And those who have insight will shine brightly like the brightness of the expanse of Heaven, and those who lead the many to righteousness, like the stars forever and ever. But for you, Daniel, conceal these words and seal up the book until the end of time. Many will go back and forth, and knowledge will increase.

DANIEL 12: 3-4

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Evaluation of the selection and breeding of Friesian horses in Southern Africa

By

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ABSTRACT

In this study, the selection and breeding of Friesian horses in Southern Africa were evaluated. Literature was reviewed for subjective and objective selection criteria in horse breeding with special reference to the Friesian. 852 Pedigree records from Friesian horses registered at the FPSSA and SAFBA, were included for pedigree analyses and 232 horses were measured for eight different linear body measurements. Only 25,7% of the population was found to be inbred. A regression of average inbreeding on year of the whole population, indicated a relatively slow increase in the rate of inbreeding. It is, however, suspected that this could be a conservative estimation, because of the limited pedigree information. The results indicated that the Friesian horse is normally of rectangular (height at withers: body length) shape. A large average difference between wither height and back height was observed. The cannon length measurements were proportional to overall size, no obvious deviations were observed. Pearson correlation estimates between the eight body measurements were mostly in accordance with other studies on horses reported in the literature. A sire model was fitted for the estimation of heritability for wither-, back- and croup height, body length, cannon circumference and cannon length. Estimates ranged from 0.30 for wither height to 0.57 for cannon circumference. The results indicate that South African breeders can apply body measurements in their selection programs for Friesians. From the results, guidelines were provided for establishing a database for Friesian horses in Southern Africa to ensure a scientific approach to selection and breeding.

OPSOMMING

Die seleksie en teling van Friesperde in Suidelike Afrika is geëvalueer in hierdie studie. 'n Literatuuroorsig is gedoen oor subjektiewe en objektiewe seleksiekriteria in perde met spesiale verwysing na die Friesperd. 852 Stamboom rekords van geregistreerde Friesperde by die FPSSA en die SAFTG, is ingesluit vir stamboomanalise en 232 perde is gemeet vir agt verskillende liniêre liggaamsmates. Daar is gevind dat slegs 25,7% van die populasie ingeteel is. 'n Regressie van gemiddelde inteling op jare van die hele populasie het 'n relatief stadige toename in inteling aangedui. Dit word egter vermoed dat hierdie 'n konserwatiewe skatting is as gevolg van die beperkte stamboominligting. Die resultate dui aan dat die Friesperd gewoonlik 'n reghoekige vorm (skofhoogte: liggaamslengte) het. 'n Groot verskil tussen gemiddelde skofhoogte en rughoogte is waargeneem. Die pypbeenlengtes was in verhouding tot die algehele grootte; geen opvallende afwykings is waargeneem nie. Pearson korrelasies tussen die agt liggaamsmates was meestal in ooreenstemming met ander studies op perde gerapporteer in die literatuur. 'n Vaarmodel is vir die bepaling van erfbaarhede vir skof-, rug- en kruishoogte, liggaamslengte, pypbeenomtrek en pypbeenlengte gepas. Erfbaarhede het gewissel van 0.30 vir skofhoogte tot 0.57 vir pypbeenomtrek. Die resultate dui aan dat Suid-Afrikaanse telers liggaamsmates kan insluit in teeltprogramme van Friesperde Vanuit die resultate is 'n riglyn voorsien vir die vestiging van 'n sentrale databasis vir Friesperde in Suidelike Afrika om 'n wetenskaplike benadering tot seleksie en teling te verseker.

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CHAPTER 1

INTRODUCTION

The Friesian Horse is a very old breed, which originated from Friesland, a province of the Netherlands. The first record of these horses referred to as Friesians, was made during mediaeval times (Douma, 1994). Artist Jan van der Straat was the artist responsible for the oldest known painting of a Friesian horse in as early as 1568 **(Figure 1.1)**. Since then the survival of the Friesian horse has been in danger several times, but every recession was followed by a revival.

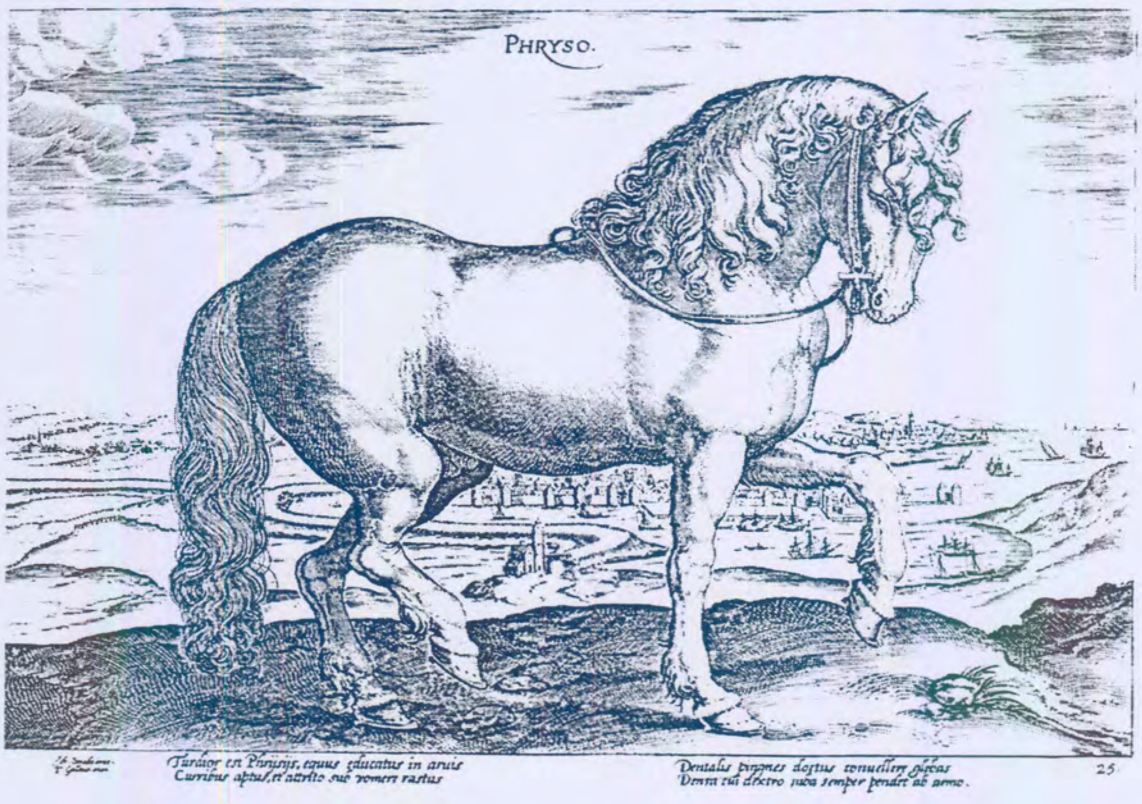


Figure 1.1 Phryso, Friesian stallion of Don Juan of Austria at Naples (1568), painted by artist Jan van der Straat (Douma, 1994).

In Mediaeval times the knights mostly used Friesians, therefore these horses had to be robust and strong to carry the knights in armour. After the invention of gunpowder by the German monk, Berthold Schwartsz, in 1338, a need developed for a somewhat lighter and faster horse. The breed had to be adapted to the changed circumstances and a leaner horse was developed through selection to suit the requirements of the time. In the eighteenth and nineteenth centuries the Friesian Horse achieved a name for trotting over short distances. This era was followed by an agricultural boom during which the Friesian horse was mostly used as carriage horse and workhorse (Douma, 1994).

The first herd book for Friesians, namely, "Het Friesch Paarden Stamboek" (FPS) was established on May 1, 1879 in Roordahuizum, now called Reduzum, Friesland, the Netherlands. The aim of the FPS was to improve the breed by pedigree recording and implementation of stud registers (Douma, 1994).

A photograph of a Friesian stallion taken in 1913 is shown in **Figure 1.2**. This stallion, Paulus, was one of the most influentual stallions of the 20^{th} century (**Attachment D**). When comparing this photograph with the photograph of a modern Friesian stallion (**Figure 1.3**), it is clear that the breed has changed over the years as a result of selection for different purposes.

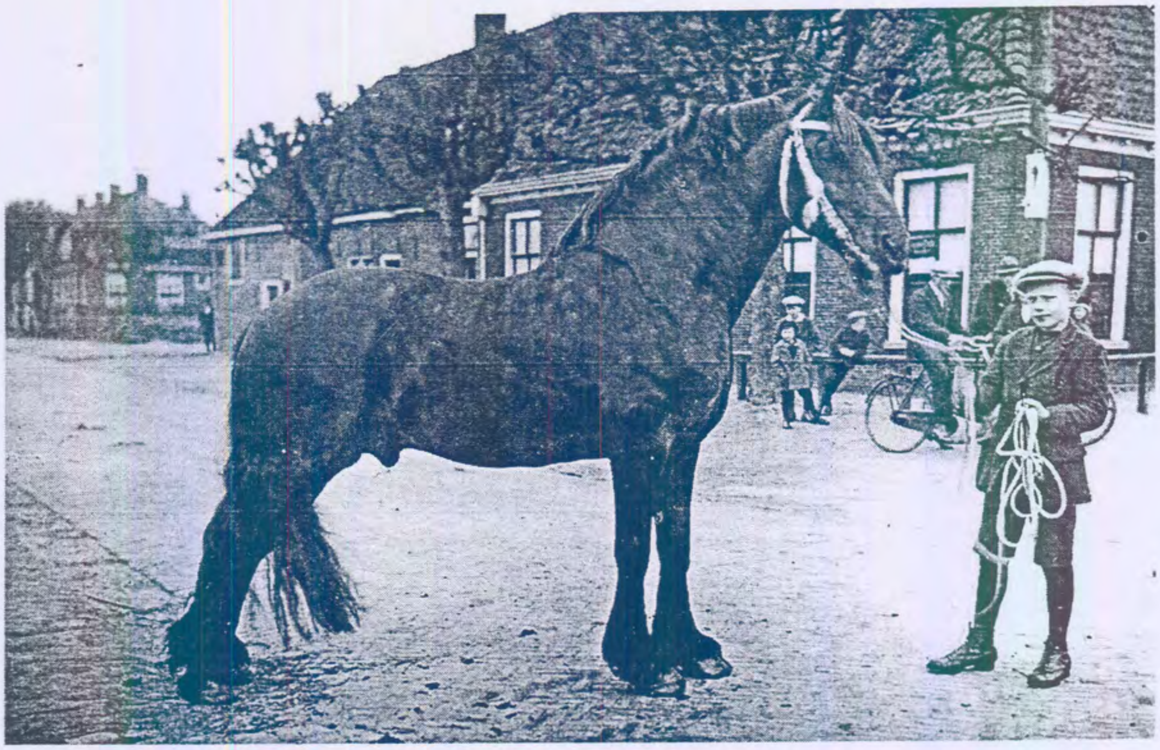


Figure 1.2 A Friesian Stallion, Paulus, photographed in 1913 (Douma, 1994).

During the 1960s the Friesian horse was once again threatened with extinction with only 500 horses registered in the studbook in the Netherlands. Only a few breeders strove for purebred Friesians, avoiding crossbreeding with other horse breeds.

During the 1970s there was a rise of interest in competition and dressage sport, which resulted in the Friesian Horse becoming popular again. The demand for this unique breed increased, and gradually the Friesian Horse emerged from Friesland. It first spread to the rest of the Netherlands and then also conquered many foreign countries. Presently, there are Friesian Horse Associations in Austria, Belgium, Denmark, England, France, Germany, Liechtenstein, Luxembourg, North America, Sweden and Switzerland, as well as in South Africa.

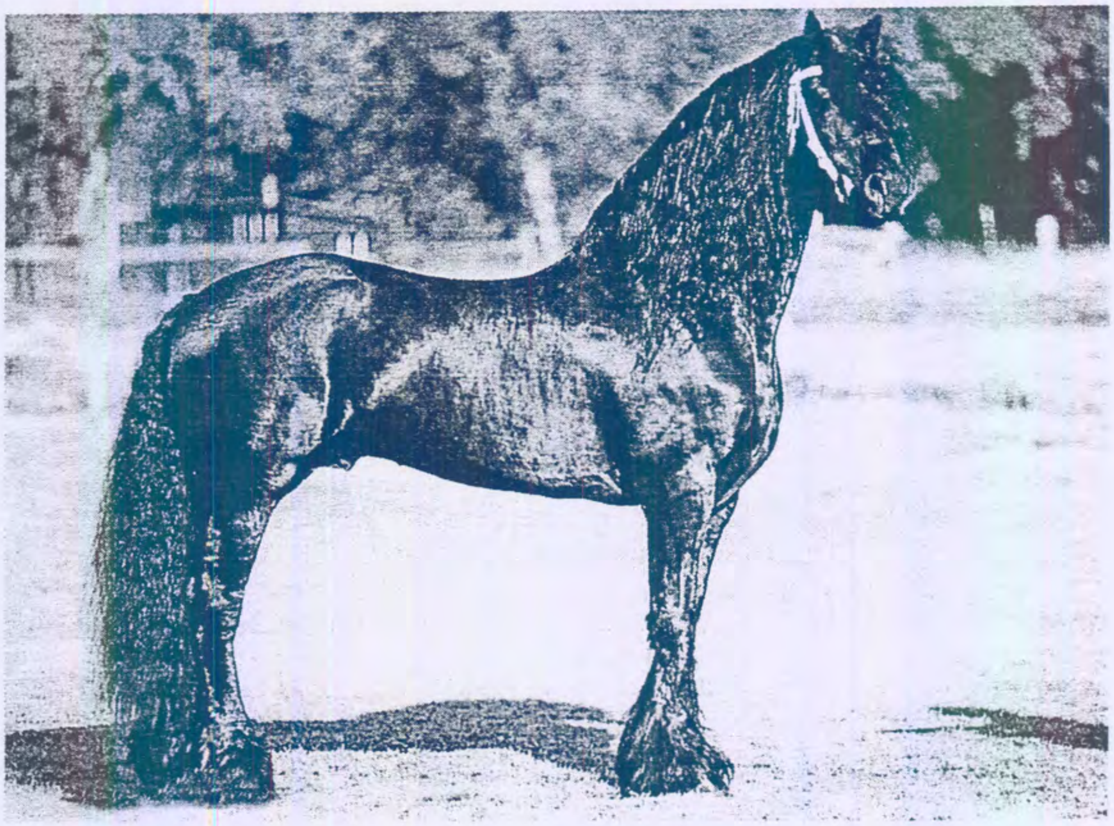


Figure 1.3 A photograph of a "modern" Friesian stallion (Gerth, 1999).

Presently, the FPS has approximately 8 800 active members in the Netherlands and abroad, with more than 30 000 registered Friesian Horses (http://www.fps-studbook.com). The FPS requires the registration certificates to contain the name and sex of the horse, breeder's information, owner's information, the complete pedigree data of four generations, wither height, inbreeding coefficients and the Studbook status of the horse, for example: Studbook, *Bijboek I, Bijboek II,* Foalbook or Sportbook (Personal communication, Mrs Schimmel, 2001). See

Appendix C, the breed standards of the FPSSA, for the requirements for each of the abovementioned registers within the studbook.

The first recorded importation of Friesians to South Africa was in 1906, when a Mr Hoogendoorn imported two stallions to harness for use in his funeral undertaking business. Over the years many Friesians, mares and stallions, came to South Africa from Holland, some of which were crossed with Hackneys, Boerperde and other breeds in an effort to improve the draught horses (South African Livestock Breeding, 1998). From 1957 to 1962 two gentlemen, Mr Ben Mostert and Mr Slabbert, imported four studbook stallions, but unfortunately no registration of progeny was done. Some of the progeny of these four stallions were kept pure, but over time most were crossbred with the earlier Friesian crosses (Personal communication, Dr B.F. Smit, 2001).

In 1980 the Friesian Horse Breeders' Society of South Africa was formed with twelve members (South African Stud Book and Livestock Improvement Association, 1998). From 1983 to 1988 more imports of mares and stallions took place. These imports were not popular amongst a number of members, because they wanted to set a South African standard, and move away from the international standards. A number of the larger breeders preferred pure-breeding and were against crossing with other lines or breeds. Tension rose between the groups, which resulted in a breakaway, and the foundation of the Friesian Horse

Studbook of Southern Africa (FPSSA) in 1989 (Personal communication, Dr B.F. Smit 2001).

The main differences between the two organizations are that the South African government and South African Studbook recognizes 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 judging Friesians of the Friesian Breeders' Society of South Africa (Personal communication, Dr B.F. Smit 2001).

There are many modern techniques and methodologies applied in animal science for breeding and selection, especially for the estimation of accurate breeding values. The ideal would be for these methodologies to also be applied in horse breeding in general and especially, Friesian horses. Until recently the breeding of Friesian horses was only aimed at the beauty of the animal and the desired breed characteristics. The judges and breed inspectors used to only judge horses according to their knowledge or experience without motivating their decision to the horse owners or breeders. Therefore, the knowledge concerning the horses and the breeding objectives was very much limited to the abovementioned experts (Osinga, 2000).

The fact that the objectives for breeding horses differ completely from that of other farm animals, requires a different approach to selection and genetic evaluation. At present, Friesian horses are selected mostly on the grounds of their esthetical value rather than for functional efficiency. In South Africa, like in the Netherlands and elsewhere in the world, the Friesian horse is receiving attention again as a horse to use for riding under the saddle, or in cart. It has, however, not yet accomplished itself as a great achiever in sport. They are also being used in harness for activities such as weddings, funerals and sight seeing trips for tourists. Therefore, there is sufficient reason to evaluate the potential of breeding methodology, which can be applied to achieve a reasonable improvement of the Friesian horse breed. This approach need not ignore the beauty of the breed or its special characteristics. It should emphasize that beauty has to be functional and not be obstructive to the functionality and/or the application of the animal. This could be referred to as efficient beauty (Osinga, 2000).

Economic motives are also of importance in the horse industry and breeding because of the high financial value of these horses. Breeders make substantial financial investments in Friesian horses and therefore, more scientific breeding is essential in order to achieve an internationally acceptable population. It would be a great advantage if South African breeders could also export their stock to other countries of the world. There is already a need for importing *new blood* into the Netherlands to achieve greater genetic variation there and elsewhere in the world.

Therefore, the prospective owner of a horse is likely to request information on the expected breeding value of the animal he plans to invest in. In sectors of livestock production, e.g. the cattle and pig industries, where economics has played an important part for much longer, estimated breeding values (EBVs) can be determined with reasonably high accuracy and the genetic merit of animals for specific traits can therefore be predicted. The EBVs are contributing to genetic improvement of these species.

Discussion with the FPSSA resulted in a need being identified in South Africa to breed pure Friesian horses with the aid of properly formulated breeding structures and principles. Although one organization, FPSSA, is affiliated with the Dutch organization, FPS, South Africa is still far from being able to calculate Estimated Breeding Values for their horses or establish a genetic evaluation system based on linear scoring.

The South African Friesian Horse breeders will not be able to make the genetic progress that the breed deserves, before a sound scientific approach is followed and complete records and information about their horses are known to them. Objective measurements and linear scoring of horses would make it possible to provide breeders with a more accurate system for selection.

The aim of this study was:

1. To evaluate the current status of all Friesian Horses in South Africa.
2. To distinguish between objective and subjective measurements that will make genetic progress possible.
3. To provide guidelines for the scientific breeding and selection of Friesian Horses in South Africa.

CHAPTER 2

OVERVIEW OF BREEDING AND SELECTION IN HORSES

2.1 Introduction

The goal of contemporary horse breeding is to select animals for a wide range of activities including racing, jumping, dressage, cross-country, leisure riding, cattle herding and showing, to mention only the most popular. In order to select for these activities, it is important to know which characteristics are required for the different specialities. The sport horse is an athlete, and its value depends mainly on performance in competitions. Performance is the result of a complex combination of conformational, physiological and behavioural traits, which have been found to be mostly heritable to some degree, as well as factors such as the trainer and the rider. Performance in competitions is also the only means of performance testing for sport horses. Speed is only one quality of a racehorse; equally important are its temperament, the ease with which it can be trained and the health of its limbs. Moreover, the temperament and conformation required to win a race on the flat are very different from those necessary to win a high-level show jumping competition. Therefore, a thorough knowledge of the genetic transmission of various traits is crucial in breeding programs (Bowling & Ruvinsky, 2000).

The genetic aspects of the horse have not been well researched, partly due to the long generation interval, small number of offspring per mare and the relatively small size of studfarms. Other factors include high management costs and requirement of highly specialized personnel. In addition, measuring the horse's phenotypic performance is problematic, because the quality of a horse competing at high level can only be evaluated many years after it has been born. This is particularly true for show jumping and dressage horses where full maturity is reached at 7-9 years of age and top-level mares are kept in competition for an extended period of their lifetime, impairing their reproductive capacity (Bowling & Ruvinsky, 2000).

An important aspect to be considered is that strict selection for certain desirable performance traits may reduce genetic variation. For this reason it is likely that autochthonous breeds (i.e. minor breeds native to a particular region) that are specialized for agriculture and transportation, are doomed for extinction. For the survival of horse diversity, it would be the ideal that conservation programmes complement selection for performance traits (Bowling & Ruvinsky, 2000).

The following section provides an overview of the most important traits emphasized in selection and breeding of horses, with special reference to Friesian horses.

2.2 Conformation and Linear Scoring

The conformation of a horse can be defined as its morphological form, overall size and shape of the body and the limbs, and the relationship of the limbs with one another and with the body (Hawcroft, 1993). The conformation of the 'modern' horse is a result of both natural and artificial selection for various purposes. The conformation of the body varies among different breeds and even between different subpopulations and lines of the same breed. A quantitative approach to conformation traits was undertaken in the 18th century by Bourgelat , who studied linear measurements of the body segments of the baroque horses. In the 19th and early 20th century, other scientific studies developed hippometric methods and took into account the joint angles and inclinations of the limb segments (Saastamoinen & Barrey, 2000).

The selection of sport horses is based mainly on their performance results, but conformation and gaits have an important role in judging horses at studbook shows of most breeds, including the Friesian. The modern horse is in many cases either an athlete or a working animal and its value is determined largely by its exercise ability and the health of its limbs. Thus, more emphasis is now put on functional conformation and gaits, instead of certain exterior details, to select horses for athletic disciplines (Rivero & Barrey, 2001).

Poor conformation can produce abnormal strain on a particular part of the body or legs. Depending on the severity of the conformation defect, the tissue in the area can be stretched, torn or broken, thus leading to lameness (Hawcroft, 1993).

Conformation judging is used as an indicator of better soundness and for selection of horses with less risk of developing lameness. Conformation judging is useful for breeders, trainers and buyers as they can avoid purchasing horses with limited potential due to serious conformation defects and physical handicaps. It is especially important since most of these defects are detrimental on the horse's performance ability after full maturity has been reached. Correct conformation and good movements are important factors for marketing of horses. However, the horse may have good conformation when examined from one side and poor conformation when examined from another (Saastamoinen & Barrey, 2000).

The most popular way to judge conformation traits in horses is by way of linear measurements, either objective measurements or linear scoring, which is of a more subjective kind.

2.2.1 Evaluation of conformation traits

Conformation determines the general appearance of the horse to a large extent. Body and leg conformation are known to be highly heritable. The heritability estimate for general conformation of the Arab horse has been found to be 0.52

by Seidlitz *et al.,* (1991) (**Table 2.2**). It is also known that the subjective scoring of conformation is influenced by several non-genetic factors. These include, for example, the judging team, gender, body condition and management of the horse, month of the year of judging and the age of the foal in growing horses. All these factors should be taken into account when the conformation results or data are applied in selection of horses and genetic analyses (Koenen *et al.*, 1995).

Conformation traits include body measures and angles, leg stances, hoof quality, movements (their length, elasticity and regularity) and teeth structure. The traits can be divided into scored (subjective) and measured (objective) traits as shown in **Table 2.1**.

The conformation traits shown in **Table 2.1** were obtained from research done by Koenen *et al.* (1995) on the Dutch Warmblood Riding Horse (KWPN) population and from research done by Zechner *et al.* (2001) on the Lipizzan horse population. The subjective measurements, as they appear in the table, are also included on the linear scoring sheet of the KWPN (**Appendix A.3**). Although some of these subjective measurements could be measured objectively such as length and height, these traits are only assessed subjectively in many horse populations.

Table 2.1 Conformation traits classified as scored subjectively or measured objectively (Koenen *et al.*, 1995; Zechner *et al.*, 2001).

Subjective:	Objective:
Throat latch	Height at withers
Length of neck	Height of back
Position of neck	Height of rump
Muscularity of neck	Body length
Length of withers	Length of forequarters
Height of withers	Length of barrel
Length of shoulder	Length of rear quarters
Position of shoulder	Depth of chest
Length of back and loins	Width of chest
Line of back and loins	Width of hips
Shape of croup	Width of thurls
Length of croup	Length of neck
Muscularity of haunches	Length of shoulder
Stance of forelegs	Circumference of chest
Stance of hindlegs	Circumference of cannon bone fl.[a]
Stance of pastern	Circumference of cannon bone hl.[b]
Shape of feet	Length of head
Heels	Width of head
Quality of legs	Length of upper arm
Substance of legs	Length of forearm
Walk: length of stride	Length of cannon bone fl.[a]
Walk: suppleness	Length of cannon bone hl.[b]
Walk: correctness	Length of pastern fl.[a]
Trot: length of stride	Length of pastern hl.[b]
Trot: elasticity	Shoulder angle
Trot: propulsion	Pelvis angle

[a] forelimb

[b] hindlimb

The objective traits can either be physically measured with measuring devices like a measuring stick or measuring tape (e.g. body measurements, angles) or evaluated using, for example, photography or video techniques (Saastamionen & Barrey, 2000).

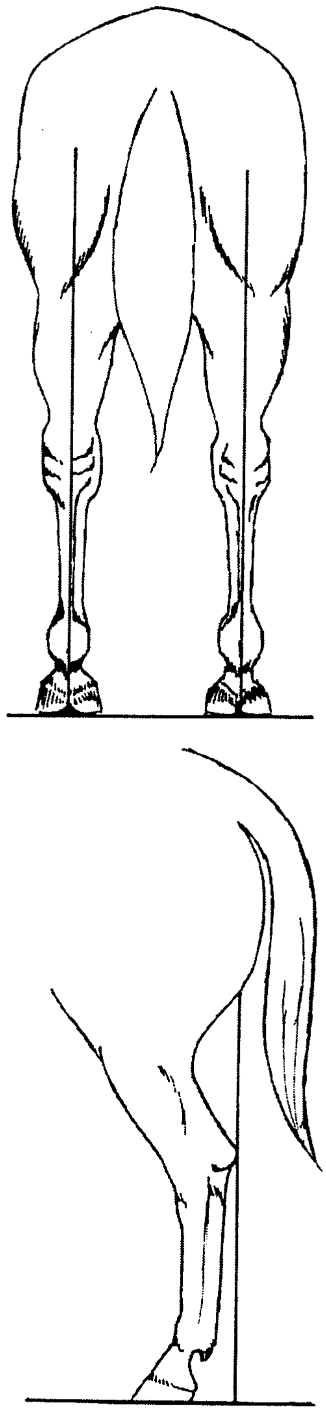
The limbs of the horse are essential for the functionality of the animal and conformation faults are strongly discriminated against. Various conformation faults such as bowlegs, knock knees, standing over in the knees and standing under in the knees, bench knees, cow hocks and sickle hocks are reported in horses, and all of them can cause unsoundness, like bog spavin, bone spavin, curb and many more, on the legs of the horse (Parker, 1998). As already mentioned, poor conformation can produce abnormal strain on a particular part of the body or legs. Depending on the severity of the conformation fault, the tissue in the area can be stretched, torn or broken, thus leading to lameness. A horse with one or more of these conformation faults is also likely to suffer from joint problems as a mature animal, which would impair its movement and performance ability (Hawcroft, 1993). Limb conformation is therefore a very important aspect of linear scoring and, as conformation faults are highly heritable, an important factor in selection of horses (De Boer, 2002). Heritability estimates of individual defects recorded for leg stances ranged from 0.00 to 0.65 (Saastamoinen & Barrey, 2000)

To assess the limb conformation of a horse, the horse should be standing squarely on a flat, hard surface, bearing its weight equally on all four legs. Ideal conformation does not exert excess strain on any single structure of the limb (Hawcroft, 1993).

Figures 2.1 to **2.10** show the differences between normal limb conformation and some of the commonly found conformation faults in horses.

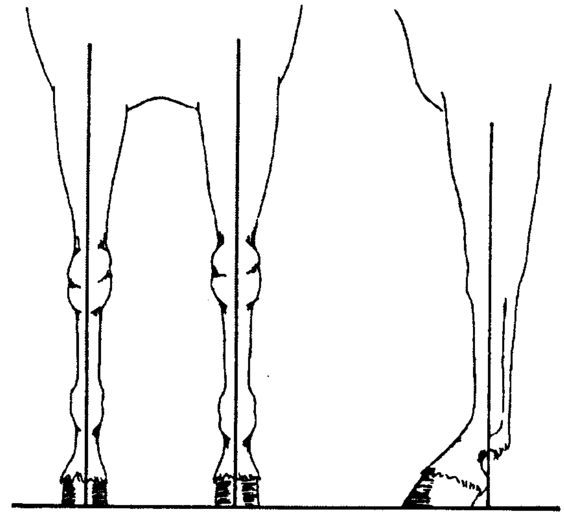
When the horse is studied from behind, an imaginary line drawn from the point of the pelvis should divide the leg into two equal parts. The hocks should be well defined (**Figure 2.1**).

When the horse is seen from the front, the chest should appear to be well developed and well muscled and the legs should be straight. An imaginary line from the point of the shoulder to the foot, should divide the leg into two equal parts. From the side, an imaginary line from the spinous process of the shoulder blade should divide the leg into two equal parts down to the fetlock joint and continue to ground level to a point just behind the heel (**Figure 2.2**).



Normal hindlimb conformation

Figure 2.1 Normal hind limb conformation.



Normal forelimb conformation

Figure 2.2 Normal forelimb conformation.

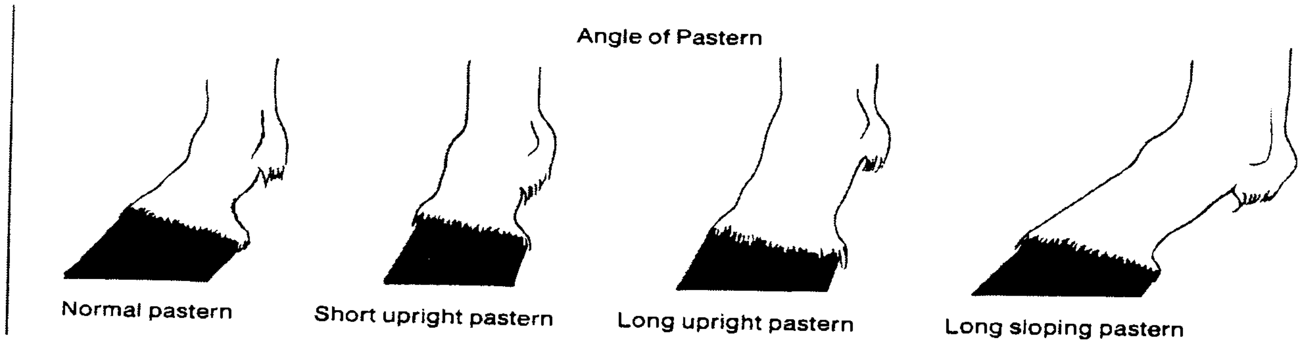


Figure 2.3 The correct angle of the pastern with some wrong angles.

A correct pastern should be in proportion to the total length of the leg and the hoof wall should slope at the same angle as the pastern. The angle between the sloping hoof wall and the ground surface should be between 45 and 50 degrees (**Figure 2.3**). If the horse has short or long upright pasterns, the concussion on the fetlock joint, pastern and navicular bone may predispose the front of the fetlock to osselet formation. Concussion on the navicular bone may lead to navicular disease. Short or long upright pasterns increase the concussion impact on the bone, causing an inflammatory reaction on its surface, which stimulates a bony growth or swelling known as ringbone (Hawcroft, 1993).

If a horse has long, sloping pasterns, instead of the concussion being distributed between the bones and the tendons when the horse is in motion, most of it is placed on the flexor tendons, suspensory ligament and sesamoid bones. This predisposes the flexor tendon and suspensory ligament to sprain and the sesamoid bone to inflammation and fracture (Hawcroft, 1993).

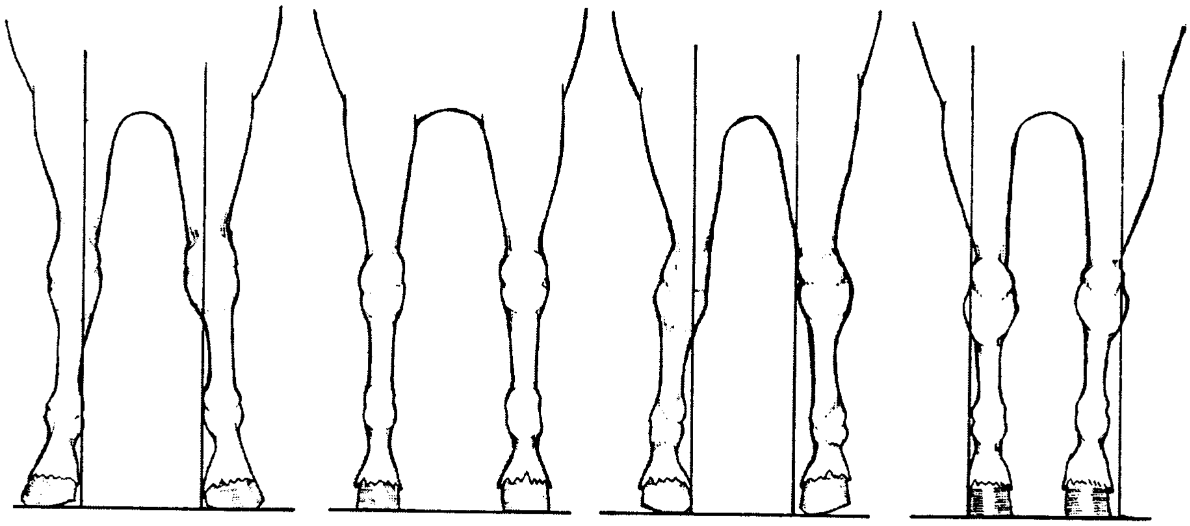


Figure 2.4 Normal forelimb conformation contrasting some forelimb conformation faults.

The toes of the feet should point straight forward and the feet should be as wide apart on the ground as the origin of the legs at the chest (**Figure 2.4**). There are several conformation faults that occur in combination, such as base-wide with feet turning out or base-wide with feet turning in. Irrespective of whether the feet turn in or out, this fault places abnormal stress on the medial part of the leg, because the horse tends to land on the medial wall of the hoof. The horse is thus more likely to suffer from medial sidebone, ringbone and windgalls of the fetlock joint.

The base-narrow conformation results in the outside edge of the foot hitting the ground first, placing stress on the lateral aspect of the limb. Lateral sidebone, ringbone and windgalls of the fetlock joint are related to this type of fault.

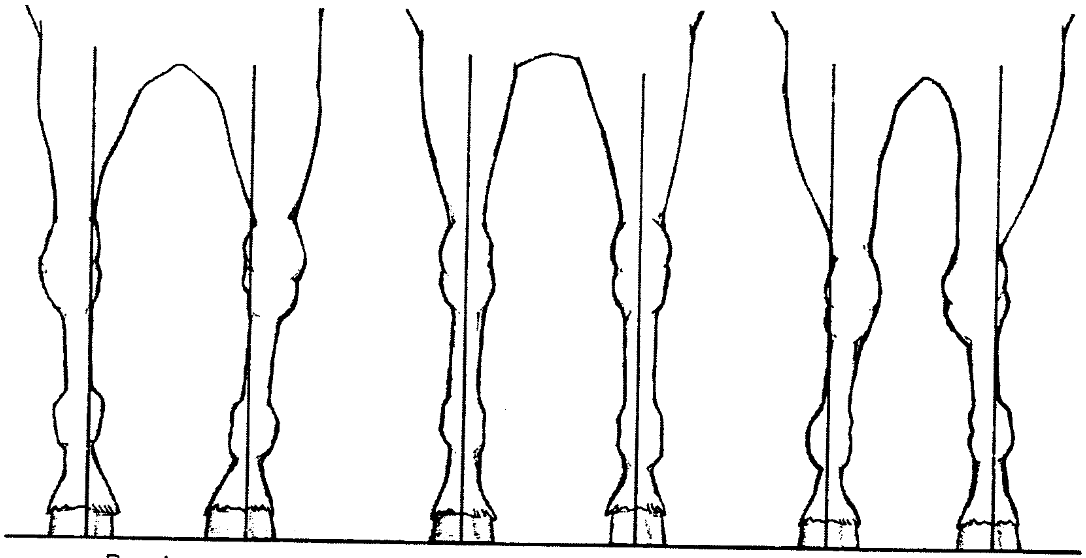


Figure 2.5 Normal forelimb conformation in contrast with some forelimb conformation faults.

The knees should be flat, not deviating towards or away from one another (**Figure 2.5**). They should not deviate forward (standing over at the knee) or backward (standing under at the knee) (**Figure 2.6**). Knee problems can range from joint capsule strain to ligament strain, arthritis, chip fractures and slab fractures. Slight forward deviation of the knees (over at the knees) is not necessarily bad. Backward deviation of the knees (under at the knee), medial deviation of the knees (knock knees) and lateral deviation of the knees (bow legs) are all serious conformation faults. They can give rise to one or more of the abovementioned problems.

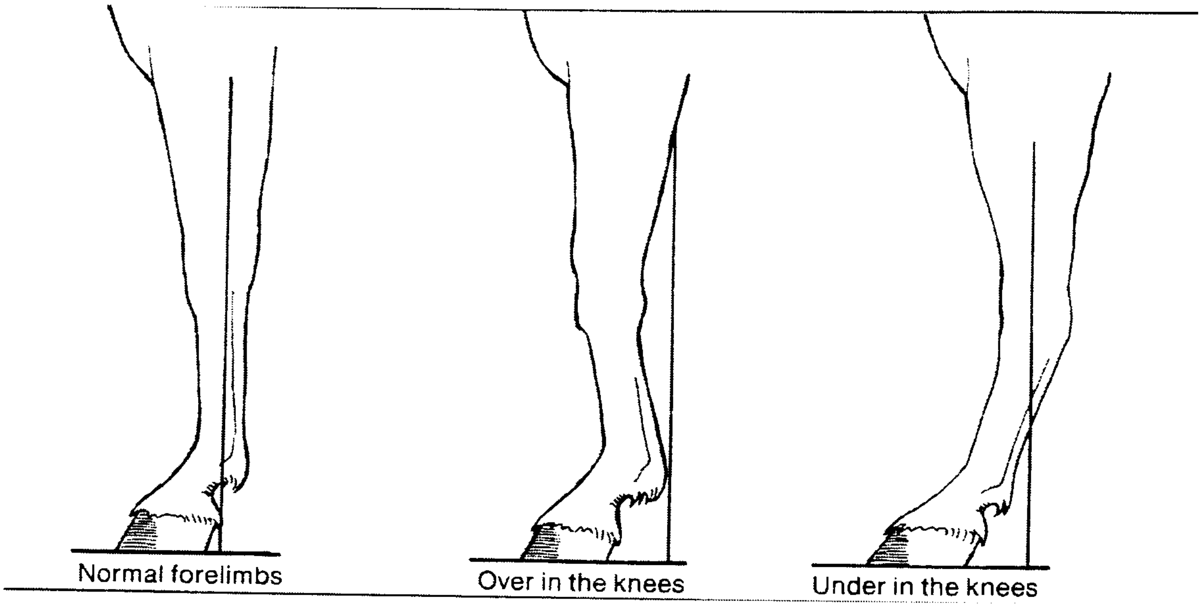


Figure 2.6 Normal forelimbs as seen from the side contrasting over in the knees and under in the knees.

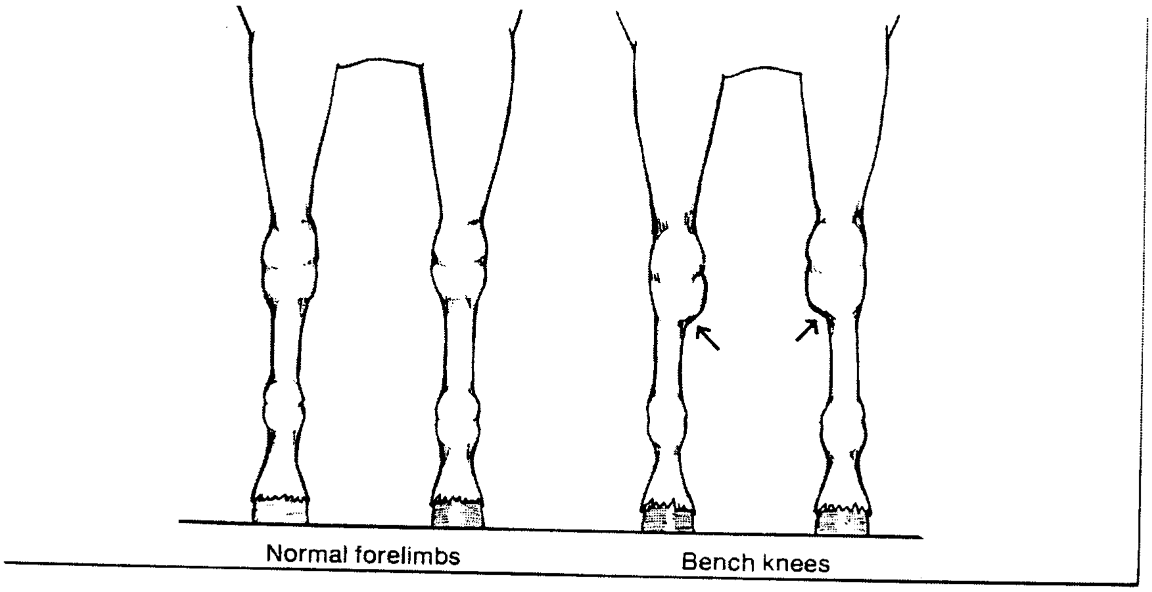


Figure 2.7 Normal forelimbs and bench knees.

The cannon bone should be centred under the knee and not give the impression of being tied-in below the knee. When the cannon bone deviates laterally from under the knee, the upper medial area of the cannon is placed under excessive strain, predisposing it to splint formation. This condition is known as bench knees (**Figure 2.7**).

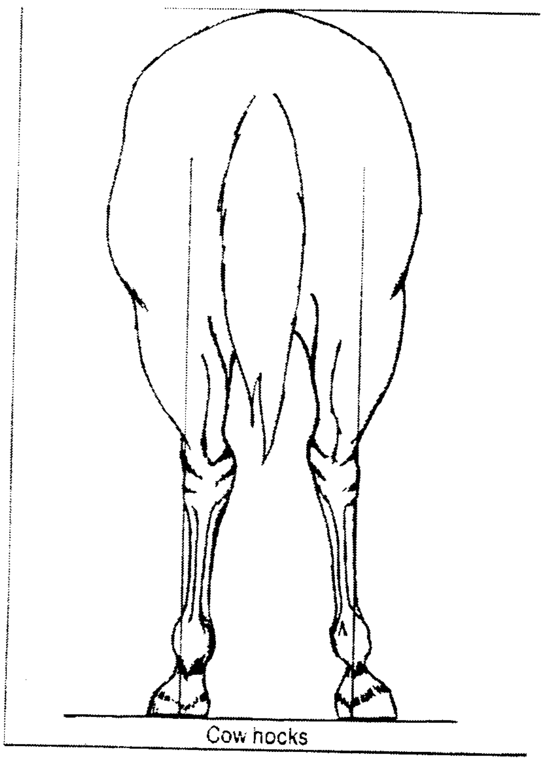


Figure 2.8 Cow hocks.

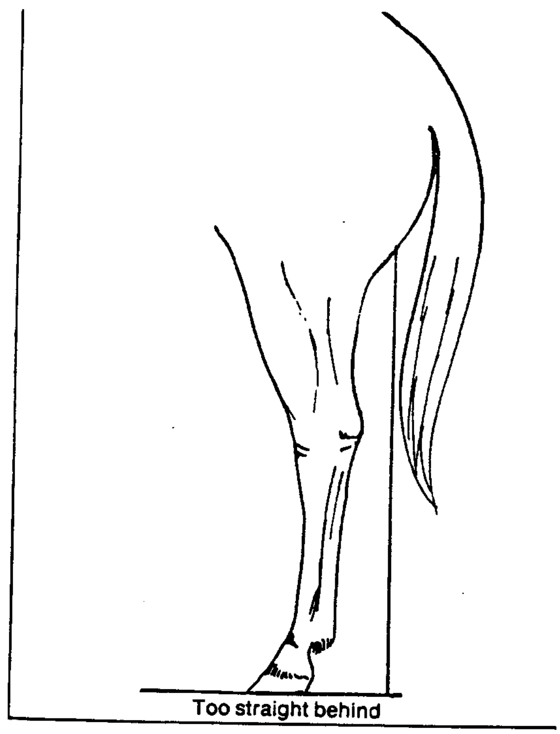


Figure 2.9 Too straight hind limbs when viewed from the side.

Cow hocks are often found in horses. When the horse is studied from the rear, the hocks are close together and point toward one another and the feet are widely separated with the toes pointing outwards, causing strain on the inside of the hock (**Figure 2.8**). This predisposes the horse to bog and bone spavin.

When the horse is viewed from the side, a line drawn from the point of the pelvis should touch the point of the hock, run down the rear aspect of the cannon and touch the ground seven to ten centimetres behind the heels. The angle of the stifle and hock should be neither too straight, nor too acute.

When a horse is too straight behind, the small angle in the stifle can result in upward fixation of the patella (locked stifle). Too little angle in the hock may give rise to knee problems (**Figure 2.9**).

Another hock fault is known as sickle hocks (**Figure 2.10**). The angle of the hock joint is greater than ideal, placing stress on the ligament just below the point of the hock and predisposing the horse to curb (Hawcroft, 1993).

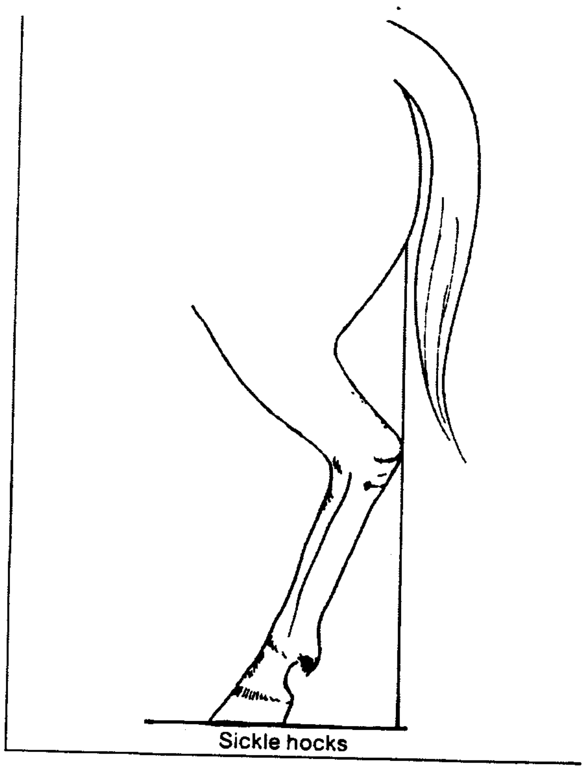


Figure 2.10 Sickle hocks.

All of the abovementioned conformation faults receive attention in the selection of Friesian horses in the Netherlands. They are all included on the linear scoring sheet of Friesian horses. The scoring sheet was designed in such a way that some of these problems are opposite each other, as they are the extremes of one another (De Boer, 2002).

2.2.2 Subjectively Scored Traits

Linear assessment or linear scoring has been used for many years in different livestock industries. In sheep production, the conformation of breeding rams is considered when assessing soundness and functionality (Croston & Pollott, 1994). In many countries the shape of pigs, judged by visual assessment, is considered to cover all the required criteria for carcass and meat quality. Visual appraisal is also used by pork producers to assess the condition and the variation in condition of the growing pig. The variation in condition of the growing pig informs about growth, disease and likely carcass quality. Visual appraisal of the condition of the breeding sows at the points of weaning and farrowing, informs about nutrition and feeding management (Whittemore, 1993). In the dairy industries all over the world, linear scoring has been used for years to assess the conformation and soundness of dairy cows (Wilcox, 1992). Beef cattle in South Africa have shown a marked improvement since the inception of performance testing in 1959 and visual appraisal based on functional efficiency introduced by the late Prof. Bonsma during 1946 (Bosman, 1999).

Subjectively scored traits usually are evaluated by awarding marks for the correctness of the trait. The choice of conformation traits included in the evaluation varies between countries and breeds or studbooks. Typically a scoring sheet for scoring horses makes provision for type, head, neck, over line, leg stances (limb alignment), quality of hooves and gaits/movements (their length, elasticity and regularity). The overall balance, harmony and symmetry of the body are usually also evaluated. (See **Figures 2.11** and **2.12** and **Appendices A.1, A.2** and **A.3** for examples of scoring forms for the Dutch Warmbloods and Friesians.) The heritabilities for subjectively scored conformation traits (**Table 2.2**) vary from low to relatively high (0.20- 0.50), which are lower than those for objectively measured traits (**Table 2.6**). The aim of this linear assessment trait evaluation system is to describe where the individual being assessed lies between the biological extremes for a particular conformational trait. The choice of the traits used for the different horse breeds is based on their importance for movements and performance, economic value and also their heritability. The heritabilities for linear traits are of the same magnitude as those for subjectively scored conformation traits (Saastamoinen & Barrey, 2000).

The genetic correlations between subjectively scored traits are moderate to high. The highest correlations have been reported between regularity of the gaits and points for type and conformation of the horse (Saastamoinen & Barrey, 2000).

Table 2.2 Heritability estimates for subjectively scored conformation traits.

Trait	Heritability	Breed	Reference
Type	0.28-0.31	Trakehner	Preisinger *et al.* (1991)
	0.25-0.36	Trakehner	Von Butler-Wemken *et al.* (1992)
	0.34	Arab	Seidlitz *et al.*(1991)
Conformation	0.17-0.18	Trakehner	Preisinger *et al.* (1991)
	0.52	Arab	Seidlitz *et al.* (1991)
	0.21	Icelandic Horse	Arnason (1984)
Regulation of gaits & movements	0.14-0.17	Trakehner	Preisinger *et al.* (1991)
	0.15	Andalusian Horse	Molina *et al.* (1999)
	0.45	Arab	Seidlitz *et al.* (1991)
Trot	0.20	Icelandic Horse	Arnason (1979)
	0.22	Icelandic Horse	Arnason (1984)
Trot: stride	0.22	Dutch Warmblood	Koenen *et al.* (1995)
Correctness of legs	0.16	Icelandic Horse	Arnason (1979)
Leg stances	0.20	Icelandic Horse	Arnason (1984)
	0.14	Dutch Warmblood	Koenen *et al.* (1995)
Temperament	0.02-0.06	Italian Haflinger	Samoré *et al.* (1997)
	0.08	Andalusian Horse	Molina *et al.* (1999)

Heritabilities for a number of traits important in sport horses have been determined in the Netherlands for the Dutch Warmbloods (**Table 2.3**).

Table 2.3 Heritability estimates for a number of subjectively scored and performance traits in the KWPN (Van Veldhuizen, 1991).

Trait	Heritability	Trait	Heritability
Pulling power	0.15 – 0.25	Free jumping	0.15 – 0.45
Speed	0.05 – 0.25	Jumping under saddle	0.00 – 0.35
Exterior	0.25 – 0.45	Dressage	0.15 – 0.25
Legwork	0.20 – 0.30	Character	0.05 – 0.15
Walk	0.15 – 0.40	Movement	0.20 – 0.35
Trot	0.00 – 0.40		
Canter	0.20 – 0.40		

The introduction of linear scoring on horses in the Netherlands, provided data for estimation of heritabilities for scored traits. With linear scoring the subdivisions on which a horse is judged are represented as marks on a scale. Van Veldhuizen (1993) determined heritabilities using scoring sheets of the Dutch Warmbloods for subjectively scored traits, and wither height, which is the only trait measured objectively (**Table 2.4**).

Table 2.4 Heritability estimates for linear scored traits in the Dutch Warmbloods (KWPN) (Van Veldhuizen, 1993).

Trait	Heritability	Trait	Heritability
Wither height [a]	0.20	Hoof shape	0.18
Wither length	0.19	Quality of legs	0.11
Shoulder position	0.15	Walk: Scope	0.11
Length of back & loins	0.18	Suppleness	0.21
Croup position	0.26	Correctness	0.20
Muscling of thighs	0.18	Trot: Scope	0.17
Front leg stance	0.20	Suppleness	0.15
Hind leg stance	0.12	Power impulse	0.19

[a] Wither height is the only objective measurement

In 1996 The Friesian Studbook of the Netherlands (FPS) requested *Het Nederlands Rundvee Syndicaat* (NRS), a division of the Department of Animal Science in the Netherlands, to assist in estimating breeding values for the Friesian breeding stallions. This led to a research study in which the scoring sheets of approximately 2000 Friesian horses were analysed and heritabilities determined for the various traits. The heritabilities for linear scored traits in Friesian horses are listed in **Table 2.5**. All of these traits listed are scored subjectively, except for wither height, which is measured with a measuring stick.

Table 2.5 Heritabilities of 39 linear scored traits (subjectively measured) and wither height (objectively measured) in the Friesian Horse (Osinga, 2000).

Trait	Heritability	Trait	Heritability
Head expression	0.09	Hind legs stance	0.10
Head length	0.20	Hind leg shape	0.12
Poll length	0.13	Development of joints	0.08
Throat latch	0.23	Pastern length	0.04
Neck length	0.12	Hoof shape/size	0.10
Neck position	0.09	Height of heals	0.02
Neck weight	0.16	Quality of bones	0.08
Wither length	0.07	Bone weight	0.14
Shoulder length	0.10	Walk: scope	0.02
Shoulder position	0.20	Walk: correctness	0.16
Back length	0.20	Walk: length	0.12
Back shape	0.13	Walk: regularity	0.06
Loin width	0.17	Walk: expression	0.15
Loin shape/strength	0.23	Trot: length	0.22
Croup shape	0.07	Trot: expression	0.18
Croup length	0.11	Movement/impulse	0.20
Length of semitendinosus	0.08	Gait	0.15
Length of forearm	0.23	Colour	0.31
Front legs stance	0.09	Thickness of mane, tail & feathers	0.20
Front legs shape	0.05	Wither height [a]	0.66

[a] Wither height is the only objective measurement

Genetic parameters and breeding values were estimated for linear type traits (subjectively scored) in the Italian Haflinger horse population. Estimates of heritability ranged from 0.02 to 0.53. Lowest estimates were found for temperament traits (0.02 and 0.06), while highest values were for coat description traits (0.29 to 0.53). Estimates of genetic correlations between traits ranged from –0.32 to 0.99. The highest correlation obtained, was between volume and expressiveness of the head (0.99). Breeding values were estimated using a multi-trait animal model. These standardized breeding values can now be used for selection on morphology in the Italian Haflinger population (Samoré *et al.,* 1997).

It is thus clear that the collection of data from subjective and objective measurements for horses plays a very important role in the assessment of the value of each individual as a potential breeding animal.

2.2.3 Body Measurements

For a number of horse breeds various objective body measurements are taken by the judges at studbook and judging shows. These include, among others, height at withers and/or croup, body length, heart girth and circumference of the cannon bone. Body measurements are moderately to highly heritable (h^2 = 0.25-0.90) (Hintz *et al.,* 1978; Von Butler & Krollikowsky, 1986). These are similar to heritabilities for body measurements in beef cattle, h^2 = 0.37 for body length at 205 days of age and h^2 = 0.77 for hip height at 205 days (Köster, 1992). In

Table 2.6 examples of objective body measurements and their estimated heritabilities are shown. Body measurements show high genetic correlations among traits (0.80-1.00). Therefore, only some of the measurements are required to be taken at studbook shows, and traits with the largest influence on the performance, usefulness and soundness of the horse, are included. This, however, would only be possible if correlations can be determined accurately (Saastamoinen & Barrey, 2000). Height at withers and height at croup show the largest average genetic correlations (0.89-0.99) (von Butler & Krolikowsky, 1986). Genetic correlations, reported by Árnason (1984) and Biedermann & Schmucker (1989), between conformation and performance traits are shown in **Table 2.7**. For Friesians, wither height is the only objective measurement taken on a regular basis by some horse owners and/or breeders and by the studbook judges (Osinga, 2000).

Other objective (quantitative) methods for evaluating the conformation of the horse include an objective method using photographs of horses. This photometric method has been improved using digital cameras and image analysis applications. Videotaping and a computerized gait analysis system have been used in several studies, but they have not been applied routinely. In such studies, conformational details of high performance horses in different disciplines have been described. A gait analysis system (Equimetrix) has been designed for early performance evaluation in trotters and show-jumping horses in France. In some countries, radiographs from certain joints are taken in connection with conformation evaluation in order to determine the orthopaedic status of a horse. Limited genetic data are available for the conformation traits obtained by the quantitative methods described above (Saastamoinen & Barrey, 2000).

Table 2.6 Heritability estimates for objective body measurements.

Trait	Heritability	Breed	Reference
Height at withers	0.33-0.88	Thoroughbred (growing)	Hintz *et al.* (1978)
	0.77	Icelandic Horse	Arnason (1979)
	0.60	Icelandic Horse	Arnason (1984)
	0.25	Warmblood Riding Horse	Von Butler & Krollikowsky (1986)
	0.48	Arab	Seidlitz *et al.* (1991)
	0.25	Trakehner	Kaiser *et al.* (1991)
	0.89	Shetland Pony	Van Bergen & van Arendonk (1993)
	0.25-0.71	Finnhorse (growing)	Saastamoinen (1990)
	0.40-0.46	Halfbred Riding Horse	Kapron *et al.* (1994)
	0.52	Lipizzan Horse	Zechner *et al.* (2001)
	0.40	Thoroughbred	Biedermann & Schmucker (1989)
	0.25	German Riding Horse	Von Butler & Krollikowsky (1986)
Height at croup	0.34	Thoroughbred	Biedermann & Schmucker (1989)
	0.15	Lipizzan Horse	Zechner *et al.* (2001)
	0.06-0.52	Finnhorse (growing)	Saastamoinen (1990)
Body length	0.13-0.65	Finnhorse (growing)	Saastamoinen (1990)
Heart girth	0.71	Icelandic Horse	Arnason (1979)
	0.24	Warmblood Riding Horse	Von Butler & Krollikowsky (1986)
	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)
	0.24	German Riding Horse	Von Butler & Krollikowsky, (1986)
	0.18-0.99	Finnhorse (growing)	Saastamoinen (1990)

Table 2.6 Continue

Cannon bone circumference	0.12-0.77	Thoroughbred (growing)	Hintz *et al.* (1978)
	0.50	Icelandic Horse	Arnason (1979)
	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)
	0.30-0.55	Finnhorse (growing)	Saastamoinen (1990)
	0.55	German Riding Horse	Von Butler & Krollikowsky (1986)
Body weight	0.13-0.90	Thoroughbred (growing)	Hintz *et al.* (1978)

Table 2.7 Genetic correlations between conformation and performance traits.

Traits	Correlation	Breed	Reference
Wither height x Handicap weight	-0.61	Thoroughbred (galloping)	Biedermann & Schmucker (1989)
Wither height x Performance	0.00	Icelandic Horse	Arnason (1984)
Leg stances x Performance	-0.02	Icelandic Horse	Arnason (1984)
Conformation x Performance	0.22	Icelandic Horse	Arnason (1984)

A study performed for 18 morphofunctional traits in the Andalusian Horse using an animal model indicated moderate to high (0.35-0.95) heritabilities for objective body measurements. The estimates obtained for subjectively scored regional conformation, were lower (0.03-0.50). The heritability for the racial fidelity and overall forms were 0.58, while the scoring for movements was 0.15 and 0.08 for temperament, which agrees with the fact that they are the most subjective and complex features being closely tied to the behaviour variables. The heritability of the overall evaluation trait, which included all the previous characters, showed an intermediate value (0.25). The genetic correlations ranged between 0.11 and 0.94 for zoometric (objective) measures and between 0.12 and 0.91 for regional morphologic evaluations. The punctuation for racial fidelity and overall forms shows a genetic correlation of 0.55 with movement scorings and 0.74 with the overall evaluation of the animal (Molina *et al.*, 1999).

2.2.4 Linear Scoring in Different Horse Breeds

Royal Warmblood Horse of the Netherlands

The Royal Warmblood Horse Association of the Netherlands (KWPN) implemented linear scoring in evaluating their horses a few years before the Friesian Horse Studbook (FPS). The data obtained from linear scoring were applied to estimate heritabilities for a number of important traits in sport horses (**Table 2.3**). These data were also used to estimate breeding values for their breeding stock and compilation of an exterior index for stallions similar to the

Friesian studbook. The KWPN was the model on which the FPS based their exterior index, with the only difference being fewer subdivisions on the scoring sheet of the KWPN. **See Appendix A.3** for a copy of the Linear Scoring sheet used by the KWPN.

Koenen *et al.* (1995) estimated genetic parameters of linear scored conformation traits in the KWPN in relation to performance in competition. Heritabilities of 26 linear scored conformation traits were estimated and ranged from 0.09 to 0.28. Several conformation traits had high to very high mutual genetic correlations. Competition results of performance in dressage and performance in show jumping were linked to the conformation data to estimate the genetic relationship between conformation and performance in competition. The model for the evaluation of the competition results included the fixed effects riding club, age and sex. Estimated heritabilities of dressage and show jumping were 0.17 ±0.05 and 0.19 ±0.04, respectively. Genetic correlations between conformation and performance were low to moderate. The length of the neck, length and position of the shoulders, shape and length of croup and muscularity of the haunches had a significant genetic correlation with show jumping. The results indicate that, due to the low genetic correlations with performance traits, indirect selection for performance using conformation results is of limited value (Koenen *et al.*, 1995).

Friesian Horses

The Friesian Horse Studbook of the Netherlands implemented linear scoring in 1993. During the first two years of using linear scoring, the horse owners were not involved in any way, but since 1995 the owner of the horse has received a copy of the linear scoring sheet shown in **Figure 2.11** (Exterieur-Index, 2000). There were a few prerequisites in the development of the linear scoring sheet for Friesians. Firstly, it was important to determine a number of traits of an animal as objectively as possible. Secondly, it had to supply sufficient room for variation within the trait, which is important for successful selection and breeding. Another prerequisite was that the data had to be easily procurable by computer. This presented the judges with quite a difficult task as traits now had to be quantified and not qualified or valuated as in the past.

On the linear scoring sheet there are, besides the wither height measurement, 39 traits that are being scored. The selection effect per trait diminishes when numerous traits are being selected for simultaneously and therefore the selection progress is relatively slow. A long generation interval further contributes to a slower genetic response (Osinga, 2000). As the many traits scored generates a vast amount of data that have to be computerized and processed, and because of the diminishing effect of selection for numerous traits on the selection progress of a single trait, the FPS recently (Desember 2001) decided to implement a somewhat shortened version of the original linear scoring sheet.

Place:	Country:	Cat.nr:
Date:	Name of Horse:	
Sex: S M G	Reg. nr:	Tonguenr:
Height:	Father:	Mother:
Marking:	Reg. nr:	Reg. nr:

	Feature:	5	10	15	20	25	30	35	40	45	Feature:
Head	plain										noble
	long										short
Poll	short										long
Throat latch	heavy										light
Neck	short										long
	horizontal										vertical
	heavy										light
Withers	short										long
Shoulder	short										long
	steep										sloping
Back	long										short
	weak										roached
Loins	narrow										broad
	weak										tight
Croup	straight										steep
	short										long
Semitendinosus muscle	short										long
Length of forearm	short										long
Front leg(s)	standing over										standing under
	back at the knee										over at the knee
Hind leg(s)	bowlegged										cow hocked
	sickle hocked										straight
Development of joints	coarse										fine
Pastern	short										long
Hoofs	small										big
Heals	low										high
Quality of bones	spongy										hard
	heavy										fine
Walk	wide										narrow
	toeing-in										toeing-out
	short										long
	irregular										regular
	weak										powerful
Trot	short										roomy
	irregular										regular
Movement/impulse	weak										powerful
	flat										lifted
Color	faded black										jet-black
Thickness of mane, tail & feathers	thin										dense

o Dressage-type o Harness type	Breed type	Build	Muscling	Quality of bones	Walk	Trot

o Deep from the chest o Too heavy lower neck o Defect of the knee o Defect of the hock o Umbilical hernia o Mane eczema	Not registered	Studbook	Star	Provisional model
		Member of the jury:		

Fig 2.11 A copy of the original linear scoring sheet used by the FPS since 1993. See Appendix A.1 for the Dutch version.

Figure 2.12 is a copy of the new, shortened linear scoring sheet implemented in January 2002 by the FPS in the Netherlands (Personal communication, De Boer, 2002)

The procedure with linear scoring in Friesians is as follows:
All horses (mares and geldings 3,4 and 5 years of age) that are presented at a studbook judging for inclusion in the studbook since 1993, are being scored by expert and trained judges (usually 1 or 2). This happens by appointing a number for every part on the sheet of between 5 and 45 in multiples of 5. The population mean has been set at 25. The numbers 1 – 10 are not used because it might tempt the judges to give an assessment mark instead of objectively awarding a number. The sheet has been designed in such a manner that 45 is not always highly positive, but on the other hand, 5 is always negative. An example of this would be the throatlatch. A very heavy throatlatch is undesirable, because this impairs the movement of the head and prevents the horse from bringing down its head in dressage or leisure riding. A very light throatlatch is not desirable either. However, a light throatlatch is better than a heavy throatlatch; therefore the ideal score in this case would be 35. Thus, for every one of the subdivisions scored, a different ideal score might be desired. Because of this, it took a while for judges and breeders alike to get used to and to learn how to read and use the scoring sheet (De Boer, 2001).

The advantages of the scoring sheet are firstly the identification of the superior and inferior points of the horse. If the owner is planning to use the horse for breeding, the choice of the stallion is essential. The stallion will have to compensate for the poor scores of the mare while the mare's strong points can possibly compensate for the imperfections of the stallion. Secondly, the scoring is very valuable to compare the daughters of a stallion. If the mean for a certain trait is for example below 20, it can be assumed that the stallion has a negative effect on the population as far as that specific trait is concerned (Osinga, 2000).

It is clear that the linear scoring system produces a vast amount of information. If all this information for as many progeny as possible is arranged in a computer for all the sires, then it is possible to see which traits a stallion can be selected for or against. Also the degree of improvement or the degree of fixation of an abnormality or defect can be evaluated. The application of this information may result in a reliable estimation of a detailed index for each stallion (De Boer, 2001).

Essential for an effective linear scoring system is judging uniformity. Fundamental differences of opinion over the exterior characteristics of a horse and the assignment of scores must be limited or preferably not arise at all. For this reason it is essential that the judges frequently meet to make sure that they agree on their approach to linear scoring. The same judges as far as possible should always do linear scoring (De Boer, 2001).

Place:	Cat. nr:
Date:	Name of horse:
Sex: S M G	
Marking:	Reg. nr:

	Feature	5	10	15	20	25	30	35	40	45	Feature
Head	Plain										Noble
Throat latch	Heavy										Light
Neck	Horizontal										Vertical
Shoulder	Steep										Sloping
Back	Weak										Roached
Loins	Narrow										Broad
Croup	Straight										Steep
	Short										Long
Semitendinosus muscle	Short										Long
Length of forearm	Short										Long
Front leg(s)	Standing over										Standing under
Pastern	Short										Long
Hoofs	Small										Big
Quality of bones	Spongy										Hard
Hind leg(s)	Sickle hocked										Straight
	Toeing-in										Toeing-out
Walk	Short										Long
	Weak										Powerful
Trot	Irregular										Regular
Movement/impulse	Flat										Lifted
Color	Faded black										Jet black
Thickness of mane, tail & feathers	Thin										Dense

○ **Deep from the chest** ○ **Too heavy lower neck** ○ **Defect of the knee** ○ **Defect of the hock** ○ **Umbilical hernia** ○ **Mane eczema** ○ **.....**	Breed type	Build	Quality of bones	Walk	Trot
	○ Star ○ Studbook ○ Not registered First premium Second premium Third premium No premium				
		Member of jury:			

Figure 2.12 A copy of the new, shortened linear scoring sheet used by the FPS since January 2002.

In 1999 the FPS also introduced linear scoring of foals. The scoring sheet for foals is a simplified version of the scoring sheet for mature horses. It is very important when scoring the foals, to determine which traits can already be estimated at an early age. The result of this is yet to be seen (Osinga, 2000). See **Appendix A.2** for a copy of the linear scoring sheet used for foals.

2.2.5 Breeding Values of Linear Scored Traits

Linear scoring may contribute to the overall value of breeding value estimation of all stallions. Breeding values for the Friesian stallions are calculated using Best Linear Unbiased Prediction (BLUP) whereby the progeny are being compared with a base group in the population at a specific time. BLUP is defined by Bowling & Ruvinsky (2000) as a standard statistical method for estimating breeding values in (large) populations. BLUP accounts for genetic relationships and adjusts for systematic fixed effects. A group of studbook-approved mares, born in 1991, serves as the base group for the Dutch Friesian population. The breeding value is shown as a relative breeding value with a mean of 100 and a standard deviation of 4. The normal distribution thus shows that 68% of the animals (stallions) have an Estimated Breeding Value (EBV) of between 96 and 104 (Exterieur-index, 2000). These are the animals that do not contribute much or are not detrimental to the quality of the population as far as the specific trait is concerned. The system is easily readable and the traits are intercomparable. It also provides insight into the position of the EBV relative to the rest of the population. If certain breeding trends appear, it can be determined whether they are desired or not.

The reliability of the estimation is calculated using a method including the number of judgings, number of progeny and number of parents and the heritability. The accuracy of the estimation depends on the number of progeny and relatives and on h^2. **Figure 2.13** contains two examples of EBV indexes as calculated for all the Friesian stallions approved by the FPS as studbook stallions.

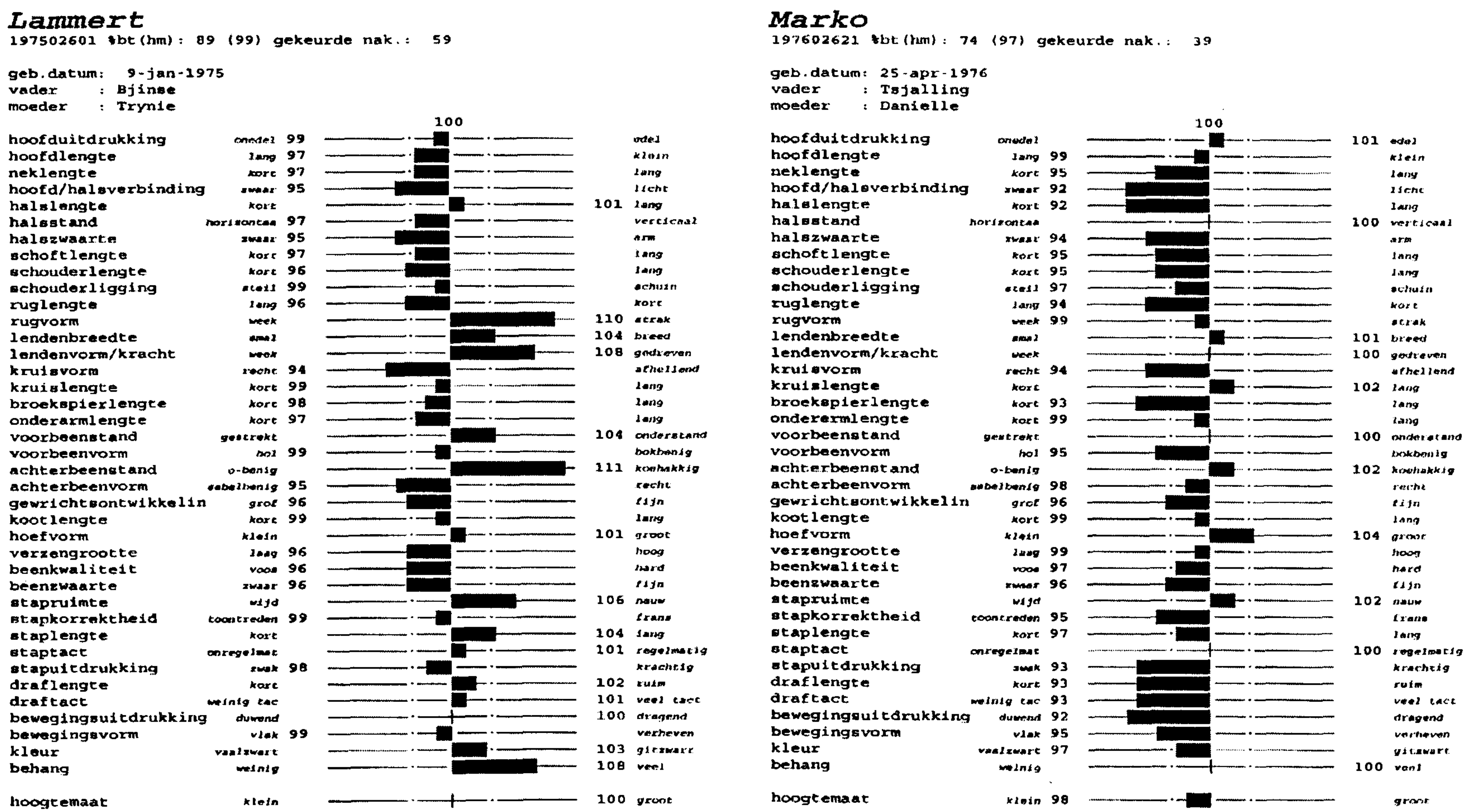


Figure 2.13 EBV indexes for two studbook approved Friesian Stallions in the Netherlands (Exterieur Index, 2000)

2.3 Traits associated with Racing, Jumping and Eventing

Traits associated with racing, jumping and eventing have also been included in the estimation of genetic parameters. As type I fibre percentage, cross-sectional area and relative area are directly correlated with success in endurance performance horses, these traits have been researched in Spanish (Andalusian) horses. Heritabilities and genetic correlation for muscle fibre type composition, fibre size and capillaries of the gluteus medius muscle were estimated for purebred Andalusian horses (Rivero & Barrey, 2001) using restricted maximum likelihood with an animal model. Heritabilities of muscle fibre type traits were moderate to low (0.11 – 0.28). Heritabilities for type I fibres-related traits (fibre percentage, cross-sectional area and relative area, 0.28±0.09, 0.19±0.06 and 0.23±0.09, respectively) were higher than those estimated for type II fibres-related traits (0.11 – 0.17), but heritability for type IIX (fast glycolytic) fibre percentage was moderate (0.25±0.09). However, type I and type IIX fibre percentages were phenotypically (-0.86) and genetically (-0.36) negatively correlated. Both type I and type IIA, as well as type IIA and type IIX were also genetically negatively correlated (-0.48 and –0.85, respectively). Present data show that type I fibre-related traits are more heritable than type IIA and type IIX fibre properties. The phenotypic variability observed for these traits is largely explained by non-genetic factors such as training and nutrition. The inclusion of these traits in breeding programs of Andalusian horses could be of interest for early selection of appropriate sires and mares in order to improve the athletic endurance capacity of this breed.

The average heritability estimates of pulling ability and cutting ability in sport horses have been determined to be 0.25 and 0.04, respectively. Heritability estimates are 0.18, 0.19 and 0.17 for log of earnings from jumping, 3-day event and dressage, respectively. Heritability estimates of performance traits for the Thouroughbred, Trotter and Pacer are shown in **Table 2.8**. The effectiveness of selection will depend on which performance trait is to be improved (Hintz, 1980).

Table 2.8 Heritability estimates of performance traits for Thoroughbreds, Trotters and Pacers respectively (Hintz, 1980).

	Thoroughbred	Trotter	Pacer
Performance rates	0.55		
Log of earnings	0.49	0.41	
Earnings	0.09	0.20	
Handicap weight	0.49		
Best handicap weight	0.33		
Time	0.15	0.32	
Best time	0.23	0.25	0.23

Genetic parameters of eventing horse competitions have also received attention. The performance measurements included logarithmic transformations of annual earnings, annual earnings per start, and annual earnings per place, and underlying variables responsible for ranks in each competition. Heritabilities were mostly low ranging from 0.11 to 0.17 for annual results, and 0.07 for ranks. Genetic correlations between abovementioned criteria were high (greater than 0.90) except between ranks and earnings per place (0.58) or per start (0.67). Genetic correlations between ages (from 5 to 10 years old) were also high (more than 0.85) and allowed selection on early performances. The genetic correlation between the results in different levels of competition (high/international and low/amateur) was near 1. Genetic correlations of eventing with other disciplines, which included partial aptitude needed for eventing, were very low for steeplechase races (0.18) and moderate with sport: jumping (0.45), dressage (0.58). The results suggest that selection on jumping response could be obtained if a specific breeding objective and selection criteria were developed for eventing (Richard & Chanu, 2001).

Research on the racing performance of quarter horses resulted in the development of genetic prediction summaries on all horses, with at least one start on record for each horse at the American Quarter Horse Association. A reduced animal model was used, which incorporated the repeated records of individuals. The individual race was the contemporary group after the data were adjusted for distance, sex and age. Estimates of heritability of 0.24 and repeatability of 0.32 suggest that increased racing performance can be achieved if the predictions are used by breeders. Continued research in variance component estimation includes the genetic covariances among the several distances, maternal influence and genetic parameters for racing longevity (Willham & Wilson, 1991).

First, genetic parameters for traits evaluated in the Swedish stallion performance test (SPT) were estimated. Then the correlations between stallion performance test traits and 4-year-old offspring results from field tests, could be estimated. Heritability estimates were on average 0.40 for individual gaits under rider and 0.23 – 0.47 for jumping traits at SPTs. Repeatabilities between tests at 6-month intervals were 0.75 – 0.77 for gaits and 0.38 – 0.47 for jumping traits. The genetic correlation between the gaits ranged from 0.30 – 0.71. Positive genetic correlations were found between gaits under rider and jumping traits (0.14-0.54), thus breeding for both characteristics is facilitated. Free jumping results were highly correlated (0.93) to results in jumping under the rider, and because of their higher heritability the former are useful for selection purposes. Genetic correlation estimates between a trait in SPT and the same trait at 4-year-old offspring field-tests were of the same magnitude for gaits under rider and jumping. The genetic correlations between gaits and jumping at the two different tests were 0.26 – 0.35. It was concluded that the field tests are well suited for early progeny testing of the stallions, and will improve the accuracy in selection of stallions for performance traits (Olsson *et al.,* 2000).

2.4 Reproduction and Breeding

The unique aspects of reproductive physiology in the horse are not advantageous to a high rate of genetic progress. The potential for a rapid annual improvement in performance is limited due to a long generation interval and low reproductive efficiency. The generation interval is dependent on a combination of the age at first mating, the length of the horse's reproductive life, and the average number of offspring per parent (Boers, 2001). When considering reproduction rate, relative to that of some other domestic species like sheep, mares produce only one foal per year or very rarely twins, and have a gestation period of just over 11 months. This means that very few full sibling families are available for genetic investigations (Allen & Antczak, 2000). Furthermore, the mare is generally considered as having the lowest reproductive efficiency of all the livestock species. Conception rate to first service in pigs, sheep and cattle has been reported to be 85 - 95%, 80 – 90% and 55 – 65% respectively, and only 40 – 50% for horses (Gordon, 1997). Improving horse breeds using classical genetic techniques is also more complicated than for other species due to some of the evolutionary adaptations of the reproductive system of the horse that occurred as a result of domestication.

The mare's reproductive control mechanisms are quite efficient when left to function in the wild, but it seems like domestication and confinement have reduced the efficiency of the reproductive process. Of all the domestic animals, the reproductive cycle of the mare shows the greatest variation. Individual mares sometimes have the ability to breed any time of the year, while other mares are seasonally polyestrous (i.e., they have a series of estrous cycles limited to a portion of the year). Wild horses breed only during the time of year that corresponds to the longest days of the year to ensure that the foals are born in the spring of the following year when feed is likely to be the best (Parker, 1998). Increasing daylight, increasing ambient temperatures and (under natural conditions) increasing food supplies, are the three most important factors stimulating the start of cyclical ovarian activity in the anoestrous mare. Ovulatory activity of the mare is at its peak from April to July in the northern hemisphere and in the southern hemisphere from November to January. Increasing the photoperiod with artificial lighting can be used to bring mares out of anoestrous during the early part of the breeding season (Bearden & Fuquay, 1997; Gordon, 1997).

Twinning is not undesirable in domestic species like sheep, because it increases the number of lambs that are weaned in a given year. Double ovulations occur in about 25% of all estrous cycles in the mare, but twinning in mares is undesirable. In 1964 it was reported that twin births in horses occurred only 0.5 – 1% of the time (Gordon, 1997). Only 9% of all conceived twins are carried to term and of those, in most cases, 64.5% of the time, both foals are born dead, one foal is born alive 21% of the time, and live twins are born 14.5% of the time. If, however, live twins are born, both of the live twins are usually small and weak and one usually dies within three or four days. If ultrasound investigation or rectal palpation shows that a mare has two large follicles, it is recommended to still breed the mare, which increases initial pregnancy rate from 50% to 75%. The embryonic vesicle is attached to the uterus wall between 15 and 17 days postconception. This is when ultrasound can be used to determine whether twins are present; in which case one can be manually destroyed by pinching if they are attached separately. Those twin foetuses that are attached together should be left because 75% to 90% will be naturally reduced to a single foetus by 40 days after conception. In cattle, heritability of twinning has been found to be low (Bearden & Fuquay, 1997). No literature could however be found where heritability of twinning in horses has been reported. The heritability of fertility in general, has, however been found to be very low, 0.00 – 0.05, in Dutch Warmbloods (Van Veldhuizen, 1991).

A substantial percentage of mares fail to produce a foal each year. Some of the problems encountered in horse reproduction may arise from unique features of the mare's reproductive physiology and endocrinology, but others are man-made. In the first place, in the racehorse industry, the physiological reproductive season does not necessarily coincide with the artificial breeding season imposed on the animal. Secondly, the selection for competitive excellence on the track has probably been regarded as more important than selection for the animal's ability to reproduce (Davies Morel, 1993).

There are several areas in which reproductive management of the mare may be facilitated by the application of controlled reproduction procedures. Breeding with extremely valuable animals, in many cases emphasizes the need for applying all the modern breeding technologies available (Gordon, 1997).

2.4.1 Modern Breeding Technologies

Artificial insemination (AI) can be a means of increasing the number of mares covered in the breeding season. The application of AI in horses has many advantages to be considered by horse breeders. The technology concerning superovulation of the breeding mare has not yet been optimized for horses, but continued research is being done in the field (Davies Morel, 1993).

Sex determination by Polymerase chain reaction (PCR) has been carried out on a sample of cells taken from horse embryos or expanding blastocysts. The method has been found to be rapid and accurate, but the application of such a method in practice may be limited. When equine blastocysts have been split, subsequent survival has been poor (Gordon, 1997).

The non-surgical flushing of an embryo from the uterus of a donor mare and its non-surgical transfer to the uterus of a synchronized recipient mare are relatively simple manipulative procedures compared to the same manoeuvres in the cow. Advantage can thus be taken of embryo transfer to improve reproductive success in horses. Cryopreservation (freezing) of equine embryos is not yet accepted practice in the equine embryo transfer industry because of the limited success that has been reported with this technique. Horse embryos are much more sensitive to low temperature preservation than cattle embryos (Allen & Antczak, 2000). Despite the difficulties involved with the freezing of embryos, however, the first 'deep-freeze' Friesian foal was born from a trotter mare on 30 May 1999 in the Netherlands. The foal and her mother were healthy and no complications occurred. According to the owner of the foal, Mr Jaap van der Meulen, the aim of the experiment was to develop a method that would make it easier to exchange genetic material with countries over the world (Faber, 1999).

Other facilitated breeding techniques have also been applied to Friesians in the Netherlands as well as in South Africa. AI is slowly but surely becoming the breeding method of preference for Friesian owners in the Netherlands and even in South Africa Friesian foals have been procreated from frozen semen imported from the Netherlands over the last two years (Personal communication, Mrs Schimmel, 2002).

The high economic value assigned to individual horses makes the application of reproductive technologies economically feasible for breeders and owners. Expertise in equine reproduction is readily available and widespread around the world. Thus, the potential is great for applying the combined information from the emerging genetic maps of the horse with the most modern techniques in reproduction to the propagation and improvement of the horse (Allen & Antczak, 2000).

2.5 The Role of Genetic Markers in the Selection of Horses

In recent years, genomic tools have become available for most livestock species, including the horse, and are now being routinely used to map quantitative trait loci (QTL) underlying the genetic variance for numerous economically important traits (Georges, 1999).

The use of genetic markers to define the genetic makeup (genotype) and predict the performance of an animal is a powerful aid to animal breeding. DNA markers are, by definition, polymorphic, and include restriction fragment length polymorphisms (RFLPs), microsatellites, and single nucleotide polymorphisms (SNPs) (Beuzen *et al.,* 2000).

The most pursued map of any species is the one that locates a gene's position relative to that of other identifiable signposts (genetic markers) on the chromosome. Known as a linkage map, this type of representation does not tell where on a chromosome, or even necessarily on which chromosome, the gene is found. Rather, it indicates the probability that it will be inherited along with other known sequences (markers) in the genome. Such information is valuable because if two genes are linked, they have a higher chance of being co-inherited. This means that if an animal has a certain marker, there is a high probability that it also has the code for the specific trait (or the gene). This knowledge can then be applied to Marker Assisted Selection (Georges, 1999).

The construction of genetic and physical maps of the horse genome is finally underway, but marker density is still low. A Horse Genome Project began in 1995 with the aim of promoting international collaboration in the field of horse genomics. The results obtained so far are encouraging, with over 500 markers localized. By contrast, complete sequencing of the genome is still beyond the reach of the relatively small group of laboratories involved in the project (Chowdhary & Raudsepp, 2000).

The goal of the First International Equine Gene Mapping Workshop, held in 1995, was the construction of a low density, male linkage map for the horse. A more comprehensive analysis including synteny group data and FISH data suggested that 26 autosomes out of 31 are covered (Guérin *et al.,* 1999).

The simplest way to avoid dominantly inherited Mendelian diseases is to avoid breeding with affected individuals. DNA tests are usually not required for dominant diseases unless there are difficulties identifying the individuals with the affected gene and the disease. The simplest strategy to avoid recessive Mendelian diseases is to ensure that at least one parent is not a carrier. For relatively common diseases, sire catalogues of the breeds for which they exist, will list animals that have been tested and are known to be carriers or non-carriers (Beuzen *et al.,* 2000). In South Africa, however, such catalogues exist only for Thoroughbreds.

A study on the comparison of Greek horse breeds using RAPD markers indicated its usefulness for the identification of individual horses, as well as for determination of the genetic variance found among breeds, which is important for a proper management policy designed to protect the different species (Apostolidis *et al.,* 2001). The evaluation of the genetic diversity of four native Norwegian horse breeds was investigated using 35 genetic markers including nine biochemical loci and 26 microsatellites. Significant population differentiation was detected between all breeds, also between the recently diverged Døle Horse and the Coldblooded Trotter (Bjørnstad *et al.*, 2000).

A study on the purity and diversity of the horse breeds in South Africa was conducted by Botha (2001). Relatively small differentiation values were observed between the American Saddler and the S.A. Boerperd and between the Boerperd and the Cape horse. The most distinct difference was observed between the Friesian horse and the Cape horse. It was shown that the S.A. Boerperd and the Cape horse are very closely related. The Friesian is the least related to any of the other horse breeds, except for the Przewalski horse.

The exploitation of DNA polymorphisms that are associated with multifactorial traits, depends on whether the polymorphism defines a marker or the QTL itself. If the QTL has been identified, then exploitation is relatively straightforward. The relative advantage of DNA typing will depend upon the cost and how much improvement DNA typing makes over current methods. The improvement will also depend upon the relative contribution of a QTL to the overall genetic variation (Beuzen *et al.,* 2000).

At present, evidence for the existence of quantitative traits loci (QTL) with large effects (major genes) in horses is limited. Traits, however, such as the lateral gaits, pace and toelt, ‘cow sense’ and other unusual behavioral characteristics related to special movements affecting dressage and jumping characteristics in horses could quite probably be influenced by major genes (Bowling and Ruvinsky, 2000).

In the future, interest in possible use of marker-assisted selection (MAS) for enhanced genetic improvement in horses, is likely to increase. As the gene map of the horse becomes more complete, the chances increase of finding genetic markers closely linked to major genes affecting some important quantitative traits included in the breeding goal. The only indication of a plausible marker for a quantitative trait in horses found in the literature, is the report of Anderson *et al.* (1987) on an association between different alleles at the serum esterase locus *(Es)* and racing status (all-or-none trait depending on whether the horse has started in a race or not) in Swedish Standardbred trotters. MAS is likely to be a valuable complement to selection on EBVs obtained by the BLUP method, rather than as a replacement for EBVs. The use of MAS in horse breeding schemes could be particularly useful for traits that are expressed late in the horse's life because the genetic markers will already be known in the foal. The effect of MAS is likely to shorten the generation interval and thereby increase the rate of genetic progress.

2.6 Importance of Pedigrees in the Selection of Horses

Performance information from relatives is of great importance in the application of selection in animal breeding. The traits to be selected often have low heritabilities, thus, selection for genetic improvement should be based on progeny, collateral relatives and pedigree information in addition to the animal's own records (Hintz, 1980). When the outcome of selection is a matter of economic gain, as with horses, even quite a small improvement of the response, will repay the extra effort of applying the most accurate technique (Boers, 2001).

The best achievers are not always the best producers. A general opinion is that appearance shows what a horse looks like, a pedigree reveal how the animal should develop, performance records shows the ability of the horse and the progeny is an indication of how the animal breeds (Jones, 1982).

If records are kept and included in the pedigree, the pedigree provides a good indication of the genetic composition of the horse and how the traits will be inherited. Pedigrees without performance records are of limited value in terms of the genetic value of the animal. It is, however, valuable in determining inbreeding. Pedigrees are only of value if they are accurate. Records of poor performers are as important as records from elite performers. A pedigree with performance records has to contain records of all relatives, but the performance of the sire and dam are more important than those of more distant relatives (Jones, 1982). According to Parker (1998), it is not as important to buy a registered horse with a complete pedigree when purchasing a horse for recreation only. Horse breeders, however, should realize the importance of only buying horses with complete pedigrees (Parker, 1998).

When reading through all the literature available on horse breeding and genetics, it becomes clear that there are many different aspects to be considered in the selection and breeding. In South Africa no scientific research has been done on Friesian horses specifically. There are, however, quite a few books and articles that have been published in the Netherlands on Friesians and the characteristics distinguishing this unique breed from other breeds. As more information becomes available for a particular breed, the more tools will be developed to enable breeders to plan scientific breeding strategies, and provide standards for comparisons.

CHAPTER 3

MATERIAL AND METHODS

The aim of this study, as stated in Chapter 1, was to evaluate the current status of all Friesian Horses in South Africa, to distinguish between objective and subjective measurements that will make genetic progress possible and to make recommendations on the scientific breeding and selection of Friesian Horses in South Africa.

In order to achieve these aims:

1. Literature on horse genetics and breeding programs was reviewed,
2. All available pedigree data were collected and evaluated,
3. Objective measurements were taken of as many Friesian horses as possible.

3.1 Material

The information for this 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, according to the South African Studbook, in total 192 horses registered with their association on 1 July 2001. Two separate data files were compiled, consisting of a file with the objective measurements taken from horses between August 2001 and April 2002 and a pedigree file. The two files were then combined in order to fit a sire model to estimate genetic parameters for the population.

3.1.1 Objective Measurements

The objective measurements were taken from a total of 232 horses, registered with either the FPSSA or with the Friesian Horse Breeders' Society of South Africa. The horses measured were all four years of age and older and belonged to breeders and horse owners in South Africa and Namibia (**Table 3.1**). 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. All measurements were taken by one person in order to minimize human error. Approximately 20% of the horses in each stud were measured twice on the same day for data validation. SAS® (2001) [1] was used to analyse the data.

All the horses were not necessarily measured on the stud where they reside, as some were, for example, stabled at other breeders at the time of measurement, to be covered. A number of horses were also measured while stabled at the Pretoria Police Academy at the time of the Annual Friesian Horse Show held in October 2001. In **Table 3.2** the horses were grouped according to their region of origin or where they permanently reside.

For the purpose of fitting the Sire Model (see 3.2.3), however, the horses were grouped together according to the location of measurement in order to be able to compile contemporary groups of reasonable size.

[1] SAS® Version 8.2 (TS2M0) (2001), SAS Institute Inc., SAS Campus Drive, Cary, NC USA 27513-2414.

Table 3.1 Breeders and number of horses objectively measured in the geographic regions of South Africa and Namibia.

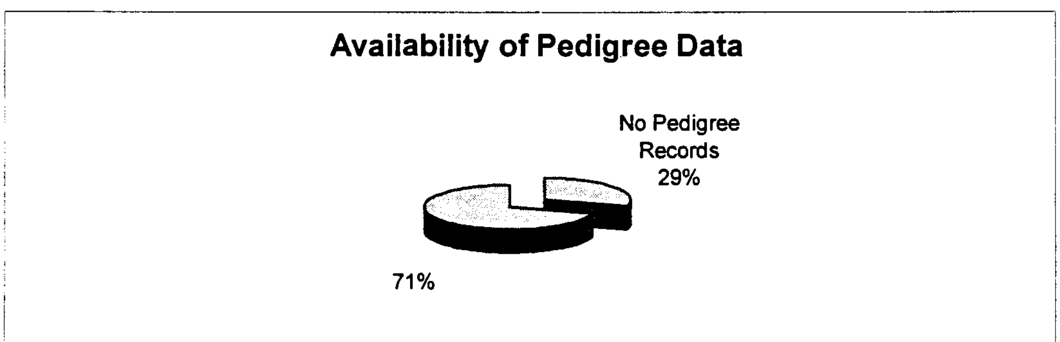
Breeder	Number of horses measured	Geographic Region
Beyers, M.	3	Gauteng
Blom, R.	6	Western Cape
Bongers, J.	4	Western Cape
Botes,M.	10	Gauteng
Botha, B.	8	North West
Botha, P.H.	54	North West
Bronner, C.	2	Kwazulu Natal
De Haas, D.	1	Kwazulu Natal
De Jager, A.	1	Mpumalanga
De Villiers, L.	1	Nothern Cape
Faanhof, A.E.	2	Gauteng
Giachetti, C.	3	Eastern Cape
Hanns, J.	1	North West
Jensen, M.	8	Namibia
Jooste, J.	4	Gauteng
Kemp, M.	4	Namibia
Le Roux, J.	1	Free State
Loubser, P.	9	Western Cape
Muller, S.	1	Gauteng
Naude, P.	1	Free State
Potgieter, L.J.B.	8	Mpumalanga
Saayman, W.H.	8	Gauteng
SAP	34	Gauteng
Schimmel, K.	5	Gauteng
Schoeman, S.C.	4	Gauteng
Scrace, L.	4	North West
Smit, B.F.	22	Western Cape
Swanepoel, B.	1	Western Cape
Van den Bosch, H.	5	Gauteng
Van Heerden, D.P.	1	Gauteng
Van Wyngaarden, C.	1	Namibia
Van Zyl, C.	2	Free state
Veldhoen, P.	3	Western Cape
Visagie, W.	5	Western Cape
Visser, F.	2	Western Cape
Visser, G.	3	Western Cape

Table 3.2 Geographic distribution of horses measured objectively.

Geographic Region	Number of horses measured in the Region
Eastern Cape	3
Free state	4
Gauteng	77
Kwazulu Natal	3
Mpumalanga	9
Namibia	13
North West	67
Western Cape	56
Total Measured	**232**

3.1.2 Pedigrees

The pedigree file was compiled from the records provided by the FPSSA. These records consisted 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 abovementioned associations, judging sheets and even change of ownership notifications. See **Appendices B.1 to B.6**. Any available data were combined in an attempt to maximize the amount of pedigree information obtained. There was absolutely no pedigree data available for 29% of the animals (**Figure 3.1**), and for the remaining 71%, the records were very incomplete.



Many of the horses registered [illegible]y belonged to members of the Friesian Horse Breeders' Society of South Africa and their old registration certificates were still available. This ensured that the pedigree data compiled also include some horses registered in the Friesian Horse Breeders' Society of South Africa. The pedigree data obtained is therefore a fair representation of the entire Southern African Friesian horse population.

3.2 Methods

3.2.1 Objective measurements

The following instruments were used to perform the eight body measurements:

1. Measuring stick: for measuring the three straight height measurements.
2. Metal measuring tape: a contractible, non-elastic metal measuring tape for measuring the body length and the length of the cannons.
3. Plastic measuring tape: a soft, non-elastic plastic measuring tape for measuring the circumference of the canon bone (forelimb and hindlimb).

Following a standard protocol, measurements were taken in the same order as described in **Table 3.3**. 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 been taken. The measurements were taken in much the same manner as by Zechner *et al.* (2001).

Photographs of how the measurements were taken and the three different measuring devices used for the measurements can be seen in **Figures 3.1** and **3.2.** In **Figure 3.1 a**, **b** and **c** the wither height, back height and croup height measurements are shown respectively, the measuring stick was used for all of them. **Figure 3.2 a** shows how body length was measured and **Figure 3.2 b** how the cannon length of the front- and hind limbs were measured using the metal measuring tape in both cases. The cannon circumferences of both limbs were measured with the plastic measuring tape (**Figure 3.2 c)**.

Statistical analyses of this data were prepared using SAS® (2001).

Table 3.3 Procedures for measuring the eight body measurements in the study.

Measurement	Measuring device	Anatomical description
1. Height at withers	Measuring stick	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	Distance from the deepest point of the back to the floor
3. Height of croup	Measuring stick	Distance from the rump (ileum) to the floor
4. Body length	Metal measuring tape	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	Distance from the lateral tuberculum of the *os metacarpale* IV to the middle of the fetlock joint
6. Length of cannon – hind limb	Metal measuring tape	Distance from the lateral tuberculum of the *os metatarsale* IV to the middle of the fetlock joint
7. Circumference of cannon bone – forelimb	Plastic measuring tape	Smallest circumference of the cannon bone of the forelimb
8. Circumference of cannon bone – hind limb	Plastic measuring tape	Smallest circumference of the cannon bone of the hind limb

a

b

c

Figure 3.1 Photographs of how the three height measurements were taken, showing the measuring stick.

a

b

c

Figure 3.2 Photographs of how the body length, cannon length and cannon circumference measurements were taken showing the different measuring devices.

3.2.2 Pedigrees

Records of in total 535 horses were included in the pedigree file. Every parent and grandparent were also recorded as an 'animal' with its pedigree information, if available, in order to be able to calculate inbreeding coefficients for the population. Basic checks were done on these pedigrees to ensure that all animals were born after their parents. The base population was identified and all the members of the population with unknown birth dates were issued with hypothetical birth years allocated to them systematically. Every individual was then issued with a unique identification number and the file sorted from the oldest animals to the youngest, in order to calculate inbreeding coefficients for the population using Animal Breeder's Tool Kit ® (Golden *et al.*, 1992).

In total, 852 pedigree records were included, consisting of 68% mares, 28% stallions and colts (thus, any non-castrated male) and 4.7% geldings. It can be assumed that the amount of geldings included is an underestimation of the number of Friesian geldings present in South Africa, as 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.

The 852 pedigree records contained the following information:

- Horse's registered name
- Birth date
- Birth year
- Sire
- Sire's sire
- Sire's dam
- Dam

- Dam's sire
- Dam's dam

Of the 852 records included, 29.46% had unknown parents and grandparents. Of the remaining 70.84%, 36.94% had a complete two-generation pedigree, 8.82% had only their parents known and 6.99% had only one known parent. Both parents were known for 86.52% of the records, while only information from the sire and dam's families were known for 27.95% and 3.66% respectively.

3.2.3 Sire model

The following sire model was fit to the data, using SAS® (2001).

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

Where Y_{ijkl} = Observation of the *l*th animal (*l* = 1,2,...80)

μ = the population mean

L_i = fixed effect of of the *i*th Location of measurement (*I* = 1,2,...13)

U_j = fixed effect of the *j*th Use of the animal (*j* = 1,2)

G_k = fixed effect of the *k*th gender (*k* = 1,2,3)

S_l = random effect of the *l*th Sire(*l* = 1,2,...29)

e_{ijkl} = random residual error effect

The results of the sire model was used to calculate heritabilities of the different linear body measurements.

CHAPTER 4

RESULTS AND DISCUSSION

In this study, data of the Friesian horse population of Southern Africa were evaluated for inbreeding, as well as the potential of objective measurements as a selection criterion, instead of the subjectively scored traits, which are extensively applied in selection of horse breeds worldwide.

4.1 Inbreeding

Horse breeders rarely apply inbreeding as a purposeful mating practice. The reason being that inbreeding tends to increase the incidence of defects and reduces the vitality of offspring. However, line breeding is often used to keep the relationship high between an offspring and a particular outstanding ancestor (Tolley, 1984). Since line breeding, a mild form of inbreeding, may have similar detrimental effects as inbreeding, breeders should take care in using this practice.

In the present study inbreeding coefficients were calculated for the Friesian horse population, but only 219 or 25,7% of the horses were found to be inbred. These horses were all born between 1969 and 2002. **Figures 4.1** and **4.2** illustrate the percentage of inbred animals and the average inbreeding for this period.

The lowest inbreeding coefficient for the inbred animals was 0,07% and the highest, 27.78% for an animal born in 1992. The average inbreeding shown in **Figure 4.2** is not particularly high considering the relatively small size of the South African Friesian population. It is suspected that this might be a conservative estimation, because of the limited pedigree information available, as discussed in material and methods (section 3.2.2). **Figure 4.3** illustrates the number of inbred animals per birth year contrasted with the total number of animals registered from 1910 to 2002. The regression line in **Figure 4.4** shows the rate of inbreeding. Although there is an increase in average inbreeding, the rate of inbreeding is relatively low. Another possible explanation for this relatively low inbreeding is the strict control executed by the FPS in the Netherlands and also by the FPSSA in South Africa (**Appendix C**).

In the Friesian horse industry, the FPS have taken it upon them to control and limit inbreeding in Friesian horses, because historically the Friesian horse 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 (see **Appendix D**), while the influential stallion, Ritske, didn't 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. What aggravates the potential danger of inbreeding even further in South Africa, is the fact that only a limited number of Friesians were imported originally, and the few stallions were used by many breeders, limiting the gene pool even more. It should, however, be noted that especially in the early stages of the establishment of the Friesian 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. A study conducted by Vaez Torshizi *et al.* (1998) found the average level of inbreeding of Australian Thoroughbred horses to be 9.26%. This is considerably lower than the results of the present study, but the dataset consisted of 190 879 Australian-born Thoroughbreds of which 102 634 had complete pedigree records. The actual inbreeding coefficient estimates were found to be smaller than would have been if all the horses included in the specific study had complete pedigree records (Vaez Torshizi *et al.*, 1998).

Outbreeding mating systems, in which individuals from separate lines are crossed, can produce heterosis or hybrid vigor, which means that the offspring performs better than the average of its parents. Since most horses are purebreds, crossbreeding is of limited importance in horse breeding. A notable exception is the modern Quarter horse, which has recently received a large infusion of Thoroughbred breeding. This crossing has altered the type as well as the performance abilities of the quarter horse (Tolley, 1984). Crossbreeding is also mentioned in the history of the Friesian horse in South Africa, especially just after the first Friesians were imported. From these out-crossings a new breed evolved, namely the South African Vlaamperd. Fortunately, some Friesian breeders strove towards preserving the breed, and kept it pure, resulting in the Friesian population as it is presently known in South Africa (South African Stud Book and Livestock Improvement Association, 1998).

In the Netherlands, it is possible for a Friesian breeder to obtain an inbreeding coefficient for a proposed combination of the breeder's mare with any stallion in the population (Osinga, 2000). The calculation of inbreeding coefficients for as many individuals of the Friesian population in South Africa as possible, will be a positive step towards emulating the Dutch system. The limiting factor is the absence of complete pedigrees for the South African Friesians.

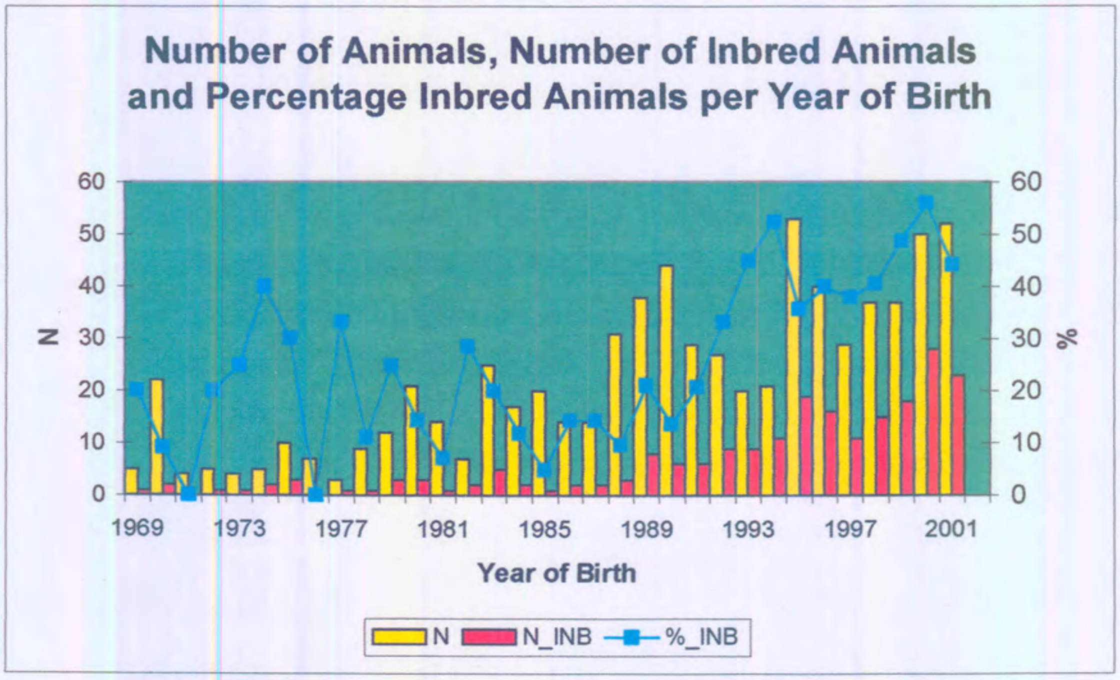


Figure 4.1 The number of animals, number of inbred animals and the percentage of inbred animals per year of birth from 1969 to 2001.

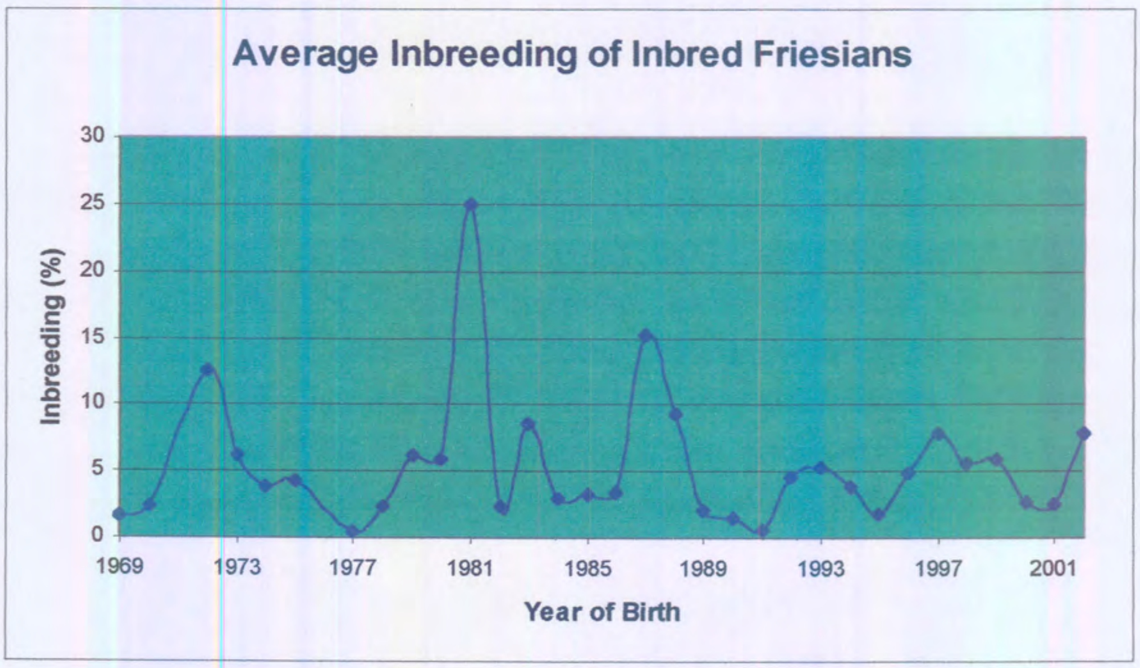


Figure 4.2 Average Inbreeding percentages of all the inbred animals born per year from 1969 to 2002.

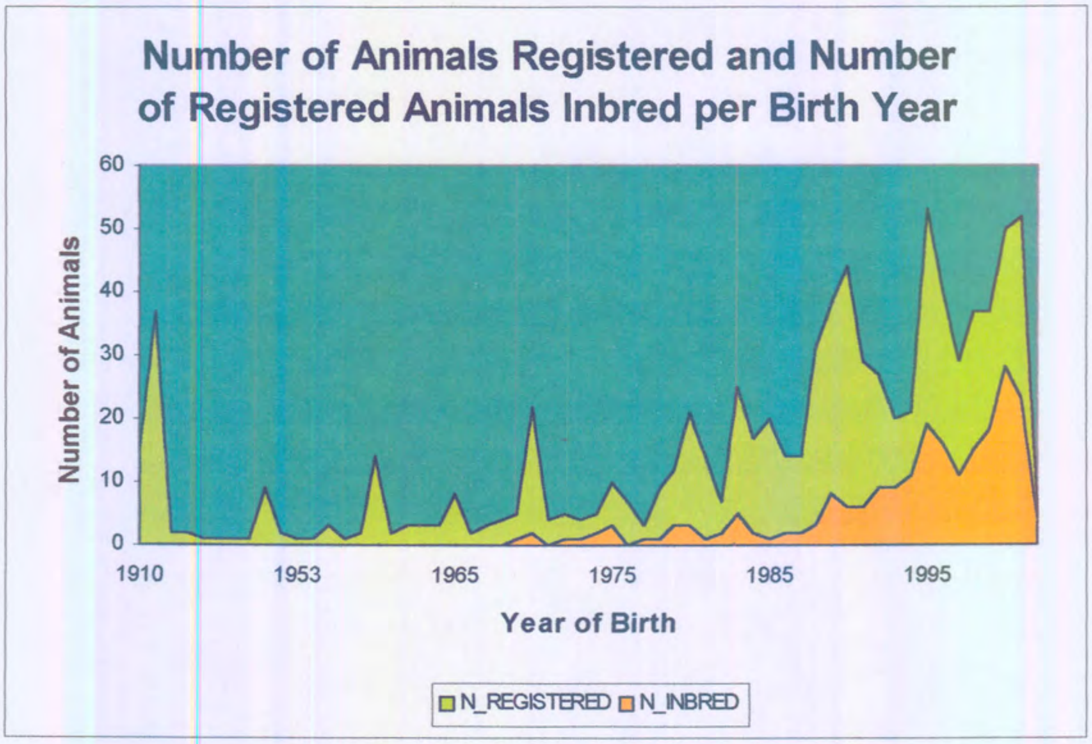


Figure 4.3 An indication of the number of animals inbred of the total number of registered animals, per year of birth, for the period 1910 to 2002.

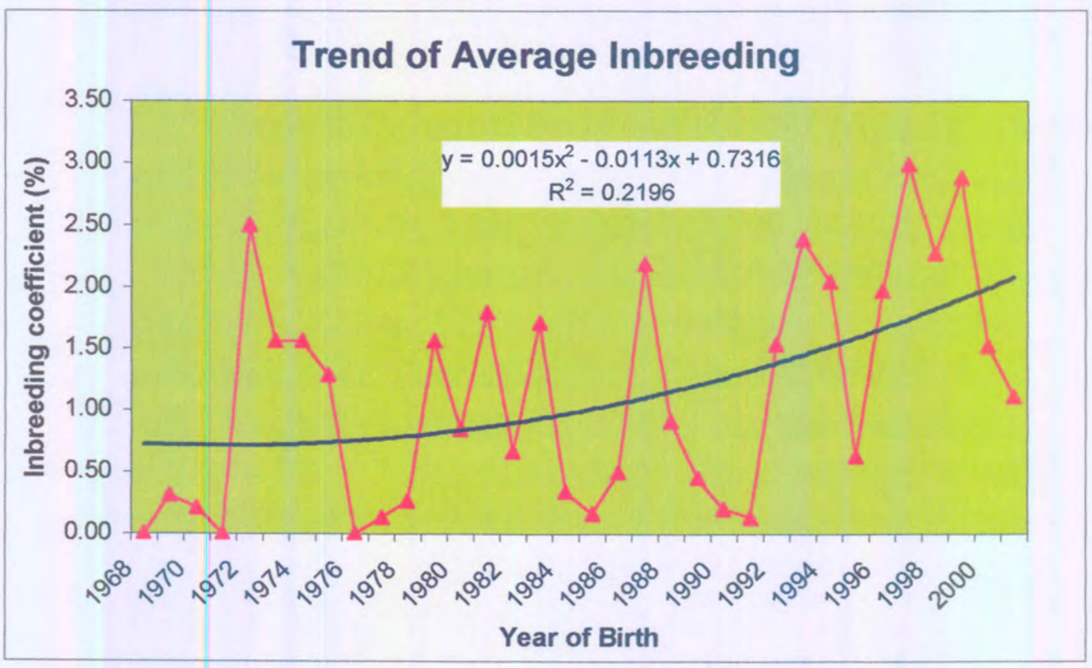


Figure 4.4 Average inbreeding in the population from 1968 to 2001, showing the rate of inbreeding.

4.2 Objective Measurements

In the horse industry, subjective, linear measurements are mostly the only traits used by studbook associations and breeders to judge and select 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 (similar to those seen in **Appendix A**) for their horses, which can then be used to select breeding partners for positive assortive matings.

In this study, eight different body measurements of 232 horses were measured objectively. The results of the eight objective measurements, for each of the three genders, are given in **Table 4.1**.

Graphic presentations of the results in **Table 4.1** are illustrated in **Figure 4.5** and **Figure 4.6,** providing an indication of the variation that exists between individuals of the same gender within the population of measured animals.

Table 4.1 General Statistics for eight body measurements for each of the three genders.

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

Stallions

Variable Label	N	Mean	Std Dev	Std Error	Var	Min	Max	Skewness
Wither-height	33	160.3	6.09	1.06	37.08	151.0	169.0	- 0.02
Back-height	33	148.9	4.95	0.86	24.50	140.0	158.0	0.04
Croup-height	33	158.4	4.74	0.82	22.43	148.0	167.0	-0.12
Body-length	33	165.7	6.53	1.14	42.66	153.0	179.0	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	24.0	29.5	0.28
CL-FL	33	31.5	1.99	0.35	3.94	25.0	35.0	-1.32
CL-HL	32	36.9	2.24	0.40	5.02	32.0	41.0	-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	147.0	171.0	0.28
Back-height	176	146.2	4.45	0.34	19.83	136.0	161.0	0.45
Croup-height	176	155.3	4.22	0.32	17.81	146.0	167.0	0.21
Body-length	176	166.5	6.72	0.51	45.22	150.0	182.0	-0.11
CC-FL	175	21.8	1.04	0.08	1.09	19.0	24.0	-0.06
CC-HL	173	24.1	1.16	0.09	1.35	21.0	27.0	0.17
CL-FL	175	29.2	1.85	0.14	3.42	24.0	33.0	-0.15
CL-HL	174	34.6	2.12	0.16	4.50	29.0	41.0	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	149.0	168.0	0.01
Back-height	23	148.3	3.99	0.83	15.95	142.0	156.0	0.29
Croup-height	23	158.0	4.06	0.85	16.50	151.0	169.0	0.85
Body-length	23	163.7	6.04	1.26	36.47	149.0	173.0	-0.43
CC-FL	23	22.9	1.18	0.25	1.39	21.0	25.0	0.21
CC-HL	23	25.1	1.03	0.21	1.05	23.0	27.0	-0.40
CL-FL	23	30.7	1.61	0.34	2.60	28.0	34.0	0.20
CL-HL	23	36.3	2.26	0.47	5.11	32.0	41.0	0.42

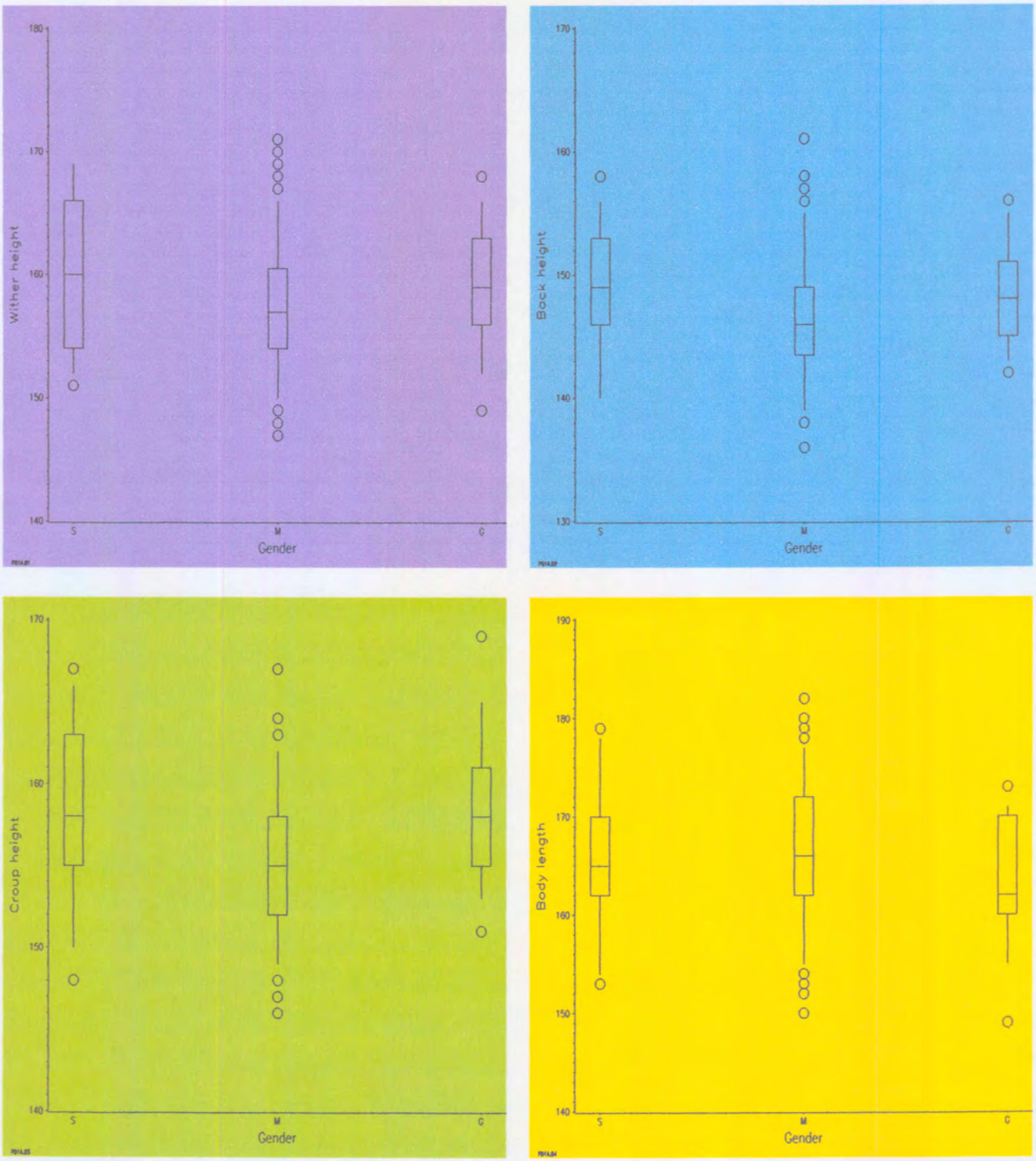
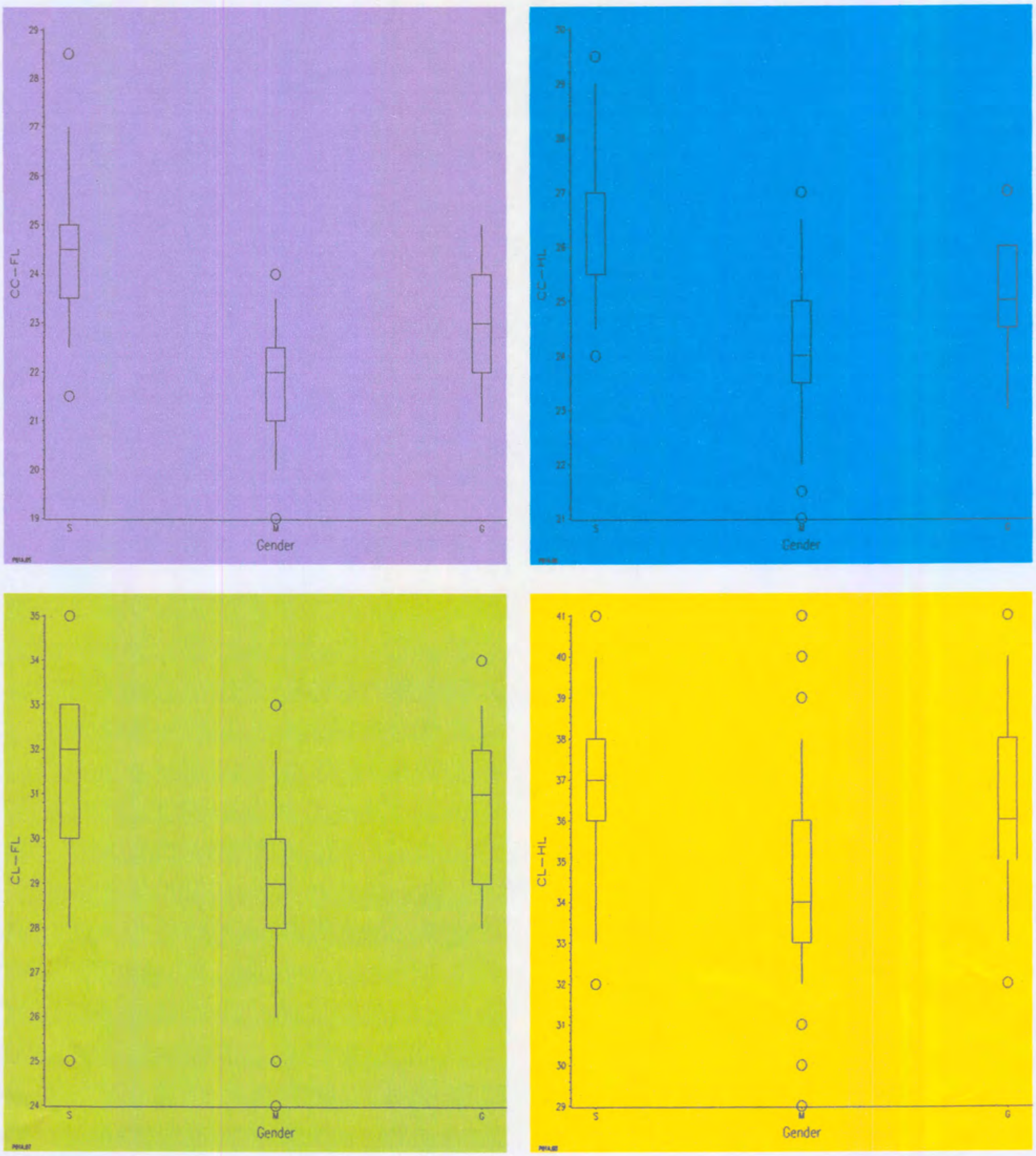


Figure 4.5 Graphic presentations of the distribution of the results around the mean for the three height measurements and body length.



CC = Cannon Circumference
FL = Front Limb

CL = Cannon Length
HL = Hind Limb

Figure 4.6 Graphic presentations of the distribution of the results around the mean for cannon length and cannon circumference.

For all of 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 mares' mean body length was higher than that of the stallions and of the geldings. This might be due to the greater selection pressure exerted on the stallions in the Netherlands as well as in South Africa. When selecting for strong and powerful movement, it 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, 2002).

The fact that the means of the measurements for the geldings were not higher than those of the stallions, was somewhat surprising. In most species, like cattle for instance, and even in humans, the absence of the hormone testosterone, which is a natural antagonist of growth hormone, can lead to an animal growing larger (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 cattle and sheep, for instance, which are mostly castrated shortly after birth or just before weaning.

The lowest wither height measurement of 147 cm was observed for a mare. This is below the minimum wither height, of 150 cm, for an animal to be registered in the studbook (**Appendix C**). It is interesting to note that the highest wither height measurement of 171 cm was also observed for a mare. This particular mare, however, didn't have the highest value for any of the other body measurements and was only five years old at the time of measurement (**Figure 4.5**).

The results of the measurements show that the Friesian horse is normally of rectangular (height at withers: body length) format. The mean values for wither height were 5 to 9 cm smaller than values for body length for all genders. 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. A difference of 10 – 11 cm was found for all three genders. This 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 for any sport discipline. Some of the horses get no other exercise than walking on pasture, while the horses that are exercised 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).

Genetic parameters have been reported for a number of subjective traits in various horse breeds as well as their application in selection (Preisinger *et al.,* 1991; Seidlitz *et al.,* 1991; Von Butler-Wemken *et al.,* 1992; Van Bergen & Van Arendonk, 1993; Koenen *et al.,* 1995; Samoré *et al.,* 1997; Osinga, 2000). The range of estimates for heritability vary from as high as 0.89 for height at withers for Shetland Ponies (Von Butler-Wemken *et al.,* 1992) to as low as 0.02 for temperament traits in the Italian Haflinger Horse (Samoré *et al.,* 1997). Heritability estimates for objective, morphological measurements have also been reported for different horse breeds, ranging from 0.06 for heart girth for the Bavarian Coldblood to as high as 0.90 for body weight in Thoroughbreds (Hintz *et al.,* 1978; Biedermann & Schmucker, 1989; Grosshauser & Von Butler-Wemken, 1991; Kaiser *et al.,* 1991; Kaproń *et al.,* 1994; Zechner *et al.,* 2001).

Heritability estimates for six of the eight objective body measurements, taken in this study, were obtained from applying the sire model (**Table 4.2**). Due to limited pedigree information and a relatively small data set, only 80 animals could be included in the sire model, the estimated heritabilities are therefore not highly significant, as can be seen from the 90% confidence intervals.

Table 4.2 Estimated heritabilities for objective body measurements.

Trait	Heritability	90% confidence interval
Wither height	0.30	(-0.108; 0.329)
Croup height	0.37	(-0.082; 0.358)
Body length	0.48	(-0.025; 0.418)
Cannon circumference: forelimb	0.57	(0.032; 0.473)
Cannon circumference: hind limb	0.45	(-0.045; 0.397)
Cannon length: forelimb	0.35	(-0.089; 0.350)

A 90 % confidence interval for the estimated heritabilities all include zero, except for that of cannon circumference of the forelimb, this indicate that most of the heritability estimates are not significant. This is due to the limited records and data available for this study. The heritability estimates are, however, all within similar range of estimates reported in the literature for the respective measurements in different horse breeds.

In this study Pearson correlation coefficients for the different genders were calculated and are shown in **Tables 4.3 – 4.5.**

Table 4.3 Pearson correlations (r_p) with significance levels, for the stallions, as calculated by SAS® (2001).

	Wither height	Back height	Croup height	Body length	CC FL	CC HL	CL FL	CL HL
Wither height	1.00 n = 33	0.82 <.0001	0.80 <.0001	0.43 0.0130	0.26 0.1401	0.51 0.0028	0.36 0.0387	0.35 0.0510
Back height		1.00 n = 33	0.87 <.0001	0.45 0.0094	0.16 0.3790	0.45 0.0102	0.44 0.0101	0.46 0.0088
Croup height			1.00 n = 33	0.55 0.0010	0.35 0.0468	0.58 0.0005	0.58 0.0004	0.54 0.0013
Body length				1.00 n = 33	0.33 0.0649	0.45 0.0091	0.43 0.0125	0.31 0.0879
CC FL					1.00 n = 33	0.75 <.0001	0.14 0.4212	0.29 0.1127
CC HL						1.00 n = 32	0.33 0.0672	0.39 0.0291
CL FL							1.00 n = 33	0.74 <.0001
CL HL								1.00 n = 32

Table 4.4 Pearson correlations (r_p) with significance levels, for the mares, as calculated by SAS®(2001).

	Wither height	Back height	Croup height	Body length	CC FL	CC HL	CL FL	CL HL
Wither height	1.00 n =176	0.70 <.0001	0.73 <.0001	0.48 <.0001	0.38 <.0001	0.41 <.0001	0.34 <.0001	0.29 0.0001
Back height		1.00 n =176	0.84 <.0001	0.35 <.0001	0.37 <.0001	0.38 <.0001	0.38 <.0001	0.33 <.0001
Croup height			1.00 n =176	0.43 <.0001	0.43 <.0001	0.40 <.0001	0.39 <.0001	0.38 <.0001
Body length				1.00 n =176	0.35 <.0001	0.32 <.0001	0.12 0.1286	0.18 0.0156
CC FL					1.00 n =175	0.69 <.0001	0.22 0.0028	0.30 <.0001
CC HL						1.00 n =173	0.23 0.0029	0.26 0.0005
CL FL							1.00 n =175	0.56 <.0001
CL HL								1.00 n =174

CC = Cannon Circumference
FL = Front Limb

CL = Cannon Length
HL = Hind Limb

Table 4.5 Pearson correlations (r_p) with significance levels, for the geldings, as calculated by SAS® (2001).

	Wither height	Back height	Croup height	Body length	CC FL	CC HL	CL FL	CL HL
Wither height	1.00 n = 23	0.77 <.0001	0.72 0.0001	0.51 0.0135	-0.05 0.8235	0.02 0.9303	-0.18 0.4117	-0.22 0.3095
Back height		1.00 n = 23	0.66 0.0006	0.40 0.0618	-0.08 0.7070	-0.07 0.7645	0.12 0.5759	0.09 0.6948
Croup height			1.00 n = 23	0.45 0.0309	-0.26 0.2228	-0.21 0.3410	-0.03 0.8837	0.10 0.6574
Body length				1.00 n = 23	0.12 0.5873	0.38 0.0731	-0.16 0.4553	0.04 0.8734
CC FL					1.00 n = 23	0.78 <.0001	0.03 0.8747	0.00 0.9826
CC HL						1.00 n = 23	0.11 0.6157	0.12 0.5863
CL FL							1.00 n = 23	0.67 0.0004
CL HL								1.00 n = 23

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

The Pearson correlation coefficients show high and significant correlation between wither height and back height, wither height and croup height and back height and croup height in all three genders. All of these correlations were found to be highly significant (P< 0.0001). A phenotypic correlation of 0.87 between wither height and croup height for Thoroughbreds, similar to this study, was reported by Biedermann & Schmucker (1989). Body length was not found to be as highly correlated with any of the other measurements, but did show correlations varying from 0.43 to 0.51 for the 3 genders with wither height (**Tables 4.3** to **4.5**). A similar pattern was observed for body length and croup height.

Strong correlations were further seen between cannon circumference of the front and hind limbs, as well as between cannon length of the limbs. This is in accordance with what could be expected. According to Batt (1980), a proportional rate of growth throughout the body causes the external form to be maintained whilst the size increases.

It is interesting to note that wither height and cannon length did not show a very high correlation in any of the genders and showed a negative correlation in geldings. Significance levels were, however, low and require further investigation. Biedermann & Schmucker (1989) found phenotypic correlations of 0.82 and 0.68 between wither height and cannon length and croup height and cannon length, respectively.

In studies done by Kaproń *et al.* (1994) and Von Butler & Krollikowsky (1986) the phenotypic correlation between wither height and cannon circumference were found to be 0.50 and 0.60 respectively, which is in agreement with the observed values of 0.41 for wither height and cannon circumference of the hind limb for mares and 0.51 for stallions. The value for geldings was, however, much lower but shows low significance and could therefore be due to the small number of geldings measured (only 23). The correlation between wither height and cannon circumference of the front limb, was not significant.

An important aim of these measurements was, in the first place, to morphologically evaluate the Friesian population of South Africa, and secondly, since linear measurements grow in proportion to each other (Batt, 1980), to see whether some measurements were correlated with each other. The results, generally in agreement with literature cited, can be seen as confirmation that the animals measured in this study could be a reasonable representation of the entire Friesian population of South

Africa. These results further indicate that these objective measurements could be applied as a tool by local breeders to evaluate and select their horses for conformation traits, while waiting for the annual visit of the Dutch judges.

4.3 Critical Review

During the course of the study, it became clear that Friesian horse breeding in Southern Africa is subject to a number of problems and difficulties that should receive attention in order to achieve a level of scientific breeding comparable to international horse breeding standards.

One of the most important limitations is the fact that there are two breeders' organizations operating separately from each other. If the two organizations could unite it would mean that the effective gene pool would increase and that the potential variation in the population would be larger. At the moment there are two separate subpopulations of Friesian horses in South Africa as only a few breeders have contact or do business with the breeders of the opposing organization. The majority of the members of the South African Friesian Horse Breeders' Association are based in the Cape province and their annual show is therefore held in Tulbach. The majority of the members of the Friesian Studbook of Southern Africa (FPSSA) live in the Northern parts of the country and therefore the annual show is hosted in Pretoria. The "minority" members of both organizations, living far from where the show is hosted, have to travel long distances with their horses to attend the show and therefore often do not bother to incur the expense or take the trouble to attend the annual show. This has further implications: because their horses never compete with other horses, they cannot establish performance records.

According to Tolley (1984), a horse is performance tested each time that it competes against other horses in races, shows or any other events. Pedigrees without performance records are of limited genetic value, although they are useful for estimation of inbreeding. The importance, therefore, of all Friesian horses taking part in shows or other sporting events cannot be stressed enough. It is the responsibility of horse owners to get involved in organizing sporting events in their areas. If there was only one breeders' organization, two shows could still be held annually, one in the north and one in the south, but at least this would mean that all Friesian horse owners and breeders could attend and compete in a show.

In Friesian horses, as in many other breeds, linear scoring is used for studbook judging and when selecting horses. The FPS uses only a few judges to judge horses all over the world, limiting the effect of any difference between judges - thus far it has proved to be a very successful way of judging. The judges also receive intensive training and are required to have many years of experience. South Africa, however, has the limitation of having no internationally qualified local judges. The judges have to be flown in every year from the Netherlands for studbook judging and shows, making it an expensive operation. Furthermore, there are no judges/experts readily available as consultants to provide breeders with advice regarding breeding and selection at any given time. The South African Friesian Horse Breeders' Association uses only local judges, but as they are not trained in the same way as the Dutch judges, they do not judge the horses by the internationally set standards for Friesian horses. If breeders from South Africa could send a group of selected people or volunteers to the Netherlands to be trained as international judges, it would ensure that breeders of South Africa have the better of two worlds. They would have local judges, but need not take a back seat in terms of international standards or Friesian horses from other countries.

Another limitation to the development of proper scientific breeding strategies for Friesian horses, identified in this study, is the availability of records, or rather the lack thereof. The records of the Friesian horses in South Africa are incomplete, inaccurate and non-computerized. The importance of the accuracy of pedigrees cannot be emphasized enough. During the collection and preparation of pedigree information for this study, a simple database was developed in Microsoft Access containing all the relevant information for each animal. This database provides a guideline for establishing a record system for the Friesian horse industry of South Africa. It makes provision for the following information:

- Horse's registered name
- Stud name
- Gender
- Birth date
- ID/ Chip number
- Registration number
- DNA number
- Register
- Premium
- Designation
- Colour
- Markings
- Wither height
- Owner
- Breeder
- Sire
- Sire's sire

- Sire's dam
- Dam
- Dam's sire
- Dam's dam
- Death date
- Inbreeding coefficient
- Sporting or competition results
- Conformation defects
- Breeding status, i.e. how many foals
- Objective measurements, other than wither height, taken by the breeder/owner at certain intervals
- Results of linear scoring
- Performance of progeny

This database should not replace the current filing system of registration certificates, but should be supplementary.

It is important to know that unfavourable performance records are as important as good performance records. A horse's record should also contain any conformation defects. In view of the fact that all the conformation faults probably are under genetic control, a horse used for breeding should be free from such defects.

It is also important that the breeder is aware of the degree of inbreeding present in horses he/she wants to breed with. The influence a certain ancestor has on its progeny, decreases proportionally the further related they are, for example, a parent has a 50% influence, while an ancestor seven generations back only has a 0.7% influence (Jones, 1982).

Another complicating factor in horse breeding is the absence of defined breeding objectives. Friesian breeding in South Africa is no exception. It was observed that breeders have no knowledge of the population parameters, and therefore do not know which traits to select for, and which ones would yield the greatest response and a correlated response in other traits.

The traits included in a breeding program should be determined by the potential for genetic progress, in other words, the genetic variation and the costs involved with the estimation of genetic merit for all animals. The most important components of a breeding program are: Conformation, pedigrees and performance. Therefore, a database containing this information will aid the breeders in planning a sound breeding program, which may result in genetic progress within the population.

The fact that there are two separate record sets for the two subpopulations of Friesians in South Africa, further complicates the situation. Some horses for instance, belong to a member of one organization, but its pedigree record is only available at the other organization, because it was bought from a member of that organization. If one central record system could be kept, the effective number of horses with records would therefore increase.

It is very important that breeders realize that breeding is not simply the act of mating two horses, but that there is an enormous responsibility involved in sensible breeding. Breeding is the purposeful mating, through selection, of male and female animals in an effort to improve certain characteristics in the progeny without any weakening of the existing good properties. The success of breeding depends on a number of factors, of which the following are the most important:

- Well-planned objectives. These objectives should be aimed at the needs of the co-breeders and possible horse buyers. Breeding objectives should be compiled with reference to the type and use of the horse. A breeder who wants to breed a good riding horse will use different selection criteria than will the breeder breeding a carriage horse.
- A well-planned and efficient breeding program, which is strictly adhered to.
- The purchase of genetically superior animals from recognized stud-breeders.
- Careful record-keeping and easy identification of all breeding animals and their progeny (Visser, 1993).

In practice selection is based on decision-making. The efficiency of decision-making is dependant on the availability of relevant and suitable information. Selection and breeding value, defined as the ability of an animal to transmit desirable genetic traits to its progeny, cannot be separated from each other. The more information is available on an animal, the more accurately its breeding value can be assessed (Visser & Voordewind,1993).

It is important that breeders understand that genetic principles have a practical importance and an economic value. This should justify the investment by breeders and breeders' organizations in further research. Genetics and animal breeding involve the logical application of a few simple concepts. Once breeders comprehend the genetics vocabulary, application of research results to their breeding programs could be easily accomplished.

CHAPTER 5

CONCLUSION

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.

During the course of this study, the current status of inbreeding in Friesian Horses in Southern Africa was evaluated and objective body measurements were taken. It was discovered that although the majority of breeders are uninformed about proper selection criteria and do not always follow a very sound scientific approach towards breeding, the Friesian population of South Africa is a fast growing population with a lower than expected average rate of inbreeding.

Upon investigation whether some objective body measurements could be used by the breeders as selection criteria, it was observed that objective body measurements in Friesian horses have medium to high heritability estimates, which is in accordance with estimates found in the literature for other horse breeds. These objective measurements regarding conformation could therefore be considered as selection criteria by breeders in order to achieve genetic progress in certain linear traits in the South African Friesian horse population. These objective measurements may be used in addition to the linear measurements annually evaluated through linear scoring by the

FPS judges. Breeders can then use these objective measurements as a selection tool, thereby selecting prospective parents for desired size and overall conformation.

The limitations experienced in applying a sire model, emphasizes the importance of complete pedigree records for a scientific evaluation.

A unified breed organization for Friesians with a central record database will maximize the potential of the breed in Southern Africa. The combination of politics and science has proved to be unsuccessful as far as Friesian breeding in South Africa is concerned. A more complete, central record system will facilitate future genetic progress for the breed, as well as the possibility of estimating more accurate and significant genetic parameters for the population. By uniting the two organizations, the effective gene pool for Friesian horses will increase as well as the potential variation.

It can be concluded that South African Friesian Horse breeders will not be able to achieve the genetic progress that the breed deserves, before a sound scientific approach is followed and complete records and information about their horses are known to them.

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APPENDICES:

Appendix A.1: The Dutch version of the linear scoring sheet used for scoring adult Friesian horses in the Netherlands.

Plaats	Cat.nr:
Datum:	Naam paard:
Geslacht: H M R	
Aftekening	Reg.nr:

	Kenmerk	5	10	15	20	25	30	35	40	45	Kenmerk
Hoofd	onedel										edel
	lang										klein
Nek	kort										lang
Hoofd/hals verbinding	zwaar										licht
Hals	kort										lang
	horizontaal										verticaal
	zwaar										arm
Schoft	kort										lang
Schouder	kort										lang
	steil										schuin
Rug	lang										kort
	week										strak
Lendenen	smal										breed
	week										gedreven
Kruis	recht										afhellend
	kort										lang
Broekspier	kort										lang
Lengte onderarm	kort										lang
Voor be(e)n(en)	gestrekt										onderstandig
	hol										bokbenig
Ontwikkeling gewrichten	grof										fijn
Koot	kort										lang
Hoeven	klein										groot
verzenen	laag										hoog
Kwaliteit Benen	voos										hard
	zwaar										fijn
achterbe(e)n(en)	o-benig										koehakkig
	sabelbenig										recht
Stap	wijd										nauw
	toontredend										frans
	kort										lang
	onregelmatig										regelmatig
	zwak										krachtig
Draf	kort										ruim
	weinig tact										veel tact
Beweging/impuls	duwend										dragend
	vlak										verheven
Kleur	vaalzwart										gitzwart
Behang	weinig										veel

o diep uit de borst
o onderhals
o afw. knie
o afw. sprong
o nevelbreuk
o manenexceem
o ......

Rastype	Bouw	Bespiering	Beenwerk	Stap	Draf

o ster o stamboek o niet opgenomen

o eerste premie o tweede premie o derde premie o geen premie

Juryfid:

versie 1-1999

Appendix A.2: The Dutch linear scoring sheet used by the FPS to score Friesian Foals.

Plaats:	Cat. nr.
Datum:	Naam veulen
Geslacht:	Geboortedatum:
Aftekening:	Vader:

	Kenmerk	5	10	15	20	25	30	35	40	45	Kenmerk
Hoofd	onedel										edel
Nek	kort										lang
Hals	kort										lang
	horizontaal										verticaal
	zwaar										arm
Schouder	kort										lang
	steil										schuin
Rug	kort										lang
Lendenen	smal										breed
Kruis	recht										afhellend
	kort										lang
Broekspier	Kort										lang
Voorbenen	gestrekt										onderstandig
	kort										lang
Achterbenen	sabelbenig										steil
Stap	toontredend										frans
	kort										lang
	stug										met souplesse
draf	kort										ruim
	stug										met souplesse
	slap										krachtig
0 diep uit de borst 0 onderhals 0 afw. sprong 0 navelbreuk 0 afw. knie											

Appendix A.3: The linear scoring sheet used to score Dutch Warmblood Horses in the Netherlands (in Dutch).

KWPN

Keuringsplaats:	Datum:	Afd.:	Insp.:
Paardnaam:	Paardnr.:	Type: RP / TP / BP / AR	
Geb. datum:	Geslacht: ME / HE / RU	Vader:	

Stokmaat: 1. m Opname ja / nee Gebrand ja / nee Inschrijving bet. ja / nee 6 / 18,5%

Eigena(a)r(en):

Adres:

Postcode / Woonplaats: Tel.nr.: Lidnr.:

Kleur: Aft.: Hoofd.

R.V.:

L.V.:

L.A.:

R.A.:

Overige aft.:

Kenmerk	Score	Afwijking/gebrek
Konditie		O overkonditie
		O schraal
Mond		O onderbeet
		O overbeet
Hoofd		O ramshoofd
		O grof / O lang
1. Hoofd-halsverbinding		
2. Halslengte		
3. Halsrichting		O diep uit de borst
4. Halsbespiering		
5. Schoftlengte		
6. Hoogte van de schoft		
7. Schouderlengte		
8. Schouderligging		
9. Lengte rug en lendenen		
10. Verloop rug/lendenen		
lendenen		O hol / O bol
11. Kruisligging		O dakvormig
12. Kruislengte		
13. Bespiering v/d dijen		
14. Stand voorbeen		O onderstaand
bouw voorbeen		O ingesnoerd pijp

Waardering: exterieur:

beweging:

algemene indruk:

Kenmerk	Score	Afwijking/gebrek
15. Stand achterbeen		O koehakkig
Bouw achterbeen		O ingestoken pijp
		O afw. spronggewricht
		O afw. kniegewricht
16. Kootstand		
17. Hoefvorm		O ongelijk
18. Verzenen		
19. Kwaliteit benen		
20. Omvang beenwerk		
21. Stap: ruimte		O onregelmatig
22. Stap: souplesse		
23. Korrektheid in stap		
24. Draf: ruimte		O onregelmatig
25. Draf: souplesse		
26. Draf: kracht/impuls		

Geel en rose bestemd voor stamboek; blauw bestemd voor inspekteur; wit bestemd voor eigenaar.

Appendix B.1: An example of a Birth Notification of the FPS in the Netherlands for a foal born in 2000.

Koninklijke Vereniging
"Het Friesch Paarden-Stamboek"

BESCHERMVROUWE
H.M. KONINGIN BEATRIX

Postlaan 1a
9204 WT Drachten
tel.: 0512 - 523888
fax: 0512 - 532146

P.H. Botha en susters
Posbus 595
2740 Lichtenburg
Zuid-Afrika

No. **04983** onderwerp: **Bevestiging**

DRACHTEN, 26.03.2001

Volgens het door u toegezonden geboortebericht is geboren:

een	**Hengstveulen**
datum	**24.08.2000**
naam	**Abacus van Geyerspan**
aftekening	Geen
vader	199316781 Eibert Veulenboek
moeder	880003440 Patrice Lynne Veulenboek
fokker	659610 P.H. Botha en susters Posbus 595 2740 Lichtenburg Zuid-Afrika
eigenaar	659610 P.H. Botha en susters Posbus 595 2740 Lichtenburg Zuid-Afrika

Ing. S.H. de Boer. sekretaris

Belangrijk
* Dit veulen moet dit jaar worden voorzien van een microchip: hiertoe dient het bij de moeder te lopen.
* Chippen kan plaatsvinden op fokdagen of andere, door het FPS-bestuur aan te wijzen keuringsplaatsen.
* Na implantatie van de chip wordt door het FPS een bewijs van inschrijving afgegeven.

Deze 'bevestiging van geboorteopgave' dient ingeleverd te worden op de dag van chippen.
Als inlevering achterwege blijft wordt u ƒ 15,= administratiekosten in rekening gebracht.

Appendix B.2: An example of a Birth Notification of the South African Stud Book Association for a foal born in 1988.

F I

S.A. STAMBOEKVERENIGING
S.A. STUD BOOK ASSOCIATION

№ 2[illegible]64

Posbus 270 BLOEMFONTEIN P.O. Box 270

GEBOORTEKENNISGEWING – BIRTH NOTIFICATION

1 DOKUMENTKODE / DOCUMENT CODE: 2 3 2 1
2 LIDNOMMER / MEMBER NUMBER: C 3 1 1 7 6 0

3 NAAM VAN RAS / NAME OF BREED: S.A. FRIESPERD / S.A. FRISIAN HORSE
4 RASKODE / BREED CODE: 6 2 1

5 VOORVOEGSEL / PREFIX: Perseel
6 NAAM VAN DIER / NAME OF ANIMAL: B A S I E

7 GEBOORTEDATUM / DATE OF BIRTH: JAAR / YEAR 8 8; MAAND / MONTH 0 9; DAG / DAY 1 2
8 GESLAG / SEX: MANLIK / MALE X; VROULIK / FEMALE 1

9 GEBOORTESTATUS / BIRTH STATUS: ENKEL / SINGLE X; TWEELING / TWINS 2

10 VUL VERWEK DEUR / FOAL BEGOTTEN BY
EIE HINGS / OWN STALLION 1
NIE EIE HINGS / NOT OWN STALLION X
K.I / A.I. 3

11 IDENTIFIKASIE / IDENTIFICATION
BRAND / BRAND 6
TATOEËER / TATTOO X

12 KENMERKLETTERS / DESIGNATION MARKS: D V
13 JAAR / YEAR: 8 8
14 VOLGNOMMER / SEQUENCE NO: 0 3

15 NAAM VAN HINGS / NAME OF STALLION: Beake (Ingev. FPS 47/259)
16 REGISTRASIE NR. / REGISTRATION NO.: 5 F 4
17 IDENTIFIKASIE / IDENTIFICATION: 1 9 8 F 8 1

18 NAAM VAN MERRIE / NAME OF MARE: Smitsvlei Jony
19 REGISTRASIE NR. / REGISTRATION NO.: 2 2 1 F 3
20 IDENTIFIKASIE / IDENTIFICATION: S S 8 3 2

21 GEBOORTE OPMERKINGS / BIRTH REMARKS: NORMAAL / NORMAL X; ABORSIE / ABORTION 2; DOOD NA GEBOORTE / DIED AFTER BIRTH 3

22 NAAM EN ADRES VAN TELER / NAME AND ADDRESS OF BREEDER
Mr. G.N.F. Visser
Perseel 23 Lutzville
9165 POSKODE / POSTAL CODE

EK VERKLAAR DAT BOGENOEMDE DIER DEUR MY GETEEL IS EN DAT DIE STAMBOOM, BESONDERHEDE EN IDENTIFIKASIE KORREK IS.
I DECLARE THAT I BRED THE ABOVEMENTIONED ANIMAL AND THAT THE PEDIGREE, BREEDING PARTICULARS AND MARKS ARE CORRECT.

23 DATE SIGNED / DATUM GETEKEN: 25/7/89
24 HANDTEKENING / SIGNATURE: p.p. [illegible]

Appendix B.3: An example of an registration certificate of the South African Friesian Horse Breeders' Society.

Suid Afrikaanse Friesperd Telersgenootskap — **South African Frisian Horse Breeders' Society**

REGISTRASIESERTIFIKAAT/REGISTRATION CERTIFICATE

Uitgereik deur die Suid-Afrikaanse Stamboekvereniging/Issued by the South African Stud Book Association

Hiermee word gesertifiseer dat hierdie S.A. FRIESPERD aangeneem is vir inskrywing in die Kuddeboek van die S.A. Friesperd as 'n
This is to certify that this S.A. FRISIAN HORSE has been accepted for entry in the Herd Book of the S.A. Frisian Horse as a HINGS

NAAM / NAME	" DIEMER " (380/237) (INGEVOER)	Reg. Nr. / Reg. No.	59F4
Kleur / Colour	Swart.	Deel / Vol.	1
Geboorte / Birth	9 Junie 1982	Identifikasie / Identification	194 F 82 (Tat.)
Vader / Sire	Wessel 237	Nr. / No.	
Moeder / Dam	Katterine 6160	Nr. / No.	
Teler / Breeder	C M v d Akker, Parallelwei 3, 8711 CH. Workum, Friesland		
Eienaar / Owner	Dr B F Smit, Smitsvlei, Bus 91, Piketberg, 7320 (Ingevoer) (Aaankoms op plaas 1985/10/19)		

Datum van Inspeksie / Date of Inspection 1986/04/03

Datum van Uitreiking / Date of Issue 1986/04/16

GESERTIFISEER KORREK / CERTIFIED CORRECT

Sekretaris/Secretary

SUID-AFRIKAANSE STAMBOEKVERENIGING (Posbus 270, BLOEMFONTEIN)
SOUTH AFRICAN STUD BOOK ASSOCIATION (P.O. Box 270, BLOEM. (FEIN)

Enige byvoegings en/of veranderings wat nie deur die Sekretaris geparafeer is nie, sal hierdie Sertifikaat ongeldig maak./Any additions and/or alterations not initialled by the Secretary will render this Certificate invalid.

rk

oranjeSenekal 22853

Appendix B.4: An example of a registration certificate issued by the FPS to a South African horse registered as a Bijboek I horse.

FPS register	geslacht registratienummer	chipnummer 98512	geboortedatum	inteeltcoëfficiënt	geregistreerde naam
Bijboek I voor veulens	Hengst200049701	0005832912	05.10.2000	7,81 %	Alchemist van Geyerspan

Kleur Zwart
Aftekening Geen

2001: 3e premie

Fokker
659610 P.H. Botha en s ters Posbus 595
Lichtenburg 2740 Zuid-A ika

Eigenaar
659610 P.H. Botha en s ters Posbus 595
Lichtenburg 2740 Zuid-A ika

N.B. As one or more parents (ancestors) of this horse are registered in the foalbook or auxiliary studbook, this horse has not been entered in the main register of F.P.S. but in secondary studbook I.

EIDERT 199316781 Vb	REITSE 197802721 Stb Preferent	Hearko 197302541 Stb Preferent	Mark 196402321 Stb Preferent
			Gelbrich 196149830 Stb Model + Pref
		Pauliene 196553150 Stb Ster + Pref	Hotse 196102231 Stb
			Aef 195848830 Stb Model + Pref
	HERMIEN 197359040 Stb Ster	Maine 196402301 Stb	Bouke 194301741 Stb Preferent
			Corina 195948390 Stb Model
		Marianneke 196452890 Stb Ster	Ritske 195502021 Stb Preferent
			Afke 195846460 Stb Model
DUNJA MICHELLE 199322680 Bbl Ster	EVERHARD 830202721 Vb	Reitse 197802721 Stb Preferent	Hearko 197302541 Stb Preferent
			Pauliene 196553150 Stb Ster + Pref
		Ynskjen 196956080 Stb Model	Gerke 196102201 Stb
			Foekjen 196049480 Stb Ster + Pref
	FLOOR A. 198398790 Stb Ster	Oege 197702671 Stb Preferent	Wessel 196802371 Stb Preferent
			Wieske 196855260 Stb Ster + Pref
		Margje 197662940 Stb Ster	Fokke 196002171 Stb
			Lutske 100008680 Hb

9201240

Koninklijke vereniging He Friesch Paarden Stamboek
Oprijlaan 1
9205 BZ Drachten
telefoon 0512 - 523888 fax 0512 - 532146

Afgegeven 06.02.2002 I . S.H. de Boer, sekretaris

Appendix B.5: An example of a registration certificate issued by the FPS to a South African horse accepted in the Hulpboek register.

FPS register	geslacht	registratienummer	chipnummer 9851	geboortedatum	inteeltcoëfficiënt	geregistreerde naam
Hulpboek	Merrie	100010860	)006479139	00.00.1981	0 0 %	Alexia

Kleur Zwart
Aftekening Kol

Schofthoogte 156 cm. 01.09.2000

Fokker
828212 P.W. Smit Posbus 134
8910 Marydale Zuid-Afrika

Eigenaar
659610 P.H Botha en susters Posbus 595
2740 Lichtenburg Zuid-Afrika

		Onbekend	Onbekend
	ONBEKEND		Onbekend
		Onbekend	Onbekend
ONBEKEND			Onbekend
		Onbekend	Onbekend
	ONBEKEND		Onbekend
		Onbekend	Onbekend
			Onbekend
		Onbekend	Onbekend
	ONBEKEND		Onbekend
		Onbekend	Onbekend
ONBEKEND			Onbekend
		Onbekend	Onbekend
	ONBEKEND		Onbekend
		Onbekend	Onbekend
			Onbekend

Koninklijke vereniging Het Friesch Paarden Stamboek
Postlaan 1A
9204 WT Drachten
telefoon 0512 - 523888 fax 0512 - 532140

Afgegeven 27.02.2001 Ing. S.H. de Boer, sekretaris

Interne kopie

Appendix B.6: An example of an registration certificate issued by the FPSSA to a accepted in the Sportboek register.

Die Vereniging van die Friesperd Stamboek
van Suider Afrika

The Association of the Frisian Horse Stud Book
of Southern Africa

Registrasiesertifikaat
UITGEREIK DEUR "DE KONINKLIJKE VERENIGING HET FRIESCH PAARDEN STAMBOEK"

Registration Certificate
ISSUED BY: "DE KONINKLIJKE VERENIGING HET FRIESCH PAARDEN STAMBOEK"

HIERMEE WORD GESERTIFISEER DAT / THIS IS TO CERTIFY THAT Adri

GEBORE / BORN 1989

GESLAG / SEX V

AANGENEEM IS VIR REGISTRASIE IN DIE HUIDEBOEK AS / IS BEEN ACCEPTED FOR REGISTRATION IN THE HERD BOOK AS

MET DIE VOLGENDE REGISTRASIENOMMER / WITH THE FOLLOWING REGISTRATION NUMBER 9610 HSA

IDENTIFIKASIE / IDENTIFICATION 9610 HSA

IDENT. METODE / I.D. METHOD Tong Tatoeage

Onbekend VADER / SIRE

REGISTRASIENR. / REGISTRATION NO

Onbekend MOEDER / DAM

REGISTRASIENR. / REGISTRATION NO

TELER / BREEDER

TELERSNOMMER / BREEDER NUMBER

DATUM GEREGISTREER / DATE REGISTERED Augustus 1996

HUIDIGE EIENAAR / PRESENT OWNER PH Botha

LIDNOMMER / MEMBER NO

DATUM UITGEREIK / DATE ISSUED

HIERDIE REGISTRASIESERTIFIKAAT MAG DEUR DIE VERENIGING VAN DIE FRIESPERD STAMBOEK VAN S.A. GEKANSELLEER WORD INDIEN HIERDIE DIER NIE TYDENS VERPLIGTE KLASIFIKASIE AAN DIE KLASIFIKASIE- OF ANDER VEREISTES VOLDOEN NIE.

THIS REGISTRATION CERTIFICATE MAY BE CANCELLED BY THE FRISIAN HORSE STUD BOOK OF S.A. IF THIS ANIMAL DOES NOT CONFIRM TO THE CLASSIFICATION OR OTHER REQUIREMENTS AT THE TIME OF COMPULSORY CLASSIFICATION.

KORREK GESERTIFISEER
CERTIFIED CORRECT

Appendix C: The Breed standards of the FPSSA.

REGULATIONS OF THE FPSSA

These Regulations shall be read in conjunction with, and are supplementary to, the Constitution of the FPSSA.

Relationship with the Royal Society "het Friesch Paarden Stamboek" (FPS) in the Netherlands:

The FPSSA recognises the FPS as the sole worldwide authority and registry for the Friesian Horse.

The FPS recognises the FPSSA as its sole representative in Southern Africa.

The FPSSA is affiliated to the World Friesian Horse Organisation (WFHO) and abides by its Rules and Regulations.

Membership of the FPSSA

Applications for membership shall be accompanied by payment for the category of membership desired. Upon completion of processing by the FPSSA the member shall be entitled to all the rights and privileges of the membership category.

Memberships are not transferable.

To maintain their membership status in good standing, members are to abide by the Constitution and Regulations of the FPSSA, to deal fairly with the Association and its members and to fulfil all obligations including timely payment of dues and fees.

Membership will be terminated if annual membership fees (FPS and FPSSA) are not paid by June 30. However, until members have paid the current year fees they are not considered to be in good standing and therefore are not entitled to vote in Association proceedings, have registrations processed, or receive other services of the Association.
Any horse(s) registered in name of a member who's membership has been terminated or who has terminated his/her membership, will be withdrawn from the Studbook Registers.
Consequently, offspring of such horses will not be eligible for registration.
In order to re-register as a member or have previously registered horses re-registered, all outstanding and current fees must be settled in full.

Membership of the FPS, the Netherlands, is compulsory for owners of all Studbook,87 Foalbook and BB I horses and Hulpboek and BB II mares.

Where possible, all fees are payable in advance of services.
No registration documents will be processed, horses judged or any other services rendered by the FPSSA or the FPS until the appropriate fees have been received and processed by the FPSSA.

Members are to notify the FPSSA Secretary promptly of: termination of membership, any change in address, telephone number or personal status as well as the change in status of any of their horses (e.g. birth, death, ownership transfer).

FPSSA Membership List

Only the FPSSA Committee or FPSSA appointed Officials are entitled to use the FPSSA Membership List, for the sole purpose of distributing information regarding FPSSA related matters to its members.

Breeding objective of the FPSSA

The breeding objective of the FPSSA is to breed beautiful horses with typical Friesian characteristics, which are competitive as driving horses and under saddle in dressage, as well as being suitable for recreational use. This should be accomplished by selection within the breed, while further reducing inbreeding.

The breeding objective advocates a "modern" Friesian horse that retains the typical characteristics of the breed. Although the conformation is mentioned first in the breeding objective, the movement of the horse counts for 60% of the judging evaluation.

FPSSA Breeding Policy

Members are strongly encouraged to abide by the following breeding policy:

Mares: Friesian mares registered in the FPS Studbook, Foalbook, Aidbook (Hulpboek), BB I (Bijboek I), or BB II (Bijboek II) should only be bred to FPS Studbook Stallions (by means of Artificial Insemination) or Foalbook Stallions with a breeding permission for South Africa.
Cross breeding to stallions of other breeds is strongly discouraged and no registration papers will be issued to the offspring of such breeding.
Stallions: FPS Studbook Stallions or Foalbook Stallions with a breeding permission should only be bred to mares registered with the FPS and FPSSA. Crossbreeding to mares of other breeds is strongly discouraged and no registration papers will be issued to the offspring of such breeding.

Breeders should select a stallion whose conformation, movement, sport performance and pedigree will best complement the specific mare that is to be bred.

In selecting a stallion, the mare owner has the responsibility to carefully consider the inbreeding coefficient of the resulting foal.
A low inbreeding coefficient indicates that the parents of a foal have few common ancestors, thus minimising the chance of genetic defects.
In the Friesian breed, retained placentas, among others, may be associated with high inbreeding coefficients.
A simple rule of thumb is that in a foal's pedigree no one name should appear more than once within the first three generations.

Mares should not be bred under the age of three.

At a time when many breed registries have experienced a decline, the FPS has continued to grow. This is due, in part, to the appearance and charisma of the Friesian. The attraction exerted on devotees by the appearance of the Friesian cannot be jeopardised when breeding for specific performance qualities.

Breeding for performance- The Friesian horse is used in various equestrian disciplines: show driving, combined driving, dressage under saddle and recreation. To become more competitive in all sports, attention should be given to the following points:

- Strong, powerful hindquarters
- A luxurious horse that is not too heavy, but has ample power
- A long, sloping shoulder
- Hard, dry legs
- Light-footed movements with a moment of suspension
- Ideal range of height is 1.59 -1.63 meters
- Sufficiently long and well muscled forearm and gaskin
- Strong, smooth transition from loin to croup; long and well developed gluteal muscle
- Good, wide hooves with proper heels
- Good head/neck connection
- An honest nature, eager to work
- Stamina

Friesians should not be trained under saddle or in harness under the age of three.

Approved breeding methods

Natural cover, artificial insemination and limited embryo transfer are permitted. Written permission for embryo transfer must be obtained from the FPSSA in advance of the embryo transfer procedure.
Permission will depend on evaluation of the donor mare, evaluation of previous foals of the mare and analysis of the mare's pedigree.

Only mares registered in BB I or higher are eligible as donor mares for embryo transfer.

A recognised veterinarian using ultrasound or equivalent technology to verify a healthy reproductive tract must examine all proposed recipient mares.

Cloning will not be allowed.

Importation of Semen

The importation of semen into South Africa is strongly encouraged. In addition to the goal of improving the purebred Friesian horse, enlarging the gene pool in South Africa is of major importance.
Written permission for importation of semen must be obtained from the FPSSA in advance of the import procedure.
Permission will depend on the bloodline of the stallion(s) of which semen is to be imported.

Importation of Stallions for Breeding purposes

Written permission for import must be obtained from the FPSSA in advance of the import procedure. Permission will depend on the bloodline of the proposed stallion(s) and will be granted only after consultation with the FPS.
This to protect prospective buyers and to ensure that only stallions, that make a positive contribution to the SA breeding program will be imported.
All proposed stallions must have been x-rayed according to FPS specifications. In addition they must have been tested for and be approved on the quality of their semen and must be free of the chestnut-factor.
Imported colts/stallions, that did not participate in the Annual Stallion Selection in the Netherlands and/or did not undergo above-mentioned tests, can be presented for application for breeding permission from the age of three. After evaluation of the stallion by inspectors from the FPS, all above-mentioned tests must be performed within six weeks of evaluation.
Breeding permission will depend on the result of these tests.

Failure to obtain permission for import will result in refusal of breeding permission.

It should be clearly stated that the FPSSA is not in the business of importing semen or horses. However, it is the concern of the FPSSA that those members importing semen or horses follow the requirements of the Government agencies that have jurisdiction over biological importation.

Stallion Record Book

Owners of stallions with a breeding permission shall maintain a record book in which they record the date and insemination method each time a specific mare is covered or inseminated. Any breeding of a mare in South Africa must be recorded on a Breeding Certificate (Dekbewijs), issued by the FPS, in order for the resulting foal to be eligible for registration.

Breeding Certificate (Dekbewijs) Foalbook Stallions

The Stallion owner shall submit a copy of the Breeding Certificate within 30 days of the last covering to the Secretary.
Should the Secretary receive a Confirmation of Birth (Blue Certificate) for a foal from the FPS, the Netherlands, but not have the corresponding Breeding Certificate on file, the stallion owner will be fined.
In addition, DNA testing will be performed on this foal at the time of registration. The stallion owner will be responsible for the costs of DNA testing.

Birth Announcement

Following the foal's birth, the foal's owner must complete the Birth Announcement portion of the Breeding Certificate. The completed form must be submitted to the FPS, Drachten, within **14 days** of the foal's birth.
After processing the Birth Announcement, the FPSSA will forward the Confirmation of Birth to the foal's owner. This document serves as a temporary registration paper and must be presented to the FPS judges on the day the foal is to be registered and chipped.
All foals must be registered within a year of their birth.

Each foal is chipped by the FPS judges on the left-hand side of the neck. This is customarily done at the time of initial registration, usually within the first year after birth. The code of the chip will appear on the horse's permanent Registration Certificate.

Registration Certificates

All Registration Certificates of horses registered with the FPSSA are the sole property of the FPS, the Netherlands.
Upon the death of a horse, the original Registration Certificate + Notice of Death shall be sent to the Secretary.
Upon the sale of a horse to a non-FPSSA member, the original Registration Certificate shall not be released to the new owner but shall be sent to the FPSSA Secretary.
Should a member terminate his/her membership, or have his/her membership terminated, all original Registration Certificates of horses registered in that member's name at the time of termination of membership shall be sent to the Secretary.

Linear Scoring

Linear scoring is strongly recommended for Studbook, Foalbook and BB I mares over three years old. In the near future linear scoring will become compulsory.
In time this system (evaluation based on subjective measurements) will provide breeders with a world of information. The linear scoring form will show the weak and strong points of a mare, which enables breeders to choose a stallion that will complement the mare and improve on her weak points.

A detailed index for Studbook Stallions, based on linear scoring results of their offspring, is supplied by the FPS on an annual basis. This index indicates on which points the stallion does or does not improve the breed and if he passes any defects on to his offspring.

Studbook Judging

Horses can be presented for Studbook Judging from the age of three.
This evaluation is conducted annually at Breeding Selection sites throughout South Africa. The original Registration Certificate must accompany the horse. Criteria for acceptance in the Studbook require that the horse demonstrate conformation and movement according to the Friesian Breed Standard.

Horses presented for Breeding Selection must be registered in name of an FPSSA member.

Breed Standard

Typical Friesian characteristics may be found in a horse that is harmoniously built and properly proportioned, with feathering on the lower legs, thick, long mane and a long and wavy tail.
The Friesian has fluid, elegant and suspended gaits. Jet black is the preferred colour.
This is a horse of luxurious appearance, with a good temperament, honest and eager to work.
A description of ideal Friesian conformation follows:

The head is relatively short and the width is proportional to the length. The ears are small and alert with the tips pointing slightly towards each other. The eyes are large and shining. The nasal bone is slightly hollow or straight; nostrils are wide. The lips are closed and the teeth meet properly.
The jawbones are not too heavy with sufficient space in between.
The head is set gracefully on the neck with adequate space for the throat.
Overall, the head is dry and expressive and blends smoothly into the neck.

The neck is lightly arched at the crest. It should be long enough for the horse to bend properly and adequately muscled. The neck is set on high enough on the chest and the lower neckline does not bulge between the throat and the chest.

The withers are well developed, prominent and blend gradually into the back.

The back is not too long and well muscled. A slightly hollow back is allowed.

The loin is wide, strong and well muscled and makes a smooth transition into the back.

The croup is of good length and slopes slightly downwards; it is wide and muscular. It neither forms a point nor is overly rounded. The tail is not set on too low. The semitendinosus muscle (broekspier) is long and well developed.

The shoulders are long and sloping and are set widely enough apart to form a good chest, which is neither too wide nor too narrow.

The ribs are long and curved, supplying ample space for the heart and lungs, without being rotund. The abdomen maintains sufficient depth towards the rear.

The legs The front legs are properly positioned and when viewed from the front, are set parallel with a hoof width of space at the ground. Viewed from the side, they are perpendicular down through the fetlock joint. The cannon bone is not too long; the forearm however, has good length. The pastern is resilient, of good length and is at a 45-degree angle to the ground.

The hind legs, viewed from the rear, are straight. Viewed from the side, the legs are set directly under the hindquarters and are strong with good, strong hooves. The hind cannon is a little longer than the front; the gaskin is long with well-developed muscle. The angle at the hock is approximately 150 degrees; the rear pasterns are at a 55-degree angle to the ground.

The joints in the legs are dry, well developed and provide a good foundation for the tendons and ligaments.

The overall appearance of the body is more rectangular than square. When the shoulder is long and sloping, the back not too long and the croup of adequate length, the ratio of fore-, middle-, and hindquarter can be an ideal 1:1:1. The horse should be neither too heavy nor too light.

The walk is straight, vigorous and supple. There is a good length of stride coming from the shoulder with sufficient drive from the hindquarters.

The trot is a reaching and forward movement with powerful drive from the hindquarters. It should be elevated and light-footed with a moment of suspension. The hock flexes as the horse moves forward and the inside angle of the hind leg closes during each stride.

The canter is well supported and lively with sufficient drive from the hindquarters and flexion in the hock.

Studbook Registers

Hulpboek /Aidbook

Included in this register are mares born before 01-01-1989 of untraceable lineage that demonstrate physical characteristics of a Friesian.
The Aidbook was used by the FPS to help establish the Studbook in South Africa. This Register is closed from 01-11-2002.

Four generations female offspring of a Hulpboek mare need to be bred to Studbook stallions in the Netherlands for the fourth generation to obtain FPS Studbook status.

Bijboek II / BB II

Included in this register are horses born after 31-12-1988 of which one or both parents are not FPSSA registered, but who demonstrate sufficient Friesian characteristics.
From 01-11-2002, BB II in its present form is closed. However, mares of unregistered parentage over three years old might be considered for inclusion in BB II if they demonstrate quality of conformation and movement equal to that of BB I Star. The Board of Inspectors and the Committee of the FPS, the Netherlands, will make the final decision for inclusion of a specific mare in BB II.

Sportboek / Sportbook

Included in this register are stallions and geldings of untraceable lineage over three years old. Horses registered in the Sportbook can be used for promotion in various equestrian disciplines only.
Stallions registered in the Sportbook do not have a breeding permission. Consequently, offspring of Sportbook-registered stallions are not eligible for registration.
This register is closed from 01-11-2002.

Veulenboek / Foalbook

Offspring of a Foalbook mare and a Studbook stallion will be registered in the Foalbook. From the age of three, mares and geldings born to a Foalbook mare are eligible for Studbook Judging and Star Designation. Stallions are not eligible for Studbook Judging and do not have a breeding permission, but can be presented for Star Designation from the age of three.

Bijboek I voor veulens / BB I for foals

Included in this register are offspring (under three years old) from mares registered in Studbook, BB I, BB II or Aidbook bred to a Foalbook stallion with breeding permission and offspring from mares registered in BB I, BB II or Aidbook bred to a Studbook stallion in the Netherlands.
Mares and geldings registered in BB I for foals are eligible for BB I Studbook Judging from the age of three.
Stallions registered in BB I for foals will not be eligible for BB I Studbook Judging and do not have a breeding permission, but can be presented for Star Designation from the age of three.

Bijboek I / BB I

Included in this register are mares and geldings over three years old who are approved for entry in BB I at Studbook Judging. Mares and geldings registered in BB I are eligible for Star Designation.

Three generations female offspring of a BB I mare need to be bred to Studbook stallions in the Netherlands for the third generation to obtain FPS Studbook status.

Eligibility for BB I mares or geldings requires that they:

- Be at least 1.50 meters at the withers
- Be black and have no white except for a small star or a few white hairs on the forehead or muzzle; white is not permitted on the body, legs or hooves
- Be sound; unsound horses cannot be entered in the Studbook
- Be free of hereditary defects (mares with hereditary defects should not be used for breeding)
  Criteria for rejection are, among others: ringbone, bone spavin, bog spavin, swollen stifle joint, lameness, insufficient shoulder height, poor use of the hind leg, defects of the stifle including a locking or loose stifle or improper development of the hock.

Star Designation

Studbook, Foalbook and BB I horses over three years old may be presented for Star Designation.
The original Registration Certificate must accompany the horse to the annual Breeding Selection.

Criteria for Star Designation requires the horse demonstrate to the judges:

- Conformation and type meeting the Breed Standard
- Totally correct movement
- The walk must be straight, powerful and flexible, with good reach from the shoulder and powerful drive from the hindquarters
- The trot should be a reaching and forward movement with powerful drive from the hindquarters and flexion in the hock; it should be elevated and light-footed with a moment of suspension

Imported Foalbook Stallions

All imported Foalbook Stallions with a breeding permission must be judged annually.
They are also informally evaluated on the basis of their offspring every year. A decline in the quality of offspring or the discovery of hereditary defects may result in the withdrawal of breeding permission. Consequently, foals that were

conceived after the withdrawal of breeding permission will not be eligible for registration.

General Registration Guidelines

All registration procedures and issues regarding Friesian horses in South Africa must be handled by the FPSSA Secretary.
Only FPSSA members in good standing are eligible to utilise the registration, judging, chipping and related services of the FPS. Fees are due in advance of services, whenever possible.
The Registration Certificate is strictly a statement that a specific horse has a recognised pedigree and the privilege of being entered in the official, worldwide registry for the Friesian horse. It has no specific rights or privileges in conjunction with it and is not, in itself, a proof of ownership; Buyers should obtain a properly executed Bill of Sale from the Seller for this purpose.
The Registration Certificate is not the property of the horse owner and can be withdrawn by the FPS or FPSSA for justifiable reasons.

Transfer of Ownership

To transfer the recorded ownership of a registered horse, the Seller must fill in the back of the Registration paper (Studbook, Foalbook, BBI, BBII) plus the Transfer form.
Both Buyer and Seller must sign the back of the Registration Certificate. The Buyer must send the Original Registration Certificate, Transfer form and payment for transfer to the FPSSA Secretary.
Without the relevant form or payment the transfer will not be processed.

When a foal is sold prior to being registered, the original Confirmation of Birth Certificate -not changed in any way- should be given to the Buyer to be handed in at the day of registration.

To become a recorded owner and receive the Registration Certificate, the Buyer must be a paid up FPSSA member in good standing.

Death

Upon the death of a horse the original Registration Certificate, together with the Notice of Death must be send to the FPSSA Secretary. If an autopsy was performed a copy must be sent with the Certificate.

Breeding Selection and Shows

General

All events held under the auspices of the FPSSA shall be organised by an FPSSA appointed Convenor and Show Committee.

Owners of horses participating in an FPSSA event must be paid up members of the FPSSA.

Only FPSSA registered horses can participate in events held under the auspices of the FPSSA.

Participating horses must be registered in their owners' name on the closing date of entries.

All fees are payable in advance.

Any outstanding dues or fees (FPS and FPSSA) will result in elimination of members' horses for that event.

Breeding Selection will be cancelled if fees are not received and processed by the FPSSA Secretary 14 days prior to the date of Breeding Selection or if the applicant has any outstanding dues or fees (FPS and FPSSA).
Should any additional fees arise, e.g. Star Designation, the applicant will be responsible for payment of these fees.
Should monies received by the FPSSA Secretary exceed the amount charged, excess monies will be refunded to the applicant.

Hair samples may be taken from horses randomly selected by the judges for DNA testing. The FPSSA will carry the cost of these tests, unless they prove that parentage of the selected horse differs from that submitted on the Application form for Breeding Selection. In that case the owner will be responsible for the costs involved
.

In accordance with the International Breed Standard, Friesians should be presented with full mane, tail and feathers.
Judges will discriminate against shaven/clipped mane and feathers.

At no time will persons other than handlers and assistants be allowed in the show-arena.

Cruelty of any kind at the venue of an FPSSA event will not be tolerated and will be severely punished.

Judges will discriminate against any unusual shoes or method of shoeing.

Horses in substandard condition will be eliminated at judges' discretion.

Presentation in hand

Horses will be judged on movement, conformation, type, quality, soundness and manners.

The handler may have an assistant who encourages the horse to be attentive while standing and to move forward vigorously at the walk and trot.
The assistant may carry a whip and/or a noisemaker to encourage the horse to move forward, showing consideration for other competitors at all times.

Foals and yearlings may be presented in a halter and lead-rein, with or without a chain.

Horses 2 years and older should be presented in a bridle with a snaffle bit.
White halters, bridles and leads are traditional but not compulsory.
Only black, brown or white halters and bridles are allowed.

If, in the opinion of the judge, a horse behaves in an unruly or dangerous manner or displays continued disobedience, he/she is entitled to eliminate the horse from participation.

All instructions from the judge and steward shall be carried out and no competitor may retire from a class without the judge's permission.

Horses are to be clean and well groomed with full, un-plaited manes and tail.
Additional grooming, such as removing superfluous hair is optional.

Dress Code:

It is compulsory for the handler to wear white trousers (no jodhpurs or leggings) and a white shirt (no T-shirt) with an FPSSA tie. Shoes must be suitable for running. The assistant also has to be dressed in white.

Judging Procedure:

Enter arena and present horse, standing square, for evaluation of conformation. Walk and trot a triangle for evaluation of movement. Present horse again.

Under Saddle Classes

Horses will be judged on movement, conformation, type, soundness, manners and the ride.

Only English style tack and black, white or brown numnahs are allowed.
All horses are to be ridden in a snaffle bit. Auxiliary reins and martingales are not permitted.

Horses are to be clean and well groomed with full, un-plaited manes and tail.

Show ring etiquette

All instructions from the judge and steward shall be carried out and no competitor may retire from a class without the judge's permission.

No persons, other than officials may give assistance to a competitor during competition.

When under judgment, in any class and at any gait, a competitor may overtake either on the inside or outside, provided he/she does not obstruct the competitors he/she is passing. Any competitor who wilfully obstructs another will be penalized.

Judging Procedure:

Enter arena, line up in middle of arena for inspection.
On command of judge walk, trot, canter, changing rein through the trot. When called in, line up in middle of arena from left to right.

Dress Code:

Black or navy coat - black or navy hard hat/bowler - beige, cream or white breeches/jodhpurs - black boots - white or cream shirt - FPSSA tie - plain conservative gloves (if worn).

In Harness Classes

Horses will be judged on movement, conformation, type, soundness, manners, willingness and the drive. The overall picture is important.

Style, set, action and balance must be maintained throughout the class whenever the horse is in movement. Action must be flowing and harmonious.

Turn out of horse and carriage

All horses should be turned out according to the breed standard.
No horses should be shown with their manes or feathers clipped or shaved. Horses have to be shown naturally. Plaiting is only allowed for demonstration purposes.

Exhibitors may have a groom on the vehicle at any time. It is not compulsory to carry a groom in the show ring, except in four-in-hand.

Any style harness may be used, provided it is in good condition, clean and safe. Bearing reins (ophalers), standing martingales or any auxiliary reins are not permitted. Auxiliary reins include any auxiliary connections to the bridle, bit, rein or head collars. Any exhibitor who shows in prohibited harness or accessory is subject to elimination.