The feasibility of determining the relationship between bloodline and performance in the Australian sport horse population.

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CERTIFICATION STATEMENT

I certify that the contents of this report are entirely a product of my own investigations except as otherwise acknowledged in the report.

ABSTRACT

An investigation of the Australian sport horse industry has been undertaken to ascertain the level of data available for research purposes, and its use in estimating the relationship between bloodline and performance in horses competing in the top levels of the Olympic disciplines.

A total of 545 performance horses was analysed, with four generation pedigrees obtained for 348 of these animals. The major sire lines have been identified, and a heritability estimate of total score, as a performance measure was calculated using the Derivative Free Restricted Maximum Likelihood (DfREML) method. The major sire lines were identified and data are presented on the top 17 of these lines, and the major sires within them. The heritability estimates attained range between 0.47 and 0.77, and a discussion concerning reasons for these high estimations is included. A number of problems were identified within in the industry and recommendations to overcome these have been made.

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INTRODUCTION

Methods for selecting the desired horse have existed since man first used horses for work and sport. These methods have varied over time until the present day, when many countries now use large databases of performance and pedigree records for the selection of both breeding and performing animals. In Thoroughbred racing, both in Australia and overseas, many factors are assessed when selecting breeding and performance animals. These factors include pedigree, conformation, personal performance, progeny and relative performance. Australia has yet to develop a national plan for the selection of breeding animals for the Olympic disciplines, however, in equestrian sports there is a lack of industry guidelines pertaining to the desired standard of horses, as well as in methods to develop the genetic quality of our horses.

Heritability studies undertaken in European countries are used in the development of selection procedures for elite sports horses. There are no published reports, using Australian sport horse data, on which to plan or assess selection procedures. This study was undertaken to establish the level of performance and pedigree information on the Australian sport horse and ascertain if it is feasible to quantify the relationship between bloodline and performance from existing data.

Through becoming a consistent producer of high performing horses, that compete and/or are available for trade, greater international recognition will come to Australia. To achieve this, Australia's industry needs to attain a more cohesive approach between breeders, trainers and competitors. Currently in Australia, the sport horse industry consists of a number of non-interacting breeding and training groups, many of which are involved in the sale and export of horses. This contrasts with the industry organisation in Europe, where all sectors work in unison to produce the desired animal for a particular sport.

An understanding of the sport horse industry structure in other countries, and the current situation in Australia, provides a basis from which the possibilities of the future for sport horse production and performance in Australia can be assessed. The following literature review will provide an overview of the European and Australian industry structures, the genetics of performance traits, heritability estimates for these traits attained in other studies, and the major computer methods used to analyse performance and pedigree data for sport horse selection.

LITERATURE REVIEW

Governing Bodies and Methods of Selection

In Europe, the Warmblood associations have set strict guidelines for the selection of horses to be utilised in breeding for the performance horse industry. Many countries have commissioned a single governing body for the collection and collation of breeding and performance data. In Germany, The German Riding Association registers the results of A and B grade competitions in the form of both error points and earnings. Breeding values are estimated annually from this, and from phenotypic information of the horses. Stationary performance testing, conducted under standardised environmental conditions, is used to gain phenotypic information for both mares and stallions (Bruns 1990).

The Danish National Committee on Horse Breeding represents 23 major horse breeds used in sports other than racing (Arnason *et al.* 1994). Finland and Norway also have national organisations that are responsible for the organisation of horse sports, registration and breeding.

The Swedish Horse Board, formed by the breeder organisations, is responsible for official breeding activities of all horses except racing animals (Arnason *et al* 1994). In that country, the selection of stallions is based on a three stage procedure which incorporates conformation, performance testing and competition results in advanced competitions; mares are selected using conformation and performance testing only (Philipson, Arnason & Bergsten 1990).

France also has a national body for the collection of data on individual horse's competition results and earnings. Using this data in selection, showed that young horses were gaining less recognition than their older competitors. Thus, France has now instituted competitions for particular age groups (Travernier 1990).
New Zealand has recently investigated the need to set selection objectives, and in doing so they have concentrated on sire selection to gain high selection intensities and generate maximum genetic improvement (Rogers & Wickham 1993). The study used data from European systems, and as such may not be fully relevant to the New Zealand industry. New Zealand has a similar situation to Australia in that many sport horses are selected from horses specifically bred for racing. In their study, Rogers and Wickham (1993) predicted that the use of a 'Normal Horse Competition Model', utilising competition results, would increase selection intensity and reduce the

generation interval from their current level of 16.8 years to 5 years plus. As such it was envisaged that this method would double the gains of the present system. Other models were proposed, however a number of assumptions were made, including inflated horse numbers, genetic parameters from other horse populations, and high costs. Thus, they cannot be seriously considered on the basis of this article.

The Australian Situation

In Australia, horses are registered with their relevant breed society and/or the Equestrian Federation of Australia (EFA). To be registered with a breed society horses must be pure bred, or as in the case of Warmbloods, show a particular phenotype. Owners must be able to show evidence of the relevant parentage of the horses to enable bloodlines to remain true. Registration through the EFA is open to any breed, and enables entry to official competitions. The results of these competitions are recorded in points per placing and total career points. Each state has its own branch of the EFA responsible for the coordination of competitions and collection of results within that state. There is no central register for breeding or competition results, and no records are kept of non-placing horses.

With so many societies governing breeding and competitions of sport horses, there is little cohesion within this faction of the horse industry. All breed societies hold competitions, however, some societies allow entry by non-registered horses, and many breed society results are not recorded by the EFA. This has resulted in incomplete knowledge of all competition horses.

Australian sport horses mainly come from the Thoroughbred industry. However Warmbloods, Arabians, Stock Horses, Quarter Horses and Andalusians also compete in the Olympic disciplines. Thus many horses were originally selected for qualities other than those required by a sport horse, such as racing ability, or for multiple qualities such as showing, lead work, jumping, endurance and stock work. This leads to problems of lack of specialisation and a high selection rate (Tavernier 1990), which results in higher training costs, due to increased time spent on horses which may not have the ability to succeed. Accompanying this is a lack of advancement in genetic quality of sports horses, as mediocre horses are selected for both breeding and training.

The Warmblood Association of Australia is the only breed society that grades its best horses for breeding. This is achieved through the classification of mares, and colt selection followed by performance testing of stallions. The overall aim of grading the horses is continued long term genetic improvement, and thus maximisation of performance potential. For progeny to be registered in the Warmblood Stud Book the mare and stallion must both be classified.

It is unrealistic to expect that all horses selected for the Olympic disciplines come from classified stock, especially considering that many combinations of breed are utilised in obtaining the desired animal. However, reliable information of the major bloodlines present in elite sports horses would provide selectors with the data to make informed decisions. Over time this will lead to a reduction in the cost of training, and an increase in the general level of performance, as successful bloodlines become known and have the opportunity to prove their value. By involving breeders in the development of equestrian activities and industry aims, a positive economic response is guaranteed (Blanc 1990). This will lead to an increase in genetic quality of our sport horses, allow greater exploitation of economic potential, and provide the key to external markets (Tavernier 1990). The result of this will be the induction of greater cohesiveness within the industry.

By using bloodlines to select performance horses, the specifics of performance potential and heritability of traits can be determined. Such factors as the number of relatives competing, their performance level, and the major discipline of performance could be ascertained. Genetic qualities such as character heritability, breeding values and the level of inbreeding can then be reliably estimated. Currently the selection of sport horses rests on visual appraisal and on the riding capacity of trainers, breeders and riders. Many horses are trained for Olympic disciplines based solely on their conformation as a young horse, or in other cases because they are available. Some of these horses are successful in one or all of the disciplines, however, much time is spent on those unlikely to succeed at the upper levels.

Genetic Merit of Riding Performance

The performance traits of horses in various sports are easily measurable by the requirements of that sport. However, in attempting to breed for these traits it is not always found that the following generations possess them. In the past, conformation was a major criterion in the selection of a performance horse, but genetic parameters allow a more accurate appreciation of performance (Tavernier 1990). It has been proposed that performance traits are quantitative, controlled by genes at several loci acting together in an additive fashion (Bowling 1992). However, there has been minimal research into equine genetics, especially for patterns of inheritance for various quantitative traits. Breeds tend to be highly specialised with regard to certain sets of traits, and in most cases genetic differences are only important in terms of selection made within horse populations or breeds (Tolley, Notter & Marlowe 1985). All sport horse breeders and selectors are dealing with a particular population of horses, regardless of breed, and as such would gain from interaction to allow the development of precisely defined breeding goals as is the case in other livestock enterprises (Klemetsdal 1990). Breeding for performance has increased in popularity over the last decade (Huizings 1990), however, some populations have such broad aims for performance that genetic advancement towards a specific goal is not always the outcome.

Estimation of genetic merit for riding performance can be based on such data as competition scores, earnings, placings (Bowling 1992; Langlois 1975), and percentage of progeny with earnings (Tavernier 1990). Other researchers have proposed log of earnings per placing (Bruns 1990; Hintz 1980), log of annual earnings divided by the number of competitions in the year (Tavernier 1990), and earnings per ranking (Wilkens, Preisinger & Kalm 1990).

In race horses it has been found that some of the differences associated with racing class are genetic, and that the progenies of superior sires compete on average in better races (Tolley Notter & Marlowe 1983). There is no reason to expect that the genetic situation in sport horses would be any different.

The choice of criteria for evaluation is constrained by the characteristics of the data base available (Tolley Notter & Marlowe 1985). In Australia it is not possible to assess all horses on some of the above mentioned factors, as data collection rests on point scores only, earnings are not recorded in this country for sport horses.

Ideally, to gain the greatest advantage from the assessment of data, all competition starts and the records of relatives should be included, as this will result in a high accuracy of prediction (Bruns 1990). However, in Australia as many sport horses were bred for racing, there are very few relatives with records in the desired area. It is also difficult to obtain complete data on performance results, as only placings not performances, are recorded by some EFA branches.

Within the Thoroughbred breeding industry, it is found that a few stallions dominate the production of horses, and this domination carries on to the sport horse industry.

Langlois (1989) states that in this case, the phenotypic mean of his progeny generally contributes the most to the knowledge of the stallionos genetic value. As these horses were bred for a sport that is unrelated to the sports being investigated here, the phenotypic mean can only be made of those animals noted to achieve a high level of performance in jumping, dressage or eventing.

Heritability Estimates

The heritability estimate is a measure of the genetic component of phenotypic variation. Most published reports for horse performance provide heritabilities of low to moderate value, especially when data come from competition results (Huizings 1990). Those obtained in standardised performance tests of European Warmbloods, however, show moderate to high heritabilities (Table One).

Many biases can occur in the estimation of heritabilities as a result of poor data structure, and environmental effects which are not randomly distributed (Langlois 1980). However, through the use of large sample sizes heritability estimates are generally significant (Tolley Notter & Marlowe 1985).

Heritability scores of conformation can be measured early in life, and it is found that the heritability of this factor is moderate, but varies with gender. Heritability estimates of conformation from sire to offspring are found to be higher than from dam to son, which are higher than from dam to daughter (Strom & Philipson 1978). Thus, heritability estimates become important in selection as an indicator of the potential genetic phenotype of a particular horse, taking special note of its gender and the phenotype of its parents, especially its sire.

The source of the data is also important, as heritabilities have been found to be higher in standardised performance tests (Klemetsdal 1990; Arnason 1984; Bowling 1992) than in competition (Langlois 1975; Hintz 1980). This may indicate that genetically, some horses are more able to perform well in standardised performance tests and yet are unable to pass on the ability to perform in competition. Alternatively, this variation in heritability estimates could be a function of the greater number of variables that surround competition data and confound its interpretation.

When heritabilities are low (less than 0.41) progeny records and those of close relatives increase the accuracy of prediction (Bowling 1992). An accurate heritability score at this level indicates that genetic variability is present and selection should therefore lead to marked genetic progress (Langlois 1980). With this knowledge, and the fact that most heritability scores for performance are low to moderate, it would be expected that through a directed selection program and the use of high quality breeding animals, Australia could produce a genetic improvement within the sport horse population. This would improve both our level of competitiveness and sales of performance horses, especially internationally.

TABLE ONE: HERITABILITY ESTIMATES OF PERFORMANCE TRAITS

TRAIT	STANDARDISED PERFORMANCE TEST	COMPETITION PERFORMANCE
Riding ability	0.36	
Gaits	0.5	
Jumping Ability	0.72	0.17 - 0.19
Cross Country	0.33	
Racing Time	0.53	
Temperament	0.25	0.07
Three day event		0.14 - 0.26
Dressage		0.17

Source: Adapted from data published by: Hintz 1980; Langlois 1975; and Klemetsdal 1990

Factors Influencing Performance Measurement

In obtaining heritability values from primary data, consideration should be given to a number of non-genetic influences. The performance ability of a horse is affected by factors including management practises, training effects and gender, consideration of these influences ensures that the heritability estimates more closely reflect the genetic merit of the specific qualities being measured. These non-genetic influences are collectively known as environmental factors with age, gender and height being the main ones considered (Bowling 1992; Hintz 1980). The level of influence on heritability data, reported for each of these environmental factors, varies between published articles, and some researchers include further environmental factors. Each factor will be addressed individually.

Age

The majority of published work agrees that age affects performance in all sporting activities (Tavernier 1990; Hintz 1980; Arnason 1984; Oki, *et al* 1995a; Katona 1979;

Buttram, Willham & Wilson 1987). This trait was found to especially affect show jumping and three-day eventing ability (Hintz 1980), while Arnason (1987) found there to be a significant year of birth effect on both jumping and dressage performance in Swedish horses, which may be due to the greater experience of older horses. In France, the repeatability of the performance trait is considered in the assessment of the genetic merit of trotters, as these horses may run from the age of two to ten (Tavernier 1989). This may be a factor in the assessment of sport horses as they also compete over a long period of time. However, the period of time spent competing at a given level will vary from horse to horse depending on its ability and the effectiveness of its training.

Gender

In racing animals and other sport horses, many research articles have recorded a variation in ability related to the gender of the animal (Tavernier 1989; Hintz 1980; Bruns 1990; Katona 1979). Others, however, have found that some traits are not sex-linked (Huizings 1990).

In relation to speed, it has been found that stallions are superior to mares and geldings in Belgian trotters (Leroy, Kafidi & Bassleer 1989). This contrasts to studies on the Icelander Toelter horse, where stallions were found to be inferior in speed, although generally gained a higher performance score when all factors were considered (Arnason 1987). Further to this, in the American Quarter Horse, gender and age were found to interact, in that stallions were faster than geldings as two-year-olds, yet slower as four-year-olds (Buttram, Willham & Wilson 1987). In the Icelander Toelter horse, jumping ability, temperament and gait were superior in males than females, especially mares with foals (Arnason 1987). Tavernier (1989) found that in French Trotters, stallions were superior in performance, however, the reason for this appears to be stricter selection procedures. It was also shown that breeding mares performed better than non-breeding mares for the same reason.

Height

Height was shown to have a significant effect on jumping ability, with taller horses showing better performance, except in three-day eventing in Russia, where the opposite was found to be true (Hintz 1980).

Other Factors

Other factors considered in studies include regional and seasonal effects of the competition, riders' quality group (Bruns 1990; Oki *et al* 1995a; Buttram Willham &

Wilson 1987), trainer effect (Klemetsdal 1994), year of judgement (Arnason 1984; Buttram Willham & Wilson 1987), handicap weight (Oki *et al* 1995a; Wilson 1990; Oki, Sasaki & Willham 1994; Buttram Willham & Wilson 1987), race course, track condition, starting method and temperature (Katona 1979; Buttram *et al* 1987). It is likely that many of these factors would also affect the performance of sport horses, and as such, a study undertaken to assess the genetic value of sport horses should consider these factors as fixed environmental factors in the statistical analysis.

Computer Analysis Methods

An individual's breeding value is the weighted sum of the Mendelian components of its ancestors; selective breeding is utilised to identify novel variations in an individual and promote or suppress its contribution accordingly (Wooliams & Thompson 1994). In most breeding schemes a balance between genetic gain and inbreeding is sought. Increased genetic gain in the short term is usually associated with increased inbreeding. However, this leads to decreased genetic gain in the long term, as inbreeding causes a decline in fitness and a loss of genetic variance.

Selection procedures should aim at achieving a genetic gain that can be carried on to future generations. Thus, methods of genetic evaluation should be able to ascertain the breeding value of animals, the level of genetic gain, and the level of inbreeding. Best Linear Unbiased Prediction (BLUP) methodology is advantageous for less heritable, but highly variable traits (Meyer *et al.* 1991), thus this method has been used in many published reports (Klemetsdal 1990; Klemetsdal 1994; Leroy *et al* 1989; Macbeth 1994; Tavernier 1989). BLUP can be used on both standardised performance tests and competition data, however there are limitations to its effectiveness depending on the quality of the data available and the expected outcomes of the analysis. These include the following

* The occurrence of great sampling variances when utilised on small data sets (Arnason 1982).
* The amount of individual pedigree information available significantly influences the estimated breeding value (EBV) gained (Macbeth 1994).
* Klemetsdal (1990) found that the value of data utilised in BLUP is reduced by preselection of animals. Horses used in competition are likely to be preselected, thus BLUP may not be the program of choice to analyse these animals.

Williamson and Beilharz (1996), in estimating heritabilities of racing performance in Australian Thoroughbreds, rejected the use of BLUP on the basis of these problems. Their data had incomplete pedigrees, and performance data were imperfect. As such they elected to use simple ANOVA methods to obtain heritabilities. These methods are, however, also affected by preselected bias (Meyer 1993). The effect of preselection is small with the use of the Derivative Free Maximum Likelihood (DfREML) program, and this program is generally considered to be the best method for quantitative genetic analysis where there is unbalanced breeding data (Boldman & Vanvlek 1991; Meyer & Hill 1992; Graser Smith & Tier 1987).

DfREML was designed for animal breeding analysis where estimates of covariance components and the resulting genetic parameters are desired. DfREML provides estimates of heritabilities, genetic variance and estimated breeding values for both univariate and multivariate analysis. The major disadvantage found with DfREML discussed in published articles is the computational requirements (Meyer & Hill 1992; Graser Smith & Tier 1987). DfREML was first available in 1988, and has since been revised twice. The most recent version, 2.1, contains better ordering of equations, sparse matrix solver, and improved choices for the operator (Meyer 1993). This has significantly reduced the computational effort required.

Despite its limitations, the BLUP animal model is used to assess the genetic trend of performance horses in France (Tavernier 1990), Germany and the Netherlands. BLUP is also used in the genetic evaluation of conformation, dressage and jumping in Danish Warmbloods, employing data from both standardised performance tests and competition results. The animal model BLUP has also been used in Sweden since 1993 for progeny testing of stallions. Currently Sweden is aiming to develop a BLUP animal model system for the estimation of breeding values by combining competition results, quality field tests and stallion performance tests (Arnason *et al* 1994).

Pedigree Information

The amount of pedigree information available on a particular individual significantly affects the accuracy of estimated breeding values and heritabilities. The number of generations used in pedigree analysis varies between studies. Wilkens Preisinger & Kalm (1990) used four generation pedigrees and applied the completeness index to measure the degree of unknown ancestors. Oki, Sasaki and Willham (1995b) found that by using one generation only, the genetic variance and thus the heritability was overestimated. They recommend that pedigrees be traced back two to five generations, as this resulted in genetic and environmental variances remaining almost unchanged. The main disadvantage of tracing the pedigree back a number of generations is the increased time and computer usage required for analysis. Within the first generations there is a dramatic loss of founder genes. At least 89% of founder genes are lost after 10 generations of selection, with between half and two thirds of the remainder being lost from generation 10 to generation 30 (Verrier Colleau & Foulley 1994). This being so, it would be unnecessary and uninformative to trace a pedigree back 10 or more generations, as these ancestors no longer exert a significant effect on the phenotype of current performers.

The selection of horses by using pedigree information only, allows horses to be selected at a younger age than when they are selected on progeny information. This was found by Brisbane and Gibson (1994) to increase short-term genetic gain and inbreeding due to an increased concentration of family selection. For this reason it is important to use bloodlines as an adjunct to performance ability and conformation assessment in selection procedures. As the Australian Continent is large, inbreeding is not considered to be a potentially large problem. However, family lines such as those within the ancestors of Gainsborough (GB) or Pharos (GB) are so widespread, that inbreeding is a factor that requires constant consideration. Other breeds in Australia, such as the Warmblood, have a limited number of horses on which to draw for breeding animals, and without the input of outside lines a risk of reducing the genetic pool exists. Assessment of our sport horse population, using information from all states, is unlikely to show a large familial trend, however, this factor must be considered in the development of a national selection program.

Selection at a younger age than would be possible with the use of progeny information, is an obvious outcome of the use of pedigrees. This may be an advantage as the generation interval will be kept to a minimal level, thereby achieving some genetic response within a realistic time-frame. At this stage in the development of a selection program for Australian Sport horses, a knowledge of which bloodlines have been successful in sports competitions will provide a baseline of information from which to develop a plan for selection of both performing and breeding animals.

Summary

Breeding programs should guarantee that the genetic quality of future generations is being positively influenced through breeding with superior animals (Klemetsdal 1990). To enable this to occur in Australia, a knowledge base concerning our current best performers is required. Analysis of the performance level of these horses will enable estimates of breeding value to be obtained and lead to the prediction of future changes in the average performance of our sport horse population.

The overall estimation of the horse population, to enable the development of accurate production objectives, is a very useful tool for the breeder as it enables selection to be measured and focused (Tavernier 1990). Through knowledge of those animals that perform at the highest levels of equine sports, an indication of the quality within Australia's riding horses can be established. This will provide breeders with knowledge of the quality to aim for, and the ability to see areas which could benefit from selection and improved genetic quality. The use of a genetic selection package such as BLUP or DfREML will allow maximisation and accurate comparison of breeding values, and result in the selection of breeding animals with high priority given to the balance of genetic gain and inbreeding.

MATERIALS AND METHODS

Data Collection

Performance Data

Performance records were obtained through the EFA in Victoria, South Australia and New South Wales, on horses competing in the top two levels of the Olympic disciplines. Data for Queensland performance horses were gained from horse owners and riders.

Access to data varied between each state branch of the EFA. Full performance information on the top horses was available in South Australia and Victoria. Access to performance data in NSW required that the relevant councils supply the names or registration numbers of horses. The Horse Trials Council and the Dressage Council were able to supply these as requested. However, the Showjumping Council were only able to supply the names of owners or riders. A poor response was gained from contacting owners and riders, and so limited data were gained on NSW showjumping horses.

Pedigree Data

Pedigree information was sought from societies of all breeds represented in the data. The Australian Stud Book, the Victorian, South Australian and New South Wales branches of the Warmblood Horse Association, the Andalusian Horse Society and the Stock Horse Society were able to assist in the research. The level of information available from each of these societies varied. Four generation pedigrees could reliably be gained through the Australian Stud Book and the Andalusian Horse Society; other societies could provide pedigrees varying from two to four generations. Stock horse pedigrees and dam lines in Warmbloods contain a large proportion of Thoroughbred bloodlines, thus some four generation pedigrees were gained when the data from these three breeds were combined.

Performance Measurement

The measurement used to analyse performance, should ideally reflect biological activity. The highest heritability estimates have been gained in other studies when performance rates or log of earnings were analysed as the major trait. Total point score and number of placings are the standard performance data available in Australia. In this study we have utilised total point score as the performance measurement because data on the number of competitions was limited for a significant number of horses.

Analysis

Simple analysis of data was undertaken to ascertain mean values and standard deviations for height and performance score between breeds and events. The major stallion lines have been assessed for number of occurrences among the pedigrees of performance horses within four generations and actual numbers of horses influenced. The heritability analysis of total point score was undertaken at the Victorian Institute of Animal Science (VIAS) using Version 2.1 DfREML computer program devised by Meyer (1993). This program was chosen as being appropriate for the small volume of data collected and because of the ópreselection factorô discussed above. The total point scores were analysed as recorded by the EFA, however, log transformed score, and square root of transformed score were also used for some calculations.

One heritability estimate was calculated for all horses in the data set as a result of the small numbers being obtained per discipline. For this reason the heritability of performance ability within any particular discipline cannot be ascertained accurately from the present results.

The fixed effects included in the model were year, breed, state, and gender. Height was used as a covariate in one run, and analysis was performed using the fixed effects either included or removed to identify any variations in the heritability estimate obtained.

RESULTS AND DISCUSSION

Accessibility of Performance and Pedigree data in Australia

The aim of the initial data search was to determine the feasibility of gaining a complete record of all horses competing in the top two levels on the Olympic disciplines in Australia. Very few horses were gained from contacting individual riders and owners for Queensland horses and New South Wales Showjumpers, no horses were gained from Western Australian, Tasmania or Northern Territory. Thus a compete record was not obtained.

Within the performance data gained through the EFA, a number of records are incomplete. Varying degrees of information such as number and location of competitions, breed, sire, dam, birth date and height were missing. Incomplete performance and identification records held by the EFA are due to a number of factors, including transfers interstate and incomplete registration forms. On transfer interstate, the total points score attained by the horse is communicated to the new EFA branch, however, other performance data are not transferred and are no longer easily accessible in the state of origin. Incomplete or incorrect parentage information supplied on registration forms by owners, increased the difficulty of tracing horses through their breed society. The EFA records do not routinely record the breed of competing horses and because of this some horses could not be traced.

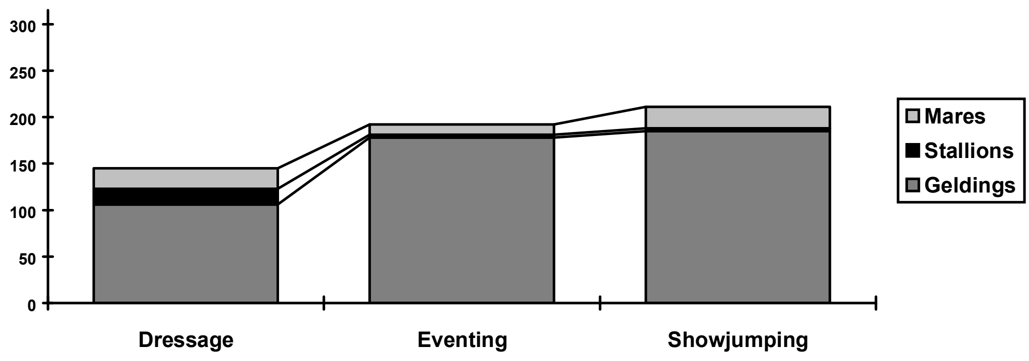
Cooperation with the supply of data varied between breed societies, with no data being forthcoming in some cases. A number of breed societies required the provision of their registration number to allow access to computer records, however, if the horse had retained its original registration name it could be traced through written records. Breed society registration numbers are not recorded by the EFA and a high proportion of horses are known by names other than their stud name, These factors limited access to pedigrees. These problems indicate the difficulty in researching the Australian sport horse population, and may negatively affect the precision of the statistical analysis.

Description of Horses

Gender

The distribution of gender varies between disciplines (Figure One), however, the majority of the horses in this study are geldings. Geldings are considered to be more consistent performers than mares, and easier to handle than stallions, thus this result was expected. High performing stallions and mares are required for breeding purposes, thus the number of these horses is of greater interest in genetic evaluation and selection than the number of geldings. In this study stallions constitute a total of 5% of the performance horses and mares 9%. In dressage there are 17 competing stallions, being 12% of all dressage horses in the study, this is greater than the number in both in eventing and showjumping, where 2% and 1% respectively of performance horses in those disciplines are stallions. The number of stallions found to be competing in showjumping in this study, is low compared to the 13% found to be competing in the same discipline in Ireland by The Irish Horse Board (IHB) (1996). Two factors may account for this, the first being the Irish study analysed data from all levels of competition, and it is likely that many stallions are retired to stud, or gelded, prior to reaching the upper levels of competition. The second factor contributing to the greater number of stallions competing in showjumping in Ireland is the trend in that country to use more entire males in competition with a view to the development of selection procedures. The percentage of females in the Irish study (37%) is also higher than those found in this project (15% dressage, 6% eventing, 7% showjumping), this may be a reflection of the use of mares in breeding, or the effect of the mares seasonal hormonal fluctuations, which may reduce their reliability in competition when compared to geldings.

Figure One Distribution of Gender in Dressage, Eventing and Showjumping



Age

The age distribution of horses in this study was from 5 to 24 years, with 9 horses over twenty years of age present within the data. The distribution of ages within each discipline is shown in Figure Two, where it can be seen that the majority of dressage horses (75%) are between the ages of 10 to 16 years. This range is narrower than that in the other two disciplines, where 76% of horses competing in eventing are between 8 and 16 years and 78% of showjumping horses are aged between 7 and 15 years, with a further 7% of showjumpers being 16 years old. These differences in age range are likely to reflect the physical demands of each discipline, with dressage being a highly skilled gymnastic sport, eventing a multiskilled discipline requiring a degree of gymnastic ability along with strength, speed and endurance, while showjumping requires precision and strength and some degree of speed. A great deal of time is required to learn the skills, and develop the strength, to correctly perform the movements required in the upper levels of dressage, thus it was expected that the dressage horses in this study would be older than those entering this level of competition in eventing and showjumping. It was expected that the high athletic requirements of eventing and showjumping, would result in less horses competing in these disciplines at an older age. However, the results indicate that horses compete in all disciplines to a similar age, with the eldest competitor, of twenty-four years, performing in eventing. Figure Two also shows the mean of total score for each age group, which will be discussed later.

Height

The average height of horses was 16 hands with a standard deviation of 0.51. It was found that the average height of horses competing in showjumping (15.94 hands) was lower than that of dressage (16.03 hands) or eventing (16.10 hands), but not significantly so.

Performance Data

Number of Records

Performance information was gained on a total of 548 horses. Although this is a large proportion of the horses competing at the elite level of competition, it is not an entire list. Numbers were limited from Queensland and New South Wales, as stated previously, and a further small group of horses was not included from Tasmania and Western Australia. Due to limited numbers of competitors, these latter states elected not to participate.

TABLE TWO PERFORMANCE AND PEDIGREE DATA AVAILABLE					
State	**Discipline**	**Total**	**Pedigree**	**Perform**	**Both**
NSW	Dressage	72	45	0	0
	Eventing	76	57	75	56
	Showjumping	21	14	19	12
Victoria	Dressage	48	29	39	22
	Eventing	83	60	70	58
	Showjumping	138	85	138	85
Queensland	Dressage	7	4	2	1
	Eventing	5	3	5	3
	Showjumping	2	2	1	1
Sth Australia	Dressage	19	10	19	10
	Eventing	28	16	28	16
	Showjumping	50	23	50	23
Total		548	348	290	287

Completeness of performance records

Number of placings could not be provided by the NSW Dressage Council, and this information was also limited, or lacking, on horses that had been transferred interstate during their career. This resulted in 290 records with a complete set of desired information being obtained. (Table Two). Using total score rather than score per placing in the analysis, the number of adequate records increased to 545, allowing almost full use of the data set.

Variations in Mean Score between age groups

Figure Two provides the means scores for all age groups in each discipline, it is shown that among the dressage horses there is an overall rise in the mean of total score from the age of 6 to 16 years, however a reduction is noted beyond this point. A dip is also present at the age of 15 years, it was found that the majority of these horses were advancing into the highest level of dressage competition, and as such were performing tests of increased difficulty, and competing against more experienced performers.

In eventing there is an rise in mean of total score from 30 points to 125 points from the age of 7 to 16 years, with performances generally declining from this age. The two peaks visible on this graph after the age of 16, represent the performance ability of single horses within the particular age group and are not likely to be repeated in all horses of this age.

There is less of an age related variation in mean total score within the showjumping horses, and apart from one peak, reflecting the performance of the highest scoring showjumping horse in the data, mean scores can be seen to rise from 50 to 160 points from the age of 5 to 22 years. This may indicate that there is a large component of competition based learning in showjumping, which increases the performance ability of individual horses. This factor is likely to play a role in all disciplines.

Mean and standard deviation of score

The mean of total score throughout all animals included in the data is 166.37, with a standard deviation of 202.27. Table Three provides the means of total scores per breed and discipline. The value obtained for Thoroughbreds, Stock Horses and horses of unknown breeding is similar, however, the value for the Warmblood horses is much higher. This variation may be due to the concentration of breeds within disciplines. The majority of Warmblood horses compete in dressage: a sport which is less physically demanding, and thus allows entry to more competitions throughout a horseôs career, providing the opportunity to amass more points. Analysis including the total number of competitions would provide a better estimate of the level of performance per competition, thus indicating if there are variations between the breeds and horses. The mean of score shown for dressage horses is very similar to that for Warmbloods in all disciplines, further indicating that this dressage competition is a major factor in the higher means obtained. Between the states it was found that the mean of score obtained in New South Wales was 224.81, which was higher than both South Australia and Victoria, where the means were 125.65 and 139.2 respectively. This is also likely to be a reflection of the greater number of dressage horses in NSW (Table Five) The standard deviation measured for dressage can be seen to be much higher than that for the other competitions, indicating there is a high variation between scores gained by Australiaôs top dressage horses.

TABLE THREE: MEAN VALUES OF POINT SCORE PER BREED AND DISCIPLINE

Breed	Number of Records	Mean	Discipline	Number of Records	Mean	Std. Dev
Thoroughbred	301	118.43	Dressage	146	392.36	236.79
Warmblood	101	327.01	Eventing	192	68.72	59.10
Stock Horse	30	129.83	Showjumping	211	99.92	98.20
Andalusian	3	127.00				
Quarter Horse	4	294.75				
Other	10	239.70				
Unknown	99	147.89				

Total Point Score per Number of Competitions

The total score gained by horses in competition was found to be strongly correlated to the number of starts in Irish showjumpers by the Irish Horse Board (Bartels 1996). As "points gained in scoring competitions" was the measure available for use in this study, it is logical that total score will rise with increasing competitions (Figure Three). Within each discipline it is shown that some horses have gained a greater number of points per number of competitions than their competitors, it is likely these horses have a superior performance ability, however, to estimate the significance of this performance level further investigation is required that will allow the estimation of individual breeding values.

TABLE FOUR MEAN NUMBER OF SCORING COMPETITIONS ENTERED PER DISCIPLINE		
Discipline	**Mean**	**Standard Deviation**
Dressage	51.61	21.88
Eventing	9.61	5.27
Showjumping	36.76	33.46

Mean and Standard Deviation of Number of scoring competitions

The mean of number of scoring competitions between disciplines was calculated (Table Four). Although the number of dressage horses is significantly lower than the number of horses in other disciplines, it is apparent dressage horses compete in a far greater number of competitions than horses in the other two disciplines. Similarly, showjumpers compete more often than eventers. Eventing is a more physically demanding discipline than showjumping and dressage, and this is likely to be the reason for entry into a lower number of competitions.

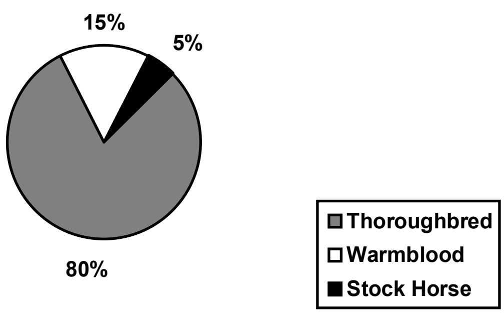
Pedigree Data

Table Five shows the distribution of breeds per state and discipline. The variation in number of horses accessed between states and disciplines can be noted. There is an obvious Warmblood influence in dressage competition, which was expected. The Thoroughbred was found to be the dominant breed in showjumping and eventing, indicating the superiority of this breed in sports that demand speed and endurance. Of the 30 Stock Horses competing in the upper levels, 68% were found to compete in showjumping with a further 28.5% competing in eventing. The Stock Horse has a major Thoroughbred influence, and so this result was not surprising. There are relatively few other breeds competing at this level, the most interesting being 2 Quarter Horses competing in the upper levels of dressage, when this breed is commonly known for western riding and stock work.

TABLE FIVE - DISTRIBUTION OF BREEDS PER STATE AND DISCIPLINE													
	Dressage				Eventing				Showjumping				Total
State	NSW	Vic	Qld	SA	NSW	Vic	Qld	SA	NSW	Vic	Qld	SA	
T/Bred	26	9	1	2	50	64	2	19	10	88	1	28	301
W/Blood	33	30	3	12	6	7	0	3	2	4	1	4	101
S/Horse	1	1	0	0	4	3	1	0	4	12	0	2	30
Andal.	0	1	0	0	0	0	0	0	2	0	0	0	3
Q/Horse	0	0	2	0	0	0	1	0	0	0	1	0	4
Other	3	1	1	1	1	0	1	0	0	2	0	0	10
Unknown	10	6	0	4	14	9	0	7	3	31	0	16	99
Total	72	48	7	19	75	83	5	29	21	137	3	50	548

The number of horses for which bloodlines were obtained is recorded in Table Two. It was possible to trace 348 horses from a total of 548 with records. From Table Five it can be seen that breed was not established on 99 horses, thus a further 101 horses could not be traced through their breed societies. Lack of, or incorrect, information obtained from the EFA on the identity of horses was the major reason for this.

Figure Four Distribution of Breed among Major Sire Lines



Greater than 70 specific bloodlines were present in the data distributed mainly between Thoroughbreds, Warmbloods and Stock Horses (Figure One). Table Six records the major Thoroughbred and Warmblood lines, the numbers of times the line is represented in each generation from the main sire, and the total number of horses containing this bloodline from either their dam or sire line. This table includes Thoroughbred sires that are represented in the bloodlines of 15 or more sports horses, and all major Warmblood sires. The Pharos (GB) and Gainsborough (GB) lines are clearly the most prevalent, this is an expected outcome as these lines are highly significant within the Australian Thoroughbred population. The genetic influence of the main sire reduces significantly over the generations and Oki, Sasaki and Willham

(1995b) recommend that pedigrees be traced back no more than five years. Table Seven provides those sires within the major lines that are within four generations of the majority of performers, and are represented in the bloodline of greater than 15 current sport horses.

TABLE SIX INFLUENCE OF THE MAJOR THOROUGHBRED AND WARMBLOOD LINES (INCLUDING NUMBER OF HORSES INFLUENCED).								
Main Thoroughbred Sire Groups.	**Number of bloodline entries within each generation**							**Number of Horses**
Generation Number	**3**	**4**	**5**	**6**	**7**	**8**	**9**	
Pharos (GB)	0	9	71	144	86	16	1	278
Gainsborough (GB)	0	3	32	90	93	66	18	233
Fairway (GB)	0	13	59	13	7			86
Bahram (GB)	0	13	35	35	15			83
Blenheim (GB)	0	6	26	29	18	2		69
Prince Rose (GB)	0	7	36	30	5			65
Djebel (FR)	1	14	21	9				44
Hurry On (GB)	0	4	19	18	2			40
Gold Bridge (FR)	2	13	19	5				37
War Relic (USA)	0	9	12	6	1			29
Bobsleigh (GB)	0	3	14	3	2			28
Bellini (GB)	0	1	13	13				24
Bois Roussel (FR)	1	11	8	1				19
Dante (GB)	1	9	6	2				17
Panorama (GB)	0	12	4					16
Polynesian (USA)	0	2	6	8				16
Supreme Court (GB)	1	11	4					15
Main Warmblood Sire Groups	**1**	**2**	**3**	**4**	**5**	**6**	**7**	
Gygant	0	0	0	1	9	2		13
Lugani I	0	0	0	8				8
Fax I	0	2	2	4				8
Foxlight	0	0	0	4	3			7
Altan	0	0	2	3	2			7
Sandor	0	0	0	6	1			7
Goldregen	0	0	0	4	2			6
Manometer	0	0	0	1	3	1		5
Pfrinzen	4							4
Hetilas	0	0	4					4
Dominik	0	2	1					3
Dolman	0	0	0	3				3
Witzbold	3							3
Total Influences								1,099

Never Bend (USA), who was named among the World Breeders Federation for Sports Horses (Bartels 1996) top ten eventing sires, is among the major sires in this data. A further two horses named by this organisation, Straight as a Die (USA) and Loosen up (USA), have collectively sired three Australian sport horses who compete in eventing and showjumping at this level. Within this data set it was found that the influence of the major Thoroughbred lines was distributed fairly evenly between eventing and showjumping.

The Warmblood lines significantly influence the population of dressage horses, with the Goldregen line, through Copernicus and Wesuw (IMP), and the Fax I line through

Flaneur, exclusively influencing dressage horses. Access to a greater number of Warmblood bloodlines would assist in ascertaining the true influence of specific sires.

TABLE SEVEN: SIRES FROM MAJOR LINES INFLUENCING MORE THAN FIFTEEN HORSES IN LESS THAN FOUR GENERATIONS		
Line	**Sire**	**No. of influences**
Pharos (GB)	Sir Ivor (USA)	19
	Bold Ruler (USA)	16
	Neocracy (GB)	16
	Sovereign Path	15
	Never Bend (USA)	15
	Rego (IRE)	15
Gainsborough (GB)	Alycidon (GB)	28
	Tudor Minstrel	26
	Biscay	*15*
Bahram (GB)	Big Game (GB)	28
	Biscay	*15*
Prince Rose (GB)	Round Table	22
	Bold Lad (USA)	17
	Prince Chevalier (FR)	16
Fairway (GB)	Honeyway (GB)	19
Blenheim(GB)	Crepello (GB)	16
Djebel (FR)	My Babu (FR)	23
Bellini (GB)	Ribot (GB)	23
Gold Bridge (FR)	Vilmorin (GB)	20
War Relic (USA)	Relic (USA)	17
Bobsleigh (GB)	Sovereign Path (GB)	16
Hurry On (GB)	Summertime (GB)	15

A major difference noted between Thoroughbred and Warmblood pedigrees, is the divergence of Thoroughbred lines to multiple sires of performance horses, and the convergence of Warmblood lines to a single or few sires. This reflects the variation in selection methods. The Thoroughbred is selected for Olympic disciplines on individual merit, considering conformation, and where possible, performance. However, the Warmblood horse undergoes strict selection procedures to allow its progeny to be registered with the Stud Book. The standard for classification is high with the aim of improving the genetic quality of the breed. Thus, relatively few stallions pass. In Australia, the Warmblood population is small, and such selection procedures would reduce the genetic variability to a level that could inhibit genetic improvement if this stud book was closed. However, the use of Thoroughbred mares and importation of semen allows input from other bloodlines. Thus the Warmblood Society selects high quality horses with a high performance ability, and this maintains genetic variability and enhances genetic improvement. Selection procedures should be designed to increase the heritability of desired traits, and thus improve genetic quality.

Computer Analysis - DfREML

Using DfREML, varying amounts of pedigree information were entered for each calculation to note the effect on the heritability estimate obtained.(Table Eight)

TABLE EIGHT ESTIMATED HERITABILITIES AND STANDARD ERRORS							
Trait	score	log	score	S.root	score	scores	log
Fixed Effects	Yr sex state brd	yr sex state	yr sex state	yr sex state	breed	breed	sex
Co variables	-	-	-	-	height	-	-
No. of records	211	548	548	548	548	548	548
No. of animals	227	1382	4867	1382	2785	2785	1382
Sires with progeny records	0	406	407	406	185	185	406
Dams with progeny records	0	434	434	434	125	125	434
Heritability	0.47	0.63	0.76	0.71	0.71	0.77	0.67
Standard error	1.4	0.12	0.15	0.12	0.27	0.27	0.11

1. *All fixed effects*

Using year, sex, state and breed produced a moderate heritability score, however, the standard error is very high, thus this measure must be treated with some caution.

2. *Year, Sex and State as fixed Effects*

These fixed effects were used in calculations using score, log transformed score and square root of score, The heritabilities gained are high (0.63 to 0.76), with standard errors of 1.2 to 1.5%. Different levels of pedigree information were included in these calculations, with the result that heritability was higher with more pedigree data.

3. *Breed as a fixed effect*

When breed was included in the model as a fixed effect, the heritabilities remained similar to those obtained with the fixed effects of year, sex and state, however the standard error increased. Height was included as a covariate in one of these measurements, and the heritability was reduced slightly, even though, the estimate remained high. Height could not be utilised in the analysis as a trait, as a greater number of horses within each discipline would be needed to allow the estimation of the influence of height on performance.

The heritability estimates obtained, varied from 0.47 to 0.77. These estimates are higher than expected, especially when compared to other published results on sport horses. However, they agree with the heritability estimates of 0.45 to 0.82 for performance rates of Australian Thoroughbreds gained by Williamson and Beilharz (1996). If accurate, this level of heritability would indicate that the potential for elite performance among Australiaõs sport horse population is high. It was also noted that the phenotypic standard deviation obtained by using log transformed score is fairly large (0.8819 to 0.9325) this may indicate that although the heritability of total score is high, the current selection procedures are not efficient enough to remove the large variability. Thus the Australian sport horse population may benefit from a more efficient selection program.

A number of sources of bias may have influenced the calculation of this high heritability estimation. These include the following:

1. In some cases there may be a permanent environmental effect due to horses being raised and trained on the same property, in other cases the similarity of stabling and feed and routines may be significant. The trainer effect is often considered to be a part of the environmental effect, however, some workers prefer to treat it as a herd effect. It is likely, the top horses are trained by the top trainers. Thus, this environmental effect represents the combination of a skilled rider and horse, and this may bias the heritability estimates upward.

2. As shown in Table Six, there are greater than 1,000 entries of the top seventeen Thoroughbred sires in the current performing population. Thus many of these horses are more than half siblings. This is likely to bias the heritabilities obtained upwards.

3. Assortive mating may also influence the upward trend of the heritability estimate. In the Thoroughbred population it is known that the best mares are mated almost excusive to the best sires, thus this trend may be demonstrated by these current results. The Thoroughbred mares used for breeding in the Warmblood population are required to be classified, and this is likely to enhance the effect of assortive mating further.

4. As stated, the heritability estimates obtained represent the sport horse population as a whole. Thus when relating these estimates to a particular breed or discipline they may not be accurate. The way in which they are biased for any particular group would require further research to ascertain.

5. By using the top horses in this study, the heritability score may have been influenced upward, as all these horses display the phenotypic ability to perform at this level.

6. Significant problems were encountered while running DfREML to analyse the data. These problems were due to the use of total points score as the performance measurement. This trait is not distributed normally and as such does not fit the basic assumption of DfREML. The inclusion of total competitions entered would have produced a data set which approached normality more closely, and thus would be expected to provide a more accurate heritability estimate.

CONCLUSION AND RECOMMENDATIONS

This project was commenced to determine the level of data available within the sport horse industry and investigate if this information is adequate to undertake genetic research. This study has ascertained the level of specific breeds competing in the upper levels of Olympic competition, along with the major bloodlines. An estimate of heritability was obtained using score as a trait, however, the value of this measurement may contain serious bias.

As mentioned above, the level of information available in Australia is poor. Large deficits were found within both performance and pedigree data, and this has severely limited the validity of statistical analysis. For further genetic research to be successfully carried out on the Australian sport horse population, a number of changes will be required within the industry.

<u>Recommendation One</u>: Assessment of measures taken at competitions and consideration to the recording of more information per event.

Further study is required to identify the traits which best demonstrate a horses biological ability. Score, which is awarded at varying levels depending on the level and quality of competition, and the number of horses competing within the event, is not a good measure of performance ability. This trait does not show a normal distribution and as such is not accurately assessed by computerised selection packages. A number of measures can be recorded from competitions, such as number faults or error points, times, placing and winnings. The introduction of a ranking system which considers all horses in the event, and the specific measures of the competition, such as errors and times, would allow the collection of data which reflects the biological variability within the Australian population of competing horses, and thus ensure genetic analysis is accurate.

In racing analysis, the other horses within the race are also looked at, as it is found that individual performance rises with higher quality competitors. This may also be true within the sport horse population, and as such would be worthwhile to include this information in performance records. Prize money for sport horses in Australia is low, and at times non-existent, and so it is not expected that this trait would be of use within this population.

Recommendation Two: That all competitions entered be recorded, along with the horse's placing within the field.

Currently only those competitions in which a horse gains a winning place are recorded by the EFA. To ascertain true performance levels, it is important to know how many competitions in total were entered, along with the placing within the field, winning or not. The number of competitions entered varies greatly between horses, and so total score is not truly comparable between animals.

Recommendation Three: That all breed societies operate stud books on a federal basis.

Among the breed societies contacted for this project, the Warmblood Horse Association is the only one that operates its stud book on a state basis. This method of organisation makes tracing the bloodlines of these horses difficult, especially when horses are often moved interstate. In this case their bloodlines remain in the state of origin. The Warmblood Association, realising this problem, are currently working on a computerised package to record all Australian Warmblood pedigrees. However, this package has been planned for the last two years, and original records have not been updated since this package was approved. Thus Warmblood pedigrees were hard to obtain.

Recommendation Four: That the EFA federal branch sets guidelines for the provision of information for research purposes, and that all states adhere to these guidelines.

The EFA operates on a state basis, and access to information from individual branches varies. The EFA offices in Victoria and South Australia offered great assistance, but in NSW information was limited, because specific discipline councils control records. The Queensland EFA refused to give any assistance on the grounds of confidentiality, and they were unable to see the need for, or benefits of, research into our sport horse population. All other states were contacted to gain access to performance records, however, due to there being very few competitors in these states no information was forthcoming. This variation between state branches, on policies concerning information access, affects the results of research, making them less representative of the horse population as a whole. With the development of information access for the purpose of research, or a central record of performance results, these problems could be removed.

Recommendation Five: That the EFA require proof of identification prior to registration.

The difficulties faced while tracing horses from the EFA to the relevant stud books could be avoided through greater collaboration between these groups. The EFA is concerned with performance, whereas breed societies are concerned with breeding and bloodlines. Performance horses are all specific breeds or combinations of breeds, and through insisting on the provision of identifying information from the horsesô original stud book, where one exists, and by recording the name and number allocated by that stud book, the EFA could ensure that these horses are able to be identified and traced to their breed society. This would be of great assistance in research in the current organisation of the industry.

Recommendation Six: That future research includes a larger range of competition levels.

Many problems encountered during the analysis were due to insufficient data, which was not entirely a result of the lack of access to information. Only the top two disciplines were used in an attempt to reduced the rider/trainer effect within the experimental group. Australiaôs elite sport horse population is not large, so this decision restricted the analysis. The inclusion of horses that compete at lower levels would overcome some of the problems of insufficient data.

Insufficient data forced heritabilities to be ascertained for all horses as a single group. The performance traits between disciplines and breeds are different, therefore to be accurate, heritabilities should be estimated for each group. This will further demand that measures of performance accurately reflect the physical ability of the animal.

A further advantage of increasing the size of the data set is the increased knowledge of influential bloodlines, allowing the recognition of discipline and the level progeny compete at.

<u>Recommendation Seven</u>: The development of a national performance and pedigree body responsible for maintaining records and research into performance and breeding.
The EFA is currently our national performance body, and as such is concerned with the organisation and Coordination-ordination of official competitions, recording of results from these competitions and the registration of horses. Currently discussions are under way to form a federal body, however, a complete change in record keeping and focus of results is unlikely. Australia could benefit from a national body for the collection and collation of performance and pedigree information, as this would enable easier access to accurate information which could be used for research purposes. This body could concentrate on the development of criteria for the measurement of performance, and develop the data base required to accurately estimate heritabilities and breeding values within the Australian sport horse population.

Through establishing and maintaining contact with the industry, a national body would function to enhance the selection knowledge and practises within the sport horse industry. Through this service functioning to enhance the genetic quality of the Australian sport horse population, rather than for short term gains through overseas sales, consistent high quality sport horse production will be the outcome. In the long term this will maximise returns through the production of a greater number of horses with high performance ability available for breeding, performance and sales.

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