EXAMINATION OF ALTERNATIVE SELECTION POLICES FOR SPORT HORSE BREEDING IN NEW ZEALAND

A thesis presented in partial fulfilment
of the requirements for the Degree of Master of
Agricultural Science
in
Animal Science
at
Massey University

CHRISTOPHER WILLIAM WARNOCK ROGERS

1993

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ABSTRACT

The present structure for breeding sport horses in New Zealand was summarised. The New Zealand sport horse breeding population probably consists of about 5750 mares mated to 288 stallions. There are approximately 35,000 horses in the total recreation category of which about 4500 are registered for competition use with the New Zealand equestrian federation.

Most horses produced will be used locally but there is a lucrative export market. Breeders range from amateurs with 1-2 mares producing mainly for their own use through to professionals with sizeable herds. Some are heavily involved in exporting.

At present the industry lacks an effective genetic improvement structure. A high proportion of breeding stock are recruited from the racebred thoroughbred population and are not evaluated for a sport horse objective before entry. If sport horse breeding is to attain its potential a more efficient structure must be developed.

A industry objective was identified for the breeding, development, and competition system. Economic weights had to be subjectively derived due to limited industry data.

Alternative single stage schemes to generate genetic response in the proposed breeding objective were compared using deterministic models. Benefits and costs were predicted and analysed. The one day field test appeared to generate the most genetic progress and the best benefit-cost result of the single-stage sire-selection models. Station tests lasting 14 - 100 days gave good genetic gain although it was assumed that high costs would greatly limit the number of 3 year old colts tested as potential sires in comparison with the one day field test. Selection on data generated in competitions restricted to young horses also generated a good rate of genetic gain.

The use of the one day field test to evaluate dams of sires as well as potential sire candidates offered an 7.7% increase in total genetic response. This model offered the best benefit cost result due to greatest efficiency of genetic improvement but it also offered significant secondary benefits. However further research on other alternatives is desirable before an evaluation programme is firmly established.

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CHAPTER ONE
INTRODUCTION

The belief that New Zealand could successfully establish an export industry for horses was first proposed in 1892 "There are few, if indeed there are any climates better adapted to the breeding and rearing of horses of all kinds than that of New Zealand" (Von Dadelszen 1892). More recently overseas buyers have proposed that New Zealand offers the best environment in the world for producing sport horses. If New Zealand develops a Sport horse breeding programme, it could create, in 10-15 years, an enormous industry that could export quality horses all over the world.

The success in international eventing and showjumping competitions of a number of New Zealand-bred sport horses, has focused world attention on the New Zealand sport horse industry. The New Zealand sport horse studbook has recently become recognised by the Federation Equestre Internationale and was this year ranked 11th highest performing studbook (out of 16 studbooks) based on international performances of registered stock (Libbrecht 1992). The increased demand for the New Zealand-bred sport horse on the export market has been reflected by increased prices. These have fuelled the transition of sport horse production from a hobby enterprise toward a professional industry.

Within Europe, the production of sport horses is a highly organised industry often receiving significant financial support from both local and central government (Kidd 1980, Clarke and Wallin 1992). As the New Zealand sport horse industry is making the transition from an amateur hobby to a professional industry, it has become apparent that in order to maintain or increase its current market share the industry needs a nationally coordinated selection and breeding programme. This need is emphasised by Ireland's diminishing market share and export returns while continental European countries with their national selection and breeding programmes are experiencing expanding market shares and export returns.

The primary objective of this study was to model the impact of various selection and breeding programmes on the New Zealand sport horse population. Because of the current lack of literature addressing sport horse breeding in New Zealand a number of secondary objectives needed to be initially addressed, these being:

a) to identify the present industry structure and its potential for development,

b) to formulate a breeding objective for the New Zealand sport horse in both its simple and complex form, and,

c) to derive a selection index utilising economic weights applicable to the New Zealand sport horse industry.

The need to satisfy these secondary objectives before addressing the primary objective of development of a selection and breeding programme suitable for the New Zealand industry was based on the proposal of Harris et al (1984).

CHAPTER TWO:
LITERATURE REVIEW:

2.1 DEFINITION OF A SPORT HORSE:

Tavernier (1988) proposed that sport horses are horses that partake in the activities of showjumping, dressage, and eventing. The expansion of these activities has been rapid in the last few years. This situation has led to the creation of a new horse market for a sport greatly influenced by the jumping shows (Langlois et al, 1983).

2.2 BREEDING OBJECTIVE

2.2.1 Introduction

According to Dickerson and Hazel (1944) the first aim of a breeding programme is to produce 'most improvement per unit of time', but how is "most improvement" defined? A key decision in any animal improvement programme is to decide what will constitute the most desirable improvement. The objective defines what the breeders seek to maximize in their population. Clear definition of breeding objectives is essential if livestock breeding programmes are to have maximum impact on the efficiency of animal production (Harris 1970, and Dickerson 1982). If the objective is poorly defined, the genetic changes made can be "sub optimal" and at worst in the wrong direction. Too often, in the long history of animal breeding, objectives have been determined by fashion, or ease of producing obvious genetic changes in size, conformation, or production of animals, without adequate examination of net effects on life cycle efficiency for production (Dickerson 1982).

Some breeders may seek to maximize resemblance to some conceptual ideal animal, but more often the objective will be some measure of economic performance (James 1982). James (1982) drew attention to the difficulty in deciding the level of detail required in specifying the objective. As explained by Harris et al (1984), the objective should be determined as a mathematical function, or set of functions that describe the contributions of various aspects of the system (especially the genetic aspects) to its productive efficiency. They also stated that the objective should be described in both its simple and complex form. Ponzoni (1986a) proposed that the establishment of a breeding objective can be described as consisting of four phases:

(i) specification of the production and marketing system,

(ii) identification of sources of income and expense in commercial populations,

(iii) determination of biological traits influencing income and expense, and

(iv) calculation of the economic value of each trait.

These four steps are very similar to the first four steps of the eight steps Harris et al (1984) suggested should be followed when establishing an animal breeding programme.

Fowler et al (1976) highlighted that while the choice of objective is an important and sometimes difficult decision, at that time it was rarely treated as a topic in its own right in scientific literature. Dickerson (1982) stated that professional geneticists had neglected definition of breeding objectives in livestock improvement. Great strides had been made in developing and refining methods for maximizing rate of genetic change in any performance trait, or combination of traits, but breeding objectives had seldom been carefully evaluated in terms of expected net effects on efficiency of livestock production. Fowler et al (1976) proposed a number of reasons for this. One is that their resolution requires an understanding of a far wider field than genetic theory alone. Another is the reluctance to attempt to stabilize selection objectives in a dynamic environment of evolving production systems, advancing nutritional science and changing market requirements. Land (1981) emphasised the problem of forecasting future requirements when setting the breeding objective, proposing an "alternative philosophy of developing strains of divergent biological characteristic's". Wickham (1975) and McArthur (1982) proposed that the production and preservation of animals bred for different objectives may provide some future flexibility to meet changes in demand. Individual breeding groups and the government were suggested as likely candidates to take on such responsibility.

2.2.2 Who should benefit from the objective ?:

Moav (1973) drew attention to the problem of who benefits from genetic gain. Discussion as to who should benefit from the extra profit obtained by genetic response in the objective has been provided by Miller (1977), Miller and Pearson (1979), and Moav (1969 cited by Pearson and Miller 1981). Pearson and Miller (1981) also drew attention to this problem, providing discussion as to a national vs individual viewpoint. Nationally, supply and demand are important considerations. Increases in production income are worth relatively less than decreases in expenses for the additional output probably will not sell at the current price. In contrast to the national viewpoint, increases in production are relatively more valuable to the individual producer as they can market their increased production without affecting the price received.

2.2.3 Economic vs biological objectives:

It is simplest when evaluating a breeding programme to deal solely with physical measurements and ignore monetary costs and benefits. Interest rates, commodity prices and trade balances fluctuate markedly and the future demand/price relationship can never be known exactly (Hill 1981).

Economic objectives relate directly to some measure of the maximization of profit from the production system. In contrast biological objectives relate to increased output and biological efficiency economic consequences being only indirectly considered.

The application of an objective relating to economic performance (eg. profit maximization, economic efficiency) may be approached via a biological objective (increased output, increased efficiency of feed conversion) though biological efficiency may not directly translate into economic efficiency. Fowler et al (1976), when comparing economic and biological objectives for pig breeding, found that in a fixed situation the results were similar for both models. The main advantage of the biological model is that it gives good predictions of changes in traits and what selection policies should be applied in different situations. Harris (1970), Scoville and Sarhan (1978) and Rae (1982a) identified that the primary goal of most livestock producers is, simply to make money. Their objective, like that of most people, is to carry out a profitable operation so as to secure an adequate income for realizing desires as to living conditions, education for children, etc. Because of this Hill (1981) argues that every attempt should be made to set an economic objective.

2.2.4 Profit satisfiers vs maximisers:

Daniell (1970), Wickham (1981) and McArthur (1982) suggested that, for breeders, sometimes aesthetic factors offer greater marginal utility than increased income. McArthur (1987) found that in western countries there is an increasing trend towards a business perspective among farmers indicating a change from being "profit satisfiers" towards "profit maximizers". Rogers (1991a) suggested that people tend to be involved in thoroughbred breeding because of a love of horses, and for the lifestyle horse breeding offers, rather than the maximization of economic returns. Because of this, thoroughbred breeders may tend to be profit satisfiers rather than profit maximisers. Being able to breed a good racehorse may offer greater marginal utility than to achieve an economic objective of profit maximization. Dickerson (1982) proposed that efficiency of production should be the breeding objective, but stated that while this approach is acceptable for livestock used to produce food or fibre it may not be the objective of choice for animals kept for pleasure or companionship.

2.2.5 Types of goals in horse breeding:

European sport horse breeders seem to have chosen a biological rather than economic objective (Huizinga & Van Der Meij 1989, Philipsson et al 1990, and Tavernier 1990a). Klemetsdal (1990) stated that "it is often claimed that the genetic gain in these traits is not associated with profit" thereby making the establishment of an economic objective redundant. Harris (1970) proposed that the main source of long term profitability for a livestock producer seems to lie in their competitive advantage over other producers. Therefore, if the whole industry made genetic progress for the competition performance traits of jumping and dressage there would be no competitive advantage, and hence no profitability from genetic gain in these traits. However, if the objective is being defined for the a nation, genetic gain in these traits may confer a competitive advantage over another nations sport horse breeding industry.

Langlois et al (1983) proposed that horse breeding objectives are highly variable. He raised the question of whether it would be advisable to found a large number of "schools" around the many breeders and users associations, leading to rapidly to a very dispersed structure.

Nissen (cited by Slavin 1990a) stated that the majority of horses are ridden as a hobby and for pleasure, so breeding good quality horses is the first priority with specialization being secondary. Two situations can be distinguished. The first is that of a product with a high added value. It corresponds to a capital intensive production system conducted by professionals and with pure-breed selection by performance testing. The second corresponds to a product with low added value. It is a semi-extensive or extensive system (low investment) conducted by amateurs using cross-breeding to supply saddle and draught horses for leisure or rural activities. Strom & Philipsson (1978) proposed that the breeding objective for most populations of sport horses is not competitive ability alone, but includes riding traits such as willingness to work and, ease of handling. They suggested equal importance might be placed on these two groups of characteristics. This appears to be the predominant theme throughout the published objectives set by many European sport horse breeding associations. Their objectives tend towards breeding a quality riding horse suitable for all riding purposes rather than specialization towards breeding specifically for one aspect of the market (Tavernier 1990a, Philipsson et al 1990, Huizinga & Van Der Meij 1989). Langlois et al (1983) proposed that while the breeding objective may be multi-trait this does not mean that the same horse may participate in all the forms of equestrian activities with the same success, but that the range of horses produced may be fitted to the different types of uses. However, some breeders are becoming increasingly specialized and on account of the economic importance of competitive activities such as jumping, the creation of specialized lines seems to be possible.

The definition of a sport horse provided by Tavernier (1988) and Langlois et al (1983) clearly demonstrated that, when setting a breeding objective for sport horses, a multi-trait objective is required. Even when evaluation is directed to competition performance traits, at least two traits, jumping and dressage, have to be dealt with (Huizinga & Van Der Meij 1989).

Klemetsdal (1990) proposed that genetic gain in performance traits was not always associated with profit, citing potential areas for the industry to take in the objective as:

(a) to stimulate the local horse production, reduce the cost of importation and increase the income from exportation of animals

(b) to reduce the labour cost attached to preparing a horse for competition.

Klemetsdal (1990) also stated that the common types of unsoundness eg. osteochondrosis and carpitis show quantitative variation in their occurrence, and should be included in the breeding plan.

2.3 METHODS OF COPING WITH MULTI-TRAIT ObJECTIVES:

The traits in an objective are unlikely to be of equal economic importance or totally independent of each other genetically or phenotypically. Methods of selection which cope with multi-trait objectives have been described and discussed by Hazel and Lush (1942), Finney (1962), Abplanalp (1972), Jones (1982). These methods were:

Tandem selection,

Independent culling levels,

Selection of extremes and,

The selection index.

Index selection usually is more genetically efficient and never less efficient than other methods of selection when two or more traits are involved. Thus for multi-trait objectives under most conditions, use of a selection index is likely to result in the greatest genetic gains. Hence, it is not surprising that the literature contains a vast amount of discussion on selection index theory (McPherson 1982).

2.4 TRAIT WEIGHTINGS:

Objectives usually include more than one trait and it becomes necessary to devise a system that leads to the different traits receiving the appropriate emphasis.

The relative economic value (REV) for a trait may be derived from changes in the relative market value associated with changes in each trait under consideration. Alternatively, the relative preferences of the breeder may be derived from some other consideration (Turner and Young 1969). Moav (1973) pointed out that estimates of the economic weight and the value of a unit improvement in a trait, depend on the perspective taken; whether it is based on the values applying to the producer or production unit, or the national interest. Hazel (1943) stated that, the relative economic value of each trait depends upon the amount by which net profit may be expected to increase for each unit of improvement in that trait. McArthur (1987) revised Hazel's (1943) definition of REV's as "the amount by which net benefit of the optimal policy may be expected to increase for a unit improvement in that trait."

2.4.1 Methods of Estimating Economic Weightings.

2.4.1.1 Subjective Assessment.

Jones (1982) suggested that many horse breeders when utilizing a selection index, tend to use subjectively judged REV's. The use of subjective economic weights, personally assessed by the breeder, seems to have originated at least 2000 years ago (Varo,BC37; cited by Turner 1956).

Wickham (1981) suggested that, in the early days of sheep breeding, the use of subjectively assessed economic weights may have been reasonably successful as the breeder tended to be the user and could readily evaluate which traits were most important in giving the best final product, and presumably, the greater benefits. With the advent of more complex marketing and distribution systems for the breeder's products, the establishment of accurate relative economic values became more difficult. This often seems to have led to the assignment of unfounded subjective economic weights to traits. Subjective weights may be thought of as intelligent guesses rather than accurate estimates. This method is generally not recommended for use by modern commercial breeders to assess economic weights (McPherson 1982). However with horses the breeders tend to also be major users of the product so subjective weights may be accurate provided the breeder has given adequate consideration to what is really wanted. Bruns (1987) found that subjective economic weights provided the most logical weightings for the index used by Hannoverian sport horse breeders.

2.4.1.2 Genetic progress required.

Pesak and Baker (1969) and Baker (1974) referred to this method as selection for desired gains. Yamada et al (1975 cited by Crow et al 1990) and Brascamp (1978) further developed the theory relating to the desired gains index. Crow et al (1990) further extended these methods to the context of multi-trait Best Linear Unbiased Prediction (BLUP).

Schlote (1977) reported that the selection for desired gains can cope with restricted selection indices, where the subjective optimum is replaced by a more clearly defined objective. Gibson (1989) recently showed this to be a specific case of ordinary REV's for a poorly defined system.

2.4.1.3. Regression of selling price on product trait levels.

This procedure estimates the amount of control the independent variable (traits) have over the dependent variables (price) and their respective regression coefficients (McPherson 1982). The economic weight of traits can be calculated as the product of the simple regression coefficient of that trait, and the average price received for the product (Dunlop and Young 1960).

Dunlop and Young (1960) proposed that to isolate the importance of each trait in determining the price of a product, each variable can be deleted from a multiple regression analysis, and the loss of control over the price, after each deletion noted. It is possible to include curvilinear (quadratic and cubic) terms (Skinner 1965) and product terms in the analysis (McKinnon et al 1973) to increase the control the analysis has over prices.

Gibson (1989) suggested that calculating economic weights by regression of selling price on product trait suffers from not accounting for inputs and thus takes no account of the efficiency of producers, yielding inflated economic weights with an incorrect balance between components.

2.4.1.4 Regression of profit on the selection objective traits.

This method is essentially the same as previously described for product trait levels (2.4.1.3) except that profit replaces price as the dependent variable, and traits in the objective are included as independent variables.

Pearson and Miller (1981) stated that for a dairy enterprise in the USA a profit function can be specified for each individual of a population of animals, preferably on a multi-herd basis, with the inputs and outputs weighted by their respective prices. Economic weights can then be calculated as partial regression coefficients of the profit function, on traits in the selection objective.

This approach has deficiencies because certain traits are omitted, and those included may not be accurate predictors of the indirect effects. The allocation of the costs to the individuals can also be very complex (Pearson and Miller 1981).

James (1982) stated that there will always be difficulties with regression approaches. The predictor variables included tend to be limited. The data available frequently do not include one or more important traits. Another difficulty is that the data are based on past values when breeding is for the future. There is a need to modify REV's to include perceptions of the future.

In contrast to this, Balaine et al (1981) proposed that if economic efficiency is determined as profit per day, then different price regimes may have negligible effect on individual rankings.

The high data collection costs suggest a limited application and application only to those herds having the greatest influence in genetic improvement (Pearson and Miller 1981). A difficulty of using such a technique in the New Zealand sheep industry, would result from the difficulty of accurately estimating individual feed costs (McPherson 1982). This difficulty of accurately estimating feed costs would also apply to the New Zealand sport horse industry which is also pastoral based.

2.4.2 Production systems analysis.

All the methods previously discussed to provide economic weights have approached this topic from an individual animal viewpoint. However, the improvement of a trait can change the optimal organisation of a farming enterprise. Hence, another approach involves expressing economic efficiency in a farm planning, or production systems analysis context (McPherson 1982).

Systems analysis refers to the techniques where it is attempted to account for all major inputs and outputs by the use of mathematical models that describe sets of dynamic, interacting processes that are considered to include all of the effects important in influencing the outcome (Cartwright 1979). These complex inter-relationships tend to be ignored with the relatively simple 'per animal' profit functions. The effect of such simplifications on selection accuracy has yet to be determined.

The advantage of the production system analysis technique is its flexibility. The analysis can be applied to suit the varying production conditions of individual breeders. The breeder specifies the production function, input-output prices, and the average level of traits in the flock (Rendel 1982).

This approach requires a vast amount of data for an accurate computation. This would be beyond the scope of most breeders when there is only one trait, let alone a multi-trait objective with at the very minimum 2 traits, as with sport horses. Brash et al (1990) identified that for Australian beef cattle breeders the tabulating and collecting of such data for the development of breeder customized economic weights may prove difficult even if a relatively simple system was modelled.

Wilton et al (1979) proposed that the specified functions can not be easily derived and because of this continued selection on a profit per animal basis is preferable, at least until the effects of the previously mentioned simplifications can be assessed. However, Garrick et al (1986) have successfully modelled lamb growth and feed consumption for a New Zealand lamb production system, demonstrating the potential feasibility of this approach.

2.4.3 Published economic weights for sport horses.

To date only Bruns et al (1978) and Schwark et al (1988) have attempted to calculate REV's for sport horses. They used partial regression of sale prices on phenotypically measured criteria. Relative economic values of each of the criteria were derived from partial regression coefficients of the standardized log of sale price on the measurements of the relative criteria (logarithm of earnings transforms the asymmetrical distribution to a symmetrical normal curve). This regression of value on phenotypic measures is very similar to that performed by Andrus and McGilliard (1975) for dairy cattle. A potential flaw in this method is that phenotypic and genetic associations between traits are not always stable (James 1982).

Table 2.1: Published economic weights for sport horses:

AUTHOR	TRAIT	RELATIVE ECONOMIC IMPORTANCE (%)
Bruns et al (1978)	Hannoverian elite auction horses	
	Capacity to work	22.0
	Char / Temp	18.4
	Rideability	15.5
	Movement	14.8
	Dressage ability	14.5
	Jumping ability	14.8
	Oldenburg elite auction horses	
	Conformation	7.1
	Walk	5.0
	Trot	41.6
	Canter	26.4
	Jumping ability	20.9

Schwark et al (1988)[1]	Stallions exported			
	Wither height	9.74	--	--
	Conformation	19.26	21.34	--
	Movement	17.63	19.54	24.84
	Jumping ability	27.38	30.33	30.39
	Char / Temp	4.41	4.88	6.21
	Rideability	21.58	23.91	30.39
	Mares exported			
	Wither height	20.90	--	33.60
	Conformation	41.29	62.20	66.40
	Movement	37.81	47.80	--

1. Schwark et al calculated 3 different sets of economic weights.

2.4.4 General problems associated with the use of economic weights.

Until recently relatively little research was directed toward examining the properties and problems of economic weights (McPherson 1982). Bright (1991) identified the different approaches taken by economists and animal breeders when calculating economic weights. Economist's when modelling profit changes would base their analysis on the production function, which is the physical relationship between inputs and output and is widely accepted, both in theoretical and empirical studies, as exhibiting a non-linear form. Animal breeders tend to utilize a simple profit equation, linear in form. Bright (1991) compared the accuracy of these two approaches, concluding that the simple linear profit equations are likely to be sufficiently accurate in most circumstances.

Selection index theory (Hazel 1943) assumes that the economic weights are known fixed constants. Vandepitte and Hazel (1977) stated that economic weights are seldom known with complete accuracy, and therefore this assumption is almost never fulfilled. Even in the most favourable conditions economic weights are still estimates. In this situation the economic weights are unbiased, but have usually fairly large sampling errors. For some traits however the economic information is lacking or partially available; in these circumstances economic weights are intelligent guesses rather than accurate estimates.

James (1982) emphasized that breeding objectives and their REV's are by nature speculative. Breeders should attempt to forecast market requirements for the future, while staying in business in the short term. While current profitability assumes greater importance, what constitutes profit now may not be relevant in the future. This is exacerbated by:

(a) changing markets,

(b) time lags in, or interference from market signals along the chain from consumer to seedstock producer and,

(c) slow rates of genetic improvement making it difficult to respond quickly to changes in market requirements.

Economic weights should reflect production costs and consumer preference through the pricing mechanism. Therefore the economic weights have to be adjusted periodically for changing economic situations and consumer choice.

The planning horizon for animal breeding should be medium to long term in order to reap its full benefits. Thus, the derivation of economic weights should take into account the long term structure of the market and not just immediate circumstances (Gibson 1989).

Moav (1973) found that the economic weight depends on the perspective taken. Vandepitte and Hazel (1977) proposed that individuals have their own ideas and goals, and each tends to work in the economic framework of their own enterprise. For this reason every breeder and producer has their own set of economic weights. Because of the long term nature of a breeding policy, the industry as a whole should have a well defined set of realistic goals.

McClintock and Cunningham (1974) proposed the discounted gene flow method to account for delay reaping returns in breeding plans. Ponzoni (1986b) highlighted that the relativities of economic values are not altered much by adjusting them for time by discounting. Also, breeders may be loathe to adopt decision procedures they do not understand completely. More recently McArthur and Del Bosque Gonzalez (1990) proposed a simpler method of adjusting economic values for delay using diffusion coefficients.

2.4.5 Effect of errors in economic weights on selection index efficiency.

Pease et al (1967 cited by Vandepitte and Hazel 1977) and Ronningen (1971) studied the effect of errors in estimation of economic weights, both concluding that the loss in efficiency is not serious when moderate deviations from the true economic weights are used.

Fowler et al (1976) found that the economic value of genetic improvement by a selection index is fairly insensitive to moderate changes in economic weights. Vandepitte and Hazel (1977) also found this to be so, with single errors in economic weights of +/- 50% having less than 1 % reduction in the relative efficiency for all traits considered. The effect of errors in single economic weights are non-linear and non-symmetrical. Negative errors (underestimation) are in general more critical than positive errors (overestimation).

Jones (1982) stated that "small errors in economic weights will not have great effects providing, the economically most important traits are given the heaviest weightings and their sign (positive or negative) is correct."

Only in certain balanced situations are selection indices sensitive to changes in economic weights. This occurs when the product of the economic weight of the trait and heritability are similar for all traits in the index. Thus, the effects of the anomalies in estimating economic weights may have more of a conceptual rather than practical importance (Smith et al 1986).

2.5 SELECTION OBJECTIVES AND CRITERIA IN SPORT HORSES:

The selection criteria are those traits which are addressed in order to predict the genetic worth of each animal in terms of the objective (Morris et al 1982). Since direct selection for the objective is often difficult, expensive or impossible, criteria may not be in the objective and an objective trait may not be among the criteria (McPherson 1982).

It is only in recent years that a clear distinction has been made between selection objective traits and selection criteria traits (James 1982). The traits in the objective are those desired to be changed, or the 'ends', while the selection criteria are the 'means' to those ends (Ponzoni 1988).

2.5.1 Performance.

Hintz (1980) stated that one of the most important decisions is that of which criteria to use to measure performance.

Performance in sport horses can be measured by a variety of criteria. In France competition success is assessed as earnings per year (Langlois 1980, Tavernier 1990a). Tavernier (1990b) proposed a system utilizing the rank of horses in competition, although this appears to still be at the theoretical rather than practical level. In Germany the criterion is earnings per start (Bruns 1981, Meinardus and Bruns 1987, Meinardus and Bruns 1989). As opposed to earnings, both Sweden and the Netherlands use a criterion relating to place values. In Sweden the criteria are the number of placing's and the number of starts (Philipsson 1975), while in the Netherlands the criterion is the lifetime total (Huizinga and Van Der Meij 1989).

With the exception of France, which does not utilize central performance testing for sport horses, the criteria used to evaluate performance at station are subjectively appraised 'scores' using a scale of 0 to 10 (Bruns et al 1980, Arnoson 1987, Bruns 1987, Grundler and Pirchner 1991, Huizinga et al 1991a, 1991b).

2.5.1.1 Earnings.

Earnings can reflect the ability of a horse but are also partly a function of the opportunities that a horse has to earn. With different purse sizes, horses compete for different amounts of money (Hintz 1980). As a criterion, earnings has an extremely asymmetrical distribution, and it requires transformation before analysis (Langlois et al 1983). Langlois (1975) recommended the application of logarithmic transformations. Minkema (1976) used square root, cubic root, or fourth root functions for the normalisation of earnings. Meinardus and Bruns (1989a, 1989b) concluded that, for selection of riding horses in Germany, the natural logarithm of 'earnings per start' from riding event records was the best criterion as it provided an approximately normal distributions while also accounting for opportunities to compete. Log of earnings per start has a heritability of 0.18 for jumping and 0.16 for dressage.

In France the criterion is the logarithm of annual earnings. The criterion log of annual earnings has a heritability of 0.20 for jumping (Langlois 1980, Tavernier 1986 cited by Tavernier 1990a).

With the logarithm it is possible to re-establish the extended scale of earnings as these are distributed exponentially according to the level of performance; a horse earns approximately 79% in jumping of what the horse in front of it earns. This performance criterion has been used in standardized form with a mean of 100 and a standard deviation of 20 by SIRE

("System d'Identification Reperturiant les Equide") (Tavernier 1990a).

2.5.1.2 Place value.

Hintz (1980) proposed that ranking and number of placings reflect the animals relative performance, but may be partly a function of the level of competition and number of starts. In both Sweden and the Netherlands, criteria relating to place value are utilized for the evaluation of competition success (Philipsson 1975, Huizinga and Van Der Meij 1989).

In the Netherlands the trait which expresses performance in sport competition is the "highest level" accomplished during the lifetime of the horse. The lifetime total is cumulative and reflects the level of performance of the horse in a discipline of competition. These scores, consisting of a character and number combination, are transformed to a linear scale and a square root transformation of the score is utilized to normalize the data (Huizinga and Van Der Meij 1989). For these criteria, Huizinga and Van Der Meij (1989) using the restricted maximum likehood (REML) method produced heritability estimates for jumping and dressage of 0.20 and 0.10 respectively.

2.5.1.3 Point system.

A point system on a scale of 0 to 10 is currently practised in most sport horse breeding industries usually to provide a criterion for the evaluation of sport horse traits, normally conformation and movement. This scale of points is also used for the assessment of performance traits during the testing at a central performance station (Bruns et al 1980, Arnason 1987, Bruns 1987, Grundler and Pirchner 1991, Huizinga et al 1991a, 1991b, O'Keeffe 1991, Kelliher 1991).

The use of subjectively appraised scores provides an opportunity to quantitatively evaluate traits in Sport horses, but it does suffer from a number of drawbacks. Preisinger et al (1991) stated that the reluctance of judges to utilize the full scale could impair the detection of actual difference between individuals. They also found that the scoring varies greatly between different evaluating committees or judges, reducing the accuracy and creating the possibility of biases.

2.5.2 Conformation.

Conformation is often used as an indirect indication of performance ability (Langlois et al 1983). Many trainers, horse owners and veterinarians believe there are associations between conformation, soundness, and performance. This conviction is based on practical experience (Haughton 1969, Beeman 1973, Nordon 1980 cited by Magnusson and Thafvelin 1990). In the breeding of warmblood horses for riding purposes, great emphasis is placed on conformation and movement. Most riders, and dressage riders in particular seek good looking horses and, in the selection of individuals suitable for breeding, conformation is regarded as indicative of performance and soundness (Holmstrom et al 1990).

Langlois et al (1983) stated that the study of the relationships between conformation and performance ability is a traditional horse breeding concern treated in many handbooks; it is the privileged field of "experts". Although much has been written about conformation of the horse, and its relationship to performance, during the past two hundred years, there are little objective data available. Recently a number of scientific studies have investigated the relationship between conformation and performance ability (Langlois et al 1978, Burczyk 1989, Gleissner 1989, Slade and Branscomb 1989, Holmstrom et al 1990). All of these recent studies with the exception of Slade and Branscomb (1989) found generally only low or non-significant phenotypic correlations of conformation with performance ability. Langlois et al (1983) proposed that at the present time only the direct criteria (performance) can be used, and their use will most likely generate the expected progress. The procedures which are being developed (to assess performance from conformation) are not yet sufficiently proven for them to be the major selection criteria in genetic improvement programmes.

2.5.3 Relative's Performance.

2.5.3.1 Pedigree

Wagoner (1978) stated that a horses pedigree is a valuable tool in predicting an animals worth and performance potential, but it is only an indicator and no guarantee of ability.

Two of the greatest dangers of pedigree selection are:

(1) undue emphasis on relatives, particularly remote relatives, with the result that accuracy of selection is reduced;

(2) bias resulting from management and training advantages for progeny of favoured

individuals (Rice et al 1967).

The amount of attention which should be paid to the records of a particular ancestor depends on:

(i) the coefficient of relationship eg. parents 1/2, grandparents 1/4, great grand parents 1/8 etc. And how well the merit of the ancestors is known;

(ii) the heritability of the trait, the higher the heritability the greater the accuracy of selection for that trait from the pedigree;

(iii) the size of the correlations between the relatives resulting from similarities in the environmental conditions within the related group in comparison with the variation in the environmental conditions imposed on the whole population (Rae 1982b).

2.5.3.2 Siblings.

In general there is increasing accuracy of selection from increased sources of relevant information, though when utilizing the data from full sib and half sibs for the estimation of breeding values it is still important to consider the above points mentioned by Rae (1982b).

2.5.3.3 Relationship matrix.

With modern computing technology it is possible to use information from all relatives when calculating breeding values. Henderson (1965, 1973 cited by Henderson and Quaas 1976) described how, genetic relationships among all of the animals that are to be evaluated can be incorporated into the best linear unbiased prediction (BLUP) method.

Extending earlier work, Henderson (1975) developed a method by which the inverse of the relationship matrix could be incorporated directly into the simultaneous equations without the need to first derive the relationship matrix itself.

This development, coinciding with rapid improvements in the processing power and availability of computers, has led to routine inclusion of the relationship matrix within the BLUP animal model for the computation of breeding values. This method has been adopted for calculating breeding values of sport horses in France and Germany (Tavernier 1988, 1989, 1990a, 1990b, Meinardus and Bruns 1989a, 1989b). Routine use of the BLUP animal model for breeding value estimation of European harness-racing horses is also being planned (Arnason et al 1989, Klemetsdal 1989, Leroy et al 1989, Petzold et al 1989, Tavernier 1989).

2.6 FACTORS AFFECTING GENETIC GAIN:

The principle aim of selection is genetic improvement of the population towards the objective. This is expressed by a rise in the average value of the characters of interest to the breeder in each successive generation. The genetic gain per year depends on the selection differential, the accuracy of selection (r_{TI}) of the character/s and the generation interval as can be expressed by the following equation:

$$G = r_{TI}\ \sigma_T i \ / \ L$$

where, G = genetic gain per generation,

r_{TI} = the genetic correlation between the breeding objective and the selection index, frequently termed the accuracy of selection,

σ_T = the additive genetic standard deviation of the selection objective,

i = selection intensity (i.e. the standardised selection differential) and,

L = generation interval.

The generation interval is the average age of both parents at the time their progeny replaces them in a breeding scheme.

2.7 ESTIMATION OF HERITABILITY.

2.7.1 Definition.

The phenotype (observed value or measure of performance) of an animal is often said to be the result of interaction between the genotype and the environment. The environment can be defined to include all sources of phenotypic variance except that derived from genotypic variance between individuals. The relationship can be expressed in the following equation:

$$P = G + E$$

where P = phenotype,

G = genotype and,

E = the environment.

In some circumstances it is also necessary to account for interactions between the genotype and environment.

$$\sigma^2_p = \sigma^2_G + \sigma^2_E + 2cov_{GE}$$

where σ^2 = phenotypic variance,

σ^2_G = genetic variance,

σ^2_E = environmental variance, and

cov_{GE} = covariance of genotype with environment.

The heritability is the portion of the phenotypic variance in a population that is due to genetic variation.

Heritability (h^2) can be expressed in the following equation derived by Wright (1921 cited by Falconer 1981):

$h^2 = \sigma^2_G / (\sigma^2_G + \sigma^2_E)$

or $h^2 = \sigma^2_G / \sigma^2_P$

where σ^2_G = genetic variance,

σ^2_E = environmental variance, and

σ^2_P = phenotypic variance ($\sigma^2_G + \sigma^2_E$).

Heritability in the narrow sense can be expressed as the ratio of additive genetic variance to phenotypic variance.

Heritability in the broad sense includes effects of dominance and epistasis. The heritability value is the portion of total phenotypic variation which is traceable to genetic differences in the population. The heritability and genetic correlation of the selection criteria are included in the calculation of the r_{TI}, which represents the accuracy in selecting for the breeding objective.

2.7.2 Methods of Estimating Heritability.

The methods of estimating heritability may be classified by the family relationship used in the estimation of the genetic variances. Within these classes, a variety of statistical techniques may be used. Falconer (1981) stated that in general the half-sib correlation and regression of offspring on sire are the most reliable methods. Dam-offspring correlation or regression on dam can be affected by maternal effects and pairs sharing a common environment. The full-sib correlation is the least reliable due to small sample groups.

Offspring - parent regression:

For most horse data sets there are not sufficient records of sires sharing the same environment hence only the offspring - dam regression is statistically satisfactory (Langlois et al 1983). Since the relationship between offspring and their dam (assuming no inbreeding) is 1/2 then:

$h^2 = b_{od}/½ = 2\ b_{od}$.

where b_{od} is the regression of offspring on dams.

This formula assumes that there is no correlation between the genotype of the animals and the environment they are subject to. For most domestic animal data sets there are not sufficient suitable sire-offspring pairs to produce reliable heritability estimates. Dam-offspring correlation is sometimes used but the estimate can be biassed if the dams were selected (Turner and Young 1969). Offspring-dam regression is the preferred method since the estimate is unlikely to be biassed by the selection of the dams. However, like dam-offspring correlation, the estimate tends to include a component due to the maternal characteristics of the dam (Falconer 1981) and in some data sets the dam and her offspring tend to share a common environment and this may influence the records of both.

Intra - sire regression of offspring on dam:

If females are selected to go to particular sires some of the between-sire component of variance can be included in the offspring-dam covariance and the regression may be biassed upward (Turner and Young 1969). For data sets where the matings are not chosen at random intra-sire regressions should be used. Sometimes this is achieved by an analysis of covariance that estimates the between-sire component of variance as the regression is being calculated (Snedecor and Cochran 1967, Turner and Young 1969, Searle 1971).

Paternal - maternal half-sib:

For most data sets there are not sufficient progeny of each dam to use maternal half sibs for heritability estimates. However many data sets contain useful paternal half-sib groupings. The relationship of progeny of the same sire is ¼ (assuming the dams are not related to the sire and no full sibs), therefore:

$h^2 = 4\sigma^2_S/ (4\sigma^2_S + \sigma^2_W)$

This equation assumes that there is no correlation between the genotype and the environment (these can sometimes be removed using BLUP if there are genetic links between environments).

Traditionally least squares methods were used to account for non-genetic effects when estimating variance parameters (Henderson 1953). Crump (1974 cited by Anderson 1982) derived equations which, when solved iteratively, generate maximum likelihood (ML) estimates of the parameters in a random effects model with unbalanced data. Current interest in the use of ML for mixed models with unbalanced data can be attributed to the work of

Hartley and Rao (1967). Patterson and Thompson (1971) established an alternative ML procedure now known as the restricted maximum likelihood (REML). Though still widely used, the use of method 3 of Henderson (1953) is increasingly being replaced by the use of REML for generating variance components for genetic effects.

2.7.3 Potential Sources of Bias of Heritability Estimates.

Assortative mating.

One of the assumptions for offspring on dam and paternal half-sib estimates to be unbiased for most of the statistical models applied, is that the matings should be at random.

Homogamy leads to a dam-sire correlation and frequently to an upward bias of the heritability estimate. While there are statistical methods that will cope with non-random mating (eg. intra-sire offspring-dam regression and REML) these make computation more difficult and they were seldom applied in earlier analyses.

Within the thoroughbred population, Field and Cunningham (1976) stated that the correlations between sire and dam ratings indicated some phenotypic assortative mating. Previously, Moore O'Ferrall and Cunningham (1974) had found no evidence of assortative mating.

Langlois (1980) stated that, for the French thoroughbred population, the best stallions are generally used to serve the best mares but other mares were also mated. Stallions of the poorest quality are only mated with small numbers of the poorest mares. The poor stallions tend to have only a few offspring each, and are rapidly replaced. Their contribution to the whole population should not be neglected however, since the generation interval in this sector of the industry is short.

High homogeneity of mated mares.

Langlois (1980) found a significantly higher proportion of paternal half-sibs in the harems of stallions. He suggested this was due to the traditional search for "favourable blood combinations" by breeders. Thus, paternal half-sib methods that do not adjust for the dam's genotype are likely to be subject to considerable bias.

Non random effect of the environment.

More O'Ferrall and Cunningham (1974), and Field and Cunningham (1976) found non-random effects of the environment to be the greatest of the potential sources of bias leading to overestimation of heritability values.

The differential treatment of offspring of favoured parents is substantial from the time of preparation for sale of the yearling, to the training establishment period (Langlois 1980).

The genotype-environment correlations must be taken into account in the linear model (Langlois 1980). He suggested that in horse populations, one-third of the paternal half-sib resemblance is due to common environmental effects.

2.7.4 Heritability Estimates in Sport horses.

Introduction:

There have been few investigations of genetic parameters for subjectively scored conformation and performance traits in horses (Arnason 1984). Estimates of the genetic and phenotypic parameters for competitive performance are also few and are restricted to the major European sport horse breeding nations of Germany, France, the Netherlands, and Sweden (eg. Philipsson 1975 cited by Philipsson et al 1990, Bruns 1981, Bruns et al 1985, Huizinga and Van Der Meij 1989, Meinardus and Bruns 1989a, 1989b).

Conformation.

Conformation is usually subjectively assessed by a judge or judging committee, often being evaluated on a points scale of 0 to 10 (Bruns et al 1980, Arnason 1984, 1987, Bruns 1987, Grundler and Pirchner 1991, Huizinga et al 1991, O'Keeffe 1991, Kelliher 1991, Polling 1991).

Eriksson (1948) was the first to report the heritability for conformation in the horse. Using paternal half sib and offspring on sire correlation he obtained moderate to high value heritabilities (0.29 - 0.53) for height at the withers, heart girth, and cannon bone circumference in Swedish horses.

Further estimates for a variety of sport horse breeds suggest that irrespective of breed, the various conformation traits all appear to be in the moderate heritability range.

Table 2.2: Heritability values for conformation in sport horses:

AUTHOR	BREED	TRAIT	VALUE
Eriksson (1948)	SWB	Height	0.29
		Heart girth	0.43

Eriksson (1948)	SWB	Cannon circum	0.48
Varo (1965)	FWB	Height	0.26
		Heart girth	0.32
		Cannon circum	0.13
Varo (1965)	FWB	Conformation score	0.22
Dusek (1965)	GWB	Liveweight	0.27
		Wither height	0.63
		Cannon circum	0.28
Dusek (1970a)	HANN	Conformation score	0.19
			0.24
			0.35
			0.31
Dusek (1970b)	TRAK	Conformation score	0.32
		Type	0.46
		Total impression	0.25
Kownacki et al (1970)	WELK	Wither height	0.21
			0.71
		Cannon circum	0.17
			0.58
		Liveweight	0.15
			0.17
Khotov (1971)	A-KAR	Wither height	0.42
		Cannon circum	0.25

Stamp (1973)	HOLS	Type	0.43±0.06
		Topline	0.35±0.08
		Legs	0.26±0.08
			0.32±0.06
Hintz (1978)	TB	Wither height	0.13 - 0.90
		Body weight	0.33 - 0.88
Hintz (1978)	TB	Cannon circum	0.12 - 0.77
Velea & Marcu (1978)	LIPP	Wither height	0.65
		Chest circum.	0.74
			0.61
		Body structure	0.76
Pern et al (1979)	TB	Total conformation	0.27
Thafvelin et al (1980)	AA	Total conformation	0.33
		Type	0.29±0.10
		Body structure	0.21±0.11
		Legs	0.19±0.09
		Total impression	0.027±0.11
Strom & Philipsson (1981)	AA	Topline	0.29±0.09
		Head / neck	0.37±0.10
		Type	0.29±0.09
Butler & Krollikowsky (1986)	HOLS	Wither height	0.25±0.07
		Heart girth	0.27±0.14
		Cannon circum.	0.47±0.09

Fedorski & Pikula (1988)	TB	Wither height	0.28
			0.19
		Chest circum.	0.44
			0.30
		Feet	0.12
			0.08

1. All results presented in table 2.2 utilised the paternal half-sib method.

Movement:

Movement, the quality of the gaits (walk, trot, & canter) is usually subjectively assessed (0-10) (Bruns et al 1980, Arnoson 1984, 1987, Bruns 1987, Grundler and Pirchner 1991, Huizinga et al 1991b, O'Keefle 1991, Kelliher 1991, Polling 1991).

Varo (1965) was the first to calculate heritability values for gaits using paternal half sib analysis on a population of Finnish horses (6000 progeny). His estimate for style of gait was in the moderate range (h^2 =0.41).

Most, more recent estimates for movement fall into the moderate to high heritability range.

Table 2.3: Heritability values for movement in sport horses:

AUTHOR	METHOD	BREED	TRAIT	ESTIMATE
Varo (1965)	PHS	FWB	Gaits	0.81
Dusek (1970)	PHS	TRAK	Swing	0.41
			Regularity / rthm	0.24
Dusek (1971)	PHS	HANN	Trot	0.61

Dusek (1971)	PHS	HANN	Trot	0.10
			Hunting gallop	0.67
Bade et al (1975)	PHS	HANN	Canter	0.55±0.18
Arnason (1977)	PHS	SWB	Gaits	0.18
Thafvelin et al (1980)	PHS	SWB	Walk	0.30±0.12
			Trot	0.26±0.12
			Canter	0.18±0.08
Bruns et al (1985)	PHS	HANN	Walk	0.14
Bruns et al (1985)	PHS	HANN	Walk	0.70
			Trot	0.54
				0.00
			Canter	0.66
				0.28
Huizinga et al (1990)	REML	DWB	Walk	0.22±0.07
			Trot	0.14±0.06
			Canter	0.18±0.06
Huizinga et al (1991a)	REML	DWB	Walk	0.73±0.14
			Trot	0.65±0.16
			Canter	0.54±0.16
Huizinga et al (1991b)	REML	DWB	Walk	0.55±0.29
				0.40±0.25
				0.54±0.21
				0.64±0.21

Huizinga et al (1991b)	REML	DWB	Trot	0.87±0.31
				0.91±0.12
				0.88±0.15
				0.85±0.07
			Canter	0.62±0.29
				0.84±0.18
				0.72±0.13
				0.68±0.25

Performance Traits:

Bade et al (1975a) were the first to calculate heritability estimates for performance at a central testing facility. Utilizing paternal half-sib analysis of 126 offspring of 61 Hannoverian sires they obtained the high heritability value for jumping performance of 0.71 ± 0.4.

Bade et al (1975b) obtained medium to low heritability estimates for competition performance of a population of German warmbloods. Obtaining a range of heritability estimates from 0.00±0.12 for 3 day eventing to 0.23±0.10 for showjumping (log of total earnings, log of annual earnings).

The heritability estimates for the performance traits are greatly influenced by the evaluation criteria, and whether they are field or central performance test results. Hiuzinga & Van Der Meij (1989) found that for field test data that the estimates derived from the data based on the youngest offspring of the youngest stallions are most desirable, as they are least affected by selection.

Table 2.4: Heritability values for performance traits in sport horses:

AUTHOR	METHOD	BREED	TRAIT	ESTIMATE
Bade et al (1975a)	PHS	HANN	Jumping ability	0.71±0.4
Bade et al (1975b)	PHS	HANN	Showjumping	0.23±0.10
			Eventing	0.00±0.12
Langlois (1975)	PHS	SF/AA	Showjumping	0.18
				0.19
				0.17
			Eventing	0.20
				0.26
				0.14
Philipsson (1976)	PHS	SWB	Showjumping	0.23±0.08
				0.16±0.07
			Dressage	0.04±0.04
Bruns (1981)	PHS	GWB	Showjumping	0.14±0.01
				0.18±0.01
				0.14±0.01
				0.20±0.02
				0.13±0.01
				0.12±0.01
			Dressage	0.27±0.03
				0.18±0.02

Bruns (1981)	PHS	GWB	Dressage	0.19±0.02
				0.16±0.02
			Showing	0.04±0.03
				0.00±0.03
				0.05±0.03
			Eventing	0.15±0.02
				0.18±0.02
Bruns et al (1985)	PHS	HANN	Showjumping	0.17
			Jumping ability	0.00
				0.70
				0.78
				0.56
				0.80
				0.76
Bruns et al (1985)	PHS	GWB	Jumping ability	0.78
				0.84
			Cross country	0.43
				0.33
Langlois (1986)	PHS	SF/AA	Showjumping	0.15 - 0.25
Bruns (1986)	PHS	GWB	Showjumping	0.17
Arnason (1987)	PHS	SWB	Jumping ability	0.17
Preisinger et al (1987)	REML	HOLS	Jumping ability	0.19

Preisinger et al (1987)	REML	HOLS	Jumping ability	0.16
				0.42
			Rideability	0.21
				0.11
				0.31
				0.19
				0.27
				0.08
Meinardus & Bruns (1989)	REML	GWB	Showjumping	0.18
			Dressage	0.16
			YHC. jumping	0.04
			YHC.rideability	0.09
			Eventing	0.11
Huizinga & van Der Meij (1989)	REML	DWB	Showjumping	0.20
			Dressage	0.10
Huizinga et al (1990)	REML	DWB	Jumping ability	0.15
			Rideability	0.03
Huizinga et al (1991a)	REML	DWB	Rideability	0.64±0.15
			Jumping ability	0.30±0.17
			Cross country	0.41±0.18
Huizinga et al (1991b)	REML	DWB	Rideability	0.86±0.16
				0.55±0.18
				0.54±0.24

Huizinga et al (1991b)	REML	DWB	Showjumping	0.33±0.27
				0.29±0.26
				0.28±0.26
				0.61±0.30
				0.49±0.28
				0.40±0.28
				0.38±0.27
			Cross country	0.59±0.26
				0.55±0.25
				0.39±0.27

2.8 PHENOTYPIC CORRELATION BETWEEN TRAITS.

Phenotypic correlations estimate the extent to which characteristics in the current population are associated, either positively or negatively (Turner and Young 1969). The phenotypic correlation between two traits has both genetic and environmental components. When either trait has a low heritability and the phenotypic correlation between them is high, it is almost entirely of non-additive genetic, or environmental origin (Turner and Young 1969).

The phenotypic correlation between two traits (X & Y) assuming all genotype by environmental covariances are zero can be defined as:

$$R_p = \frac{\text{cov}\,(G_x\, G_y) + \text{cov}\,(E_x\, E_y)}{\sigma^2_{Gx} + \sigma^2_{Ex} + \sigma^2_{Gy} + \sigma^2_{Ey}}$$

where R_p = phenotypic correlation,

cov = covariance,

σ^2 = variance,

G = genetic component and,

E = environmental component (from Searle 1961).

2.9 GENETIC CORRELATION BETWEEN TRAITS:

Genetic correlation results in selection on one character altering the level of another character. Pleiotropy (genes having multiple effects) is probably the major cause of genetic correlations, although it is possible for linkage to have similar but less stable effects (Lasley 1978).

If the genetic correlation between two traits is high enough, it may not be necessary to measure both traits, especially if the measurement of one requires added expense, time, and equipment. Genetic correlations can be favourable or antagonistic. Antagonistic correlations occur when selection for an economically important trait results in a decline in the performance of another favourable production trait with which it is genetically correlated (Lasley 1978).

The formula used for the estimation of genetic correlation for all combinations of traits x and y is that proposed by Hazel (1943):

$$r_g = \frac{\text{cov}\,(X_p\ Y_o) + \text{cov}\,(Y_p\ X_o)}{2\ \text{cov}\,(X_p\ X_o) * \text{cov}\,(Y_p\ X_o)}$$

where r_g = genetic correlation,
X_p & Y_p = different traits observed in parents,
X_o & Y_o = different traits observed in offspring, and
cov = covariance.

2.10 INDUSTRY STRUCTURE.

In Europe the majority of sport horse breeding organisations have significant financial support from both local and central government (Kidd 1980, De Vaulx 1990, Von Stenglin 1990, Clarke and Wallin 1991). The exceptions to this are sport horse breeding in England, the United States of America, Denmark, and a number of the smaller breed societies in Germany (Kidd 1980, Clarke and Wallin 1991).

In Germany, sport horse production is a division of the National Equestrian Federation (FN), with individual breeders generally belonging to a local sport horse breed society (the exception being the Trakehner which is a national breed) (Anon 1989). The organization of sport horse breeding as a division of the national riding organization appears to be the typical structure for the continental sport horse breeders (Kidd 1980, Clarke and Wallin 1991). In Europe there has been a long tradition of organized horse breeding (Vallance 1984), since

1975 the production of warmblood horses has been orientated towards satisfying the market for sporting horses (Bade et al 1975a, Mey & Van Der Bos 1975). Ireland is possibly the oldest producer of sport horses, though it lacks the highly organized industry structure of the continental breeders (Fell 1991).

2.11 SELECTION PROCEDURES.

The abilities required in the horse are varied, and the criteria available for measuring them are not, for the most part, objective. Criteria can be classified as:

direct - where selection is on the trait in the breeding objective;

indirect - where selection is on a correlated trait with the purpose of changing one or more other traits that form part of the breeding objective (Langlois et al 1980).

2.11.1 Indirect Criteria.

When it is not possible or difficult to measure the trait which is desired to be improved, it is sometimes possible to use a character which is genetically correlated. This has progressively led to choosing the breeding animals on "model and gaits". This method is not used any more in racing breeds in which selection on performance is practised, but it still used in sport and draught horses since performance testing, at least in broodmares is not always practicable (Langlois et al 1983).

The utilization of conformation and gaits as indirect selection criteria in sport horses is commonly practised in many breed societies (Christmann et al 1989, Clarke & Wallin 1991, Meyer 1992). According to Langlois et al (1983) the study of the relationships between conformation and ability is a traditional horse breeding concern treated in many handbooks: it is the privileged field of the "experts". They stated that only a few scientific studies have been made and that generally only weak relationships have been found between conformation, movement and, performance. Pre-selection of the samples studied may have influenced the results (Burczyk 1989, Gleissner 1989, Holmstrom et al 1990).

Indirect criteria for sport horses are not only restricted to conformation and the gaits but, can also include such indirect measures of competitive performance ability as free-jumping performance and ride-ability.

Bruns et al (1980) investigated the more objective measurement of performance traits of stallions tested at station. They suggested that the indirect criterion free-jumping was the most accurate measurement for assessing competitive jumping performance since it removed the rider effect. However, they identified that there were only low phenotypic correlations between scores awarded for free-jumping and showjumping tests. While the influence of the rider may have caused this, Bruns et al (1980) proposed that it may also be due to the attributes required for free-jumping being completely different from those required for jumping with a rider. Smith (1984) has also put forward this view, citing as evidence the lack of top competitive showjumping horses to originate from the ranks of top free-jumping horses at the elite riding horse sales in Germany.

Bruns et al (1980) also found that judges score for the indirect criterion rideability had a higher repeatability than those for the ridden dressage test evaluation, this being due to the reduction in the riders influence on the expression of the trait. In contrast, Grundler and Pirchner (1991), using data from the Bavarian Warmblood performance test found reasonably high repeatability and rank correlation results between the riders and the judges of their riding test.

Indirect criteria tend to only be used if the trait of interest is difficult or is expensive to measure (Langlois et al 1983).

2.11.2 Direct Criteria.

These estimates are generally based on the performance of the horse in various competition events. Two factors need to be evaluated, performance in the events and, estimation of the event level. Useful measures are "handicap values", "records" or "earnings" (Langlois et al 1983).

Meinardus and Bruns (1989b) examined the use of the riding event records of the German riding association (FN) from 1976 to 1986. They concluded that neglecting the rider's effect resulted in overestimation of parameters by 10-20%. There was a slightly positive correlation between the rider's performance class and the genetic quality of the horse. They suggested the estimation of breeding values could be accomplished reliably for show jumping and dressage. The size and structure of the data sets were insufficient for the other disciplines.

In sport horses the heritability estimates for performance traits tend to be of moderate value and are relatively easy to measure in both sexes (Preisinger et al 1987, Meinardus and Bruns 1989a, Huizinga et al 1989,1990, 1991a, 1991b). Because of this only the direct criteria should be used.

2.11.3 Methods to Reduce Environmental Variation.

The genetic worth of animals can be calculated with greater accuracy if the variation due to environmental causes can be minimised. This minimization can be achieved by standardizing the rearing and testing environment or statistical correction of results for known causes of environmental variation.

2.11.3.1 Central performance testing.

In sport horse breeding, the usual European approach to increasing the accuracy of evaluation of genetic merit has been the use of a central performance-testing stations to test 3 year old stallions (Bruns et al 1980, Haring 1980, Kidd 1980, Nissen and Kalm 1986, Philipsson et al 1990, Huizinga et al 1991a).

These compulsory tests last 100 and 240 days in Germany, 90 days in Denmark, 3 to 4 one week periods in Sweden, and 10 months in Switzerland (Kidd 1980, Klemetsdal 1990). In Germany, station performance testing of Holsteiner mares has been developed (Nissen and Kalm 1986) and it is steadily growing in popularity (Bruns 1989 cited by Klemetsdal 1990). In England 100 day stationary performance testing has been carried out by the Dutch Warmblood breeders association (Slavin 1990). To date, all other attempts to establish central performance testing have failed due to lack of standardised training required to provide a fair test and the expense for stallion owners (Kidd 1990).

Bruns (1987) identified a number of problems with the existing selection programme for sport horses in Germany. He suggested that stationary performance testing is not yet optimal, as performance traits are mostly subjectively assessed and, testing takes place under environmental conditions different from those to which riding horses are normally exposed. Therefore stallions should also be evaluated on the performance of their offspring in competitions.

In Germany breeding values are calculated with a selection index for data from the stationary performance test scores. It is proposed that in future this will be supplemented by an animal model BLUP (Bruns 1989 cited by Klemetsdal 1990).

2.11.3.2 Field testing and BLUP.

Field tests can be defined in the sport horse industry as short term evaluation where only simple low-cost methods are used to try and standardise environmental influences. One-day riding quality tests, young horse competitions, and standard competition classes can be placed in this category. They provide an opportunity to evaluate a greater number of candidates (Tavernier 1990a, Klemetsdal 1990). The data can be statistically corrected for some environmental effects. The field testing of mares is frequently used in Germany (Meinardus and Bruns 1989), the Netherlands and Sweden (Klemetsdal 1990). In Sweden and Germany BLUP derived breeding values (BV's) calculated from competition results are used to compare progeny tested stallions, as a further refinement of the breeding programme (Meinardus and Bruns 1989, Thafvelin et al 1980 cited by Philipsson et al 1990).

In France evaluation of young breeding stock is via field tests rather than central performance testing (Kidd 1990, Tavernier 1990, Bour 1990). The BLUP animal model is used to correct for environmental variation and calculate breeding values. However, the ability of BLUP to correct for environmental variation depends greatly on the data available, particularly the genetic linkage between environments. Sometimes these links are limited when there are only a small number of animals per environment.

Data are available in all populations of warmblood riding horses for prediction of breeding values from jumping and dressage competitions in addition to 3 day events (Klemetsdal 1990). Riding horses taking part in competitions and horse shows are most likely a pre-selected group of animals. This pre-selection will reduce the value of this kind of data with respect to prediction of breeding value and genetic trend by an animal model and may be severely biased (Arnason 1984, 1987, Meinardus and Bruns 1987, Tavernier 1986, 1988). Hopefully the magnitude of this problem will be clarified in riding horses in the near future (Klemetsdal 1990).

2.12 OPTIMIZATION OF SELECTION PROGRAMMES.

Predicting the response to selection is necessary to assess the expected economic returns from a selection scheme, and to compare different strategies of selection with respect to the genetic gain in the short and long run (Verrier et al 1991). Consideration also needs to be given to whether one is optimising response to selection from a national or an individuals perspective.

2.11.1 Optimizing Genetic Gain.

Dickerson and Hazel (1944) studied the effects of selection intensity, generation interval and accuracy of selection on genetic progress for two stage selection in livestock. Their results and conclusions have become classic, even if their formulae were strictly applicable only to certain ratios of selection intensities.

In classical animal breeding theory, attention was directed towards maximising immediate selection response, though it was realised that very intense selection could reduce long term gains (James 1972).

In practical breeding enterprises neither the immediate gain nor the ultimate limit are suitable criterion to compare alternative selection strategies and some compromise must be reached. One possibility is to maximise the gain achieved in a certain time period, and this approach has been explored by Smith (1969) and Robertson (1970). James (1972) proposed the use of appropriate discount rate as a method of balancing short term and long term gains.

Quantitative genetic theory requires us that the size of the recorded population and the selection intensities should be as large as possible, constrained only by the costs involved in recording and management. Franklin (1982) suggested that the importance of population size on the anticipated limits to selection may not be as great as previously indicated, and that there may be genetic reasons to be wary of high selection intensities.

Recently, emphasis has been devoted to evaluation of selection programmes utilizing modern reproductive technologies eg. MOET techniques in dairy cattle (Nicholas and Smith 1983, Van Vleck 1986, Ruane 1988). Verrier (1991) used Monte Carlo simulation to test the responses and suggested that the early studies provided drastically biased results. These findings being in support of those of Baker et al (1990). Reason for these discrepancies were thought to be (i) linkage disequilibrium induced by selection (the so-called Bulmer effect), (ii) a higher inbreeding rate in selected populations, and (iii) a reduced selection differential due to finite number of candidates and correlations among their estimated breeding values.

2.12.2 Optimizing Economic Returns.

First and foremost in the design of breeding programmes is the question of benefit to the industry, and one of the most popular ways of assessing this is to compare predicted returns against predicted costs, each appropriately discounted (Franklin 1982). James (1972) proposed that for agricultural enterprises the appropriate discount rate may be the monetary interest rate, treating the breeding programme as a business venture which must pay its way. Conversely, he also proposed that the discount rate should also provide some consideration of the social benefits conferred by the programme, and that discount rate can be greatly influenced by the breeder's own personal opinion. Smith (1978 from Brascamp 1978) identified three types of discount rate.

1. the opportunity cost rate, the cost of borrowing in the financial market.

2. social time preference rate, often lower than opportunity cost rates (these consider not only economic benefits but also for social good).

3. a synthetic rate, this rate is equal to the time preference rate. The choice between these rates can not be easily made. Other complicating factors are inflation rate, risk and tax rate (Brascamp 1978). Smith (1978) proposed that high rates of interest commonly used in discounted cash flow analysis have tended to underestimate the value of returns and favour breeding programmes with short-term returns.

Smith (1981) found that the total discounted returns tend to increase continuously with the logarithm of the number of animals tested (T). The costs however increase linearly with T. The total benefits (P) thus rise to a maximum and then fall. Because of the shapes of the returns and costs curves, the graph of P has a fairly flat maximum. Thus a fairly wide range in the level of testing may give benefits that are only marginally sub-optimal. If only a small amount of testing is done, the costs will be low and the genetic response will be small, but the benefit/cost ratio may be large.

2.12.3 Optimization of Sport Horse Selection Programmes.

Strom and Philipsson (1978) were the first to address the problem of optimizing selection strategies for horse populations. They compared mass selection with two stage selection (mass selection and progeny testing). They concluded that, for traits such as conformation which can be measured early in life and have high or medium heritability, selection should be based mainly on the individuals own phenotype. When the heritability is low, however, progeny testing will be more important. Progeny testing appeared quite valuable as a complement to performance testing for these traits.

Bruns (1981) investigated the estimation of the stallions breeding value from the competition performance of their offspring. He proposed that progeny testing of stallions should be included in breeding plans unless the genetic progress per year is reduced. However, practical use depends on the age of the stallion at the time of evaluation. With the demographic structure of the German sport horse industry Bruns (1981) concluded that the utilization of progeny test results was not practical. The primary limitation being the extension of the generation interval with the inclusion of progeny records into the genetic evaluation of the stallions.

Langlois et al (1983) also identified the problem of optimizing the rate of genetic response per year when progeny testing. They proposed the use of modern reproductive techniques to increase the selection intensity and to counteract the effect of the long generation interval.

In order to evaluate alternative strategies for evaluating performance in sport horses, Hugason et al (1987) modelled the impact of 3 different stallion selection strategies. The alternatives were:

1. single stage selection possibly based on pedigree and family selection,
2. two stage mass selection on the stallions own performance and,
3. three stage selection, the first 2 stages followed by progeny testing.

Maximal genetic progress was always associated with high selection intensities in the second stage. In support of Strom & Philipsson (1978), it was found that the lower the heritability the greater the importance of progeny testing. However, selection based on the individuals own performance yielded genetic gain close to the maximum in most cases. It was proposed that AI could be used to improve the reproductive capacity of stallions. However the current limitations of artificial insemination of horses would likely keep the genetic improvement below an additional 20%. The response to AI in cattle breeding is not likely to be achieved with horses within the foreseeable future due to the present industry structure.

Utilizing a computer programme developed by Hugason et al (1987) Philipsson et al (1990) modelled the impact of 3 selection strategies for selection of sires and dams of sires on a theoretical model of the Swedish sport horse population. The 3 selection strategies evaluated were.

1. Single stage (mass selection on conformation),
2. two stage (mass selection on conformation and then a performance test for dressage and showjumping),
3. three stage selection, the 2 stage selection scheme plus the stallions results from competitions in dressage and showjumping).

Results clearly demonstrated the 2 stage selection procedure to be most efficient, especially for stallions. As with the findings of Hugason et al (1987) maximum genetic response was achieved when the selection intensity for the second stage (performance test) was high. Differences in accuracy between field and station tests were assumed to be only minor and since the number of horses tested can be much higher with field testing this would allow a much greater selection differential.

Bruns (1987) stated that 2 stage selection was the optimal procedure for the German sport horse population, but its most efficient form required the use of artificial insemination. The practical difficulties in solely utilizing progeny testing to evaluate breeding stock was discussed, although progeny testing could be a useful supplement to the existing station performance testing procedure.

Tavernier (1990a) suggested that the French sport horse population was making greater genetic response to selection than the German sport horse population because of the higher selection intensity possible with the French field test based evaluation programme. She proposed that the Selle Francais (French sport horse) was improving genetically at a rate of 0.38 points per year on a standardised scale, the German sport horse population only progressing at 0.2 points per year. However, the Selle Francias is bred for the simple objective of competitive showjumping success rather than as a multi-purpose sport horse. Also the estimate was based on a BLUP projection of the rate of gain and the answers obtained using this technique to estimate genetic gain are highly dependent on the parameters assumed (Blair 1984).

CHAPTER THREE

AN INVESTIGATION OF THE INDUSTRY STRUCTURE IN NEW ZEALAND:

3.1 INTRODUCTION

In contrast to the highly organized and regulated sport horse breeding industries of Germany, France, Holland, and Sweden, the New Zealand industry tends to lack co-ordination and co-operation between the various breeders groups. This lack of co-ordination and co-operation is believed to be a limiting factor in the establishment of a national selective breeding programme for sport horses. It is also believed that a more cohesive industry structure would permit more efficient marketing of the New Zealand sport horse in a manner similar to that presently existing for the German, French and, Dutch sport horse breeders. This situation in New Zealand appears similar to the state of sport horse breeding in other English speaking nations. England, Ireland, and the United States of America also appear to lack an industry-wide organization structure (Kidd 1990, Clarke and Wallin 1991).

The aim of this study was to outline the present New Zealand sport horse breeding industry and provide comparisons with existing European sport horse industry structures. From these comparisons it is anticipated that conclusions could be drawn as to the future direction and rate of development of the New Zealand industry.

3.2 MATERIALS AND METHODS:

In August 1991 questionnaires (appendix 1) were sent out to the presidents of five breed societies (New Zealand Sport Horse Owners and Breeders assoc (NZSH), New Zealand Warmblood Breeders assoc (NZWB), New Zealand Hannoverian Society (NZHH), New Zealand Hunter and Light Horse Breeding Improvement Society (NZLH), & the New Zealand Irish Draught Society (NZID)) that were believed to be orientated towards the production of sport horses. Data were also requested from the New Zealand Equestrian Federation (NZEF) the body that governs equestrian sport in New Zealand.

The design, and organization of the questionnaire to the breed societies was developed following the steps established by Parker and Hughes (1989). The aim of the questionnaire was to obtain data as to the current demographic structure of sport horse breeding in New Zealand and an outline of current selection policies of the breed organizations. From the National Equestrian Federation data were requested on current and historical sport horse registration numbers, numbers exported and their value.

The data gathered from the breed societies cannot be claimed to be completely representative of the national sport horse breeding industry. First, a majority of New Zealands sport horses are thoroughbreds, bred primarily for the objective of racing; as a consequence, the breeders would not belong to one of the associations surveyed. Other sport horses are produced by the crossbreeding of thoroughbreds with other types, including draught or draught cross animals which are ineligible for registration with all but two of the organizations surveyed. Second, the lack of past and present documentation of sport horse pedigree and performance data means that the data and estimates provided are drawn from a very short time period, and therefore may just reflect short term fluctuations in population numbers. However, the data collected do provide indications as to the demographic structure of the New Zealand sport horse industry, from which speculation has been made as to its future direction of development.

3.3 RESULTS AND DISCUSSION:

Specifications of the Production and Marketing system.

3.3.1 Competition Structure:

Within New Zealand, the Olympic disciplines of showjumping, dressage, and eventing are run under the guidance and rules established by each discipline. The recognized competitions in each district are run by, or under the guidance of each discipline's regional council. The individual disciplines are coordinated and governed by a national body the New Zealand Equestrian Federation. This national body is in turn governed internationally by the Federation Equestre Internationale (FEI). The FEI is responsible for equestrian competitions at the highest level internationally (i.e. World Championships, European Championships, the Olympics, as well as Nations cups, etc). This structure can be observed in figure 3.1.

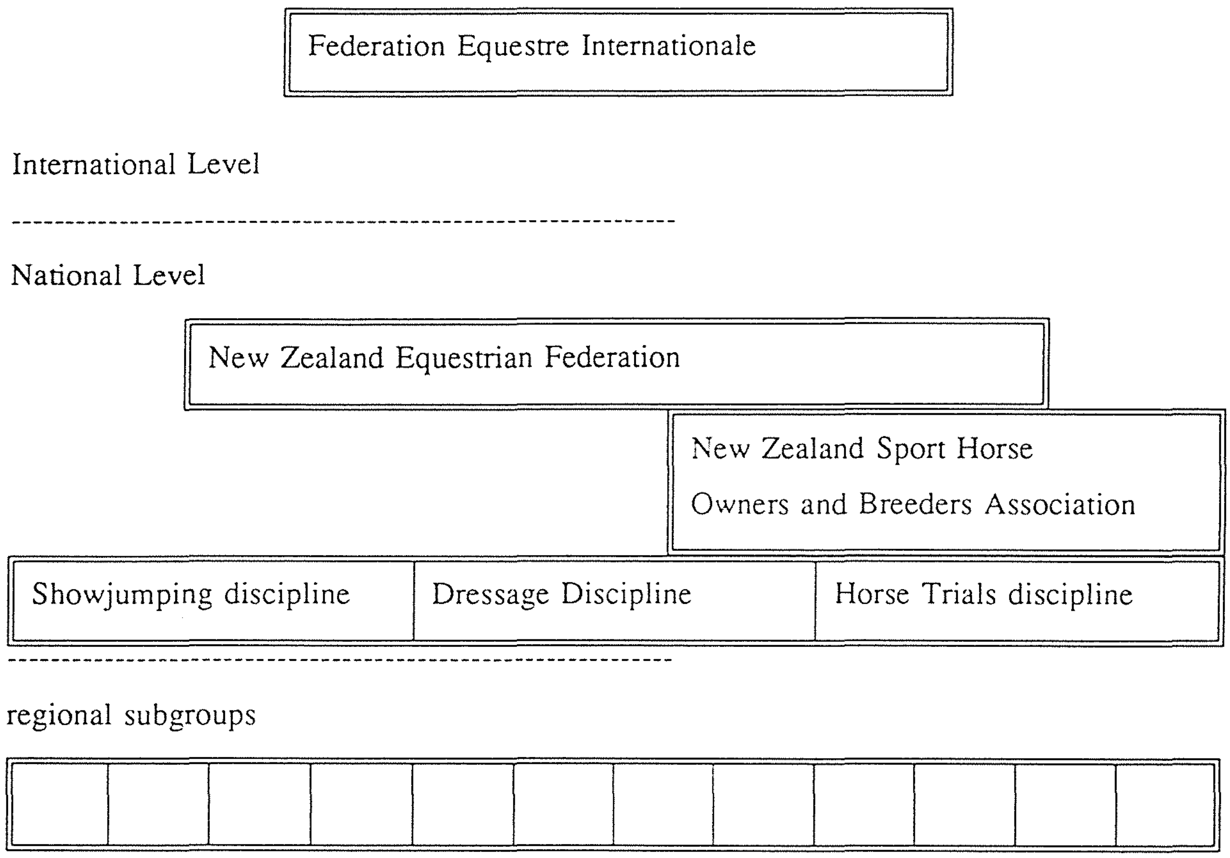

Figure 3.1

Diagrammatic representation of the structure of the New Zealand Equestrian Federation:

Source rules of the NZHS (inc).

At present the breeding of sport horses in New Zealand is very fragmented. A number of different breeders groups maintain pedigree records of their specific sport horse type or breed, i.e NZWB, NZHH, NZLH, etc. To counteract this fractionation the New Zealand Sport Horse Breeders and Owners Association (NZSH) was formed. This has developed to the present stage where it is the dominant sport horse register. It is actively involved in the promotion of performance and pedigree records for sport horses. The FEI now recognises the NZSH as an official breed society (New Zealand's only recognized sport horse studbook). Horses registered with this society competing at international level can now earn points for the NZSH stud book in the world breeding championships for sport horses. In the 1991-1992 competition season the New Zealand sport horse was the 11th highest scoring stud book (out of a total of 16) ahead of a number of the well respected German sport horse breeds

(Trakehner, Rheinland, and Bavarian) (Libbrecht 1992). New Zealand was the only non-European country represented with a stud book, indicating that the organization of sport horse breeding in New Zealand, while still in its infancy, may be more advanced and organised at an industry level than the Australian, American, and English sport horse breeders.

The NZSH is not under the control of the New Zealand Equestrian Federation, but rather tends to play a co-operative role. Within the next year it is anticipated that the NZEF will take direct control of the NZSH thus closely linking pedigree and performance data and giving greater unity between the competition and breeding sectors. In Germany, the National Equestrian Federation (FN) regulates the various sport horse breeding groups. Sport horse breeding is organized by the regional breed societies but overall regulation and control is exerted through the breeding department of the German National Federation (Kidd 1980, Christmann et al 1989, D.Winter personal communication). There is close liaison between the competition and breeding sectors, and therefore the combination of pedigree and performance data is a relatively simple task.

Showjumping in New Zealand like many other nations has a 4 grade system. Figure 3.2 shows the pyramidal distribution of numbers of horses in the grades, novice being the lowest (horses jumping over fences 1.1m in height) and A grade the highest level (horses jumping fences over 1.4m in height).

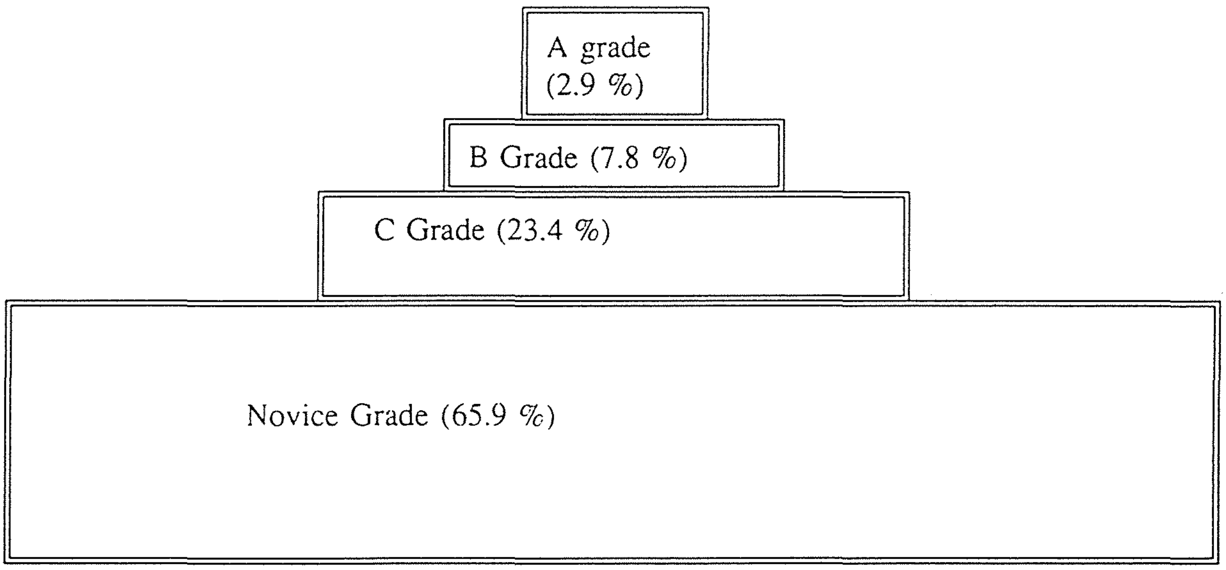

Figure 3.2:
Diagrammatic representation of the distribution of horses registered for showjumping in New Zealand (Anon 1987)

Eventing has a similar structure with three official levels novice, intermediate, and advanced. There is also has a non grading level (training) below the standard of novice, which is suitable for the non competitive rider and for young horses just starting to be ridden in competitions. The number of participants in this level is increasing, currently the numbers competing at training level would be equivalent to those in the novice group.

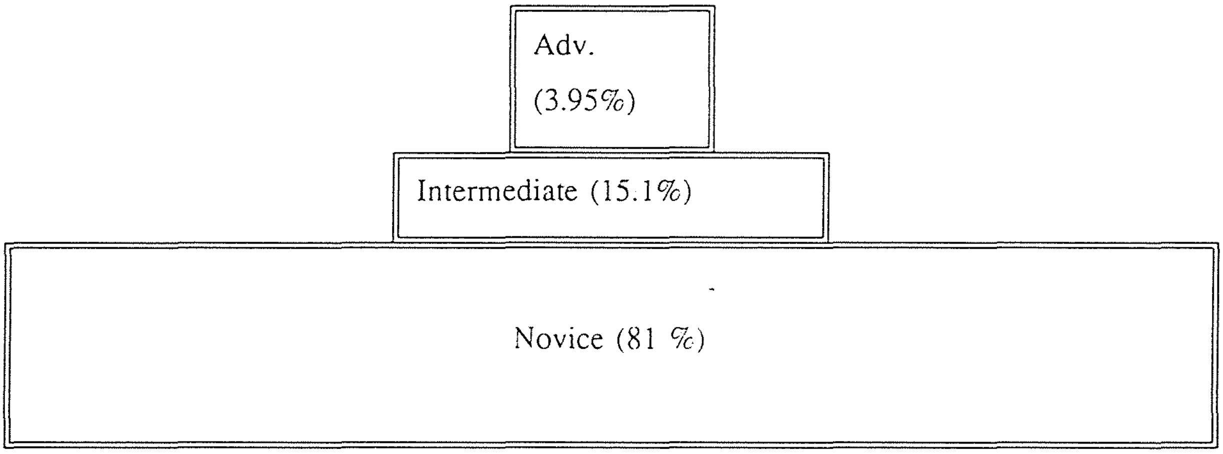

Figure 3.3:
Diagrammatic representation of the distribution of horses registered for Horse Trials (Eventing) in New Zealand: source Anon 1991

Dressage has five recognized grades, and as with the other disciplines, the majority of the horses registered belong in the lower grades. This is probably because many of these horses are ridden by recreational riders who are not highly motivated toward competition success. Nissen (cited by Slavin 1990a) stated that"the major numerical market is to the person who rides as a hobby and for pleasure."

3.3.2 Sport horses registered in each discipline and discipline growth:

A summary of the information provided by the NZEF is shown in table 3.1.

Table 3.1: Number of horses registered with the New Zealand Equestrian Federation for each discipline.

YEAR	Showjumping	Eventing	Dressage
1983/84	2000	---	---
1984/85	---	---	---
1985/86	---	800	1150
1986/87	---	---	1350
1987/88	---	---	1500
1988/89	---	---	1700
1989/1990	---	923	1942
1990/91	2500	1048	2150

The NZEF has not been efficient in maintaining statistics and could not provide data for many years. It was estimated that in New Zealand 20 to 30% of the horses were registered for more than one discipline. 80 to 90% of the horses currently registered had either their dam or sire listed on the registration form.

Data provided by the NZEF (table 3.2) clearly demonstrated that equestrian sports are becoming increasingly popular as a leisure activity. This is consistent with the pattern observed overseas (Langlois et al 1983, Kidd 1980, Wilkens 1990, Wilford 1992a). Dressage experienced greater growth in number of horses registered in the last 5 year period (1985/86 to 1990/91) than the other two disciplines. The greater increase in participants in dressage is possibly due to the trend identified by Nissen (cited by Slavin 1990a) for increased numbers of hobby or leisure riders. Many of the less ambitious and competitive riders (hobby riders) possibly may have become involved in dressage due to the lower physical demands placed on participants at the lower levels. In comparison showjumping and eventing require greater physical strength, agility and courage of rider and horse.

Table 3.2:

Sport horses registered for competition use in New Zealand and relative growth 1985/86 to 1990/91.

	No. horses registered	% Total Horses registered in discipline	% increase in registered no's in last 5 years
Showjumping	2500	44 %	25 %
Dressage	2150	38 %	86 %
Eventing	1048	18 %	31 %

G.Meech (personal communication) estimated that 20-30% of the registered sport horses were registered with more than one discipline. This number is similar to the 24% of sport horses in Sweden registered for use in more than one discipline (Lundkist 1983 cited by Philipsson et al 1990). However, it is unlikely that this would significantly alter the percentage of total horses registered in each discipline.

Showjumping and dressage are the dominant disciplines in Germany and Sweden and probably most other nations. In contrast, New Zealand has a proportionally high number of horses used for eventing. Although the smallest of the three disciplines (18 %) it is by far the most successful at international competition level (2 Olympic individual Gold medals 1984, 1988, Bronze individual medal 1992, Team silver 1992 and bronze medals 1984, 1988, Current world champion, etc.) (Wilford 1992b, Gilchrist 1992).

3.3.3 Number of sport horses in New Zealand and registered numbers in each discipline:

The 1985 census revealed that New Zealand had a total of 96,671 horses distributed amongst the various categories as shown in table 3.3.

Table 3.3:

Total Horses, and their use/type in New Zealand 1985 (NZSD.1990).

CATEGORY	NUMBER
WORKHORSES	25,224
RECREATION	30,461
STANDARDBRED	16,209
THOROUGHBRED	24,777
TOTAL	96,671

The census indicated that in New Zealand 30,461 horses are used for recreation. This statistic could potentially be quite misleading, as this value would also include ponies (horses standing less 1.47m at the wither). About 30% is the likely estimate of the percentage of ponies included in the census figures as part of the total New Zealand horse population. In Germany this percentage is 28.68% (Christmann 1989). New Zealand Equestrian Federation (NZEF) data places the total number of sport horses registered for use in competition at that period at approximately 4,500. Results from the postal survey placed the estimated size of the New Zealand sport horse broodmare herd at approximately 5,750. Respondents estimated the average number of services per sire to be 20 (range 2-100) therefore another 288 of the total could be due to sport horse sires. With a fertility rate of 70 % (Hogan 1983) and horses not able to compete until 3 years of age, 12,075 of the total could be allocated as young stock providing a numerical breakdown of horses used for recreation in New Zealand as shown in table 3.4.

Table 3.4:

Proposed demographic structure for horses used for recreation in New Zealand in 1985:

CATEGORY	NUMBER
Ponies	9138
Registered sport horses	4500
Broodmares	5750
Sires	288
Youngstock	12075
Unregistered sport horses	2500
TOTAL	34251

Table 3.4 suggests the total number of horses used for recreation in New Zealand in 1985 exceeded the census value of 30,461. This is probably due to a considerable number of horses, particularly broodmares, that may be transient in their production goal (i.e. being bred to produce a thoroughbred racehorse one year, and later on in the mares reproductive life being used to produce a sport horse). Therefore, a significant overlap may exist between the census categories of thoroughbred and recreation.

If the broodmare population of 5750 in table 3.4 is close to the true demographic parameter for the New Zealand sport horse industry, then it compares favourably with many popular European sport horse breeds eg. Holstein 5,089 broodmares, Trakehner 3766, Reinland 2720, and Bayern 4537 (Reuter 1991).

3.3.4 New Zealand Sport Horse Gene-Pool:

The gene-pool in New Zealand is predominantly thoroughbred based. The thoroughbred in New Zealand has been primarily bred for success on the racetrack but a proportion make excellent sport horses. a proportion of New Zealand thoroughbreds make excellent eventers as shown by success in international and local competitions. Recognition of this is reflected in the current high demand and prices paid on the world market for New

Zealand-bred thoroughbred sport horses.

In recent years in both showjumping and dressage at international level the competition demands have subtly changed in favour of the more refined thoroughbred type of sport horse. Burzcyk (1989) found that dressage horses with between 37.5% and 50% thoroughbred blood had significantly higher earnings in top level dressage competitions. Gleissner (1989) found that, in showjumping, horses with 50% or greater thoroughbred ancestry had the highest earnings at top level (A grade and international competitions). He concluded that horses with a higher thoroughbred portion can be used in competition for a longer period of time and that breeders should not be afraid to breed specifically for showjumping demands, using as much thoroughbred blood as possible; such horses were considered well ahead in requirements of the jumping circuit with regard to ability, speed, agility, precision and rideability compared to horses of pure warmblood ancestry.

These studies indicate that the large thoroughbred influence in the New Zealand sport horse should permit the industry to rapidly develop a high quality sport horse well-suited to the current competition demands. It would appear that the superiority of sport horses with a significant proportion of thoroughbred blood has been rapidly recognized in the lucrative North American sport horse market. Love (cited by Vallance 1987) stated that "for the intending breeders of showhunters for the USA market the breeder should aim for the more refined horse with a mixture of 75% thoroughbred. A 25% warmblood influence is also good as the horse can have the refinement of the thoroughbred, but the quiet, kind, and relaxed athletic abilities of the warmblood". C.Ladbrook (personal communication) suggests that for the American jumper market the full thoroughbred sport horse would be most popular, with the majority of the top American riders now preferring to ride thoroughbred sport horses.

Since 1977 a number of European warmblood sport horse sires have been imported into New Zealand. The progeny of these sires have gained particular popularity for dressage and to a lesser extent showjumping. However thoroughbreds still dominate the sport horse scene in New Zealand. Analysis of breed of horses entered for New Zealands richest young horse showjumping competition at the Tielcey Park sport horse show (Feb 1992) reflected this. Thoroughbred horses accounted for 52.6% (n=20) of the entries, warmblood horses accounted for 23.7% (n=9), and non-warmblood sport horses 23.7% (n=9) (figure 3.4). The horses in the warmblood and non-warmblood sport horse categories were of at least 50% thoroughbred blood, the majority being out of thoroughbred broodmares.

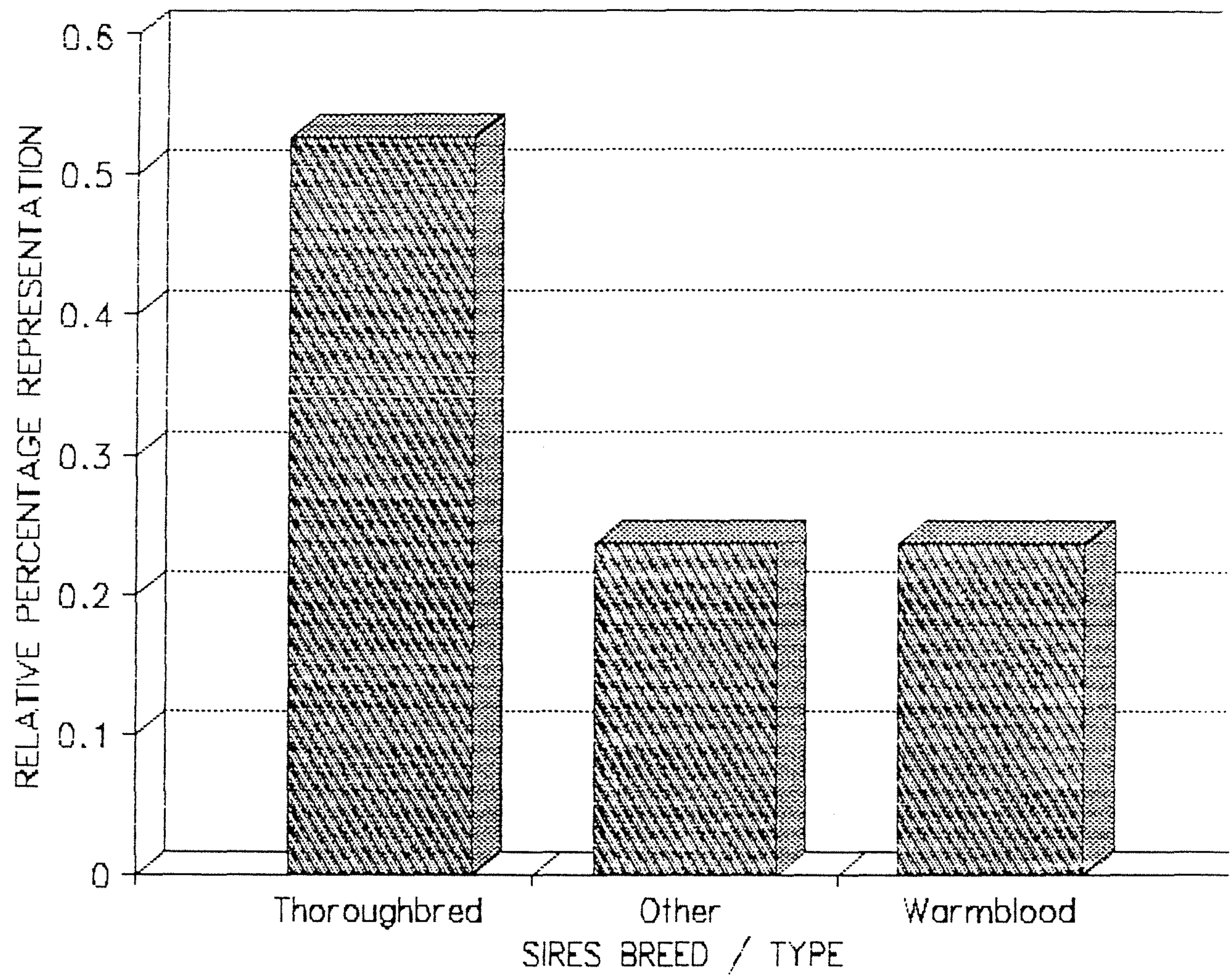

Figure 3.4:

Relative percentage of competing horses sires breed/type (at Tielcey Park showjumping show 1992).

If numbers in the warmblood and sport horse sires categories were combined this would suggest 47.4% of the horses entering this class were purpose bred as sport horses. An analysis of the sires of horses competng in a premier competition for A grade showjumpers at the 1992 Horse of the Year Show indicated a similar distribution (figure 3.5).

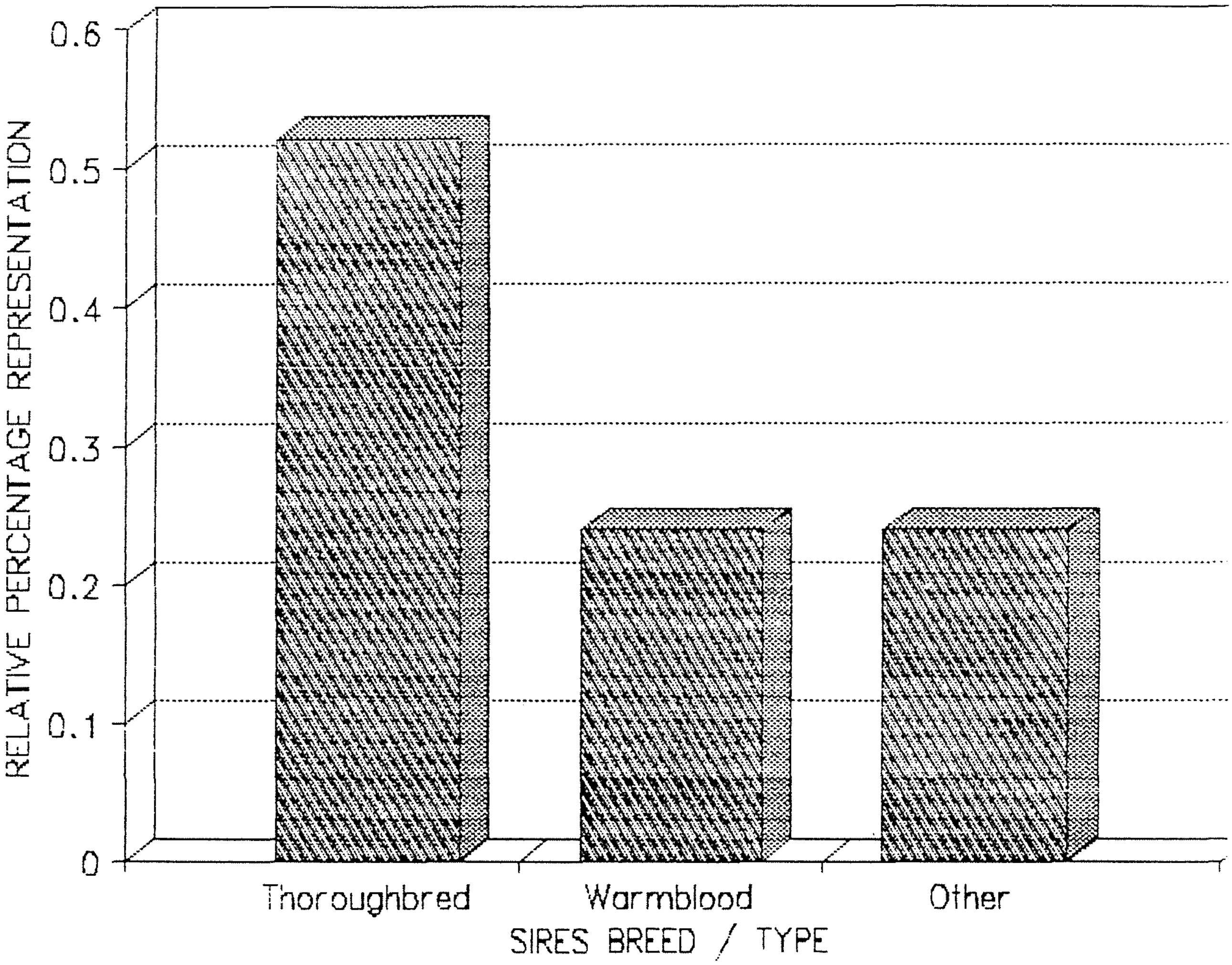

Figure 3.5:

Relative percentage of breeds of sires of horses competing in a premier showjumping event at the Horse of the Year Show 1992.

In eventing, thoroughbred dominance is greater, with 70% of both the advanced and novice classes at the 1992 Bell Taupo 3 Day event being thoroughbreds or by thoroughbred sires (figure 3.6).

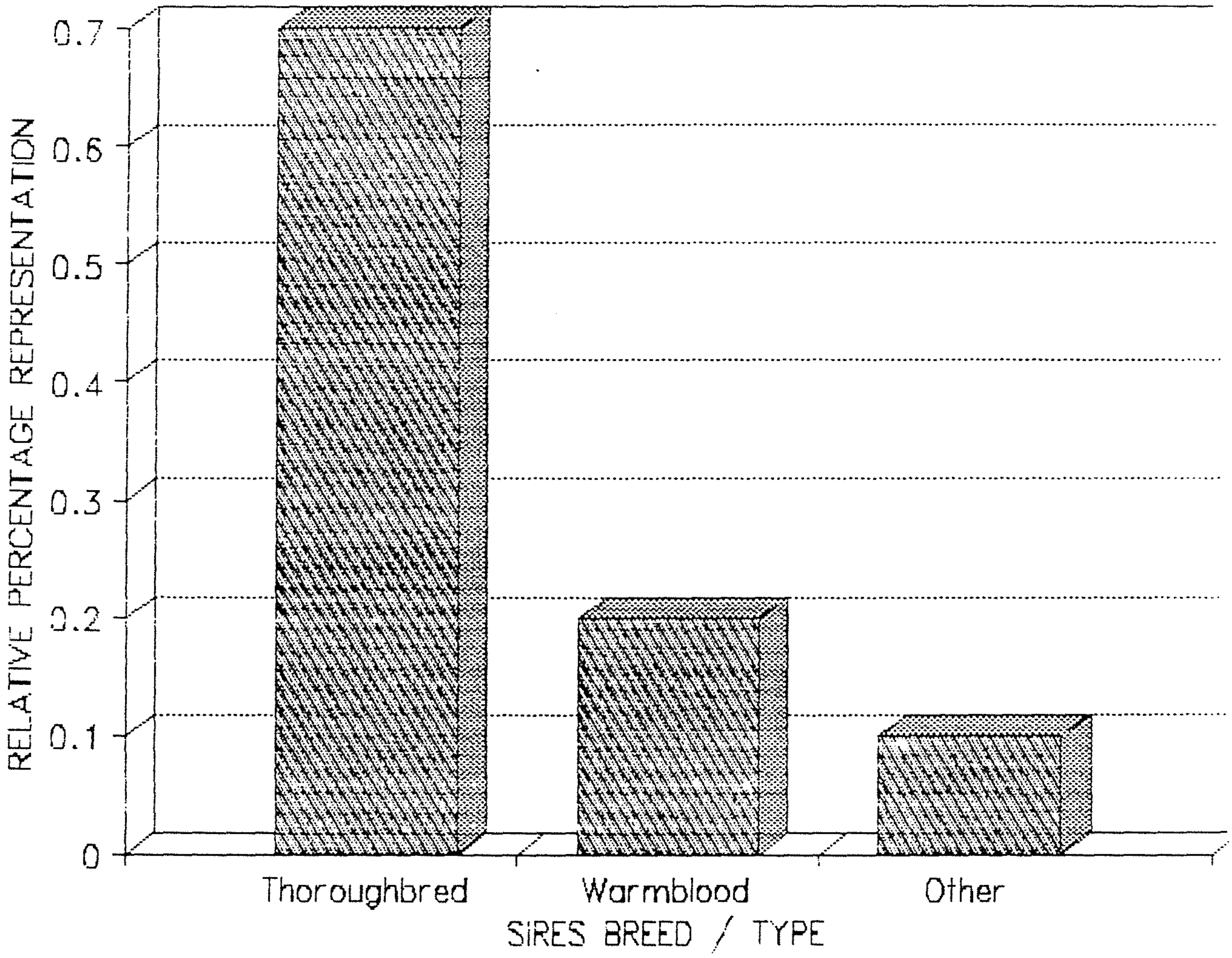

Figure 3.6:
Relative percentage of breeds of sires of horses competing in the Taupo 3 day event 1992.

The consistent high percentage of thoroughbred sires and the predominance of thoroughbreds as sport horse broodmares show that the thoroughbred breed is the dominant contributor to the New Zealand sport horse genepool.

3.3.5 Results from Breed Society Questionnaire:

Five questionnaires were posted out in August of 1991. By September 30th four had been returned; no reply was received from the NZID. The non-return of the questionnaire from the NZID was unlikely to influence results as the society, was only recording the progeny from 2 stallions.

A summary of the information provided by the breed societies surveyed is shown in table 3.5.

Table 3.5: Demographic parameters requested from breed societies August 1991.

	BREED SOCIETIES			
	NZHH	NZSH	NZWB	NZLH
Current number of sires registered with breed society	2	118	24	12
Current number of broodmares registered with breed society	53	496	N/R	115
Breed societies annually registered foal crop	19	150	263	20
Average broodmare herd size	2	2-3	1-2	2
Average services per sire	32	N/A	2-100	17
Current number of members	53	389	300	97
Total number of Sport horse broodmares in New Zealand (approx)	5000	10,000	2000	N/R

From table 3.5 it is apparent that the numbers of registered breeding stock is very low in comparison with European sport horse breeds eg. Holstein 5,089 registered broodmares, Trakehner 3,766 (Reuter 1991). This may be a reflection of the infancy of the industry, or that the breed societies are not meeting the requirements of the majority of sport horse breeders in New Zealand. Many breeders may not see any advantages in registering stock even though the cost of registration is low in comparison to the animals total production cost. Contributing to this problem may be the relative variety of societies willing to register stock.

The low estimates for services per sire and, average herd size imply that the industry is still in the transition from a hobby activity to a commercial industry.

Societies breed improvement plan

The concept of a breed society controlling or regulating, the evaluation of sport horse breeding stock is in general a relatively new and foreign concept to most New Zealand breeders. The uniqueness of this concept and the relative independence of the New Zealand sport horse breeder have made it difficult for societies to enforce any testing or evaluation system. Another problem for the breed societies is the recruitment of race-bred thoroughbred sires at an advanced stage of their reproductive career. After a number of years at stud it is often difficult to obtain any evaluation of performance other than the race performance of their progeny, which is unlikely to accurately demonstrate their potential as a sport horse sire. Table 3.6 provides a summary of the different approaches to sire evaluation undertaken by the breed societies surveyed.

Table 3.6: New Zealand Sport horse-orientated breed societies and their type of selection programme for sires.

	BREED SOCIETIES			
	NZHH	NZSH	NZWB	NZLH
Central performance testing eg. 100 day test	no	no	no	no
Field testing eg. from competition results	no	yes	yes	no
Conformation and movement assessment only	no	no	no	yes
Other	yes	no	no	no

The NZHH only registers progeny from stallions recognized and graded by the

German Hannoverian society in Germany or North America. Because of this, there is little possibility of sires bred in New Zealand being recognised by this breed society.

The NZSH operates a computerised register but has no current grading requirements for breeding stock but uses data to prove stallions. The NZSH annually publishes a sires register containing much relevant information for the sport horse breeder. This system is analogous to the role played by the New Zealand racing conference for racing thoroughbred breeding in New Zealand. A performance testing system that may be utilised within the constraints of the New Zeland industry is currently under development.

The NZWB at present only recognises progeny of approved "warmblood" stallions as suitable sire candidates, performance testing being via competition performance.

Many of the broodmares used for the production of sport horses are race-bred thoroughbreds, recruited into the sport horse population usually after a number of years at stud. Some sport horse broodmares were bred as farm hacks. Only about 20% of the broodmares were purpose bred as sport horses, but this is likely to grow in the near future. The recruitment of many of the broodmares at a relatively advanced age places some severe constraints on the breed societies when considering evaluation of broodmares. Table 3.7 provides an overview as to the selection programmes currently in place for the evaluation of broodmares.

Table 3.7: New Zealand Sport horse-orientated breed societies and their type of selection programme for broodmares.

	BREED SOCIETIES			
	NZHH	NZSH	NZWB	NZLH
Central performance testing	no	no	no	no
Field testing (eg. conformation & performance)	no	some	some	no
Conformation and movement assessment	yes	some	some	yes

For broodmares, the primary emphasis for evaluation has been an assessment of phenotypic measures of conformation and movement. This possibly is due to the advanced age of many of the potential broodmares and, the limited selection intensity possible within the dam line. Both the NZHH and the NZWB hold grading days for conformation and movement assessment, the NZSH records competition success of mares in both ridden and for in-hand classes (conformation and movement classes).

All of the breed societies surveyed operated as separate entities from the NZEF. Optimally the NZEF should become involved with the maintenance of pedigree and performance records. Under this format more efficient use could be made of records in aiding breeders. When consideration is given to current membership numbers, registration base and, present ties with the NZEF the likely candidate for amalgamation would be the NZSH.

3.3.6 Training and Sale:

Bruns et al (1978), Kidd (1980), Blanc (1990) and D.Winter (personal communication) provided data that demonstrated that the predominant age and stage of training at which European breeders sold their stock was as broken and lightly schooled 3 to 4 year olds. A.Vallance (personal communication) stated that selling of stock at this age and stage of training in New Zealand permitted the optimal return on their initial investment for breeders. At this age and stage of training the prime traits for a quality sport horse can be directly assessed (i.e. rideability, and jumping ability) rather than having to be assessed via indirect criteria such as conformation and temperament.

Rogers (1991b) expressed the view that, for the export market, the majority of buyers want to purchase either top proven competition horses, or young horses (4 to 6 years old) that are well schooled and with a demonstrated potential to be at least above average competition horses. This view has been supported by other industry observers and participants (A.Vallance personal communication, Scott 1992, A.Magnusson personal communication).

A.Magnusson (personal communication), stated that for New Zealand horses to be suitable for the North American jumper / hunter market it is best if they are only broken in and lightly schooled. Up to this stage of training very little permanent educational damage can be done. Most New Zealand riders have a poor understanding of the correct training procedures and techniques necessary to develop balanced, obedient sport horses. Rogers (1991b) stated that lack of thorough early education of sport horses was a weak point for the New Zealand sport horse industry, many horses not realizing their true potential because of poor and unprofessional early education.

Huizinga et al (1990) reported that in the Dutch sport horse industry, 40% of the horses presented and ridden in the young horse competitions were trained by professional trainers. In France the "classic cycle", (jumping competitions for young horses) is used to provide a training, evaluation and marketing medium for the French sport horse (Bour 1990, Tavernier 1990a). Rogers (1991b, 1991c, 1992) discussed the development of young horse competitions within the current New Zealand equestrian competition structure, and suggested that these competitions could promote a medium for breeders to market their stock while also encouraging a more thorough and professional education of young stock. This view supported those of Murdoch (1990). Scott (1992) stated that "overseas buyers are showing a preference for horses that are performing well and the format of such a show (young horse competitions) will encourage breeders to produce and develop their horses along the correct lines".

There appears to be little, if any documentation as to the training/ marketing structure for the New Zealand sport horse. It is unlikely that the structure and system in New Zealand differs greatly from that of other nations, the only marked difference within the New Zealand industry being the smaller percentage of full-time professional dealer/trainers linking the breeders and the general riding population. Traditionally New Zealand breeding and training has been an amateur activity dominated by the hobby breeder or trainer.

Figure 3.7 reflects the current situation of training/marketing of sport horses in the New Zealand domestic market. For the export market, the training/marketing structure is closer to the situation in other nations. A large majority of sport horses being sold overseas pass through a trainer/dealer rather than overseas buyers directly purchasing from the breeder.

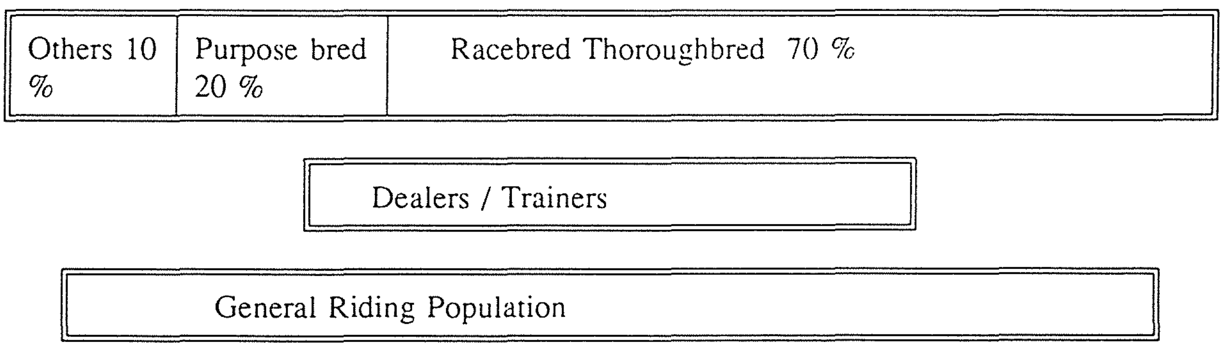

Figure 3.7:

Diagrammatic representation of possible current New Zealand sport horse marketing/

production system:

Higher prices, in the export market have created a niche within the industry for the professional sport horse breeder, and the dealer/ trainer. Vallance (1989) suggested that New Zealand is set to enter a new growth stage in the professional preparation and training of young horses for sale locally and overseas's. If the industry does develop according to expectations it is likely that it could develop into the structure shown in figure 3.8.

Others 10 %	Specially bred 45 %	racebred Thoroughbreds 45%

Dealers / Trainers

General Riding Population

Figure 3.8:

Diagrammatic representation of possible future (15-20 years) New Zealand sport horse marketing/ production system:

3.3.7 Markets:

Murdoch (1990) identified that the export market for New Zealand sport horses could be divided into three tiers. The top or elite horses from the foal crop would be suitable for the American market (USA and Canada). The second grade horses would be suitable for Japan where equestrian sport is becoming increasingly popular. It is estimated that between 600,000 and 1,000,000 people ride in Japan. Finally, the cheaper grade horses could be suitable for Korea. Korea is believed to be 10 years behind Japan in equestrian development, but many people have considerable wealth and a desire to be successful.

Vallance (1989) provided data from the American Horse Show Association demonstrating the dramatic increase in the prices paid for sport horses in the United States (table 3.8).

Table 3.8: Percentage of sport horses sold in price range in the United States (Vallance 1989).

Price (US$)	1983	1988
5000 to 10,000	37 %	14 %
10,000 to 15,000	28 %	12 %
15,000 to 35,000	27 %	55 %
over 35,000	8 %	19 %

These price increases have also been reflected in the New Zealand market with quality young horses up to 5 years of age, basically very green and from a number of breeds fetching from $4,000 to $10,000 on a regular basis, on both the domestic and export market.

Data provided by the New Zealand Statistics department revealed a 20 % decrease in the average export price for a New Zealand-bred sport horse (Table 3.9) during the 3 year period from 1988 to 1990. This does not appear to be any worse than the decrease in market returns experienced by Ireland (20% and 15% decrease) (Forde 1990, 1992) and England (14% decrease) (Kidd 1992) .

Table 3.9: Number of Sport horses exported, average price, and total earnings for 1988 to 1990.

YEAR	Number Exported	Average Price	Total Earnings
1988	334	7570	$2,528,444
1989	543	5755	$3,125,434
1990	513	6217	$3,189,716

During the last 3 to 4 years the sport horse and the racing sectors of the horse breeding industry have experienced a downward trend in market prices driven by the current worldwide recession. This may be the reason for the falling export prices of the New Zealand-bred sport horse. Another possible reason for the decreasing export prices may be due to the increasing numbers of young horses sold, rather than the more expensive proven competition horses which previously dominated New Zealands sport horse exports. This would appear to be the most likely situation. The number of horses exported and total value exported, have increased 35% and 21% respectively over the last 3 year period.

A summary of the major markets for the New Zealand sport horse is provided in table 3.10.

Table 3.10:

Major markets for the New Zealand sport horse and gross export returns.

YEAR	AUSTRALIA	UNITED KINGDOM	JAPAN	USA
1988	$1,535,000	$47,445	$16,000	$647,000
1989	$942,825	$515,282	$661,000	$493,000
1990	$1,474,200	$557,066	$465,500	$483,000

From Table 3.10 Australia would appear to be the dominant market for New Zealand sport horses. This seems an unlikely market when Australia enjoys similar competitive advantages to New Zealand for sport horse production. This value was possibly inflated by the inclusion of horses representing New Zealand in trans-tasman competitions and which would return to New Zealand. However, a large number of sport horses are purchased by Australian dealers. Many of these horses are then sold on to clients in Japan or Korea and it may be this indirect trade with Japan and Korea that provides the majority of the sales to Australia represented in table 3.10.

The upward trend in gross exports is believed to be due to good marketing achieved via the excellent performances of the New Zealand Equestrian team at the recent Olympic and World championships. These values tend to indicate that there is potential for sport horse breeding in New Zealand to become a major commercial industry supplying quality sport horses for the world markets.

3.4 CONCLUSION

The basic structure of the New Zealand sport horse industry is similar to that of many of the other major sport horse producing nations. However, the present New Zealand industry tends to lack the highly organised infra-structure that exists within the European sport horse breeding industries. This lack of a cohesive infra-structure directly related to the relative infancy of commercial sport horse production in New Zealand.

The increase in participation in equestrian sports in New Zealand is a reflection of a global increase in the popularity of equestrian sports. This increased interest in equestrian sports and the increasing demand for the New Zealand-bred sport horse has stimulated the transition of sport horse production from an amateur hobby activity to a viable commercial industry.

Numerically New Zealand would appear to have sufficient breeding stock (approximately 5750 broodmares) to sustain a viable commercial industry. At present, industry development is limited by low numbers of registered breeding stock and by too many societies attempting to maintain records. It would be more efficient if the central equestrian body (NZEF) became involved with the maintenance of pedigree and performance data, as is the situation in many of the European industries. The ideal situation would be for the NZEF to take over the running of the NZSH.

CHAPTER FOUR
BREEDING OBJECTIVE FORMULATION:

4.1 INTRODUCTION

In the scientific literature, comparatively little attention has been given to the establishment of a breeding objective for sport horses. To date only Klemetsdal (1990) has addressed the topic in any great depth, though many authors (Huizinga and Van Der Meij 1989, Tavernier 1990a, Philipsson et al 1990, and Wickham 1990) have referred to the importance of defining the breeding objective and stated a simplified objective for their respective sport horse populations.

When a multitrait objective is chosen, it is necessary to weight the different traits in the objective according to some measure of their importance. With economic objectives, various measures of economic value are used. Hazel (1943) stated that the relative economic value of each trait depended upon the amount by which net profit may be expected to increase for each unit of improvement in that trait. Turner and Young (1969) proposed that in some situations the relative economic value for a trait may demonstrate the relative preference of the breeder derived from some other consideration (i.e. marginal utility).

Moav (1973) emphasised the need to identify who is to benefit from the genetic improvement. In the current study the objective chosen was for maximisation of economic returns to the commercial sport horse breeder since for this sector monetary benefits are more important and it is easier to use economic units to provide a measure of traits than marginal utility, which could be the applicable measure for the hobby breeder.

To date, only Bruns et al (1978), and Schwark et al (1988) have attempted to calculate relative economic values for sport horses. Both of these studies were performed on the German warmblood population using phenotypic regression of measures of various traits on auction price or sales price. Bruns (1987) suggested that these values may not be that suitable for a number of traits considered important for sport horses.

The aim of this study was to derive relative economic weighting factors for traits considered important by New Zealand sport horse breeders.

4.2 MATERIALS AND METHODS:

4.2.1 Subjectively Derived Objective:

Data were obtained from the New Zealand Trade Development Board for sport horse exports in the period 1988-1990. Average export sales prices for sport horses were also calculated from data presented by Murdoch (1990), and other industry participants.

These data were utilised to produce average sales price and estimates of the standard deviation in price for horses in 4 different categories, these being:

A. Unbroken horse (age 0 to 1 year old)

B. Unbroken horse (1 to 3 years old)

C. Broken in / novice level (3 years to 6 years)

D. Well schooled / advanced competition level (7 years onwards)

Within each category traits considered to be intrinsic to quality sport horses and which could be evaluated at each stage of development were allocated a subjective relative percentage influence on final sale price. Economic weightings were then calculated utilizing the following procedure:

$$\text{econ weight} = \frac{(\text{M\$\$} - \text{av.\$\$})}{3} * \text{rel \% infl trait}$$

where,

econ weight	= economic weight for trait in objective
M$$	= maximum sales price for horse in that category (A-D)
av.$$	= average sales price for horse in that category (A-D)
rel % infl trait	= relative percentage influence of trait on sales price.

4.2.2 Regression of Selling Price on Product trait Levels:

The regression of selling price on product trait levels is similar to the procedure utilized by Bruns et al (1978) to estimate economic weightings for various subjectively measured traits in the German Hannoverian and Oldenburg sport horse populations. It is also similar to the procedure used by Schwark et al (1988) to calculate economic weights for mares and stallions exported from a population of the German sport horse.

In the most favourable case, with complete information, multiple regression techniques can be used to produce unbiased estimates of economic weights. However, they usually have large sampling errors (Vandepitte and Hazel 1977). For most sport horse traits in New Zealand suitable data are lacking.

Data were obtained as to the sales price and various subjective assessments for sport horses sold in the 5 year period from 1986 to 1991. Final sales price was inflation adjusted to avoid bias due to the different sales periods. The horses sold were grouped into 3 categories:

advanced/ well schooled competition horses (n=12),

recently broken in and novice horses (n=9) and,

low grade riding horses (n=10).

In each category retrospective subjective evaluations were made on 5 criteria, these being:

conformation,

jumping performance,

rideability,

temperament, and

bunt (markings i.e blaze, socks, etc).

The Minitab statistical computer package (Ryan et al 1986) was used to perform a multiple regression of the total sales price on the five subjectively evaluated criteria. Two models were tested. The basic model included the criteria of conformation, jumping performance, rideability, and temperament. A second model added the criterion bunt to the first model.

4.2.3 Genetic Progress Required.

A modified version of the SELIND computer programme (Cunningham and Mahon 1977) was used to calculate selection indices. Optimal economic weighting of the traits were derived that satisfied the criteria of genetic progress required. As there are no genetic parameters estimated for the New Zealand sport horse industry those published for many of the European sport horse populations formed the basis of the calculations (Bade et al 1975a, 1975b, Bruns et al 1985, Huizinga et al 1990, 1991a, 1991b, and Preisinger et al 1991).

4.3 RESULTS AND DISCUSSION:

4.3.1 Traditional Type of Objective:

Rogers (1991c) identified qualities thought to be intrinsic to a quality sport horse. "The ideal sport horse should be 16.2hh and of medium frame and bone - for example, a bigger bone thoroughbred type ranging to the lighter type of warmblood cross. They should have an attractive head and long, well set on neck. Their conformation should be good. Their movement should be straight, elastic and full of expression but without a high knee action. They should show a good attitude to 'work' and want to please their handler".

This ideal conceptual animal as a breeding objective is not a great step forward in utilization of modern animal breeding principles. This type of objective does not describe mathematically the relative contribution of the various components towards the overall breeding objective and does not promote the use of an effective selection procedure. However, it appears to be the predominant type of objective set by most sport horse breeding groups and associations (Haring 1980, Kidd 1980, McAteer 1984, Christmann et al 1989, Phillipsson et al 1990, Anon 1990).

4.3.2 A Simple Objective.

A biological objective could be set as improved performance in the Olympic equestrian sports. Huizinga and Van Der Meij (1989) identified this as the most simple objective for the Dutch Warmblood. But, since within equestrian sports there are different disciplines, even this simple goal must allow for a multi-trait objective.

Unlike most equestrian nations, eventing is popular in New Zealand (18% of all horses registered) and thus the breeding objective should include improvement in eventing. Also many of the export sales are of horses destined for eventing since this is where New Zealand has an international reputation.

A simple biological objective for the New Zealand sport horse population aimed at improving the success of the New Zealand sport horse in the Olympic equestrian sports could be mathematically described following Hazel (1943) as....

$$H = a_1g_1 + a_2g_2 + a_3g_3$$

where:

H = the aggregate genotype or breeding value,

g_1 = the individual genotype for showjumping,

g_2 = the individual genotype for dressage,

g_3 = the individual genotype for eventing and,

a_1 - a_3 = the respective weightings for each discipline.

In this particular situation it could be argued that rather than utilization of economic weightings for each genotype of equestrian discipline it may be more appropriate to utilize the proportion of sport horses registered in each discipline and therefore:

$$H = 0.44g_1 + 0.38g_2 + 0.18*g_3.$$

However this would not take account of the interest in eventing horses among the overseas purchasers.

4.3.3 Consideration of the Production System.

When considering establishment of an objective for the entire sport horse production system, it is necessary to consider other characteristic's that may not directly relate to competition success. These could be riding traits (eg. willingness to work, ease of handling, etc) and those that would relate to the production system such as fertility, efficient feed utilization, and durability. Figure 4.1 provides diagrammatic representation of the three traits in the simple biological objective and those qualities with a genetic base that contribute towards the three traits.

CONFORMATION	JUMPING	RIDEABILITY
"soundness" "durability" "flexibility"	**Jumping Ability:** "scope" "boldness"	**Movement:** "biomechanical efficiency"
	Jumping Technique: "scope" "regularity of jumping style"	**Temperament:** "will to work" "capacity to work"
		Conformation:

Figure 4.1: Qualities intrinsic to a good sport horse.

The genetic independence of jumping and dressage (Bruns 1981, Bruns 1986, Meinardus and Bruns 1989a, Huizinga et al 1990,1991a) raises the question of whether to select for both traits in the same population or just one trait, leaving the selection on the other trait for another population, or sub population. The segregation of the population into 2 groups one pursuing a jumping orientated breeding objective and the other a dressage objective does not appear a feasible proposition in New Zealand. This segregation would involve subdivision of an already small population (about 5750 broodmares) into even smaller subpopulations splitting genetic and financial resources. Also eventers need skills at both dressage and jumping as well as speed amd stamina. Philipsson et al (1990) drew a similar conclusion for the Swedish warmblood population (6000 broodmares), stating that while the market requires a multipurpose horse (jumping and dressage) specialization of the objective would be impractical.

Although the market demands a multipurpose horse, it is unlikely that each breeder would attempt to breed for every sector of the market, or that any one horse would be required to be equally competent in every field of competition. The biological criteria for the production of a superior showjumper could be:

1.jumping ability,

2.jumping technique,

3.soundness and,

4.rideability.

Both jumping ability and jumping technique have been shown to have a genetic basis (Bruns et al 1985, Nissen and Kalm 1986, Arnason 1987, Huizinga et al 1990, 1991a, 1991b) having weighted average heritabilities of 0.50, and 0.29 respectively (averaged after weighting according to the degrees of freedom). Many industry participants believe that there is a genetic basis for soundness due to its phenotypic association with good conformation but, little research has been done to establish whether many of the correlations assumed are correct. Rideability (h^2 =0.29) includes not only the quality of the movement but also the individuals capacity and willingness to work.

The breeding objective for showjumping performance could thus be described as follows:

$H_1 = a_4g_4 + a_5g_5 + a_6g_6 + a_7g_7$

where, H_1 = breeding objective for jumping,

g_4 = genotype forjumping ability,

g_5 = genotype for jumping technique,

g_6 = genotype for lifetime soundness,

g_7 = genotype for rideability and,

$a_4 - a_7$ = relative economic weightings for the respective objective traits.

When defining an objective for dressage the most basic objective could include just one criterion, "rideability". Rideability is defined as the ability of the horse to provide a pleasant and enjoyable ride due to possessing quality movement and, being willing to, and having the capacity to, perform the work being required of it, with an average heritability of 0.29 (Bruns et al 1985, Nissen and Kalm 1986, Arnason 1987, Huizinga et al 1991a, 1991b). The traits related to rideability have been shown to have weighted average heritabilities of movement (0.36), willingness to work (0.16), and capacity to work (0.24). Burger (1986) suggested that, to be successful in dressage, not only was it important that the horse had good movement but that it had the suitable conformation. This view is supported by Bolt (1978 cited by Holmstrom et al 1990) and Burzcyk (1989). Conformation also offers marginal utility through aesthetic factors, and thus should be included in a breeding objective for all horses not only dressage horses. The breeding objective for dressage could be as follows:

$H_2 = a_8g_8 + a_9g_9 + a_{10}g_{10} + a_{11}g_{11}$.

where,

H_2 = breeding objective for dressage,

g_8 = genotype of movement,

g_9 = genotype of willingness to work,

g_{10} = genotype of capacity to work

g_{11} = genotype of suitable conformation and,

$a_7 - a_{11}$ = relative economic value for each objective trait.

The objective for the eventing discipline requires a combination of both the jumping and dressage objectives, as well as a number of traits such as boldness that tend to be specific for eventing. It is possible that boldness would fall under the jumping technique category, as horses that are bold tend to have a good jumping technique due to greater self confidence in their own athletic ability. While it should be included in the objective, it could be selected for under the category of jumping technique.

Event horses require great staying ability, with top event horses covering on speed and endurance day up to 20 km of roads and tracks, up to 3400m of steeplechase, and up to 8000m of cross country course, a total of 41.4 km (NZHS rules 1989). Although, there appears to have been little work on the heritability of stamina, it probably has a genetic base due to the differences in physiological and performance parameters between thoroughbreds and other breeds (Gunn 1989a, 1989b, Bartmann 1991). The following breeding objective may be proposed as suitable for the breeding of event horses:

$$H_3 = a_4g_4 + a_5g_5 + a_6g_6 + a_7g_7 + a_8g_8 + a_9g_9 + a_{10}g_{10} + a_{11}g_{11} + a_{12}g_{12} + a_{13}g_{13}.$$

Where,

H_3 = breeding objective for eventing

g_4 - g_{11} = as above,

g_{12} = genotype for boldness in jumping

g_{13} = genotype for stamina

a_4 - a_{13} = relative economic values for each objective trait.

It costs less to produce a foal if the broodmare conceives easily and every year, so female fertility is important. With the increasing globalization of the sport horse industry, and the greater use of artificial insemination, future attention should also be paid towards the stallions rate of sperm production and, fertilization rate after freezing and thawing of the semen.

Feed efficiency should be included in the objective as greater ability to utilize feed available should promote more balanced growth and development in the young sport horse and also reduce food costs. Saastamoinen (1990) proposed that horse breeders, owners, and trainers are interested in factors affecting the growth and development of foals and young horses. Slow development and late maturity are two of the most important reasons for not starting, or for late beginning of a horses career.

Klemetsdal (1990) suggested that freedom from osteochondrosis and other skeletal disorders (DOD, developmental orthopaedic disease) in growing foals should be included in the objective. Therefore by including feed efficiency in the objective one should in theory minimize the occurrence of DOD. Horses that efficiently utilize their feed and therefore grow and develop in a balanced manner appear to be less susceptible to DOD (Hintz 1978, Stromberg 1979, Jeffcott 1991).

Recently, the inclusion of health of the horse into the breeding objective has been proposed. Clausen et al (1990) recommended greater documentation of disease in the population, so that selective breeding could play a role in the reduction of disease in the population studied. In New Zealand, J.Meyer (personal communication) suggested that the New Zealand horse breeder may have historically included durability and health in the breeding objective, and rigorously selected against horses unsound in wind, limb, or temperament or that were diseased. This was suggested as a reason why the present New Zealand horse population has such a good record for soundness, durability, and health. Because of the costs associated with disease in the horse, and the restriction it can place on a horses level of performance, it would appear essential that resistance to health problems be included in the comprehensive breeding objective for the New Zealand sport horse.

Colour and markings (bunt) should also be included. While not directly relating to the performance traits it offers marginal utility due to aesthetic factors and higher returns to breeders due to enhanced sales price. Discussion with industry participants indicated support for the hypothesis that markings (bunt) may influence final sales price. D.Winter (personal communication) indicated that Asian buyers at the recent Verden riding horse auctions (German sport horse) were significantly influenced by markings. However, Bruns et al (1978) found bunt to be of no economic value in a population of German sport horses.

Thus a comprehensive objective of the system could be

$$H_c = a_{11}g_{11} + a_1g_1 + a_7g_7 + a_{14}g_{14} + a_{15}g_{15} + a_{16}g_{16} + a_{17}g_{17} + a_{18}g_{18}.$$

where:

a_1, a_7,& a_{11} = as above,

a_{14} = genotype for temperament,

a_{15} = genotype for bunt,

a_{16} = genotype for fertility,

a_{17} = genotype for feed efficiency,

a_{18} = genotype for health and

$a_1, a_7, a_{11}, a_{14} - a_{18}$ = relative economic value for each objective trait.

However no attempt was made to establish economic weights $a_{16} - a_{18}$ due to lack of economic data and applicable genetic parameters. Therefore the objective for which economic weights were calculated for was:

$$H = a_1g_1 + a_7g_7 + a_{11}g_{11} + a_{13}g_{13} + a_{14}g_{14}.$$

where:

a_i and g_i = as abobe.

4.3.4 Derivation of Economic Weights.

4.3.4.1 Subjectively derived economic weights:

The age of marketing of sport horses can vary from weanlings through to proven competition horses. At these different stages of life and training the traits considered intrinsic to a quality sport horse vary in their relative importance. The fluctuation in the relative importance of the traits is a reflection of whether it is indirect or direct criteria that can be utilised to assess performance ability. Figure 4.2 provides diagrammatic representation of the importance of various economically important traits at different stages of life and training.

Weanlings.

Bunt 10%	Temp 15%	Movement 35%	Conformation 40%

Unbroken up to 3 yrs.

Bunt 10%	Temp 15%	Movement 25%	Conformation 25%	Jump (lunge) 25%

Broken in / Novice

Bunt 5%	Temp 10%	Rideability 30%	Conformation 25%	Jump 30%

Advance competition

Bunt 5%	Temp 5%	Rideability 30%	Confo 20%	Jump 35%

Figure 4.2
Diagrammatic representation of importance of various economic traits relating to final sale price at different stages of life and training.

When horses are sold at young ages fewer important traits can be assessed. As they get older other traits can be assessed and the factors determining economic weights change. Subjective economic weights need to be estimated for the various age groups. While a majority of sport horses may be marketed at less than 3 years of age, the sport horses sold after just commencing training or at the advanced stage of training do represent an economically significant group.

Table 4.1:

Relative importance of traits, in determining variation in estimated sales price, and estimated economic weights for sport horses ($/σ) and (%).

	AGE / STAGE OF TRAINING			
TRAIT	Weanling	1-3 yr old	novice (3-6yrs)	advanced (>7yrs)
Bunt	65 (10%)	216.7 (10%)	175 (5%)	1,000 (5%)
Temperament	97.5 (15%)	487 (22.5%)	175 (5%)	1,000 (5%)
Movement	227.5 (35%)	487 (22.5%)	---	---
Conformation	260 (40%)	487 (22.5%)	875 (25%)	4,000 (20%)
Jumping performance	---	487 (22.5%)	1,225 (35%)	7,000 (35%)
Rideability	---	---	1,050 (30%)	6,000 (30%)
Mean sales price($)	650	2,167	3,500	20,000

The estimates in table 4.1 have been weighted to account for the number of horses sold in each age group. Table 4.2 provides an example of possible economic values that can (with limited reliability) be used as economic weights for the traits in the objective. Each category was weighted according to the number of horses thought to be sold by breeders at these different ages and, stages of training.

Two theoretical models of the present market were proposed. PIY represents the present industry structure for young sport horses. PIY+A represents the present industry structure including the sale of advanced competition horses. These relative percentages are:

PIY: unbroken 75% of the market and,
broken in / novice horses 25%.

PIY+A: unbroken 75% of the market,
broken in / novice 20% of the market and,
advanced competition horses 5% of the market.

It must be borne in mind that the products of the breeding programme are to be marketed at least 4 -10 years from their date of birth. Therefore the economic weights should, if possible, reflect the demands and preferences of the future market. In an attempt to interpret the future market for New Zealand-bred sport horses the following relative volumes of horses sold at different ages and stages of training is proposed:

FIY+A. unbroken horses 15 %,
broken in / novice 75 % and,
advanced competition horses 10 %.

Utilizing this proposed structure table 4.2 provides suitable industry economic weights.

Table 4.2: Economic weights ($/standard deviation) for the hypothetical present industry structure selling either 75% unbroken and 25% broken young sport horses (PIY), or including advanced horses (PIY+A) or, predicted future industry structure (FIY+A).

TRAIT	PIY	PIY+A	FIY+A
Bunt	90	132	241
Temperament	148	189	253
Jumping performance	410	699	1,641
Movement/Rideability	367	614	1,409
Conformation	323	479	1,078

Animal breeding programmes by their very nature are long term projects. The results of present breeding decisions will be marketed in the future market that may, or may not, have the same selection objectives and economic weights as todays market. Economic weights should therefore attempt to reflect the relative economic importance of the traits that will be considered in future markets. Utilizing the proposed development of the New Zealand sport horse breeding industry outlined in chapter 3, the relative weightings for each group in table 4.2 were derived to provide subjectively estimated economic weights that should be applicable for a market 20 to 25 years (approximately 2 generations) from the present date.

Economic weights should reflect the net economic benefit from improvement in the trait of interest (James 1982). The values presented in this study represent gross benefits and therefore are not optimal. One form of correction would simply be to subtract the production costs from the returns and alot the net profit (estimated as in table 4.3 to be 20% of the gross profit) to the traits in the same proportions. However this would not change the relative weighting.

It is likely that some of the traits will influence the costs (eg. temperament and rideability could affect breaking and schooling costs) and therefore might be more important in an objective based on net benefits.

Table 4.3: Production costs and gross profit from the sale of an average 3-year old broken in sport horse.

Costs		Sales price
Year 0		
service fee	$1000	
foaling fee	$150	
mares grazing	$520	
vet, feed etc	$200	
	$1870	
Year 1		
grazing	$520	
feed, vet etc	$200	

$720

Year 2

grazing $520

feed, vet, etc $200 ---------

$720

Year 3

grazing $520

feed, vet, etc $200

breaking in,

schooling $1600 ---------

$2370

TOTAL COSTS	$5630	
SALES PRICE		$7000

The relative importance of the traits in table 4.2 were in close agreement with the relative importance of traits for the novice group (table 4.1). It was found that there was no significant difference in the genetic gain achieved with the different economic weights. The values obtained for the future industry structure (excluding the bunt category) were similar to the relative economic weighting of traits in young stallions calculated by Schwark et al (1988).

With the assumption that net profit was 20% of the gross sales price the follwing objective using 20% of the FIY+A values was chosen:

$$H = \$328g_1 + \$282_7 + \$216g_{11} + \$51g_{14} + \$48_{15}.$$

where,

a_i and g_i = as above.

Table 4.4: Comparison of subjective economic weights thought to apply in New Zealand and regression calculated economic weights from Germany.

Trait	**Relative Importance of the Economic Weighting of Traits in Sport horses (%).**			
	Schwark et al (1988)[1]	Present Study[2]		
	German	Novice	PIY+A	FIY+A
Bunt	--	5.0	6.2	5.2
Temperament	4.8	5.0	9.0	5.5
Jumping Performance	30.33	35.0	33.0	35.5
Rideability	23.91	30.0	29.0	30.5
conformation	21.34	25.0	22.0	23.3
Movement	19.54	--	--	--

1. Relative importance of economic weight for traits in young sport horse stallions in the German Democratic Republic.
2. Relative importance of economic weight for traits in young sport horses in New Zealand (both sexes).

The similarity of the relative importance of the economic weight of traits between this study and that of Schwark et al (1988) implies that sport horse buyers appear to place very similar emphasis on the selection criteria regardless of geographical location. Despite the limited data these subjectively estimated economic weights may prove useful for the short term. For the longer term there is a need for comprehensive documentation of data applicable to the New Zealand sport horse industry, so that more reliable estimates may be calculated.

4.3.4.2 Regression of Selling Price on Trait Levels:

Economic weights were calculated using the regression of sales price on trait levels. The small data set available limited the applicability of this technique. Unacceptable results with large standard errors, were obtained so the estimates were not used to calculate economic weights.

4.3.4.3 Genetic Progress Required:

Economic weights were calculated to satisfy the criteria of genetic progress required. The economic weights derived were in close agreement with the subjective estimates. Due to believed limitations in the suitability of the genetic parameters the economic weights calculated to satisfy genetic progress required were not used.

4.4 CONCLUSION

A biological objective could be set as improved performance in the Olympic equestrian sports (showjumping, dressage, and eventing).

Because of the limited data available subjective methods could only be used for allotting economic weights. In deciding on these weights predictions of the state of the industry over the next 20 years were made. The objective chosen was:

$$H = \$328g_1 + \$282g_7 + \$216g_{11} + \$51g_{14} + \$48g_{15}.$$

where:

g_1 = genotype for showjumping,

g_7 = genotype for rideability,

g_{11} = genotype of suitable conformation

g_{14} = genotype for temperament and,

g_{15} = genotype for bunt.

CHAPTER FIVE:
SELECTION STRATEGIES:

5.1 INTRODUCTION:

In Chapter Four a breeding objective for the New Zealand sport horse population was proposed. In order to improve the traits in that objective as rapidly as desirable an effective selection policy must be implemented.

Perhaps the selection system that would be easiest to implement would be to improve the recording of competition results and base selection on accurate analysis of these results.

Genetic progress per year would be enhanced if the animals being considered underwent competition at a young age. The breeders of thoroughbreds have been primarily concerned with racing success. Some of the more important races are restricted to three year olds and performance in these provides an indication of breeding value shortly after the horses reach breeding age. It may be argued that some of the traits that might be desired in the sport horse objective (i.e temperament and ease of handling) will not show directly in competition records. For the typical owner of racing thoroughbreds these are not such important considerations as they may be for the owner of a sport horse.

Several European countries (Switzerland, Denmark, Holland, Sweden, and Germany) have tended to utilize central performance testing at stations for the evaluation of potential breeding stock (Kidd 1980, Philipsson et al 1990, Huizinga et al 1991a). This primarily been brought about by a) evaluation of breeding stock by competition success not addressing all the traits in the objective, b) because these competition results may be too influenced by environmental sources of variation and, partly because sport horses are getting fairly old before they can be evaluated on normal competition results. The period during which this testing takes place ranges from 2 weeks for Holstein mares (Nissen et al 1986) and 3, week-long tests for Swedish stallions (Philipsson et al 1990), through to the most common period of 100 days for stallions (Kidd 1980, Bruns et al 1985, Huizinga et al 1991a, 1991b). The extreme is the state Hannoverian studs 11 month test (Bruns et al 1985, Christmann et al 1989).

A majority of selection programmes existing for sport horses in Europe involve a minimum of 2 stages, initially selection on pedigree, conformation and movement at either 6 months, 2 or 3 years of age, and then evaluation of the individuals own performance ability at 2.5 - 3.5 years of age (Kidd 1980, Bruns et al 1985, Philipsson et al 1990, Huizinga et al 1991a). Traditionally, minimum culling levels are used for the first stage of selection. The current trend in Germany is to base the initial selection on the colts breeding value estimated from data on its relatives (Claus and Reinhardt (1991). Index selection is then utilized at a later stage when the individuals are assessed on their own performance either at station or in the field. The exceptions to these evaluation procedures are those in England and Ireland where reliance is mainly on single stage selection (minimum culling levels) for conformation, movement and pedigree (Polling 1991, O'Keefe 1991, Forde 1992).

The aim of the present study was to estimate the genetic response achievable if one of a variety of single stage selection procedures, similar to those already in place in Europe, were introduced and implemented within the New Zealand sport horses population.

6.2 MATERIALS AND METHODS:

In total, 28 potential selection plans were modelled. Published phenotypic and genetic parameters for European sport horse populations were utilized to calculate the selection indexes and the response to selection for each of the models tested. As there are no estimates of phenotypic or genetic parameters for the New Zealand population those published in the scientific literature for many of the European sport horse populations formed the basis of the calculations (Bade et al 1975a, 1975b, Bruns et al 1985, Huizinga et al 1990, 1991a, 1991b, and Preisinger et al 1992). The estimates available were surveyed and weighted according to their degrees of freedom before averaging. The values used in calculating the index are shown in table 5.1.

Table 5.1: Assumed genetic and phenotypic parameters for the New Zealand sport horse industry.

TRAITS	heritability and Correlations[1]				
	Mov.	Confo.	Jump.	Ride.	Temp.
Movement	0.36	0.50	0.00	0.47	0.59
Conformation	0.75	0.30	0.20	0.30	0.20
Jumping	0.25	0.45	0.25	0.10	0.50
Rideability	0.53	0.53	0.28	0.25	0.70
Temperament	0.31	0.31	0.36	0.53	0.16

1. Genetic correlations above the diagonal,
Phenotypic correlations below the diagonal,
heritability on the diagonal.

In an attempt to modify the influence of genetic and phenotypic parameters obtained from the European data the parameter "accuracy of performance test" was created. This parameter attempted to adjust the r_{TI} to correct for the greater variation in pre-testing environment that would be encountered within the New Zealand sport horse industry. The r_{TI} is the genetic correlation of the selection index with the breeding objective and as such it represents the accuracy of selection. Initially the r_{TI} was calculated for the 100 day central performance test (100d CPT), theoretically the most accurate of the selection procedures. Subjective procedures were used to revise the r_{TI} for the other selection models. The adjustment factor was the so-called "accuracy of performance test", which provided a relative measure of selection accuracy in comparison to the 100d CPT. These values for the accuracy of perfromance test parameter were, Present (0.09), C + M (0.11), NHC (0.4), YHC (0.4), ODRQT (0.6), 2 w CPT (0.7), and 3*w CPT (0.7).

Model one (Present).

Model one reflected the present industries demographic and selection parameters. The assumptions were largely based on the structure discussed in chapter 3. It was assumed selection of breeding stock both male and female was based primarily on conformation and movement. Some account was also taken of competition successes of animals and their relatives, this being purely subjective.

Model Two (C + M).

This model simulated the influence of changing the populations demographic parameters towards those of the Dutch, French, German, and Swedish sport horse industries (Langlois et al 1983, Langlois 1986, Baudoin 1990, Philipsson et al 1990, Huizinga et al 1991a, Preisinger et al 1991).

Model Three.

These models tested the effect of selection on more efficient selection of stallions; selection for mares based only on conformation and movement. Six stallion selection procedures were modelled these being.

model 3.1 One day riding quality test (ODRQT)
model 3.2 Young horse competition results (YHC)
model 3.3 2 week central performance test (2w CPT)
model 3.4 3 * one week central performance test (3*w CPT)
model 3.5 100 day central performance test (100d CPT) and
model 3.6 Normal competition structure results (NHC).

Model 3.1. ODRQT

This testing procedure was based on the riding quality tests in Sweden for 4 year olds (Thafvelin et al 1980, Arnason 1988 cited by Philipsson et al 1990). Similar riding quality tests are also utilized in Germany to field test mares, and provide progeny test data (Klimke 1987, Christmann et al 1989).

The traits evaluated were proposed to be,

Conformation,

Movement,

Rideability / temperament and,

Jumping performance (free jumping).

Each trait would be scored by the judging panel using a scale of 0 to 10.

Model 3.2. YHC:

Age-specific young horse competitions are currently used for performance testing stallions in the French sport horse breeding industry (Bour 1990, Tavernier 1990).

Age specific young horse showjumping competitions in New Zealand were instigated in 1991. Initially recognition of genetic merit would be based on performance in these competitions, colts obtaining points dependent on placing, competition standard (i.e qualifying series or final at Horse of the Year Show), number of class entries, and number of competition starts. Colts would be recognized as being of suitable genetic merit to be a sire upon obtaining a set minimum of points. If sufficient data were generated, breeding values could be calculated using the BLUP animal model, as in France (Tavernier 1990).

Model 3.3. 2w CPT:

This procedure was closely modelled on the Holstein mare performance test and the recently (1988) instigated 18 day performance test for Hannoverian sport horse mares (Nissen and Kalm 1986, Von Stenglin 1990).

Stallions would be trained in a standardized environment at the testing station for 2 weeks with testing taking place on the final day. 3 indexes would be calculated, these being, a universal index, a riding index and a jumping index. Because of the longer test period a greater variety of traits can be evaluated. For definition of traits see Huizinga et al (1991b).

Model 3.4. 3*w CPT:

This method of performance testing for 3 repeated 1 week tests at 6 month intervals is based on the Swedish model for sire evaluation (Philipsson et al 1990). The evaluation procedure would use identical weighting to calculate the 3 variants of the index as with the 2 week central performance test. The difference is that testing would be for 3 one week periods. In Sweden it is now common practise for stallions to enter the central performance test at 4 years (Philipsson et al 1990). In the New Zealand model testing was proposed to start at 3 years of age.

Model 3.5. 100 d CPT:

Stallions would be evaluated at 25, 50, 75, and 100 days, similar to current practise for 100 day central performance test of the Dutch Warmblood (Huizinga et al 1991b).

Model 3.6. NHC:

Within this model recognition of a sires genetic merit is obtained via the stallions or its progeny's success within the standard competition structure. The prerequisites are identical to those currently being used by the New Zealand Warmblood Breeders Association, these being; to be placed in the first three five times at B grade showjumping or intermediate eventing, or by winning five times at elementary level dressage.

Table 5.2: Base input parameters assumed for the New Zealand sport horse industry.

BASE PARAMETERS	VALUE
Broodmare herd size	5750
Annual broodmare replacements[1]	1711
Fertility[2]	85%
Foal crop	4888
Colt foal crop	2444
Filly foal crop	2444
Services / sire	15
number of sires[3]	383
sires service life (yrs)	9
Annual sire replacements	43

1. Assumed to be equivalent to 70% of annual filly foal crop.
2. From Hogan (1983)
3. broodmare herd / services per sire.

It was proposed that the development of a selective breeding programme would change the populations demographic parameters towards those of the European sport horse industries. Therefore, for model 2 onwards,

services/sire = 22,

number of sires= 261 and,

annual sire replacements = 29.

Table 5.3: Parameters relating to the different proposed industry selection procedures and the related industry structure.

MODELS	r_{TI}	Age 1st seln.	Age 1st serv.	Genrn. Intvl.	Colts used/ tested
Present	0.04	3	3	16.9	43/244
Confo + Move	0.05	3	3	13.0	29/733
NHC	0.18	4	7	19.2	29/49
YHC	0.18	4	5	13.1	29/244
ODRQT	0.27	3	3	10.9	29/244
2w CPT	0.32	3	4	12.7	29/73
3*w CPT	0.32	3	4	11.5	29/73
100d CPT	0.45	3	4	12.7	29/49

Model four.

The aim of this model was to calculate the effect of including selection for the full index (via the earlier proposed selection methods) within the dams to breed sires pathway. Four selection strategies were tested. These were,

Conformation and movement,

One day riding quality test,

Young horse competition results and,

Normal competition results.

Central performance testing options are probably not viable in New Zealand for the performance testing of the dams of sires. The number of mares likely to be tested was far less than the minimum number of broodmares needed to breed the next generation of sires.

Table 5.4: Models tested as options for selection within the dam - sire pathway.

MODEL	SIRES	DAMS - SIRES
4.1.1	NHC	C + M
4.1.2	NHC	NHC
4.1.3	NHC	YHC
4.1.4	NHC	ODRQT
4.2.1	YHC	C + M
4.2.2	YHC	NHC
4.2.3	YHC	YHC
4.2.4	YHC	ODRQT
4.3.1	ODRQT	C + M
4.3.2	ODRQT	NHC
4.3.3	ODRQT	YHC
4.3.4	ODRQT	ODRQT
4.4.1	2 w CPT	C + M
4.4.2	2 w CPT	NHC
4.4.3	2 w CPT	YHC
4.4.4	2 w CPT	ODRQT
4.5.1	3*w CPT	C + M
4.5.2	3*w CPT	NHC
4.5.3	3*w CPT	YHC
4.5.4	3*w CPT	ODRQT

4.6.1	100d CPT	C + M
4.6.2		NHC
4.6.3		YHC
4.6.4		ODRQT

For the ODRQT assessment of the mares, temperament was substituted for the rideability test. This change in the format of the test had the effect of reducing the accuracy of performance test parameter down to 0.5 (r_{TI} = 0.23). This change in the format of the ODRQT for mares was in response to the cost of breaking in and preparing mares for the tests if their main subsequent function was to be that of broodmares and they would be seldom ridden.

5.3 RESULTS AND DISCUSSION:

5.3.1 Present Industry Structure

Genetic structure:

The New Zealand sport horse gene pool is predominantly of thoroughbred blood but many other breeds have also contributed.

Most broodmares are thoroughbreds, and many others are at least 50% thoroughbred. The remaining broodmares (containing less than 50% thoroughbred) are a small sector of the herd. At present the number of industry bred broodmares is extremely low (approximately 20%). The majority are recruited from the racing industry and to a lesser extent from the farm hack population.

Generation interval:

The majority of the thoroughbreds tend to be recruited at a relatively advanced stage of their reproductive career. Of the broodmares in the model herd 50% were 14 years or older. This produced the positively skewed broodmare age structure observed in figure 5.1. Even when the industry establishes itself and breeds the majority of its own broodmare replacements, the skewed age distribution would still persist, if present selection methods are used. This would be due to the relatively advanced age of sport horses before any measure of performance ability can be obtained within the present system. When evaluation is based on the indirect criteria of conformation and movement, it would appear that 3 years is the youngest age at which these criteria can be accurately evaluated. Before this age the immaturity, and different growth phases of the youngstock often make prediction of adult conformation and movement inaccurate.

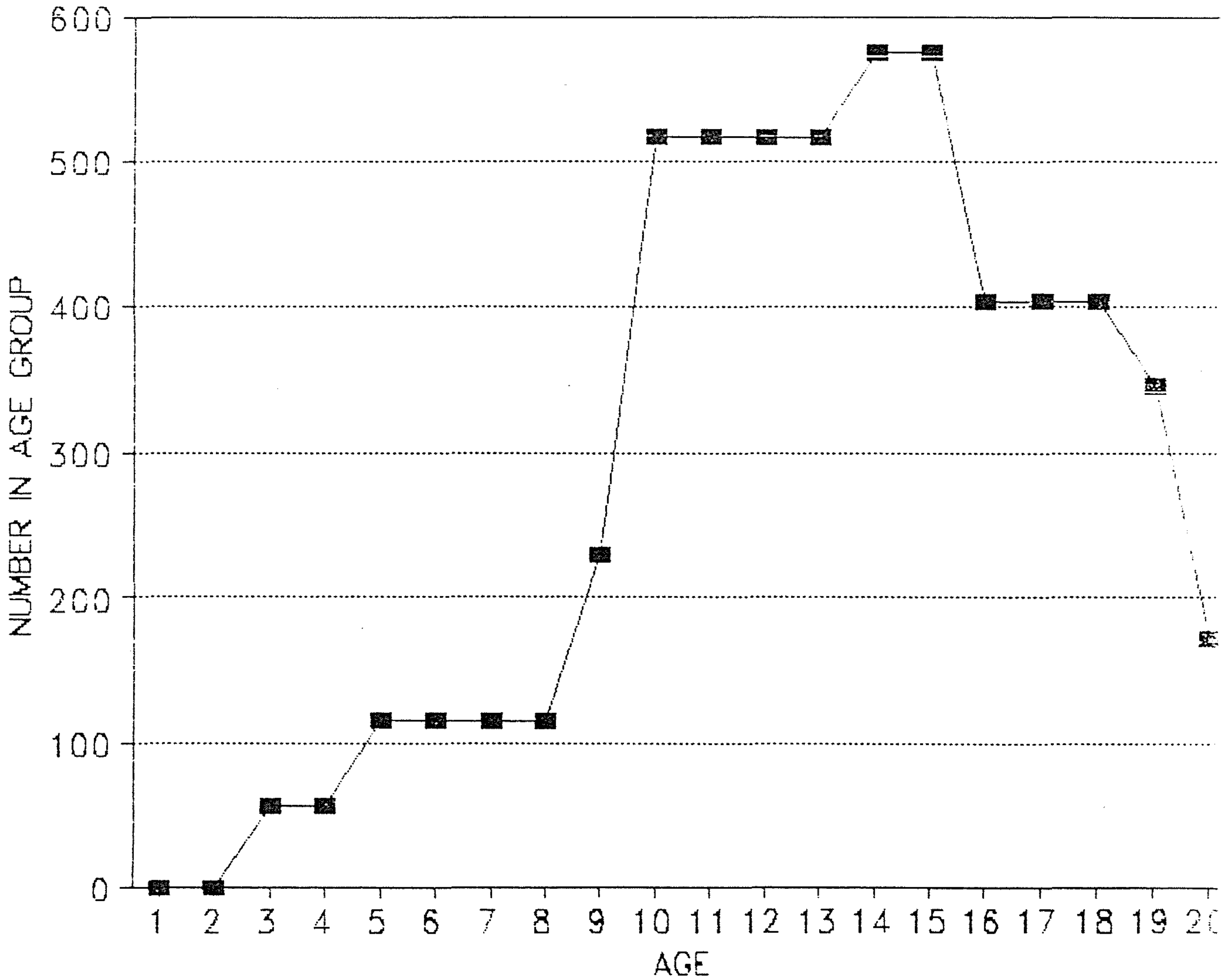

Figure 5.1:

Age structure of the present New Zealand sport horse broodmare population.

The generation interval is very long for the dams to breed dams pathway and for the dams to breed sires pathway (17.3 years). The long generation interval is directly related to the advanced age of breeding stock before genetic merit can be accurately evaluated. More often than not recognition of an mares genetic merit occurs via evaluation of her progeny. Many mares do not have any performance record. This reliance on progeny performance to evaluate the mares genetic merit tends to extend the already long generation interval in sport horses. The recruitment of broodmares from outside the industry tends to diffuse the potential genetic response achievable due to the constant intake of relatively unselected stock into the breeding programme. The effects may however be minimal since little genetic response is potentially achievable via selection in the dams to breed dams pathway. The importation of broodmares from the racing thoroughbred genepool may perhaps offer some advantage in the form of heterosis, as a number of sport horse sires are non-thoroughbred, or thoroughbred crosses. Deskur and Sosnowski (1978) suggested that heterosis may influence jumping ability and performance, when thoroughbred sires are crossed with draught mares. This situation is similar to the hybrid vigour apparently exploited by Irish sport horse breeders putting their Irish Draught and Irish Draught thoroughbred cross mares to thoroughbred sires. There appears to have been no attempt to exploit or investigate the role of maternal heterosis.

The comparison of the generation interval for the two pathways with other livestock species highlights the excessively long generation intervals in horse populations. Comparison of these parameters with established European sport horse industries identifies that this generation interval is at least 3 years longer than those calculated for the established industries, the average generation interval for these population's ranging from 10.4 to 14..32 years (Langlois 1976, Baumgarten 1974 cited by Langlois et al 1983, Philipsson et al 1990). In comparison with our industry the established European sport horse breeding populations tend to obtain one foal off the mares when they are 3 years old, before they are ridden competitively. This practise of breeding the mare once as a 3 year old may be a contributing factor to the lower generation intervals for these populations.

The sires are also predominantly thoroughbred (60-70%) being recruited from the racing industry. In a similar pattern to the broodmares this tends to extend the generation interval (as recognition of genetic merit occurs via progeny performance). This produces a similarly skewed age distribution structure for sires as that observed for the broodmares.

Unfortunately, with this structure, many sires genetic merit for competitive ability is not recognized until they are of an advanced age, or no longer in the breeding population. The current industry practise of many sires siring a few foals during a relatively short stud career compounds the effect of the low selection intensity and inefficient recognition of a sires genetic merit. The problem of many sires servicing few mares may be typical of sport horse populations. In the Trakehner breed there is an average of one stallion per nine broodmares although the German sport horse population average is 22 broodmares per sire (Preisinger et al 1991). In France the situation is very similar with the selection intensity in the sire pathway being below that optimal for maximization of genetic merit. The state stallions average 36 services per sire, and public stallions only 15 services per sire (Langlois et al 1983).

Selection intensity:

The management system of a majority of sport horse breeders places large emphasis on any period of delay from a stallion entering the evaluation programme until selection. In Europe climatic conditions necessitate the stabling of horses during most of the year. The vast majority of horses in New Zealand are kept in paddocks. Under these conditions the keeping of colts or stallions on the property can provide management problems. For this reason the majority of sport horse colts are gelded before they are 2 years old, greatly reducing the number of potential sire candidates available for any type of selection programme. This practice appears to be similar to that of breeders of the Icelandic Toelter pony, who castrate 90 % of the colt foal crop because of management problems (Hugason 1983 cited by Hugason et al 1987). Hugason et al (1987) demonstrated that maximum genetic progress is always obtained for large selection intensities in the second stage (stallions own performance). In order to achieve this a large proportion of young colts must be kept uncastrated and undergo the performance testing to form the second selection step.

Thus it is important that potential stallion prospects are identified at an early age, preferably before the colt is a yearling. In the established sport horse breeding programmes in Europe potential stallion prospects are selected on their pedigree, conformation, and movement at weaning (approx 6 months old) in Germany, (Christmann et al 1989). In the Dutch warmblood, pre-selection of stallions to enter the central performance test is based on the results of stallion shows. Annually about 30 pre-selected mostly 3 year old stallions are tested (Huizinga et al 1991a). In each of the evaluation programmes, early identification of future stallion prospects on their pedigree, conformation, and movement is the first stage of selection. The advantage of this is that breeders are made aware of the quality of their colts before the age when gelding usually occurs, and hopefully top scoring colts will be left entire in the hope they will become selected stallions. An alternative for a breeder not willing to keep a colt on their property could be to sell the top scoring colts as weanling's to other breeders willing to, or wishing to stand a stallion. Female selection was assumed to be minimal and primarily based on the assesment of conformation and movement.

The one day riding quality test offers the advantage of relatively early evaluation of breeding stock, moderate accuracy in selection, and the ability to select directly for a greater number of traits in the breeding objective.

The central performance testing options while having greater accuracy than the one day riding quality test all tended to suffer from the likelihood of fewer foals tested and therefore a lower selection intensity. The 100 day central performance test was assumed to have a high cost which limited number of colts performance tested annually and lowered the selection intensity. These discounted the advantages of low generation interval and increased accuracy of selection associated with the central performance test models

5.3.2: Calculated response to sire selection models:

Table 5.5:

Sire Selection:

r_{TI}, generation interval and relative genetic gain per year for the objective between models.

MODEL	r_{TI}	GENERATION INTERVAL	GENETIC GAIN (σ/y)
Present	0.04	17.1	0.003
C + M	0.05	12.4	0.009
NHC	0.18	15.5	0.010
YHC	0.18	12.4	0.019

ODRQT	0.27	11.3	0.026
2 w CPT	0.32	12.2	0.024
3*w CPT	0.32	11.65	0.024
100d CPT	0.45	12.2	0.024

1. Genetic gain in dam to sires, and dam to dam pathway for Present model was 0.001 & 0.001 (σ/y). Genetic gain in the d-s and d-d pathways was constant for all other selection models these were 0.007 & 0.001 (σ/y) respectively.

The present system:

The theoretical model suggested the present industry structure was providing a genetic response of only 0.003 standard deviation units per year and this estimate may well be too high as the heritabilities and genetic correlations assumed were derived from the highly standardized European warmblood breeding schemes, not the rather haphazard judging systems used in New Zealand. This value is well below that possible with just the implementation of a nationally structured breeding programme based on the evaluation of conformation and movement of breeding stock.

Conformation and movement assessment (C + M).

Model one identified two major problems with the present industry structure, the low selection intensity and the long generation interval, which is long even for horse populations. Any breeding programme for sport horses in New Zealand must aim to improve these and to standardize the judging to increase the accuracy of selection. Addressing these problems will permit maximization of genetic response within the present evaluation system. The establishment of a selective breeding programme should encourage breeders to address these problems. The parameters utilized in model two assumed a change in the age structure of both the broodmare and stallion herd.

The trebling of the increase in the rate of response to selection (0.003 vs 0.009 σ/y) can be attributed to the higher selection intensity for stallions and the shorter generation interval. These equated with those in European sport horse populations but are still not optimal.

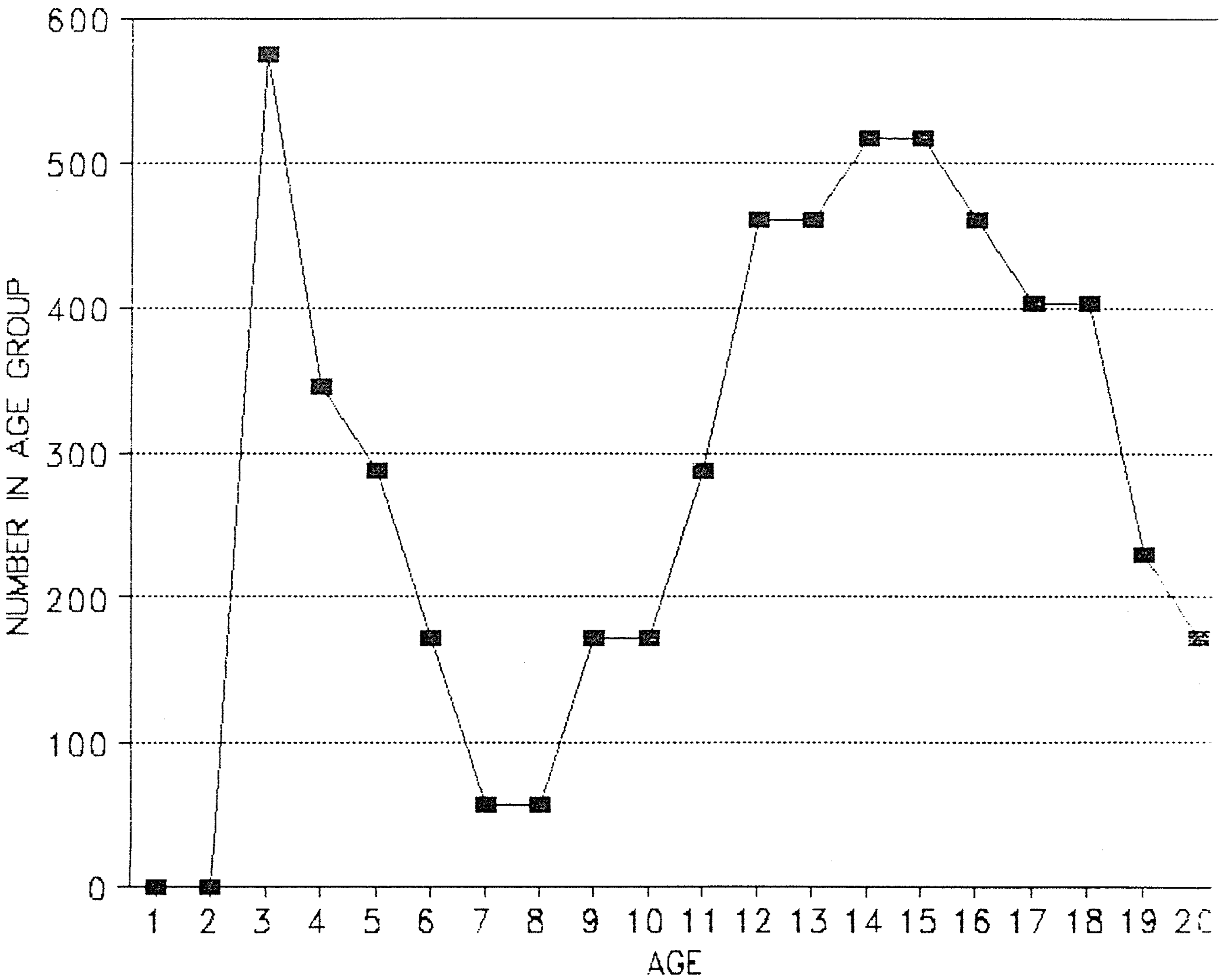

Figure.5.2: Broodmare herd age structure for conformation and movement assessment model.

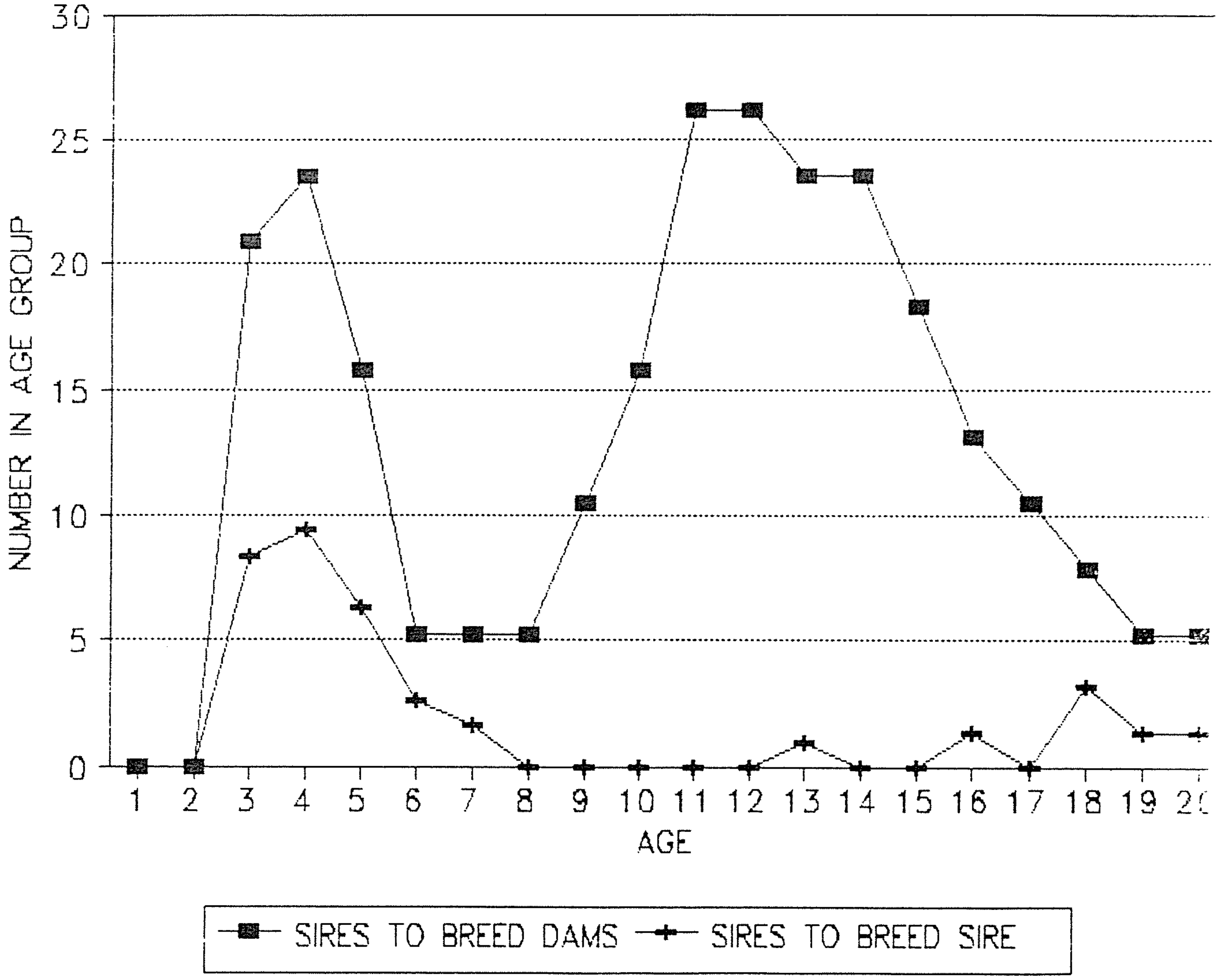

Figure 5.3: Sires age structure for conformation and movement assessment model.

The normal horse competition model (NHC):

This model simulated the impact of the implementation of potentially the most simple of the evaluation programmes. The evaluation of potential breeding stock from competition success within the existing competition structure is the present method of evaluation for the New Zealand Warmblood Breeders Association, and an alternative to the traditional central performance test for a number of European sport horse breeds (Christmann et al 1989). The simplicity of the evaluation is reflected in its limited impact on the present demographic parameters, selection intensities, and genetic response.

While offering the advantage of selection being based on the direct criteria of competition performance ability the disadvantages of low selection intensity, long generation interval and limited accuracy of selection greatly erode the potential genetic response. This is highlighted by the lack of improvement in genetic response over evaluation on only conformation and movement. There would be greater genetic gains from this system if competition riders did not discriminate against stallions and more could be evaluated.

The one day riding quality test (ODRQT):

Because evaluation takes place only on one day the ability to test a variety of traits is limited. The advantage of the simplicity of the system is that it allows more animals to be tested at low cost. Therefore a smaller proportion of the tested animals will have to be retained for breeding. If the heritabilities and genetic correlations applying in the practical situation were as high as those assumed, the high selection intensity, low age of selection and shorter generation interval would more than compensate for the reduced potential accuracy of selection. With these advantages the ODRQT model was able to generate genetic response of 0.026 σ/y, a level of improvement greater than theoretically could be generated using the central performance test models.

The young horse competition model (YHC):

In France evaluation is based on competition results, utilizing the "Classic Cycle" of showjumping competitions for young horses (Bour 1990, Tavernier 1990). The utilization of esults from highly standardized young horse competitions offers a number of advantages over . system using results from the existing competition structure. Tavernier (1990) identified hat young horses when competing against older horses suffered from the disadvantage of lack of competition experience. By providing competitions only for young horses the effect of ompetition experience is minimized, potentially increasing the correlation between ompetition success and genetic merit. The most significant advantages for the industry nodelled was the reduction in the generation interval. The impact of this was most evident n the sire pathway, providing a reduction of 4 years in the sires to breed sires pathway, and

6 years in the sires to breed dams pathway.

For the utilization of the standard competition structure for performance testing it was proposed that only 2 % of the colt foal crop would be available for performance testing. Because of the earlier evaluation, the associated reduced age at first service and the low costs of utilizing young horse competitions to performance test, the percentage of the colt foal crop available for evaluation in young horse competitions and for selection was proposed to be 10 %. Of the 10% of the colts foals available for selection not all will partake in the young horse competitions, a significant number of them will be gelded during the preparation for these competitions due to them becoming difficult to handle and train if left entire. Even so, colts are left entire until some measure of their trainability and performance was obtained, rather than the present system where most colts are gelded before they mature and some direct measure of performance is obtained.

The 2-week central performance test (2 WK CPT):

The two week central performance test for sires offered the second greatest opportunity for genetic gain in the breeding objective. This two week test was modelled on the 2 week mare performance test of the German Holstein sport horse breed (Nissen et al 1986). This model offered the advantages of moderate generation intervals (10.7 & 14.7 yrs), and relatively high accuracy of selection (r_{TI} = 0.41). It suffered from a relatively low selection intensity (29/73). Even so, with these advantages the 2 week central performance test was able to generate the greatest genetic response of the central performance test options tested.

The repeated week long test (3*w CPT):

Another of the relatively low cost alternatives for central performance test based sire evaluation was to utilize the one week central performance tests repeated at three ages of the Swedish warmblood society (Philipsson et al 1990). The accuracy of selection with this system could be debated, as each week long performance test session is separated by a 6 month period therefore providing a potentially large source of environmental bias in the evaluation. These drawbacks of this system were reflected in the lower genetic response possible 0.027 σ/y.

The 100 day test (100d CPT):

One hundred day central performance testing of colts is the predominant method of sire evaluation with the established European sport horse breeders (Kidd 1980, Bruns 1982, Bruns et al 1985). 100 day central performance testing offers significant advantages over the other evaluation systems due to its low generation interval, and high accuracy of selection. Because of the costs and large number of trained personnel needed, such a system would probably result in lower selection intensities than might be achieved with other evaluation procedures. These problems assumed for this model greatly reduced the genetic response.

5.3.3 Comparison of Sire Evaluation Models:

The ODRQT appeared to generate the greatest genetic response for the breeding objective proposed in chapter 4. The theoretical rate of genetic response was slightly larger than could be achieved by central performance testing if the appropriate genetic parameters have been chosen.

The two common approaches towards sire evaluation within the existing sport horse breeding industries are the central performance tests (commonly 100 days), and the utilization of field test data from age specific young horse competitions.

Tavernier (1990) suggested that by utilizing the field testing of young stallions in the "Classic Cycle" that the French sport horse population was making genetic progress at a rate of 0.38 points per year, a rate higher than that proposed by Meinardus (1988 cited by Tavernier 1990a) for the German sport horse population (0.2 points per year). It was suggested that this was due to the greater selection intensity possible with field testing. The physical and financial constraints of the German 100 day central performance test necessitated a greatly reduced selection intensity.

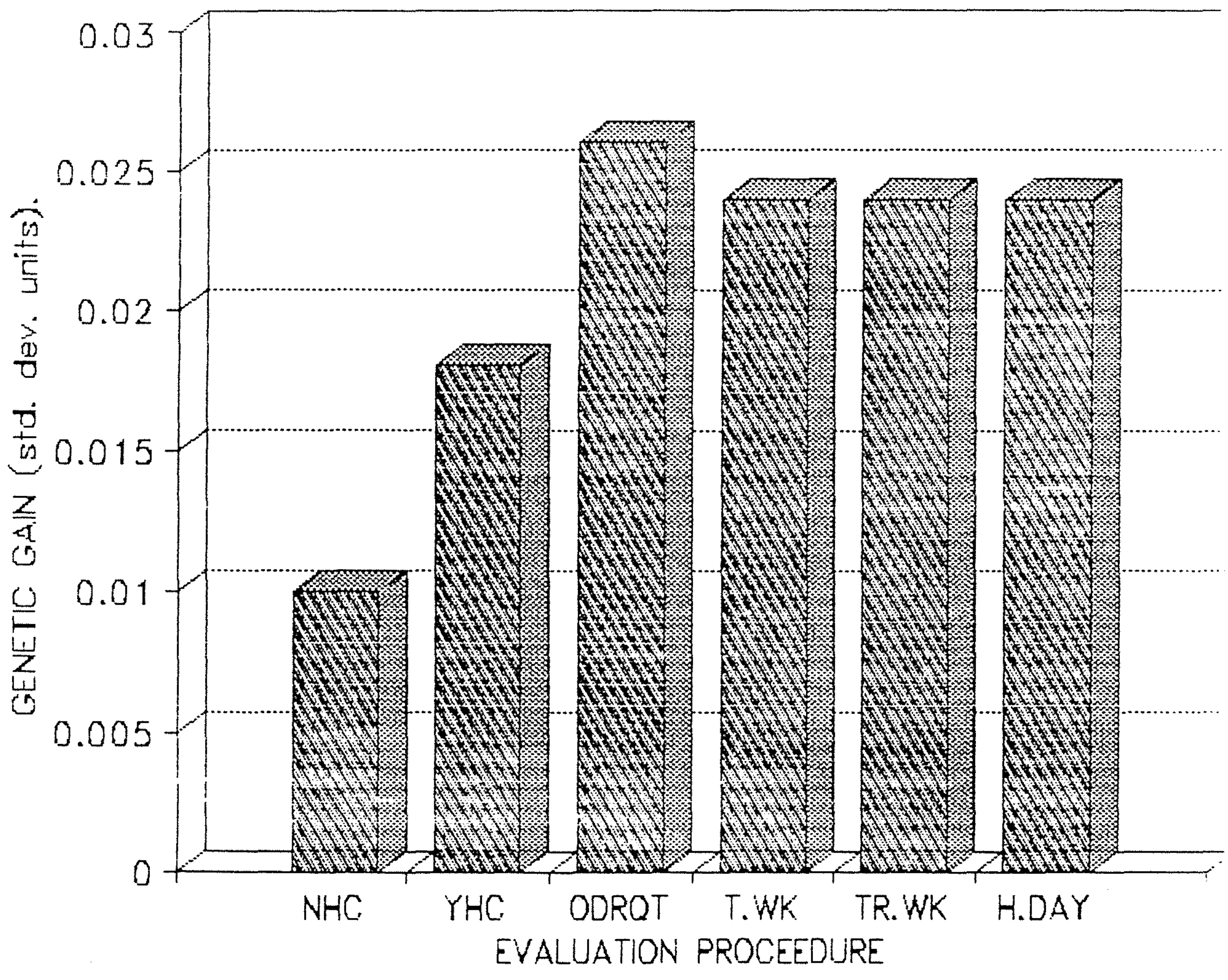

Figure 5.4: Total genetic response possible with the implementation of the different evaluation procedures.

Comparison of these results can be misleading as the French value was for the Selle Francais, which are bred for the simple breeding objective of success in jumping competitions. The German sport horse is bred for the more complex objective of a multi-discipline general purpose riding horse. If comparison is made between the French Anglo-Arab population (the French general purpose riding horse) and the German sport horse population the German warmblood population would be making greater genetic progress, 0.2 points per year as opposed to 0.15 points per year for the Anglo-Arab. The advantage of the larger selection intensity of the French system as used for the Selle Francais was possibly neutralized by the inherent inaccuracy in selecting for an all purpose riding horse almost entirely on jumping competition results.

The technique used to estimate the genetic gain is also questionable since it is based on BLUP estimates and these estimates can be a reflection of the prior values of the genetic values fed into the model than of the genetic gain that actually occurs.

The consistently greater apparent response obtained from models utilizing central performance testing as opposed to field testing (except for the ODRQT) has previously been attributed to the longer generation interval associated with field testing, negating the advantages of increased selection intensities. Another potential source of reduction in the genetic response could be attributed to the structure of the New Zealand sport horse industry and the chosen breeding objective. There is little standardisation of preliminary preparation as compared with the fairly uniform preparation associated with performance testing in Europe. This may limit the advantages of the potentially larger selection intensity. Many riders and trainers in New Zealand have a limited understanding of the fundamental training required to produce quality sport horses. This lack of rider training contributes to a potentially highly variable rider effect and a highly variable quality of early education provided for young sport horses. It is conceivable that the improvement of training and riding levels to that required to be able to utilize field tests with any accuracy may take many years.

These sources of bias were built into the model via the accuracy of selection parameter and may have been contributing factors to the lower genetic response possible via competition based selection. Huizinga et al (1990) stated that, in the Dutch sport horse industry, 40 % of the horses presented and ridden in the young horse competitions were trained by professional trainers. A similar trend in New Zealand should, in theory, increase the standard of education of young sport horses. If the New Zealand industry developed in this manner the accuracy of testing should increase due to the more standardised preparation and training of young horses. In this situation, the utilization of young horse competitions may be able to generate genetic response at a rate equal to that possible with central performance testing.

The possibility of utilizing all data in BLUP breeding values:

The French system of field testing relies greatly on their extensive data base system "SIRE", and a complex BLUP animal model for the calculation of breeding values (Bour 1990, Tavernier 1990).

In New Zealand the utilization of a BLUP animal model for the calculation of breeding values from the data would be feasible. The problem with such a system would be the inaccuracy of the correction factors and the breeding values estimated. This would result from limited data sets available for analysis and the correlations between perceived genotypes and the rearing and training environment. The sparseness of the current data sets, and the time needed to establish a comprehensive data base could also discount the suitability of such a system for the New Zealand industry. In France the inherent inaccuracies associated with evaluation based on field trials are partially corrected for by the use of the elaborate BLUP animal model on the extensive database. The records in the data base effectively date back to 1975 (Bour 1990, Tavernier 1990), providing records covering 15 years of selection, slightly over a generation.

In New Zealand the importance of selective breeding in sport horse production has only recently been recognized. Because of this, it is unlikely that more than 60% of the presently competing sport horses have a documented pedigree. This, coupled with New Zealander's traditionally lax approach to record keeping, would effectively mean that the records available for the calculation of correction factors would only exist once an evaluation programme based on competition results was initiated.

The structure of the New Zealand industry may not permit the calculation of accurate correction factors, irrespective of how elaborate the BLUP animal model and extensive the data set. An example of this is the calculation of a herd/ maternal effect, as is attempted with the French BLUP animal model. The average broodmare herd size in France is only 1-2 broodmares and for these small herds it will not be possible to reliably separate the effects of the herd environment from the genetic effects that should determine the breeding value. In France however there are large state studs and presumably comparisons of breeding values for animals from these and other large commercial studs will be accurate. In New Zealand there are many small herds but there are no state studs. It is likely that accurate breeding values will only be produced for horses generated in the larger commercial studs if the French system is relied on. However for these to be effective in this way they will need to produce progeny from a number of sires each year.

Maximization of potential genetic gain provides a quantitative measure to evaluate selection programmes. Of equal importance is industry acceptance of, and participation in the proposed evaluation procedure. The majority of the colts being submitted for performance testing should have been generated from the pseudo-nucleus commercial sport horse stud sector. Through the lay literature, the majority of sport horse breeders are aware of the central performance testing procedure, though the majority regard it as a "black box". The use of any central performance testing whether 2 weeks, 3 * one week tests, or the 100 day test would be expected to meet with reserved industry acceptance. Industry acceptance could probably be generated through an extensive education and marketing programme. Evaluation of sires on competition performance should meet with ready industry acceptance, since it can be easily comprehended.

Under the assumptions made, the ODRQT appears to offer the potential for greatest genetic improvement. From the SELIND selection index calculations the r_{TI} for the 100d CPT index was established at 0.453. The utilization of the "accuracy of performance test" parameter (0.60) effectively reduced the r_{TI} of the index for this evaluation procedure down to 0.27.

The possibility of highly variable pre-testing environment may mean that the values assumed for the heritability and accuracy of selection parameters are overestimated. Overestimation of these parameters could inflate the ability of the one day riding quality test to generate genetic gain. Reduction of the accuracy of selection parameter by 17% (0.5) produced a 15% reduction in total genetic response, dropping the ODRQT down to third most effective selection procedure.

Table 5.6: Sensitivity analysis for the one day riding quality test:

ACC. OF PERF. TEST	r_{TI}	TOTAL GENETIC GAIN (σ/y)	REDUCTION IN GENETIC GAIN
0.6	0.27	0.026	N/A
0.5	0.23	0.022	15%
0.4	0.18	0.018	30%
0.3	0.14	0.014	46%

Reducing the accuracy of performance test parameter down to 0.5 had the associated effect of reducing the effective R_{TI} down to 0.23. The limited effect of reduction in R_{TI} on the total genetic gain implies that the model is relatively stable to changes in the genetic parameter.

A significant advantage of the ODRQT was its low generation interval. Because of the short duration of the testing period it would be possible to test the stallion prospects before the start of their 1st breeding season (oct - feb). Therefore at the completion of the performance test the stallions would be able to commence stud duties as a 3 year old.

The ODRQT also offered the advantage of direct selection for a number of traits in the breeding objective, and the possibility for relative accuracy of selection. The primary advantage of the one day riding quality test is the evaluation of the willingness to work and capacity to work, both important qualities in the complex trait of rideability, which has been identified previously to be of significant economic importance.

It is likely that variation in pre-testing environment (i.e. how well broken-in, quality of early education) could influence the performance at the testing station, and lead to bias in the evaluation. The criteria need to be judged in such a way that the effect of variation in pre-testing environment is minimal. Dusek (1975) found that with Hannoverian stallions no significant effect of pre-testing environment (state stud farm or private breeders) could be found in performance (pace, movement, and schooling). Fabiani (1974a) found that after 1 years intensive training, significant correlations were found between the initial and final assessment of jumping ability (0.88, 0.82, 0.97). In a separate trial, utilizing retired racehorses, Fabiani (1974b) also found significant correlations between the initial and final assessment of jumping ability after 6 months intensive training.

The standardisation of the test, testing environment, and the use of the same basic judging panel should help minimize the possibility of bias. If the New Zealand industry followed the European model as proposed earlier, then it is possible that the ODRQT may directly influence the standard of preparation of young sport horses. Breeders and trainers presenting stock at the ODRQT would benefit from the knowledge provided by the expert riders / judges and be able to use this instruction to better prepare the next crop of young stallions. Therefore the ODRQT would provide a medium for the dissemination of knowledge throughout the industry.

5.3.4 Practical Application:

In order to allow colts to be first used for breeding at 3 years it would be necessary for the one day riding quality tests to be held in late September/ early October before the start of the breeding season (October - February).

Four evaluation sessions could be held at 4 different venues, 3 in the North Island and 1 in the South island. At each location the colts would be submitted to a standardised evaluation test by the same judging panel, this providing continuity between evaluation centres. At each location the colts would be evaluated initially for conformation and movement, then rideability, and finally free jumping. By following this format the risk of colts injuring themselves and having to be withdrawn during the test should be minimised. To account for variation in pre-testing environment colts at the beginning of the test could be allocated into 3 divisions, according to their stage of pre-testing training (in a similar manner to the categories used in the Holstein mare test, (Nissen & Kalm 1986).

The use of these divisions, a standardised test format, and the same judging panel at each location should minimise the potential for bias, and permit a relatively accurate evaluation. The concept of the ODRQT should be readily accepted by the industry. If each ODRQT was run as a show, and the public invited to observe the evaluation industry acceptance should be assured.

If the sole criteria to satisfy was the optimization of the rate of genetic improvement within the New Zealand sport horse industry via sire selection, then the optimal programme would include a one day riding quality test for potential sires. However the validity of this statement depends greatly on the accuracy of the parameters used, and how accurately the model reflects the "real" industry structure.

5.3.5 Possible refinement of the one day riding quality test:

If one wished, the model could be further refined by utilizing the one day riding quality test as a preliminary evaluation for either the 2 week CPT or the YHC.

Table 5.7:

Increase in genetic gain possible by refining the ODRQT evaluation procedure.

EVALUATION	GENETIC GAIN / YEAR (σ/y)	INCREASE IN GENETIC GAIN
ODRQT + 2w CPT	0.029	12%
ODRQT + YHC	0.027	4%

The inclusion of young horse competition based evaluation after the ODRQT only yielded a 4 % increase in total annual genetic response. The longer generation interval associated with YHC erodes the value of the increased accuracy of selection. The utilization of a preliminary ODRQT type competition to select individuals for the central performance test is currently practised for colt selection in the Dutch warmblood (Huizinga et al 1991a). By utilizing the ODRQT to preselect individuals for the 2 week CPT the selection intensity and accuracy of selection was increased. The increase in these parameters easily compensated for the addition of an extra year to the generation interval. By utilizing this form of 2 stage selection a 15% increase in genetic response was possible. However, the real impact of this form of 2 stage selection on genetic response may still greatly depend on the effect of the variation in pre-testing environment.

The increase in annual genetic gain possible with the inclusion of this format of pre-selection and the 2 week CPT implies that, provided the parameters chosen are correct, maximum genetic gain could be achieved by this 2 stage selection format. However it may be difficult to convince the industry of the need for the 2 stages of selection.

5.3.6 Additional response from selecting mares to produce prospective sires:

There are limited alternatives for the evaluation of dams to breed sires. The central performance testing options evaluated for the sires (2 w CPT, 3*w CPT, and 100d CPT) could not economically handle the number of fillies to be considered if the mare herd as to be maintained. Because of this only four options were tested, each being a field test format. Field testing of potential dams to breed sires was the predominant method of selection for the established European sport horse breed societies (Nissen and Kalm 1986, Christmann 1989, Von Stenglin 1990). Only recently has the evaluation of this pathway changed to being central performance test based, 2 weeks for Holstein mares, and 18 days for Hannoverian mares (Nissen and Kalm 1986, Von Stenglin 1990).

Table 5.8: Effect of the different evaluation procedures in the dam to bred sire pathway on total genetic response.

MODEL			GEN.INTVL	GENETIC GAIN / YEAR (σ/Y)
SIRES	DAM TO SIRE			
		SEL. INT		
NHC	C + M	39/1883	15.17	0.009
	NHC	39/71	17.32	0.008
	YHC	39/244	16.32	0.011
	ODRQT	39/293	15.17	0.013
YHC	C + M	191/1883	12.39	0.019
	NHC	191/71	NOT VIABLE	NOT VIABLE
	YHC	191/244	13.54	0.014
	ODRQT	191/293	12.39	0.019
ODRQT	C + M	191/1883	11.57	0.027
	NHC	191/71	NOT VIABLE	NOT VIABLE

ODRQT	YHC	191/244	12.72	0.026
	ODRQT	191/293	11.57	0.028
2w CPT	C + M	57/1883	11.60	0.025
	NHC	57/71	13.75	0.023
	YHC	57/244	12.75	0.021
	ODRQT	57/293	11.60	0.032
3*w CPT	C + M	57/1883	11.52	0.026
	NHC	57/71	13.67	0.019
	YHC	57/244	12.67	0.029
	ODRQT	57/293	11.52	0.030
100d CPT	C + M	39/1883	12.25	0.026
	NHC	39/71	14.40	0.023
	YHC	39/244	13.40	0.026
	ODRQT	39/293	12.25	0.031

The utilization of the normal competition structure yielded the lowest potential for genetic improvement. The ability of the normal competition structure to performance test the dams of sires and generate genetic response was lower than that possible by just selecting on conformation and movement. This limited ability to maximise genetic response was partly due to the long generation interval associated with this selection procedure (15.17 yrs). Performance testing via the normal competition structure extended the generation interval a year longer than the next longest generation interval (young horse competitions). The generation interval for the normal competition pathway was longer than that for the total dam pathway in many of the established European sport horse breeding industries (10.4yrs to 14.32yrs) (Langlois 1976, Baumgarten 1974 cited by Langlois et al 1983, Philipsson et al 1990).

The other factor limiting the value of the normal competition structure to performance test dams of sires was in the low selection intensity. In this model it was proposed that only 7% of the filly foal crop would be retained in competition to reach the level of performance required to become the dams of sires. At the lower levels mares only account for approximately 25% of the competition entries, the remainder being colts 5%, and geldings 70% (Tielcey Park young horse showjumping competitions 1992), and in eventing only 18% of the entries in the novice class at the Taupo 3 Day event were mares. At B grade showjumping or intermediate eventing the number of participating mares has reduced to 18% of the entries in showjumping (B grade class at the Horse of the Year show) and 13 % in eventing (Intermediate division of the Taupo 3 Day event). Mares would have to attain this level of performance to be selected as dams of sires. The low proportion of mares at this level reinforces the need for evaluation of breeding stock to be at as young an age as possible.

Indirect selection of conformation and movement yielded on average a 17% greater genetic response than by selecting on performance in the standard competition structure.

Because evaluation can take place as young as 3 years of age and does not require any change to most breeders existing management policies, a high number of mares should be submitted for evaluation. In this model 75% of the filly foal crop was theoretically available for selection as dams of sires. This selection intensity is slightly greater than a 1000% increase over the selection intensity for the normal competition model.

The generation interval for the dams to sires pathway was significantly reduced to 7.6 years, a reduction of 5.6 years from the utilization of competition results. The conformation and movement model had the lowest generation interval of any of the models tested. This low generation interval, high selection intensity and moderate heritability (0.30) would have counteracted the effect of selecting for an indirect criteria (r_g = 0.4). This system in theory generated a greater genetic response rather than direct selection on competition results.

By utilizing age-specific young horse competitions to performance test potential dams of sires, in a majority of cases greater genetic response was possible than by using conformation and movement assessment. In a similar manner to using the normal competition structure for performance testing the use of age specific young horse competitions did suffer from a reduced selection intensity. Using the young horse performance testing medium it was proposed that 10% of the filly foal crop could be available for selection. The remaining fillies would be either culled, used as low grade riding horses, or sent directly to the broodmare paddock after evaluation of their conformation and movement, but their male progeny will probably receive little consideration as potential sires.

In comparison to the percentage of mares competing in the young horse competitions at present (25% of entries) the value of 10% may appear low, but this value allows for those mares ridden competitively that may not be available for breeding as the owners may wish these to pursue a full competitive career. Performance testing using the young horse competition format had a higher selection intensity than the normal competition model due to the earlier age of evaluation, and recognition of genetic merit. Many breeders would prefer to obtain some direct evaluation of a mares performance ability before entering the broodmare herd. The young horse competitions should provide early evaluation of performance ability. With the young horse competition format, relatively accurate evaluation of performance ability would be obtained within 1-2 seasons depending on the number of competition starts. In comparison, using the normal competition structure it is 3-4 years before a relatively accurate assessment of performance can be made. Because of the earlier evaluation of mares, using the young horse competitions would in theory be less disruptive to a studs management policy, and therefore encourage a larger number of participants in this type of performance test.

For selection within the dams to breed sire pathway the ODRQT appeared to offer the potential for the largest genetic response, on average 23% larger than could be achieved by using young horse competitions, and an average of 46% larger than that possible by using the normal competition structure to performance test. The superiority of the ODRQT to generate genetic response would be due to its relatively high selection intensity (particularly when used in conjunction with the CPT sire options), low generation interval, and moderate r_{TI} (0.23).

It was assumed that 12% of the filly foal crop would be available for evaluation using this format, this being 2% greater than the participation in the young horse competition. The relatively high selection intensity was a reflection of the evaluation procedures potential acceptability. Because evaluation takes place at 3 years of age participation in this performance test would be the least disruptive to the studs management policy. By substituting the rideability test with temperament the need to have the fillies broken in was avoided, and therefore, minimal change to the studs management policy would be involved by participation in this evaluation procedure. The test may also be viewed as a favourable format to develop the early talents of future competition stock, and may become an integral part of the training programme of young sport horses.

The early evaluation of mares is reflected in the short generation interval (7.6 years). This early evaluation of breeding stock was possible because of the low stress testing format and the early maturity of filly foals. It is proposed that testing would take place during october / november so that the mares could be mated within the same season they were evaluated. The only drawback is the slightly lower accuracy of selection possible with this model (0.5), though the relatively high selection intensity, low generation interval and, moderate r_{TI} more than compensate for this.

5.4 Optimal Model To Maximise Genetic Response:

For a successful selection programme there are a number of criteria that need to be meet. These being:

1. to maximise genetic response
2. to attain industry acceptance
3. to have suitability for the industry conditions.

According to this analysis the ODRQT had the greatest potential to generate genetic response in both the sire and, dam to breed sire pathways. However, the impact of the ODRQT on the dams to breed sires pathway was greatest when combined with the 2 w CPT for sires. Due to the large numbers of fillies needed to be retained, selection in the dam to breed dam pathway was restricted to the assessment of conformation and movement only.

Because evaluation takes place in the field and can be easily observed by the public, industry acceptance was thought highly likely. The low-stress testing procedure and evaluation of performance ability by high calibre riders / judges may encourage many breeders to include participation in the ODRQT as part of the young sport horses education. This high level of industry participation and acceptance is in contrast to the suspected low to moderate industry acceptance of the central performance test options.

The high level of proposed industry acceptance and suitability to the New Zealand equestrian industry was reflected in the high selection intensity possible for both the sire and dam to breed sire pathways using the ODRQT. This high selection intensity was also in part due to the early evaluation of breeding stock. Because colts and fillies could be evaluated before their 1st breeding season, participation in these field tests should not interfere with the management policies of most breeders. Genetically, this translated into a low generation interval for both pathways. This compensated for the slightly lower accuracy of selection with this type of field test as opposed to the central performance test alternatives.

The model using 2 week CPT for sires and the ODRQT for the dams - sires pathway generated 7% greater genetic response than was theoretically likely to be achieved with the model utilizing evaluation via the ODRQT. The closeness of these models in their ability to generate genetic response and the potential inaccurcy of many of the assumptions emphasises the difficulty in chosing optimal breeding programmes. If r_{TI}'s had been calculated for each model rather than the use of subjective adjustments greater confidence could be placed in the results. However, the impact of this on the final results may be limited due to the absence of genetic parameters generated from the New Zealand sport horse population.

CHAPTER SIX
BENEFIT COST ANALYSIS

6.1 INTRODUCTION:

Breeders are interested in improving their stock largely to gain an advantage over competitors. Their interests tend to be relatively short term as they seek to maximise profit and stay in business. The value of the improvement to them is mainly in extra return from sales of breeding stock in comparison to the sales they would make if no improvement was made. The improvement only gives a temporary competitive advantage which may later be lost (Smith 1978). The benefit of genetic improvement to the industry and society tend to be longer term. Improvement offers the advantages of increased per unit production, lower production costs, and increased quality of product. The differences in benefit cost analysis for these two groups can be observed in table 6.1.

Table 6.1: Comparison of National vs breeder perspectives for investment in appraisal of animal improvement.

	NATIONAL	BREEDER
INVESTMENT	Improvement of national stock	Improvement of own stock
TIME TO RETURN	Longer	Shorter
RETURNS	Large	Small
REASONS	(i). Value of national production (ii). semi-permanent (iii). Value of successive improvements accumulate (iv). Low risk of no returns	(i). Extra returns from stock sold (ii). Temporary value from competitive advantage (iii). Successive improvements needed to maintain competitive position (iv). High risk of no return
INVESTMENT JUSTIFIED	Large	Small

From Smith (1978).

6.2 MATERIALS AND METHODS:

In this benefit-cost analysis an industry perspective was taken. The industry structure examined was that proposed in Chapter 3. It is thought likely that a structure similar to that already existing in the majority of the dominant sport horse producing nations will evolve. Although an industry viewpoint was taken the discount rate applied was more appropriate for an individual breeders perspective. A high discount rate (15%) was applied to allow for the potentially volatile nature of the world sport horse market. The export sector of this market appears to fluctuate according to the current fashions.

When identifying benefits, two situations need to be compared:

1. the situation as it exists (or would exist) without the project (ex-ante), and
2. the situation as it will exist with the project (ex-poste).

In many cases the situation without the project is not simply a continuation of the before situation (i.e. a status quo assumption), but rather the situation that is expected to exist if the project is not undertaken. The expected situation may be quite different from the before situation because of some increases in output, costs, and other changes.

Thus, for the present model, it was assumed that for the first 7 years the New Zealand sport horse industry would continue to enjoy the current growth in export prices. After these years it was believed that the New Zealand industry, without a national selective breeding programme, would suffer the same fate as the Irish sport horse industry, of falling export numbers and financial returns. The proposed annual decrease in sales return was set at 5%.

Table 6.2

Input parameters for the benefit cost analysis:

MODEL	EXPORT CONFIDENCE [1]	INCREASED TRAINING LEVEL	INDUSTRY ORGANISATION	GENETIC GAIN / YEAR [2]
PRESENT	0.005	N/A	N/A	0.003
C + M	0.005	N/A	N/A	0.009
NHC	0.005	0.005	0.01	0.010
YHC	0.02	0.08	0.05	0.018
ODRQT	0.01	0.05	0.03	0.026
2 w CPT	0.03	0.03	0.01	0.024
3*w CPT	0.02	0.01	0.01	0.024
100d CPT	0.05	0.01	0.01	0.024
YHC (sires + d-s)	0.03	0.12	0.05	0.014
ODRQT (sires + d-s)	0.02	0.12	0.04	0.028

1. Benefits represented as percentage increase in export sales calculated from base year exports.
2. Genetic gain in standard deviation units.

The present model was utilized as the control. Benefit-cost analysis was performed following the procedure outlined by Meister (1990).

Benefits.

In this analysis both primary and secondary benefits were included. The direct benefits are due to genetic improvement of the New Zealand sport horse. Secondary benefits such as increased industry organisation and a better local level of training of sport horses should also increase the financial returns.

In the models evaluated, the benefits, both primary and secondary, did not start to become available until the first progeny of the parents selected in year 1 became saleable on the export market at 4 years of age. In year 5, 30% of the benefits were expected to be received, year 6 60%, year 7 80%, and from year 8 onwards 100% of the potential benefit would be received. This gradual increase in the benefits would depend on the speed of the industry in responding to the newly introduced breeding programme.

Costs.

Due to the nature of the different evaluation procedures tested there is likely to be considerable variation in the potential running costs. For the field test based evaluations (i.e NHC, YHC, ODRQT) the likely direct involvement of the NZEF greatly reduced the direct running costs. The relevant costs of running each evaluation procedure are given in table 6.3.

Table 6.3.

Models tested and assumptions of their establishment and annual running costs ($).

MODEL	DATA COLLEC-TION	MARKE -TING	VENUE HIRE	STAFF[1]	STAFF TRAINING	TOTAL ANNUAL COSTS
PRESENT	N/A	7,500	N/A	20,000	N/A	27,500
C + M	10,000	7,500	10,000	20,000	2,000	49,500
NHC	5,000	2,500	N/A	20,000	N/A	27,500
YHC	10,000	7,500	4,000	30,000	N/A	51,500
ODRQT	10,000	7,500	4,000	30,000	7,500	59,000
2 w CPT	10,000	7,500	14,000	36,000	3,000	70,500
3*w CPT	5,000	10,000	21,000	39,000	3,000	78,000
100D CPT	5,000	10,000	45,000	50,000	5,000	115,000
YHC[2]	10,000	7,500	4,000	30,000	N/A	51,500
ODRQT[3]	12,500	7,500	8,000	40,000	10,000	78,000

1. For each model total establishment costs for data collection and analysis was assumed to be $NZ 35,000.
2. YHC for sires and the potential dams of sires.
3. ODRQT for sires and the potential dams of sires.

Data collection refers to the collection, and tabulation of the data into a format that can be utilized for grading and genetic analysis. Marketing refers to the publication of the results and promotion of the performance test as a suitable evaluation procedure for the New Zealand sport horse breeding industry. Venue hire covers the hiring of a suitable facility for the performance testing. Staff costs cover the annual salary of a breeding director, to promote and organise the performance testing $30,000 (it also includes where appropriate the fee paid to the trainer running the CPT). Staff training relates to the preparation of auxiliary staff needed for the performance test. This possibly would be an annual reoccurring cost.

The costs are only the costs of the organisation running the evaluation scheme. The different models will also lead to variable costs for the horse owners, and the effect of these costs have not been taken into account due to their highly variable nature between producers. Thus, if there is no charge to the owner, the 100 day test in particular will reduce the cost of rearing and developing a young horse. The young horse competition model may involve the owners in extra costs but also perhaps some extra, largely non-monetary, benefits in terms of participation in the competitions, and development of their riding and training skills.

6.3 RESULTS AND DISCUSSION:

At present the New Zealand sport horse industry appear to be benefiting greatly from the recent successes of a number of New Zealand bred sport horses competing in other countries. It appears fashionable for top international eventing riders to ride New Zealand-bred thoroughbred sport horses. How long this trend will continue is difficult to decide. These fashion trends within the international sport horse market appear to be based around a 6 to 8 year cycle, and reflect the breeding of the current Olympic and World champion sport horses. This cyclic nature of breed popularity was allowed for in the present model. Assumptions are that from year 0 New Zealand would enjoy 30 % growth in sport horse exports due to current world fashion. After 7 years it was anticipated that there would be a change in the market place and the New Zealand sport horse would start to lose its current market share. This loss in market share was proposed to be 5% of the previous years export total. The decrease reflected the potential decrease in market share associated with a relatively disorganised breeding industry without any real performance testing programme.

Benefits:

It was considered that the establishment of a national selective breeding programme would be viewed by overseas buyers as a form of quality control as to the ability of the horse purchased and as evidence that the New Zealand sport horse was likely to be genetically equal or better than those from other countries. Because of this, the instigation of any selective breeding programme was proposed to have the potential to generate an increase in export sales. There is some evidence for this in the expanding export markets for the sport horse breeds that have some form of performance testing in place and the decline in the exports (both numerically and financially) experienced by Ireland which is only now developing a performance testing system.

Breeders wish to maximise genetic response in the short term primarily for a marketing advantage over their competitors (Smith 1978), to maximise profit and stay in business. For the non-commercial breeder the goal is that of achieving long term gain that will ultimately benefit the consumer (most non-commercial sport horse breeders produce sport horses for their own use). Clarke & Wallin (1991) suggested this is the situation with the typical German sport horse breeders, who utilize the selective breeding of sport horses to provide long term improvement in their breed rather than the short term benefit of increased marketability. However, the commercial sector of sport horse breeding in Germany has not been slow in utilizing the likely genetic gains from their selective breeding programme (even though little improvement will have been generated so far) in marketing their sport horses overseas.

The analysis of the benefits from the application of a selective breeding programme was taken from the industry perspective. Financially, by far the greatest benefit of a national selective breeding programme would be to the commercial sport horse breeders aiming to sell the products of their breeding programme on the export market. Because of the potential for the selective breeding programme to provide a marketing edge over competitors a high discount rate was applied to the analysis. This high discount rate (15%) yielded the results shown in table 6.4.

Table 6.4:

Net present values (NPV) and internal rates of return (IRR) for the models tested for benefit cost analysis.

MODEL	VALUE OF BENEFITS ($)[1]		COSTS ($)[2]	NPV($)[3]	IRR (%)[4]
	GENETIC	SECONDARY			
PRESENT	60,000	8,000	27,500	-31,982	N/A
C + M	180,000	8,000	49,500	212,893	25.3
NHC	200,000	40,000	27,500	510,362	40.9
YHC	360,000	300,000	51,000	1,620,695	55.5
ODRQT	520,000	180,000	59,000	1,692,735	54.5
2 w CPT	480,000	140,000	75,000	1,396,748	48.2
3*w CPT	480,000	80,000	78,000	1,148,092	42.3
100d CPT	480,000	140,000	115,000	1,089,701	36.1
YHC[5]	420,000	400,000	51,500	1,680,956	56.4
ODRQT[6]	800,000	360,000	78,000	2,232,783	55.9

1. The annual benefits of the testing system in 1992 $NZ
2. The annual cost of the testing programme in 1992 $NZ
3. Net present value, future benefits discounted (15%) back to the present
4. The internal rate of return on the expenses of the testing system.
5. YHC for sires and the potential dams of sires
6. ODRQT for sires and the potential dams of sires

Net present value represents how worthwhile the project is in utilizing resources to maximise income (in this situation benefits). The internal rate of return represents the average earnings of the money invested in the scheme. The present lack of an industry wide breeding programme is providing no benefit to industry participants and may be causing them to forego better returns on the export market for the New Zealand sport horse. The ODRQT offered the greatest NPV from a national sire selection programme. The ODRQT was 4% better than the next most favourable evaluation programme, the YHC.

The lower ranking of the CPT models in the benefit cost analysis results partly from the increased costs to the organising body and partly from the lower genetic gain. These CPT models may also suffer from possible industry scepticism. A 100 day CPT did not prove viable in England (Kidd 1990), partially through the lack of suitably trained personal and through reluctance of the industry to become involved in the evaluation programme.

The superiority of the model based on the ODRQT was largely due to its high rate of genetic improvement (0.026 σ/ y). This accounted for 74.3% of the benefits obtained from this evaluation procedure.

In studies on economic optimization of breeding schemes financial returns are taken to result from genetic improvement of livestock (Brascamp 1978). Introduction of these evaluations (particularly the YHC and the ODRQT since they involve more horses) may stimulate more professional and thorough preparation of the New Zealand sport horse. The tests may thus generate financial returns not only from the genetic improvement in the national population and from improving perceptions of the genetic level but also through better preparation for the export market.

In the benefit cost analysis performed, the effect of the YHC and ODRQT to improve sport horse training provided a major secondary benefit. For the ODRQT increased level of local training provided 14.3% of the total benefits and for the YHC it provided 24.2%. The benefit cost ratio (increased level of training / costs of running the evaluation programme) for the ODRQT was 1.69 and for the YHC 3.11, suggesting that even from just the perspective of increasing the domestic training level it would be worthwhile running these programmes. However the owner's costs in providing the extra training and presenting the horses have not been taken into account.

Including the selection of the dams of sires from the results of ODRQT provided an increase in NPV of 31.9% to $2,232,783, and a benefit cost ratio of 11.8. This increase in NPV reflected an increase in both the primary and secondary benefits with limited extra costs being incurred. The full impact of the ODRQT on industry organisation and the domestic level of training will not be captured if the mares are not tested and therefore a larger proportion of the equestrian community interact directly with the testing format.

Although the YHC based evaluation was ranked second on its NPV this form of evaluation may be the most acceptable within the New Zealand sport horse industry. At present YHC are being run jointly by the NZSH and the NZEF with a view to utilizing these competitions as a method to performance test future sire candidates. The YHC appear to be gaining significant support within the industry, possibly because this form of performance testing is very similar to the use of 3 year old classic races to performance test thoroughbred racehorses. However, if the values chosen for accuracy of selection are correct, this evaluation procedure is not the optimum in terms of genetic gain. Also from the present base, far more entire males will be needed in the competitions if the benefits suggested by the model are to be captured. At present most of the horses in the dressage and showjumping competitions are geldings. While these data from geldings will probably be useful in future for progeny testing and family selection these forms of selection have not the same potential as selection on each animals own records.

In the long term it is genetic improvement of the New Zealand sport horse that will ensure the return of the overseas buyers and the continuation of New Zealands successful record in international equestrian sport.

Although this study has many limitations it suggests that the ODRQT would be the optimal single stage testing procedure for the New Zealand sport horse industry. Not only did the ODRQT appear to offer the greatest potential for genetic improvement but it may offer significant secondary advantages in increased domestic training level, increased industry organisation, and consumer confidence in the New Zealand sport horse.

CHAPTER SEVEN
CONCLUSION

7.1 Industry Structure:

The New Zealand sport horse breeding population probably consists of about 5,750 mares mated to about 288 stallions. There are probably about 35,000 horses in the total recreation population of which 4,500 are registered with the New Zealand Equestrian Federation for competing. Of these about 44% compete in showjumping, 38% compete in dressage and, 18% in eventing.

Most horses produced will be used locally but there is also a lucrative export market, particularly in horses suited for eventing and therefore of thoroughbred type. Local sales are usually directly from breeders to users but, for the export market, professional training and dealing seems to be developing.

The breeders range from amateurs with one or two broodmares producing horses mainly for their own use to professionals with sizeable herds. Some are heavily involved with exporting.

At present the industry lacks an effective genetic improvement structure. A high proportion of breeding stock are recruited from the raceing thoroughbred population and are not evaluated for a sport horse objective before entry.

There are four breed societies, with some horses registered with more than one society. Many sires and broodmares are not registered. These societies maintain pedigree records but do not have effective performance testing.

If sport horse breeding is to attain its potential a more effective structure must be developed.

7.2 Derivation of Breeding Objective.

It was decided that, instead of having separate breeding populations, there should be one single sport horse population bred for an objective aimed at improving ability in all three equestrian disciplines included in the Olympic competitions.

When considering establishment of an objective of the integrated breeding, development and, competition system it is necessary to consider other characteristics not directly related to competition success. Some could be described as riding traits (eg willingness to work, ease of handling, etc) some such as fertility, efficient feed utilization and durability relate to the production system. If satisfactory data were available probably an objective along the following lines should be developed:

$$H = a_1 \text{ jump} + a_7 \text{ ride} + a_{11} \text{ confo} + a_{14} \text{ temp} + a_{15} \text{ bunt}$$
$$+ a_{16} \text{ fertility} + a_{17} \text{ feed efficiency} + a_{18} \text{ health.}$$

However for the present study there were no satisfactory data to use such an objective effectively so a simpler objective was developed and used in later studies

$$H = \$328\text{jump} + \$282\text{ride} + \$216\text{confo} + \$51\text{temp} + \$48\text{bunt}$$

Although several techniques were attempted, lack of data meant that the final weights chosen depended largely on subjective assessment.

Sensitivity analysis revealed that even when only jumping performance and rideability were used as criteria only a 7% reduction in genetic gain was observed.

7.3 Selection Strategies:

Under the assumptions made in modelling it would appear that the New Zealand sport horse industry is making negligible genetic progress. Progress possibly made by a few individuals is lost to the industry due to lack of a nationally coordinated objective and breeding plan.

A primary limitation to the direct application of the traditional European 100 day CPT procedure in New Zealand is the cost involved. Of the seven different sire evaluation procedures evaluated within the limited accuracy of the modelling procedures used, the ODRQT appeared to generate the greatest genetic response (0.026 σ/y). This evaluation procedure offered the advantage of a relatively high selection intensity due to its low cost together with a low generation interval due to the early evaluation of breeding stock (evaluated at 3 years). These advantages compensated for the reduced accuracy of selection.

Expansion of sire selection to 2 stages to include the ODRQT and then the 2 week CPT offered the possibility to generate even greater genetic gain (0.029 σ/y). While genetically better it may not achieve industry acceptance.

The use of the ODRQT to evaluate dams of sires as well as potential sire candidates offered an 7.7% greater genetic response (total = 0.028 σ/y). The evaluation procedure for mares was modified from that to test colts so that the mares did not need to be broken in for evaluation, with a temperament grading replacing the rideability test.

Therefore under the limitations imposed by the model used, it would appear that the utilization of the ODRQT to evaluate both sires and dams of sires is genetically the optimal procedure for the New Zealand sport horse industry.

7.4 Benefit Cost Analysis:

The utilization of benefit cost analysis permitted greater consideration to be given to the secondary benefits of a nationally coordinated selective breeding programme. However, it was the breeding programmes ability to generate genetic gain that consistently provided the greatest benefit. Within the assumptions made in performing the benefit cost analysis the ODRQT appeared to provide the greatest net present value. Because of its associated secondary benefits of increased domestic training level, increased industry organisation and to a lesser extent export confidence the YHC based evaluation programme was the 2nd most preferred programme according to NPV ($1,620,695), only 4% less than the ODRQT alternative. The influence of these secondary benefits increased when the ODRQT was also used for the evaluation of potential dams of sires.

However the owners costs in training horses prior to the testing procedure were not included in the analyses and these are likely to be much greater with the YHC than station performance testing systems which test fewer horses and provide considerable training that is included in the costings.

In the long term it is genetic improvement of the New Zealand sport horse that will ensure the return of the overseas buyers and the continuation of New Zealands successful record in international equestrian sport.

Although this study has many limitations it suggests that the ODRQT may be the optimal single stage testing procedure for the New Zealand sport horse industry. Not only did the ODRQT appear to offer the greatest potential for genetic improvement but it may offer significant secondary advantages in increased domestic training level, increased industry organisation, and consumer confidence in the New Zealand sport horse.

APPENDIX ONE:

BREED SOCIETY QUESTIONNAIRE

Current number of sires registered
Current number of broodmares registered
Annual registered foal crop
Average broodmare herd size
Average number of services per sire
Current number of members

Current New Zealand sport horse population (your estimate)

Total no of sport horse broodmares in NZ (reg & unreg)

Societies main breeding objective or aim....

Societies Breed improvement plan

NZ bred Sires

Central performance testing eg. 100 day
Field testing eg. from competition results

No testing for NZ bred sires
Other

For broodmares

Central performance testing
Feild testing (eg. conformation & performance)
No grading of broodmares
Other

APPENDIX TWO

Abbreviations:

NHC	Normal horse competition model
YHC	Yong horse competition model
ODRQT	One day riding quality test
2 w CPT	2 week central performance test
3*w CPT	3 repeated one week central performance tests
100d CPT	100 day central performance test
NZEF	New Zealand Equestrian Federation
NZSH	New Zealand Sport Horse Owners and Breeders Association
NZWB	New Zealand Warmblood Breeders Association
NZHH	New Zealand Hannoverian Society
NZID	New Zealand Irish Draught Society
NZLH	New Zealand Hunter and Light Horse Improvement Society
AA	Anglo-Arab
A-KAR	Anglo-Karachaev
DWB	Dutch Warmblood
FWB	Finnish Warmblood
GWB	German Warmblood
HANN	Hannoverian
HOLS	Holstein
LIPP	Lippizaner
SF	Selle Francais
SWB	Swedish Warmblood
TB	Thoughbred
TRAK	Trakehner
WELK	Wielkopolski
BLUP	Best Linear Unbiased Prediction
PHS	Paternal half-sib estimate
REML	Restricted maximum likihood estimate

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