Retrospective examination of the breeding efficiency of the New Zealand Thoroughbred and Standardbred

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ABSTRACT

To describe the industry structure and breeding efficiency of the Thoroughbred and Standardbred populations in New Zealand retrospective reproductive data for the 1989/90 to 2004/05 breeding seasons were obtained from online industry databases and collated for analysis. Data were examined using descriptive statistics, and Kaplan-Meier survival analysis. From 1989/90 to 2004/05 breeding season there was a 36% and 37% reduction in the national broodmare herd and 45% and 40% reduction in foal crop for the Standardbred and Thoroughbred populations, respectively. During this period the number of sires decreased but there was an associated increase in the mean number of mares served by a sire. The mean end of season fertility was 77.9 ± 0.3 % for Thoroughbreds and 86 ± 0.2 % for Standardbreds. The commercial life of a stallion was estimated to be 3 and 4 years for Thoroughbred and Standardbred sires, respectively. Shuttle sires were younger, and covered larger books of younger mares than other sire categories. Expensive and shuttle sires cover larger books of younger mares and therefore may have an advantage compared to low or medium priced sires in producing larger numbers of potentially successful progeny.

Keywords: horse; Thoroughbred; Standardbred; New Zealand; breeding; reproduction.

INTRODUCTION

The Thoroughbred and Standardbred breeds are primarily breed for flat and harness racing respectively. In New Zealand these two breeds are the largest equine studbooks with ~6,500 and 4,500 active broodmares respectively and are also two of the most important economically. The racing industries are responsible for 1.5% of gross domestic product, NZ$ 1.5 billion in annual betting turnover and employ 18,320 full time equivalents (New Zealand Racing Board, 2004).

In contrast to the other livestock species the reproductive capacity of the horse has not been the focus of genetic improvement, and instead breeders have focused on improving performance traits such as racing, jumping and dressage ability (Koenen *et al*., 2004). Within some horse breeds the reproductive capacity may also be limited due to increasing levels of inbreeding (van Eldik *et al*., 2006; Klemetsdal & Johnson, 1989; Cothran *et al*., 1984; Sevinga *et al*., 2004*)*. Both the Thoroughbred and Standardbred have a closed studbook. In the Thoroughbred studbook it has been suggested that inbreeding may limit reproduction but the mare's age and better reproductive technology and management have a larger effect on reproductive capacity (Mahon & Cunningham, 1982).

In the last 20 years advances in equine reproduction research and reproductive technologies have been assimilated into the commercial breeding industry. The use of hormonal and light therapy to manipulate anoestrus in the mare is now commonly used on commercial stud farms (Rogers *et al*., 2007). The use of ultrasound scanning for the detection of ovulation has permitted an increase in the reproductive capacity of the sire, in many cases removing the need for multiple coverings of a mare. The use of assisted reproductive technologies such as artificial insemination and embryo transfer have been utilised widely by the Sport Horse and Standardbred industries. However, the Thoroughbred has not yet accepted the use of assisted reproductive technology.

The use of assisted reproductive technologies across the industry could translate into better conception rates in Standardbreds than those observed in Thoroughbreds where artificial insemination is not permitted. The expectation would also be that the Standardbreds would require fewer sires to meet the markets requirement for foal production, as sires are capable of covering more mares without the physical restriction on book size placed by natural mating. The Thoroughbred industry has embraced the use of shuttle stallions, the shipping of stallions for breeding from the Northern to the Southern hemisphere to breed two seasons in a calendar year (Pickett *et al*., 1998; Pickett & Voss, 1998), in part to counteract the limitation of not being able to use artificial insemination. The popularity of shuttle sires with New Zealand Thoroughbred breeders can be seen in the increasing use of shuttle sires. In New Zealand from 1993 to 2002 the number of shuttle stallions

covering mares increased from 2 to 17, and in 2002 covered 18.7% of the mares breed (New Zealand Thoroughbred Breeders' Association, 2008).

Both the Thoroughbred and Standardbred annual returns on reproductive performance of stallions, and the size and scope of the broodmare herd are published. These datasets provide the opportunity to examine changes in the size and structure of the breeding population, which permit the scientific and veterinary community to interpret and predict the future reproductive requirements of both breeds. In this paper we use the retrospective online electronic breeding records for the Thoroughbred and Standardbred studbooks to examine the breeding efficiency of these populations in New Zealand.

MATERIALS AND METHODS

Total dataset and selection of the subsets

Thoroughbred

Summary breeding records for all active sires, that is stallions covering more than 10 mares in a breeding season, from the 1989/1990 to 2004/2005 breeding seasons were downloaded from the New Zealand Thoroughbred racing website (www.nzracing.co.nz) and imported into Microsoft Excel (Microsoft Corporation, Redmond, WA, USA). The service fee of the sire, age when first standing at stud and number of years at stud were obtained from the sires details listed in the 1988/89 (Volume 15) and 2004/05 (Volume 31) Register of Thoroughbred stallions of New Zealand (New Zealand Thoroughbred Breeders' Association (Inc)).

Thoroughbred parity versus age

From the 2004/05 breeding season a dataset of 11 sires were identified, using a participant familiar with the industry, representing a cross section of the sires at stud in that given year. The service fee of the sires ranged from NZ$ 2,000 to NZ$ 95,000. For each respective sire 15 mares, except for three sires with only two, four, and eight mares, were randomly selected. Imported mares covered by the stallion were excluded from analysis due to difficulty in obtaining accurate parity records. This provided a data set of 143 mares with an age ranging from 6 to 25 years.

Effect of service fee

To examine the relationship of service fee on stallion age, and age of the mares covered, the sires active in the 2004/05 breeding season were classified as low cost ($2,000 to $5,000) (n = 59), medium cost ($5,500 to $10,000) (n = 11), expensive cost ($10,000 to $100,000) (n = 5) and shuttle sires ($6,000 to $40,000) (n = 19).

Standardbred

An electronic extract of the breeding records of all active sires from 1989/90 to 2004/2005 were obtained from Harness Racing New Zealand (www.hrnz.co.nz). The dataset contained sire identification, breeding season, number of mares covered, live foals, and the number of mares identified as not pregnant at the end of the breeding season.

Manipulations and statistical analysis

The data from the various information sources were collated and imported in MS Excel (Microsoft

TABLE 1: Total broodmares bred, exported and live foals in New Zealand from 1989/90 to 2004/05 breeding seasons for the Thoroughbred and Standardbred studbooks.

Year	Thoroughbred			Standardbred		
	Mares covered	Live foals	Exported mares	Mares covered	Live foals	Exported mares
1989	10,176	5,882	158	7,261	5,133	176
1990	9,426	5,394	195	6,738	4,712	148
1991	8,451	4,828	118	6,239	4,455	94
1992	8,050	4,828	127	5,610	3,973	97
1993	8,351	4,978	144	5,491	3,978	98
1994	7,987	4,913	121	5,238	3,755	87
1995	7,790	4,918	135	4,813	3,486	94
1996	7,440	4,639	127	4,635	3,427	95
1997	7,172	4,614	123	4,820	3,230	111
1998	6,802	4,454	144	4,197	3,049	115
1999	6,850	4,554	125	3,989	2,808	95
2000	7,357	4,692	158	4,062	2,980	78
2001	7,167	4,625	121	4,629	3,242	79
2002	6,836	4,285	131	4,629	3,218	79
2003	6,458	4,082	172	4,612	3,202	72
2004	6,488	3,181	229	4,512	3,051	62

FIGURE 1: Linear regression of parity ± standard error of mean and age at foaling for a cross section of 143 Thoroughbred mares bred in the 2004/05 breeding season.

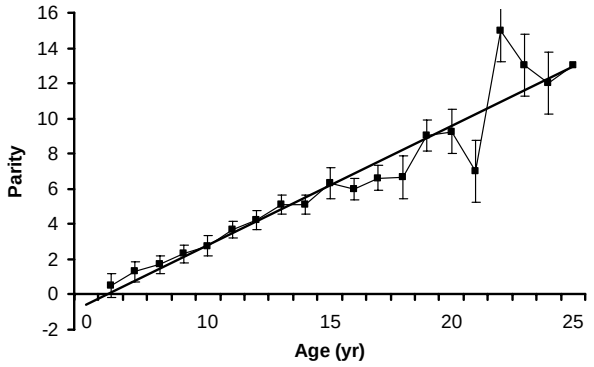


FIGURE 2: Number of Thoroughbred (□) and Standardbred (●) stallions at stud in New Zealand from the 1989/90 to 2004/05 breeding seasons.

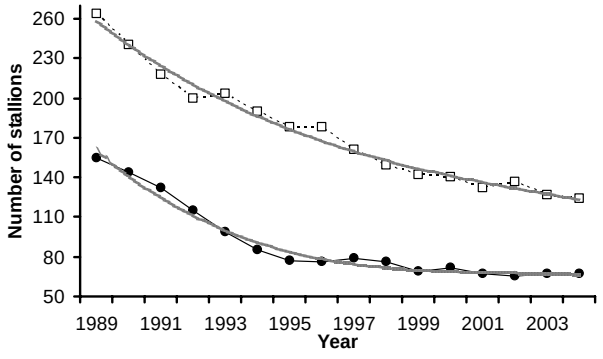


FIGURE 3: Mean ± standard error of mean of number of mares covered each season by Thoroughbred (□) and Standardbred (●) stallions in New Zealand.

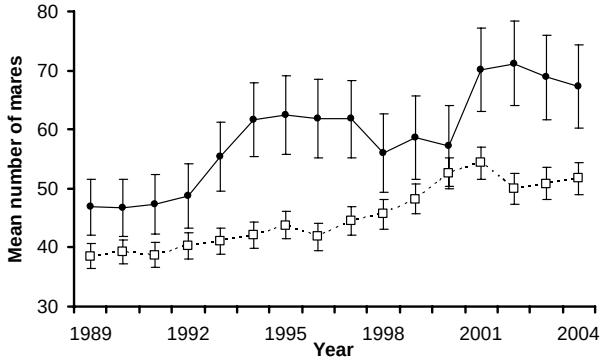


FIGURE 4: Mean ± standard error of mean number of mares covered by Thoroughbred (□) and Standardbred (●) stallions per year by number of years at stud.

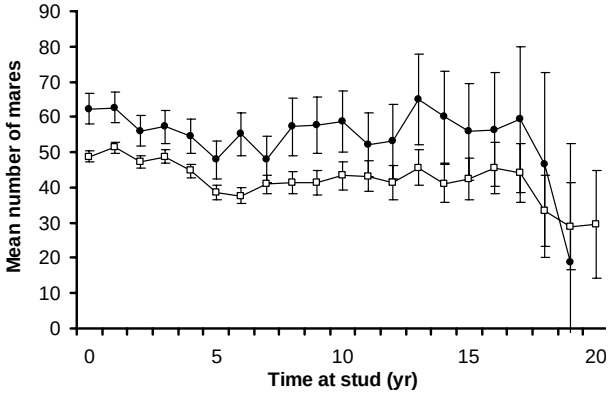
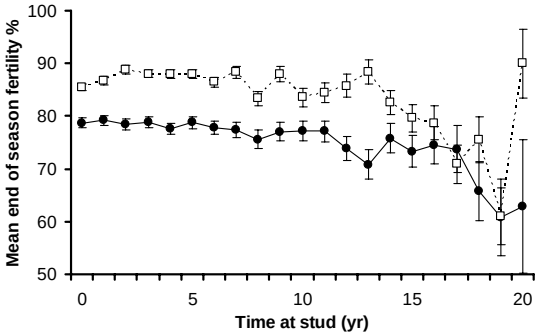


FIGURE 5: Mean ± standard error of mean of end of season fertility for Thoroughbred (□) and Standardbred (●) stallions per year by number of years at stud.



Corporation, Redmond, WA, USA). The comparison between groups was performed using a general linear model. Linear and non-linear regression models were fitted to the data to describe the relationship of stallion reproductive data to the calendar year, and the number of years the stallion was at stud. Survival analysis (Kaplan-Meier) was performed to identify the reproductive life of a stallion. A stallion was identified as inactive if he covered less than 10 mares in a season, or failed to have any covering returns in a given season. All statistical analysis was performed using a SPSS v16 (SPSS, 2004) with the significance level set at $P < 0.05$.

RESULTS

Broodmare herd data

Total mares and mares bred per year

The number of active broodmares decreased for both the Thoroughbred and Standardbred populations during the observation period (Table 1). The percentage reduction in mares covered was

similar for Thoroughbreds (36%) and Standardbreds (37%), although the relative reduction in live foals was greater in Thoroughbreds (45%) compared to Standardbred (40%).

Broodmare parity and age

Thoroughbreds

There was a strong relationship between the age of the mare and the parity status (Figure 1). The relationship between age and parity was described by the equation Parity = -3.41 + 0.6 age (years), R^2 = 0.67, P = 0.0001). That is the first foal is expected at age 6, where parity = 1, and that, on average, mares produce 0.5 foals per year. The relationship of age with parity became less consistent after 15 years of age. Data on Standardbred age and parity was not collected.

Number of active sires from 1989 to 2004

There was a consistent reduction in the number of active Thoroughbred sires at stud in New Zealand from 265 in 1989/90 to 124 in 2004/05 (Figure 2). The reduction in active sires was best described by a cubic regression, with approximately 20 fewer sires standing at stud than the previous calendar year in the early 1990s and then a plateau of numbers (Number of active sires = 258 - 18.5 year + 0.95 $year^2$ – 0.02 $year^3$, R^2 = 0.98, P <0.001). In a pattern similar to that observed with the Thoroughbreds there was a consistent reduction in the number of active Standardbred sires at stud during the observation period. A cubic regression model best described the reduction in number of active sires (Number of active sires = 160 -21 year + 1.6 $year^2$ + -0.04 $year^3$, R^2 = 0.98, P = 0.001).

Mean number of mares covered per year

There was an increase in the mean number of mares served by the active Thoroughbred and Standardbred sires (Figure 3). In the 15 years examined there was a linear trend for the size of average thoroughbred stallions book to increase by approximately 1 mare per year (Number of mares covered = 39.3 + 0.90 year, R^2 = 0.81, P <0.001). There was some yearly variation in the average number of mares covered with the peak average book occurring in the 2001/02 breeding season. There was a similar, but greater, trend for the Standardbred sires over the same period with the linear equation identifying a trend for an annual increase of 1.45 mares per sire (Number of mares covered = 47.6 +1.5 year, R^2 = 0.73, P = 0.001).

Mean number of mares covered per year a stallion is at stud

Thoroughbred

Overall the mean number of mares a stallion covered per season (book size) decreased with each year a stallion was at stud (Figure 4). During the first five years at stud the Thoroughbred stallion covers the largest number of mares, after which the book size remains stable until the sire was in the seventeenth year at stud. The variation in book size increased with the number of years a stallion is at stud.

Within the Standardbred population there was larger variation in the number of mares covered by a sire and there was no significant effect of the number of years a sire was at stud on the number of mares covered. The percentage of sires covering more than 100 mares in a season was 18.3 ± 1.35 % for Standardbred and 6.1 ± 1.3 % for Thoroughbred. The largest number of mares covered by a single sire was 435 for a Standardbred sire and 227 mares per season for a Thoroughbred sire.

Stallion fertility

There was a trend for the Thoroughbred sires end of season fertility to decrease with increasing number of years at stud (Figure 5). The mean end of season fertility including live foals and dead foals, slipped mares, mares exported and dead mares, was 77.9 ± 0.3% and remained at, or near, this level until 20 years at stud when the end of season fertility decreased to 62.8 ± 6.5% There was a similar trend for a decrease of fertility with increasing years at stud in the Standardbred population although the mean fertility percentage was 86.6 ± 0.2 % which was significantly higher than the mean observed with Thoroughbred end of season fertility (P = 0.001). Stallion fertility in Standardbreds started to significantly decease after 17 years at stud (P <0.05).

Survival analysis of a stallions commercial service career

The percentage of Thoroughbred stallions that were active after each year at stud declined consistently until 10 years at stud. After 10 years at stud the percentage of sires still active decreased at a much reduced rate than that observed during the one to 10 year period. Kaplein mieir survival analysis identified that after three years at stud only half the Thoroughbred stallions were still active (Median at three years (95 % CI 3 – 3). In the Standardbred population half the Standardbred sires were no longer active after four years (Median at four years (95 % CI 4 – 4 years).

The association of service fee on the quantity and quality of mares sent to Thoroughbred stallions

The mean age of the low priced stallions was 11 ± 0.5 (standard deviation) years and these represented 65.9% of the active sires. The medium priced sires had a mean age of 10 ± 0.4 years and represented 11.4% of active sires. The mean age of the expensive and shuttle sires was 12 ± 0.3 years and 9 ± 0.4 years and represented 6.5% and 16.3% of active sires, respectively.

TABLE 2: Mean ± standard deviation for production parameters for Thoroughbred stallions at stud in the 2004/05 breeding season grouped according to the service fee. Low = $0 - $5,000 (n = 59), Medium = $5,500 - $10,000 (n = 11), High = ($10,000 - $100,000 (n = 5) and shuttle sires ($6,000 - $40,000) (n = 19).

Parameter	Service fee			Shuttle sire
	Low	Medium	High	
Stallion age (years)	11 ± 0.5^{b}	10 ± 0.4^{b}	12 ± 0.3^{a}	9 ± 0.4^{c}
Mare age (years)	12 ± 0.7^{b}	12 ± 0.5^{b}	11 ± 0.4^{a}	11 ± 0.5^{a}
Number of mares covered per stallion	40 ± 31^{c}	69 ± 31^{b}	118 ± 32^{a}	81 ± 31^{b}
Days from first to last covering in the season	107 ± 28^{b}	139 ± 28^{a}	128 ± 28^{ab}	133 ± 28^{a}
Date of midpoint in covering[1]	$16/11/2004 \pm 80^{b}$	$17/10/2004 \pm 62^{a}$	$6/11/2004 \pm 48^{ab}$	$3/11/2004 \pm 58^{a}$

Different superscript are statistically significantly different ($P < 0.05$).
[1]Standard deviation expressed in days.

The shuttle stallions were significantly younger than any other service fee category and the expensive sires were significantly older (Table 2). Both the expensive sires and the shuttle sires covered larger books of mares that were significantly younger than the mares sent to the low and medium priced sires.

DISCUSSION

The size of both the Thoroughbred and Standardbred industries in New Zealand are small by international standard. Based on current figures New Zealand is the seventh largest producer of thoroughbred foals with 4.2% of international foal crop, and fifth for the Standardbred. In contrast to the Standardbred industry that satisfies what is a predominantly domestic market, the Thoroughbred is export driven with approximately one third of the annual foal crop exported as either yearlings or as racehorses. In recent years the number of Thoroughbreds exported has remained relatively constant while there has been a decrease in the size of the broodmare herd and foal crop. The consistency of the export numbers for the Thoroughbred implies that the reduction in the broodmare herd, and the associated decrease in foal crop, have been due to the removal and/or culling of the less commercially viable bloodstock.

The structure of the Thoroughbred racing industry is remarkably consistent across participating countries. In the United Kingdom most fillies leave training and retire to stud when three or four years-old (Wilsher & Allen, 2003). In New Zealand approximately 87% of female horses in racing in New Zealand are less than five years old (Perkins *et al*., 2005). The opportunities to race and the prize money available decreases as the horse ages, unless it is capable of competing at top level with listed and group races, which effectively means that by five years of age most mares have been retired to stud and are expected to produce a foal annually.

Within the limited dataset examined in this study it appeared that the expensive and shuttle Thoroughbred sires covered younger mares than the less "commercial" stallions. It would appear that breeders are willing to spend more on the service fees of the younger mares, perhaps to give them the best opportunity to prove themselves commercially. In contrast, older mares will be of greater parity and may be less likely to produce a foal with commercial appeal or size, as foals from older mares tend to be smaller than those from younger lower parity mares (Hintz *et al*., 1979). Anecdotal evidence suggests that yearlings smaller than the acceptable minimum height and size fail to maximise sales return, irrespective of their pedigree and vendor (Morel *et al*., 2007).

The Thoroughbred broodmare herd was larger than the Standardbred at the beginning of the observation period but appeared to have greater reproductive wastage or inefficiencies. In the 1989/90 season the Thoroughbred live foal percentage was only 57.8% compared to 70.1% in the Standardbred population at the same time. Overall, the mean end of season fertility figures were better for Standardbreds with 87% fertility compared to 78% for the Thoroughbred. It is difficult to speculate retrospectively as to the reason for this but it is possible that the consistently lower production values seen with the Thoroughbred population may be in part due to the use of natural service and not artificial insemination, as is commonly used in the Standardbred industry. Also, the longer and often later breeding season of Standardbreds may positively influence the end of season fertility rates, allowing the mare to be bred over more cycles during the physiologic breeding season.

Even with the use of artificial insemination within the Standardbred industry the mean number of mares covered by a sire was not as large as

expected. The use of artificial insenination has seen the top sires covering large numbers of mares, but this does not appear to have greatly undermined the number of sires standing or the mean number of mares covered by the less commercial sires.

Within both industries there was a trend for a reduction in the number of stallions at stud and an associated increase in the number of mares each sire covered during a season. These decreases in sire numbers probably reflect an increase in both reproductive management of the mare and stallion and increasing commercial pressure. The commercial life of a stallion is very short with the stallion only having three to four years to demonstrate its worth as a sire. A stallion must have some of the first foal crop succeed in two year-old racing to ensure continued support from the broodmare owners. Failure to have two year-old winners, or at the very least early three year-old winners, is generally associated with the end of a stallions commercial breeding career. The trend for a short commercial life has been accentuated with the use of shuttle sires which are generally young stallions that have just completed their three year-old (Classic) racing year in the Northern Hemisphere. The ability of a sire to have large foal crops in both hemispheres means that an accurate assessment of a sires worth can now occur at a much younger age.

Shuttle sires tended to be young and serve the younger mares. However, the largest books were associated with the expensive, proven sires. There was a trend for the expensive and shuttle sires to have an earlier mean service date than the other sire categories because of the commercial pressure to produce a foal born earlier in the season.

CONCLUSION

Both the New Zealand Thoroughbred and Standardbred industries have seen a reduction in the number of breeding stallions and mares in the last 20 years. The stability of export numbers during the same period indicates that this is due to culling of less commercial bloodstock. The commercial life of a stallion was estimated to be three years for a Thoroughbred and four years for a Standardbred sire. Shuttle sires were younger and served younger mares than other sire categories.

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