32	41	0.42

CC = Cannon Circumference CL = Cannon Length
FL = Front Limb HL = Hind Limb

For all the measurements, with the exception of body length, the means for the geldings were an intermediate value between those of the stallions, which had the highest values, and the mares, which had the lowest values. The mean body length of mares was higher ($P < 0.01$) than that of the stallions and of the geldings. The lowest wither height measurement of 147 cm was observed for a mare. Due to a lack of pedigree information for this mare, it cannot be confirmed if she was inbred or not. This emphasizes the importance of the availability of complete records for scientific studies. This is below the minimum wither height of 150 cm for an animal to be registered in the studbook. It is interesting to note that the highest wither height measurement of 171 cm was also observed for a mare. This particular mare, however, did not have the highest value for any of the other body measurements and was only five years old at the time of measurement. The mean values for wither height were 5 to 9 cm smaller than values for body length for all genders. A difference of 10 – 11 cm was found between height at withers and height of back for all three genders. The cannon length measurements were proportional to overall size and no obvious deviations were seen. There were also no obvious deviations from the mean in cannon circumference for any of the genders.

In the horse industry, studbook associations and breeders primarily apply subjective linear measurements in the judging and selection of horses. The only exception is wither height, which is the only objective measurement taken on a regular basis by a few breeders and some studbook associations. A panel of judges usually scores the horses and takes the wither height measurement; the owners/breeders then receive linear scoring sheets for their horses, which can then be used to select breeding partners for positive assortative matings.

Selection for strong and powerful movement can lead to a shorter body length, because powerful movement requires that the hindquarters of the horse be sufficiently brought in under the horse to better carry the weight of the body, and thus producing a more powerful movement (De Boer, 2001; 2002). It is interesting to note that the means for the body measurements for the geldings were not higher ($P > 0.05$) than those of the stallions. In most species, such as cattle, and even in humans, the absence of the hormone testosterone, which is a natural antagonist to growth hormone, can lead to an animal growing taller after castration than it would have had it not been castrated (Batt, 1980; Ganong, 1997). The reason for the lower measurements in geldings can, however, be partly explained by the fact that most horses are only castrated after puberty has been reached (at ± 4 years of age), unlike for instance cattle and sheep, which are mostly castrated shortly after birth or just before weaning. The results of the measurements show that the Friesian Horse is normally of rectangular (height at withers: body length) format. These results are in accordance with the results found by Zechner *et al.* (2001) for Lipizzan horses. A difference of 3 – 8 cm is expected for dressage horses whereas for carriage driving, a larger difference is acceptable (Zechner *et al.*, 2001). The somewhat larger difference between wither height and body length found in Friesians could be explained by the fact that some of these horses that were measured, are used for riding and others for carriage driving, while some are used for both of these activities.

Another common, but important criterion in horse breeding is the difference between height at withers and height of back. The difference of 10 – 11 cm found for all three genders is much higher than the difference of 1 – 2 cm found by Zechner *et al.* (2001) for Lipizzan horses. The only possible explanation for this could be that most of the horses measured in this study are not intensively trained. These horses are mostly used only for recreational riding or experience some light training in either carriage driving or riding for show purposes. The Lipizzan horses measured by Zechner *et al.* (2001), however, were mostly on a training schedule, resulting in better developed back muscles. The cannon length measurements were proportional to overall size and no obvious deviations were seen. There were also no obvious deviations from the mean in cannon circumference for any of the genders, which can be seen as positive, since there is a strong relationship between cannon circumference and the strength of the bones (Frandson & Spurgeon, 1992).

Heritability estimates for objective body measurements were obtained from applying the sire model (Table 3). A 90% confidence interval for the estimated heritabilities all included zero, except for cannon circumference of the forelimb. Due to the small data set, heritability estimates could only be obtained for six of the eight traits. The heritability estimates found in this study were not significant. Estimates reported by various authors indicate that similar traits are in general moderately to highly heritable (Table 4).

These heritability estimates indicate that selection for body measurements could be included in breeding programs of Friesian Horses. Objective body measurements such as height and length have also been effectively applied in selection programs in beef cattle (Winder *et al.*, 1990). Depending on the breeding objectives of the breeder, different measurements could be of use in the selection program. For example, in the selection of horses for riding under the saddle, the emphasis will be on a shorter body length as this will result in a more powerful movement (De Boer, 2001; 2002). Objective body measurements could therefore also be considered for maintaining the Friesian Horse breed standards.

Table 3 Estimated heritabilities for body measurements

Trait	Heritability	90% Confidence interval
Wither height	0.30	(-0.108;0.33)
Croup height	0.37	(-0.082; 0.36)
Body length	0.48	(-0.025; 0.42)
Cannon circumference: forelimb	0.57	(0.03; 0.47)
Cannon circumference: hind limb	0.45	(-0.04; 0.40)
Cannon length: forelimb	0.35	(-0.089; 0.35)

Table 4 Heritability estimates for objective body measurements in horses

Trait	Heritability	Breed	Reference
Height at withers	0.33-0.88	Thoroughbred (growing)	Hintz *et al*. (1978)
	0.40	Thoroughbred	Biedermann & Schmucker (1989)
	0.48	Arab	Seidlitz *et al*. (1991)
	0.25	Trakehner	Kaiser *et al*. (1991)
	0.89	Shetland Pony	Van Bergen & van Arendonk (1993)
	0.40-0.46	Halfbred Riding horse	Kapron *et al*. (1994)
	0.52	Lipizzan horse	Zechner *et al*. (2001)
	0.58	Andalusian horses	Molina *et al*. (2003)
	034 – 0.72	Pony breeds in France	Anne (2004)
Height at croup	0.34	Thoroughbred	Biedermann & Schmucker (1989)
	0.15	Lipizzan horse	Zechner *et al*. (2001)
Heart girth	0.13	Arab	Seidlitz *et al*. (1991)
	0.30	Trakehner	Kaiser *et al*. (1991)
	0.56-0.63	Halfbred Riding horse	Kapron *et al*. (1994)
	0.48	Andalusian horses	Molina *et al*. (2003)
Cannon bone circumference	0.12-0.77	Thoroughbred (growing)	Hintz *et al*. (1978)
	0.51	Arab	Seidlitz *et al*. (1991)
	0.36-0.62	Halfbred Riding horse	Kapron *et al*. (1994)
	0.36-0.52	Lipizzan horse	Zechner *et al*. (2001)
Body length	0.72	Andalusian horses	Molina *et al*. (2003)
Body weight	0.13-0.90	Thoroughbred (growing)	Hintz *et al*. (1978)

Pedigree analysis is an important tool to describe genetic variability and its evolution across generations. It also provides useful information for estimation of inbreeding, population structures in terms of census, generation interval, pedigree completeness level and effective population size (Gutiérrez *et al.,* 2003). In the present study inbreeding coefficients were calculated for horses born between 1969 and 2002. In total, 852 pedigree records were included, consisting of 68% mares, 28% stallions and colts and 4.7% geldings. It can be assumed that the number of geldings included is an underestimation of the number of Friesian geldings present in South Africa, since geldings are frequently not registered with any association, because they cannot produce any progeny and are mostly only used for recreational riding. Only 21 horses have been reported dead. Of the 852 records included, 29.5% had unknown parents and grandparents. Of the remaining 70.8%, 36.9% had a complete two-generation pedigree, 8.8% had only their parents known and

7.0% had only one known parent. Both parents were known for 86.5% of the records, while only information from the sire and dam's families was known for 28.0% and 3.7%, respectively. A total of 156 animals from The Netherlands, that were part of the pedigree file as ancestors of some of the South African horses, was removed from the database in order to calculate the completeness level of the South African pedigrees. The completeness level was calculated from a file consisting of 696 horses (Figure 1).

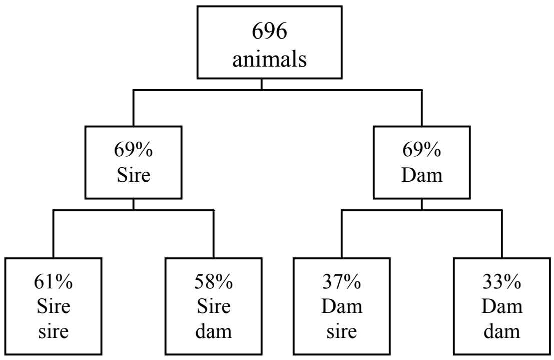

Figure 1 Pedigree completeness level in the South African Friesian Horse population for records from 1969 to 2002

A total of 25.7% (219) of the Friesian Horses studied, was inbred. The inbreeding coefficients of inbred animals varied from as low as 0.07% to as high as 27.9%. The rate of inbreeding for this population shows a positive trend of approximately 0.011% per year (Figure 2). This accounts to approximately 0.077% per generation, with an average generation interval of seven years (Osinga, 2000). This rate of inbreeding is still well below the recommended level of 0.3% per year (Van der Westhuizen & Mostert, 1998). This relatively low rate of inbreeding is probably a conservative estimation, due to the incomplete pedigrees, as incomplete pedigree information reduces estimates of inbreeding (Lutaaya *et al*., 1999).

Investigation of the pedigrees of the 219 inbred animals indicated eight individuals that were the result of father x daughter matings. There were also 12 matings between daughters and half-brothers of one certain Dutch stallion, resulting in high inbreeding in this specific family line. These matings have the potential for the occurrence of detrimental effects as it leads to an increase in homozygosity for certain traits (Bourdon, 2000). In Figure 3 individual peaks are shown with inbreeding coefficients as high as 25% in 1981, but on closer investigation it was discovered that there was only one inbred individual in this year and this horse was the result of a father x daughter mating. Historically the Friesian Horse in The Netherlands was bred from a relatively small baseline with three stallion lines dominating, namely the Tetman-line, the Age-line and the Ritske-line. It is important to mention that of these three lines, the Age-line was very "thin", with only a few stallions in the line, while the influential stallion, Ritske, did not beget many dominant stallions (Osinga, 2000). The South African Friesian population originated from The Netherlands and is therefore subjected to a similar situation as its Dutch counterparts. Only a limited number of Friesian Horses was imported originally and the stallions were used by many breeders, which potentially could have limited the gene pool.

It should, however, also be noted that especially in the early stages of the establishment of the Friesian Horse in South Africa, some breeders practiced crossbreeding. This might have been advantageous to the gene pool of Friesians in South Africa and may partially explain the lower inbreeding estimates.

Horse breeders rarely apply inbreeding as a purposeful mating practice. However, linebreeding is often used to keep the relationship high between an offspring and a particular outstanding ancestor (Tolley, 1984). It has been shown in studies of beef cattle that the rate of inbreeding over time is usually low with no significant potential for inbreeding depression (Burrow, 1993; 1998). Slow inbreeding allows selection to remove the less fit animals and thus at any given mean level of inbreeding, less inbreeding depression is expected among the animals where inbreeding effects have accumulated over a number of generations. The rate of inbreeding and not the actual level of inbreeding in a population is therefore the population parameter for monitoring and control of inbreeding (Burrow, 1998; Mostert, 2004).

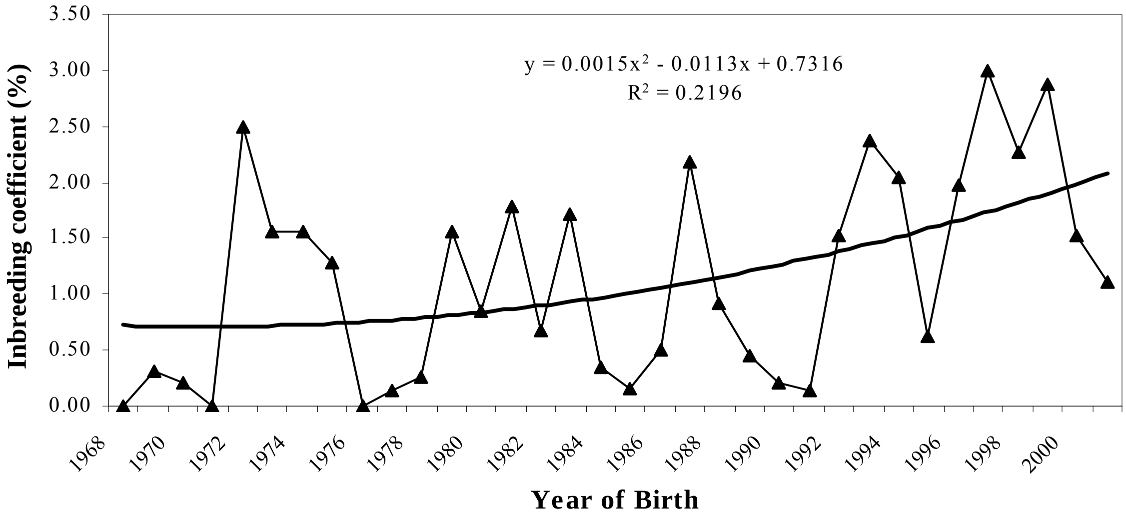

Figure 2 Average rate of inbreeding in the Friesian Horse population of South Africa from 1969 to 2001

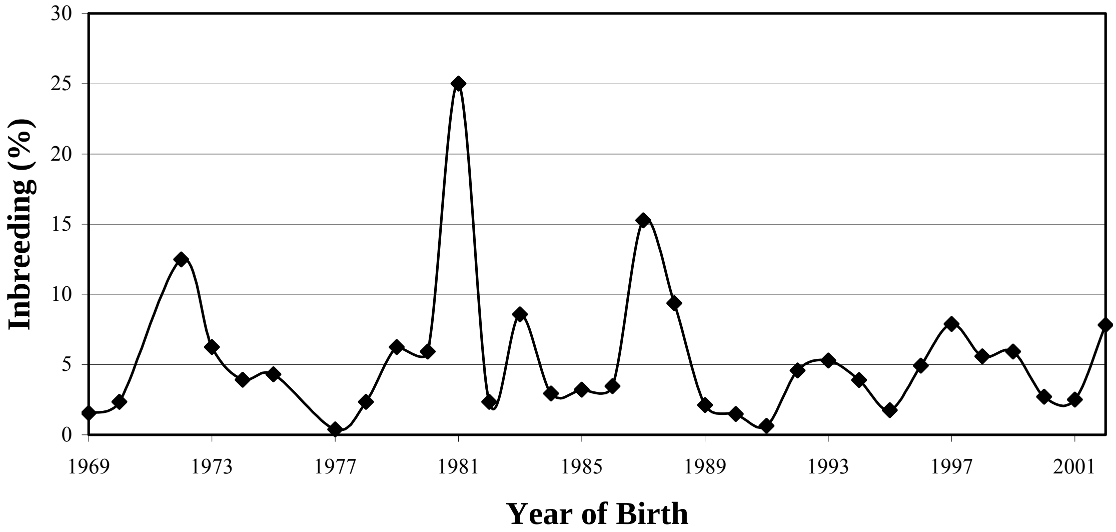

Figure 3 Average inbreeding percentages of all the inbred Friesian Horses born per year from 1969 to 2002

Conclusion

It can be concluded that the Friesian Horse breeders should consider including objective body measurements in their selection programs. Although the rate of inbreeding over time is low, individual breeders should be aware of potential inbreeding depression. Horses are very different from other livestock species in the sense that no consumable product is produced. When breeding horses, the emphasis is on the aesthetic value, and the "functional use" to humankind. A horse often is a human companion and friend. This results in a more subjective and almost philosophical approach taken in the selection and breeding of horses. The problem with subjective measurement is that it always leaves room for human error or bias. In order to maximize the potential of the Friesians in southern Africa, a central record database should be kept, including pedigrees and body measurements. Accurate and complete data recording will facilitate future genetic evaluations and progress for the breed.

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