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An epidemiological survey of the dentition and foot condition of slaughtered horses in Australia

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A report submitted in partial fulfilment of the requirements of ANIM7619 Graduate Research project, a course within the Master of Animal Studies (Animal Science and Management) program

June 2008

ABSTRACT

The goal of this preliminary investigation was to determine the approximate ages and brand types of the horses relinquished to an export abattoir and to assess the condition of their feet and dentition. An assessment was also made on the possibility of collecting further data within the abattoir setting. In this study data was collected over three collection dates from 340 horses processed at an Australian abattoir. This occurred between November 2007 and January 2008. The data showed that 59.8% of the horses had a dental age of ≤ 7 years with the remainder (40.2%) being > 7 years. Observations of the types of brands present indicated that 52.9% of the horses processed had originated from the racing industry with 40.0% of the sample group carrying a Thoroughbred brand and 12.9% carrying a Standardbred brand. The remainder of the group (47.1%) had no visible brand. Only 2.4% of horses in the sample population were found to have a dental malocclusion while 6.9% showed signs of unusual wear. An assessment of the foot condition showed that many of the hooves were overgrown and required farrier attention. An analysis of six hoof indicators, which are generally associated with overgrown and untrimmed hooves, revealed that 80.5% of the horses presented with one or more indicator. Analysis of the possible associations between the presence of foot conditions and sample period, age or brand type showed that the sample period had the most significant impact on the prevalence of various conditions. The cause of this pattern was unclear, although possible explanations could be an equine influenza backlog effect, inherent variability or a seasonal or equine industry-driven trend, and more research is necessary before definitive conclusions can be reached concerning this association. With regard to associations between brand type and foot conditions, Standardbred horses were found to have significantly fewer grass cracks ($p<0.01$) and more injuries both to the coronary band ($p<0.05$) and to 'other' areas ($p<0.05$), likely due to the different types of activities performed by these horses (pacing and trotting) compared to other racing and recreational horses. Little association was found between the prevalence of foot conditions and age. A further assessment of the slaughter process demonstrated that other types of indicators that could be measured to assess the physical condition of the horse included body condition and soundness. Overall, this study has provided valuable information on the type, age, dentition and foot condition of horses relinquished to an abattoir, ascertained that

more physical data can be collected during the slaughter process and concluded that foot problems were more prevalent than dentition problems within the study group.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER ONE

INTRODUCTION

Horses are an integral aspect of Australian life and are used in many industries for the purpose of work, entertainment and sport. However, for a variety of reasons, some horses working in these industries are ultimately relinquished to slaughterhouses. Little appears to be known about the reasons why these horses are sent to be slaughtered and a number of factors could contribute to this lack of available information. One of the main reasons is thought to be that the subject of horse slaughter can be emotive as the horse is considered, by many, to be a companion animal. Information concerning the industry is therefore limited and because of this, little is known regarding the demographics and condition of horses relinquished to either abattoirs or knackeries.

For the last 30 years horsemeat from Australian horses has been exported for the purpose of human consumption (Pilkington and Wilson, 1993). Information regarding the characteristics of horses relinquished to an Australian abattoir and the physical condition of horses at the time of relinquishment is becoming increasingly important as the both the horsemeat industry and equine industries, which supply horses for processing, come under mounting scrutiny. If this country is to be faced with similar decisions to that of the United States, where legislation has recently been passed prohibiting the slaughter of horses for meat intended for human consumption (Whiting, 2007), it is important that the profiles and histories of the horses relinquished for slaughter at export abattoirs be understood as this can add valuable information when decisions are made on the relevance and future of the slaughter export industry. From a welfare perspective, it is also important to ascertain what can be gauged regarding the physical condition of horses processed through an abattoir, in relation to previous levels of care, as this is another area in which published information is sparse.

Therefore, the purpose of this study is to collect data from horses relinquished to an abattoir with regard to various characteristics and conditions. By doing so, it is hoped that valuable information can be added to the limited knowledge base which currently exists with regard to Australian horses relinquished for slaughter at an export abattoir.

CHAPTER TWO

LITERATURE REVIEW

Literature review part A

Abattoir slaughter of horses in Australia

2.1 INTRODUCTION

Horses have been relinquished to slaughterhouses in Australia for many years although it is only since 1977 that horsemeat has been utilised as an export product for human consumption (Pilkington and Wilson, 1993). Since that time it seems that little information has been collated regarding the origins or profiles of horses relinquished for slaughter. The purpose of section A is to review the type and quality of information that is available regarding the numbers, origins and uses of relinquished horses, as well as the reasons for relinquishment, with the aim of highlighting areas for future research and identifying research priorities.

2.2. PREVIOUS STUDIES

A number of studies have been published on the various issues affecting abattoir horses relinquished to slaughterhouses (Grandin *et al*., 1999; McGee *et al*. 2001). Transport to slaughter is one of the main areas of concern as the horses are often in transit for long periods prior to reaching an abattoir. For example, Stull (1999) reported that horses in the United States may be transported for over thirty hours before reaching their destination. Similar long journeys (some over 3000km) have been reported for horses in Australia (Wright, 2001). Research has also been undertaken investigating the various transport-related stressors to which slaughter horses can be exposed. Potential stressors may include isolation from the herd, temperature extremes, food and water deprivation, novel surroundings and the exposure to new, and possibly, aggressive horses (Friend, 2001).

Studies have also been published on the welfare and profiles of slaughter horses in the United States. Grandin *et al*. (1999) surveyed 1008 horses relinquished to two

Texan abattoirs to identify the prevalence of severe welfare issues such as emaciation, fractured limbs and extensive lacerations (existing either prior to relinquishment or during transport). In a separate study, McGee *et al.* (2001) profiled characteristics of horses (e.g. soundness, body condition, foot condition, age and breed) that had been sent to auction and compared them to characteristics of horses that had been relinquished to an abattoir. To date, no known research has been performed in Australia investigating the actual welfare of horses in either abattoirs or knackeries (Hayek *et al.*, 2005). There is also little published information available regarding the profile or characteristics of a 'typical' abattoir horse including the feral horse to domestic horse ratio (Ramsay, 1994), the breed, age and gender of the horses or the specific reasons for relinquishment. Hayek (2004) conducted the only existing Australian research regarding the profile of horses relinquished for processing by the horsemeat industry. As part of a wider study the author surveyed 20 of the 33 knackeries within Australia and was able to report that these establishments processed approximately 13,500 horses annually and that the horses which entered the knackeries were predominately from two populations: old, sick and injured horses or horses whose upkeep was no longer economically feasible (such as ex-racehorses and young horses on drought-affected properties). Hayek (2004) restricted the target population of the survey to knackeries so, to date, no Australian studies regarding either the characteristics or the welfare of horses entering an abattoir have been completed. This being the case the remainder of section A is aimed at ascertaining the actual extent of the information available regarding horses relinquished to Australian abattoirs and by doing so attempts to determine the research priorities for this investigation.

2.3 HORSE SLAUGHTER IN AUSTRALIA

Horses relinquished for slaughter in Australia are sent to either an abattoir or knackery. These two types of establishments differ fundamentally in that an abattoir is licensed to export horsemeat overseas for human consumption, while a knackery sells its produce for pet food and other saleable by-products such as horse hides, hair, meat and bone meal (Dobbie *et al.*, 1993). There are two licensed abattoirs (Meramist Pty. Ltd. at Caboolture, Queensland and Metro Meats at Peterborough, South Australia) and 33 licensed knackeries (Hayek, 2004) in Australia.

2.3.1 Demographics of horses relinquished to abattoirs in Australia

The actual numbers of horses relinquished for slaughter has decreased over the last 30 years. Wilson and Pilkington (1993) noted that the most important issue facing an abattoir was sourcing sufficient numbers of horses to ensure the commercial processing of such animals was economically viable for the plants involved. Similar concerns were raised by knackery plant managers in 2004 when it was reported that the main reasons for not processing horses were the lack of available animals combined with the negative public perception of horse meat processors and the disinclination of the public to buy horsemeat (Hayek, 2004). The issue of availability is particularly relevant in Australia at the present time with the recent equine influenza (EI) outbreak and the significant restrictions which were placed upon the movement of horses around the country. One of the Australian abattoirs (Meramist Pty. Ltd.) overcome this issue by processing horses less frequently than would otherwise occur (fortnightly as opposed to weekly) as well as processing other export species in the place of horses.

2.3.1.1 The export of Australian horsemeat

Australia first exported 32,000 kg of equine meat in 1977. The amount of meat exported increased annually to approximately 8-9 million kg per year, and remained relatively steady until the end of the 1990's (Pilkington and Wilson, 1993; Australian Bureau of Statistics, 2007). By 2000, the amount exported had dropped to 3 million kg (Gordon, 2001) and the most recent available information from the Australian Bureau of Statistics (ABS) (Table 2.1) suggests that this decreasing trend is continuing with the total number of kilograms of meat exported from Australia falling 67% in the last 10 years. The countries which import Australian horsemeat are varied although Japan, Belgium/Luxembourg, France, the Russian Federation and Switzerland have become significantly greater importers of Australian horsemeat than other countries, such as Hong Kong, Singapore and Italy, over the last 10 years (ABS, 2007).

Table 2.1 Exports of equine meat from Australia*

Year	Quantity (kg)	Value ($)	Price /kg ($)
1997	5,123,000	16,767,747	3.27
1998	6,049,000	24,800,008	4.10
1999	5,743,000	25,175,027	4.38
2000	3,471,000	15,945,836	4.59
2001	3,777,000	19,079,968	5.05
2002	3,340,000	16,531,028	4.95
2003	2,952,000	12,523,754	4.24
2004	2,100,000	9,475,586	4.51
2005	2,295,000	9,393,391	4.09
2006	2,190,000	9,615,662	4.39
2007	1,998,000	8,389,049	4.20

(Source: Australian Bureau of Statistics, 2007)
*All figures taken from ABS statistics where raw data includes the quantities of meat from horses, asses, mules and hinnies. Quantities rounded to the nearest 1000kg.

2.3.1.2 Numbers of horses relinquished to abattoirs in Australia

Although information is available concerning the quantities of meat exported to various importing countries, statistics on the actual number of horses involved in the export industry are difficult to access. The Australian Quarantine and Inspection Service (AQIS) supplied Ramsay (1994) with figures of the actual numbers of horses (both domestic and feral) slaughtered at all export abattoirs in Australia for the 1987-1992 period. The total number slaughtered per annum varied between 40,000 and 60,000 horses (Table 2.2).

Table 2.2 Number of horses slaughtered at all export abattoirs in Australia for the 1987-1992 period

Calendar year	Number of horses
1987	59921
1988	45477
1989	41238
1990	46913
1991	46161
1992	47333

(Source: Ramsay, 1994 data supplied by the Australian Quarantine and Inspection Service)

Calculations extrapolated from Ramsay's (1994) data indicate that the average weight of the meat exported from each animal is approximately 200-250kg. This figure combined with the total quantities of meat exported, taken from the recent ABS figures, enables the approximate number of horses processed in the last ten years to be estimated (Table 2.3). Although AQIS records the exact number of horses processed at Australia's two export abattoirs these figures are not available due the records being classed as "commercial-in-confidence" information (Roberts, *pers.comm.*).

Table 2.3 Estimates of the number of equine animals slaughtered for export meat in the 1997-2007 period*

Year	Number of animals slaughtered
1997	29277
1998	34565
1999	32820
2000	19836
2001	21583
2002	19087
2003	16867
2004	11997
2005	13114
2006	12515
2007	11415

(Source: Ramsay, 1994; Australian Bureau of Statistics, 2007)
*Note that these figures include the exported meat from horses, asses, mules and hinnies

The number of horses slaughtered has been estimated from data collected from Ramsay (1994) and has dropped from over 30,000 in the late 1990's to the current levels of approximately 11,000 – 13,000 horses per annum.

While Ramsay (1994) reported that between 40,000 and 60,000 horses were slaughtered for meat during the 1987-1992 period the above information indicates that this number has dramatically reduced in recent years. Knackery managers have also reported a similar decreasing trend in the numbers of horses available for processing (Hayek, 2004).

2.3.2 The origin of relinquished horses

Of the approximately 700,000 equines which have been processed in Australia over the last 20 years (Ramsay, 1994; Gordon, 2001; ABS, 2007) little seems to be known of their origin and type or breed (Ramsay, 1994). While a tracking system exists for cattle, in the form of the National Livestock Identification System, which traces the movement of cattle in Australia from their birth to slaughter or export (Department of Primary Industries, 2008), no such complete system exists for horses, making studies which attempt to accurately assess origins and destinations of horses difficult, if not almost impossible.

Some industries, such as the Thoroughbred racing industry, do require that records are kept on horses. For example, all Thoroughbred breeding mares and stallions must be registered and foals branded, DNA typed and microchipped before being entered into the Australian Stud Book (ASB, 2007). Once a horse begins to train and race, data, such as the details of each race and the horse's starts, wins and earnings, are collected by the Racing Services Bureau. The end result of these data collection systems is that only those horses which are either in training or racing or are registered for breeding purposes are traceable and therefore horses which have not been registered for racing or breeding, have been registered but not raced, or those which have left the industry are virtually untraceable (Hayek, 2004).

An article published early in 2008 in the Sydney Morning Herald reported that the large majority of horses relinquished to an abattoir were unwanted racehorses and raised the issue of traceability (Cuming, 2008). However, tracing a slaughter horse does appear to be theoretically possible, as AQIS requires that a vendor declaration accompany each horse to its destination. The vendor declaration records a minimum six-month history of the horse, the place of origin, a physical description (e.g. colour, sex, brands and microchip information) as well as information regarding the recent administration of any veterinary drugs or chemicals. A horse sold for slaughter also carries a numbered neck tag which aids in traceability and is particularly important in relation to drug residues present in horses slaughtered for the human consumption market (AQIS, 2008). While an abattoir retains the vendor declarations they, unfortunately, cannot grant access to them as client (e.g. buyer, seller, transporter) privacy would be compromised.

As noted by both Duckworth (2001) and Cuming (2008) there appears to be a common perception that the majority of slaughter horses are unwanted racehorses and a connection between the surplus horses produced by the Australian racing industry and the horsemeat market has previously been suggested by various animal welfare groups (Animal Liberation, 1998; Animals Australia, 2007). "*The vast majority of Thoroughbreds (flat and jumps racers) and Standardbred (harness racers) horses fail to run fast enough or become injured and are just discarded by the racing industry. Those destined for slaughter may go to local knackeries (used for pet meat for example)—an estimated 20,000 horses each year—are purchased for slaughter at the two horse abattoirs in Australia"* (Animals Australia, 2007).

This perception may be realistic as Gill (2005) noted that if a shortage of feral or working horses occurs within an abattoir environment the viable alternatives for processing are horses reared for racing or other recreational equestrian pursuits. While there is currently little published Australian evidence that the majority of domestic horses processed through an abattoir are ex-racehorses, beyond anecdotal descriptions of horses seen in abattoir slaughter yards (see websites such as www.bigpond.com/berrime/slaughter.htm), it is certainly a possibility worth studying as Australia is estimated to produce approximately 18,000 - 20,000 Thoroughbred foals each year (Howard and Morley, 2007) with this figure second only to the United States of America (Pilkington and Wilson, 1993).

2.3.2.1 Thoroughbred and Standardbred wastage rates

Wastage or horse loss (Jeffcott, 1990; Bailey, 1998) occurs at all stages of the horse's life, including prior to racing, and it is estimated that pregnancy in 1000 Thoroughbred Australian mares produces only 300 horses which will actually race (Bourke, 1995). Similar pre-racing wastage has been found in Standardbred horses (trotters and pacers). A survey conducted on the 1990 crop of Western Australian Standardbred foals (Dyer, 1998) reported that 29% of foals were unregistered while approximately 26% were registered but never raced. Of the unregistered foals, 25% died or were destroyed and in 13% of cases, the cause of death was deliberate destruction. Of the registered, unraced horses 15% died and deliberate destruction was the cause of death in 12% of cases.

Bourke (1995) has also estimated that approximately 33% of the Thoroughbred population of Victoria may be lost to wastage each year however, these wastage figures include all areas in which horses are lost to the racing industry (e.g. reproductive failure, death of foals, various training and racing injuries and those relinquished for slaughter: Bailey, 1998). Interestingly, a more recent survey of racehorse trainers in the 2002/2003 race year reported similar figures. Hayek *et al.* (2005) found that the total wastage rate for horses in training or racing was 39% for Thoroughbreds and 38% for Standardbreds. Of the 39% of Thoroughbreds which left a racing stable only 6% were reported to have been sent to a knackery while 17% of Standardbred horses were reported to have been sent to the same destination. However, as the authors noted these figures do not include horses which were sent to a slaughter plant via a more indirect route, that is being sent to auction and purchased by an agent buying horses for slaughter, so the exact number of Thoroughbreds and Standardbreds in the study group which were ultimately slaughtered remains unknown.

2.3.2.2 Processing of Australia's feral horses

An accurate percentage of feral horses (Brumbies) processed for horsemeat and the relative proportion of feral versus domestic horses which are utilised for human consumption is unknown (Ramsay, 1994). Figures released in 1993 indicated that the estimated population of feral horses throughout Australia was between 325,000 and 350,000 with the vast majority of these populations being found in the Northern Territory (NT) and Queensland (Qld) (Dobbie *et al.*, 1993). Dobbie *et al.* (1993) reported that feral horses were in demand by export abattoirs as the leanness of meat and lack of chemical residues (from veterinary medication) gave this type of meat a significant market advantage. In 1991, it was estimated that between 20 - 30% of the horses slaughtered at export abattoirs were of feral origin (Senate Select Committee on Animal Welfare, 1991). However, the availability of such animals was reported to be seasonal in nature as feral horses were more likely to be captured during the dry season as they could be found, and caught, in large numbers near water when it was in short supply (Ramsay, 1994). Current information suggests that approximately 90% of all horses slaughtered at export abattoirs are now of domestic origin due to the prohibitive distances involved in transporting feral horses as well as various harvesting and culling operations which have decreased feral horse populations in recent years (Roberts, *pers.comm.*).

2.3.3 Reasons for the relinquishment of horses

Although specific reasons for relinquishing a horse to an abattoir are difficult to uncover and little information can be found on the demographics of unwanted horses (Kuehn, 2005), studies do exist which give some indications of the important factors involved in relinquishment. For example, McGee *et al.* (2001) reported that age may be an important factor affecting relinquishment, as horse traders in North America were reportedly able to get more money for a horse if it was under 20 years of age by selling it as a riding or pleasure horse than as a slaughter animal. This agrees with Hayek *et al.* (2005) who reported that Thoroughbreds relinquished to slaughterhouses had a greater mean age than those going to other destinations. However, the study also noted that the average age of a Standardbred horse sent to a slaughterhouse was younger than other similar individuals sent to auction or stud, indicating that the reason a horse is relinquished to an abattoir is dependent upon more factors than simply age.

The overall condition of the horse, and importantly, the condition of the feet and hooves, may be another reason for relinquishment. McGee *et al*. (2001) reported on characteristics of both auction and slaughter horses and found that of the slaughter horses 59% were classed as showing good body condition (compared with 67% of auction horses) while the remainder were either emaciated, thin or obese. The study also found that 31% of the slaughter horses had feet in an 'acceptable' condition, compared with 54% of auction horses and 28% of slaughter horses were classed as unsound in comparison with only 8% of horses sent to auctions. These findings appear to indicate that horses in poorer condition with foot, and possibly soundness, issues are more likely to be sent to slaughter than a healthier animal which may instead be sent to auctions or saleyards to fulfil the demands of "secondary markets" (Hayek *et al.,* 2005) (e.g. leisure riding and other recreational pursuits). However, the perception of an aged, unhealthy, unsound horse in poor condition sent to slaughter does not appear to be particularly realistic given an export abattoirs demand for well-muscled, healthy horses, which are more likely to produce better quality and quantities of meat, highlighting a gap in scientific knowledge regarding the exact characteristics and conditions of a 'typical' Australian abattoir horse.

Horses with a greater probability of meeting abattoir standards could be the Thoroughbreds and Standardbreds no longer required by the racing industry. A longitudinal investigation of the performance of Thoroughbreds in their first years of racing found that the most common cause of premature retirement was a lack of earnings with approximately 50% of horses earning less than $450.00 and 40% earning no money at all (More, 1999). It is estimated that the average yearly cost of keeping a Thoroughbred racehorse is approximately $11,200 in a city environment and $9,200 when the animal is housed in a rural area (figures exclude veterinary and farrier costs) (Gordon, 2001) indicating that in the majority of cases the dollar figure required to keep a racehorse far exceeds the income likely to be produced. In fact, More (1999) reported that in the first year of racing 87% of horses did not earn enough money to cover their training costs for that period.

Low earnings, caused by a lack of racing ability, has also been reported as one of the most common reasons for Standardbred horses being relinquished to a slaughterhouse (Hayek *et al*., 2005). A Standardbred ownership survey conducted by Roberts (2000), on behalf of the Australian Harness Racing Council, reported that 90% of Standardbred owners claimed ownership of their horses was unprofitable. In an earlier Standardbred study, Pollock and Brownlie (1998) reported that dissatisfaction with earnings was the primary reason for owners to relinquish their horses.

The physical location of the horse may be another reason for relinquishment to an abattoir with higher numbers of Standardbreds in South Australia relinquished to an abattoir compared with Standardbreds in other states, possibly due to an export abattoir being located in that state (Hayek *et al*., 2005). Hayek *et al.* (2005) also reported that the most common reason for Thoroughbreds to be relinquished to a slaughterhouse was an "unsuitable temperament or behaviour" although it is possible that this may be a relatively common reason for many horses to be relinquished to an abattoir, not just those from the racing industry. Finally, and perhaps not surprisingly, the survey by Hayek and others (2005) reported that greater numbers of geldings (both Thoroughbred and Standardbred) were relinquished to a slaughterhouse when compared to mares and stallions, most likely due to their inability to breed which would reduce their use to the racing industry.

2.3.4 Uses of horsemeat and horse by-products

Unlike the origin and reasons for relinquishment of a horse to a slaughterhouse, the uses of horsemeat are well documented. Australian horsemeat which is not intended for human consumption has traditionally been used for both the domestic and international pet food market. Horsemeat in the domestic market is used for pet food in either a fresh or frozen state, although none is used in pet food canneries (Dobbie *et al*., 1993). Interestingly, the majority of horsemeat utilised internationally for pet food is exported to Japan, where it is fed by zoos and animal parks to many of their carnivorous species (Ramsay, 1994).

The human consumption of horsemeat is a long held practice in many different countries, particularly those in Europe and Asia (Whiting, 2007). In other countries, such as Great Britain, the United States and Canada, the horse has traditionally been considered a work, companion and performance animal (Reece *et al.,* 2000), as opposed to a food source and, as in these countries, the Australian market supplying horse meat for human consumption has never developed (Whiting, 2007). According to the Australian Food Standards code "meat" is defined as the "*whole or part of the carcass of any buffalo, camel, cattle, deer, goat, hare, pig, poultry, rabbit or sheep*" which has not been slaughtered in the wild state, and does not include any part of any other animal unless it is permitted for human consumption under a state or territory law (FSANZ, 2000a). The same code classes game meat which is edible for human consumption as the "*whole or part of the carcass of any bird, buffalo, camel, deer, donkey, goat, hare, horse, kangaroo, rabbit, pig, possum or wallaby*" provided the animal has been slaughtered in the wild state (FSANZ, 2000b). This indicates that while the domestic horse processed through an abattoir is not considered to be meat and is therefore inedible for humans, a feral horse slaughtered in the wild is classified as 'game' and therefore fit for human consumption, providing it has been obtained in accordance with quality assurance programs (FSANZ, 2000b).

However, the uses of a slaughter horse do not end with the consumption of meat. The hides of horses slaughtered in abattoirs and knackeries are exported and used in the production of other products such as baseball mitts (Pilkington and Wilson, 1993) and as innersoles for shoes (Ramsay, 1994). The hair from the mane and tail is also used after further processing. Tail hair is reportedly blended with other products to manufacture brushes (which are mainly industrial), violin bows and traditional dartboards while mane hair is combined with latex for use in the upholstery of European motor vehicles (Ramsy, 1994). Pilkington and Wilson (1993) have also reported that hearts and spleens are sold, as pharmaceutical compounds as can be extracted from them, and that meat-meal made from by-products and horse tallow, for use in feedlots, is also produced.

2.4 VALUE AND SCOPE OF STUDY

Aside from the documented information regarding the use of horsemeat and other by-products, little recent scientific data exists (with the exception of Hayek, 2004; Hayek *et al*., 2005) concerning the life histories, profiles and condition of slaughter horses in Australia. It is important to gain this information as the issue of horsemeat for human consumption is becoming increasingly topical internationally (Squires, 2006; Whiting, 2007). In May of 2007, due to pressure from anti-slaughter groups, the United States closed the last slaughter house which produced horsemeat for human consumption and banned the transport of slaughter horses to other countries (Whiting, 2007). However, this may not be the optimal solution for the horse industry as the bill which legislated this closure now gives owners with unwanted horses few options for disposing of them humanely (Nolen, 2006) and it has been argued that unwanted horses may be subjected to neglect as their owners lack either the knowledge and/or the financial means to meet their horse's needs (Reece *et al*., 2000). Following a survey conducted by Grandin *et al.* (1999) it was reported that 8% of the horses arriving at slaughter plants in the United States had severe welfare issues, which included fractured limbs and laminitis, emaciation, a complete lack of mobility, lesions, tumours and behavioural issues. Of the severe welfare issues observed, abuse or owner neglect was reported to be the cause in 77% of cases (Grandin *et al.,* 1999). It has also been noted that older, superfluous horses in poor condition are generally purchased by meat processors (McGee *et al*., 2001) as they have little value to anyone except the horsemeat market (Kline *et al*., 1990). From these results both Grandin *et al*. (1999) and McGee *et al*. (2001) concluded that the slaughter of horses for the horsemeat market may actually provide a humane method of dealing with surplus horses and prevent them from being subjected to possible abuse and neglect. In these circumstances the horsemeat market may be a necessary industry and positively support horse welfare (Hayek, 2004). The closure of such an industry, without provision of alternative options or funding (Squires, 2006), could realistically have a detrimental impact on the welfare of unwanted horses.

Research may indicate that in Australia the majority of horses processed through an abattoir do fit the North American profile and are middle-aged to aged and exhibit poor body and foot condition. However, it is also possible that a large portion of horses processed in Australia are surplus to the requirements of the racing and recreational industries and it is no longer economically viable for them to be maintained in their present situation (Hayek, 2004; Gill, 2005). The condition in which horses present to the abattoir, in relation to previous levels of care, is also an important issue regardless of the age or origin of the animal. Therefore, this study is attempting to gather information which will add to the currently very limited knowledge base regarding the characteristics and conditions of Australian horses slaughtered for the human consumption export market. The above review has revealed three areas in which scientific data is not currently available and it is these areas, horse age, type and condition, which will become the subject of this preliminary study. The first objective of this study is to record the ages of the horses processed through an abattoir. The second is to collect data regarding the types or breeds of the horses relinquished to an abattoir and the third is to investigate what information can be collected within the confines of an abattoir setting regarding the condition and well-being of horses prior to relinquishment. While this data must be collected within the relatively restrictive confines of the abattoir setting (due to health and safety regulations), it is hoped that this study will provide some relevant findings which will then be used to complete a more overall profile of the condition, welfare and wastage issues affecting slaughter horses and, in turn, identify possible reasons for the relinquishment of horses to abattoirs.

Literature review part B

Research topics – aging, condition and brand type

2.5 INTRODUCTION

As discussed previously, several aspects of a horse can be used to indicate its well-being including the body condition, foot condition, soundness and dental condition (Wilson, 2000; McGee *et al*., 2001). Restrictions imposed on staff access into and out of the abattoir processing plant (in place to conform to health and safety regulations) meant that, in this study, it was possible to examine two specific aspects of the horse's well-being only. The feet and hooves of the horses were identified as being an area of primary interest as they have been described as one of the most important aspects of the horse's wellbeing (Moyer, 1996) and foot issues are generally regarded as being the most common cause of lameness in the horse (O'Grady, 2003a; Trotter, 2004). By also inspecting the dentition of the horses, it was anticipated that further information could be collected regarding both the wear patterns of the teeth (providing information about the conditions horses were subjected to prior to slaughter) and the dental ages of the horses (Wilson, 2000). It was therefore considered that an in-depth analysis of abnormalities present in the feet and hooves, together with examination of the dental condition of the horses would be sufficient to obtain an indication of the well-being of the horses and the care they had received prior to being relinquished to the abattoir for slaughter.

Therefore, the purpose of section B is to review the literature available regarding common foot and hoof abnormalities and dental wear, which may be found during the investigation, as well as the methodology which is currently used to assess the dental age of a horse and the type of brand it carries.

2.6 DENTITION

Dentition is one area in which important information can be gained regarding the general condition and characteristics of a slaughter horse. Teeth are commonly used to age a horse particularly when no other obvious means of identification (e.g.

branding) are available (Muylle, 1999). The wear of the dentition in horses can be used to indicate the conditions that the horses may have been subjected to prior to slaughter, including some aspects of their diet and general husbandry (Wilson, 2000).

2.6.1 Age

Horses that are utilised or bred for specific purposes commonly have some type of brand or marking on them which alerts an observer to the actual year in which the animal was born, allowing the physical age of the horse to be accurately calculated. This is certainly the case for both Thoroughbred and Standardbred horses bred for the racing industry (Harness Racing Australia, 2002; Australian Stud Book, 2007). There are however, many horses and ponies that do not carry such identification. To assess the age of these animals therefore requires an inspection of the dentition.

There are generally two aspects to determining the age of a horse. The eruption patterns of the six lower incisors (Figure 2.1) is assessed in conjunction with an examination of the alterations to the shape and appearance of the occlusal surface (chewing or biting surface) (Wilson, 2000). While neither of these methods are completely reliable, the first is more exact and a degree of accuracy can be achieved when aging younger horses (Muylle, 1999). Once a horse reaches 6 years of age all of the lower incisors have erupted and aging is then reliant upon the rate of wear caused by mastication and the subsequent contact between the upper and lower dental tables (Eisenmenger and Zetner, 1985; Wilson, 2000). Accurate assessment of the age of the horse becomes increasingly difficult as the horse ages (Dyce *et al.*, 2002) with Loch and Bradley (2000) noting that after an animal reaches 10 -15 years of age the dental age becomes merely an estimate. This has been shown by studies such as Richardson *et al.* (1995) who reported that four experienced equine clinicians were unable to accurately age a significant number of the 400 horses presented to them for testing and that the discrepancy between the true age and the dental age increased as the horses' ages increased.

One possible reason for this inaccuracy is thought to be due to the differences in the rate of wear found in the incisors of various breeds of horses (Eisenmenger and Zetner, 1985; Muylle *et al.*, 1997, 1998). Arabian horses for example, generally have a slower rate of wear than other breeds. In addition, the rate of wear in several breeds (e.g. trotters and Belgian draft horses) has been shown to be affected by nutritional and physiological influences (Muylle *et al.*, 1999).

Although, as previously mentioned, using dentition to age a horse is not a completely reliable method, a combination of shedding and eruption dates and changes in the occlusal surfaces of the lower incisors can be used to place an animal into a dental age category, such as young (≤ 7), middle-aged (over 7 - 15) and aged (15+) with some degree of accuracy. This can be done by viewing the eruption and shedding patterns of the lower incisors, occlusal surface wear, incisor profile and curvature of the dental arch, as further described below.

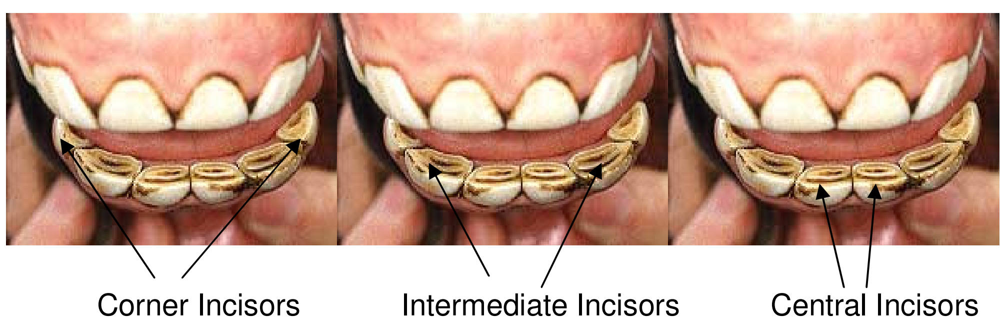
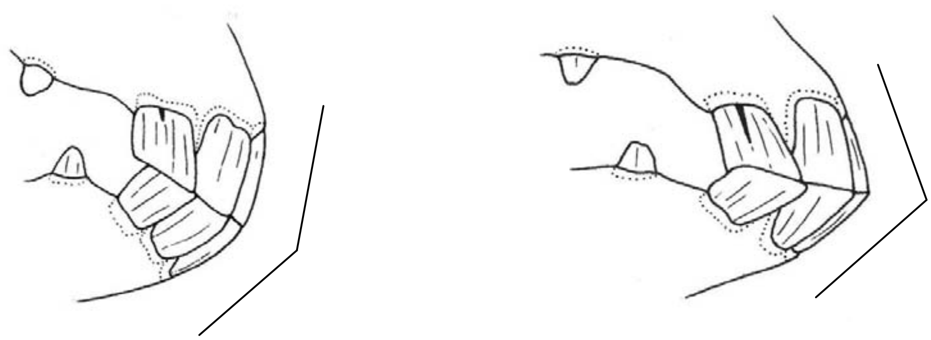


Fig. 2.1 Placement and nomenclature of the lower incisors commonly used to provide the dental age of a horse.

Adapted from Ellis Equine

Shedding of the deciduous teeth and eruption of the permanent teeth can indicate a horse's approximate age as the central deciduous teeth are shed at 2.5 and permanent teeth erupt at 3, the intermediate deciduous teeth are shed at 3.5 and permanent teeth erupt at 4, while the corner deciduous teeth are shed at 4.5 and the permanent teeth erupt at 5 years of age. At this point all of the incisors are in wear (in some measure of contact) although it is not until 6 years of age that the corner incisors are in full occlusal contact (Wilson, 2000). This shedding and eruption pattern appears to be relatively standard, although there has been some variation noted between breeds (Nicks *et al.*, 2007).

The incisor profile (angle formed by the meeting of the upper and lower incisor tables: Loch and Bradley, 2000) also changes as the horse ages with the angle between the upper and lower incisors moving from approximately 170° in a young horse to a more acute angle as the horse ages (Figure 2.2) (Muylle, 1999).



(A) (B)

Fig. 2.2 The upper and lower incisors of a young horse (A) and an older horse (B) with the incisor profile becoming more acute as the horse ages.

(Adapted from Muylle, 1999)

The appearance of the occlusal surface also changes as the horse ages. The structure of a horse's tooth primarily consists of cement, enamel, dentine and pulp. An infundibulum (funnel-shaped structure) exists in each tooth and the centre of this structure, commonly referred to as a cup, is worn away at approximately 3mm per year (Figure 2.3) (Kreling, 2003). The infundibulum continues to wear over time and eventually disappears leaving a central enamel or spot (remnant of the infundibulum) in its place. This occurs progressively throughout the lower incisors, starting in the central incisors followed by the intermediate and corner incisors (Gray, 1993; Loch and Bradley, 2000). The cups in the central, intermediate and corner incisors are usually reduced to central enamels by approximately 9 years of age, while a horse with no enamel remnants may be in its high teens or above. If further abrasion occurs, the sensitive pulp of the tooth may become exposed causing significant amounts of pain (Kreling, 2003). To prevent this from happening, secondary dentine layers are produced to seal the pulp cavity from such exposure (Wilson, 2000) and these layers eventually form a dental star (Loch and Bradley, 2000). This dental star begins as a thin line, labial to the infundibulum, and then changes to a round spot located centrally as the occlusal surface is further worn (Figure 2.4) (Rouge, 2002). Once the dental star is present, it will remain until the tooth is lost (Gray, 1993).

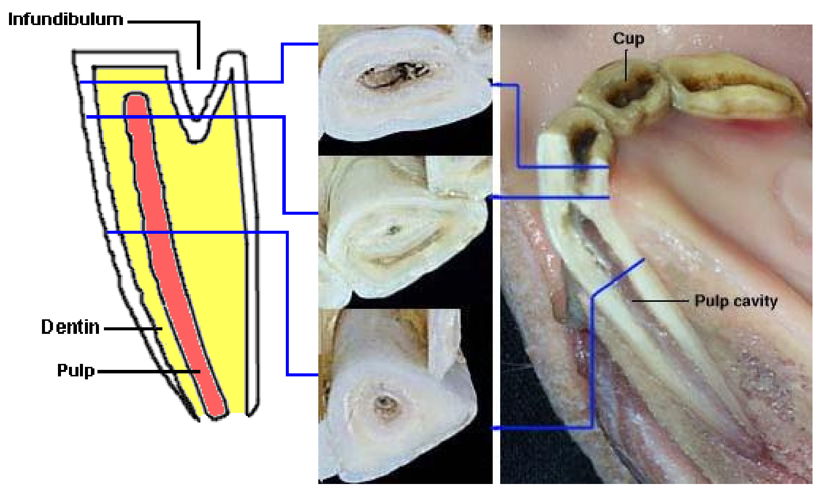


Fig. 2.3 **The structure of an incisor demonstrating the anatomical relationship between the tooth and cup. The image on the right of the figure shows an incisor cut longitudinally while in the jaw.**

(Source: Rogue, 2002)

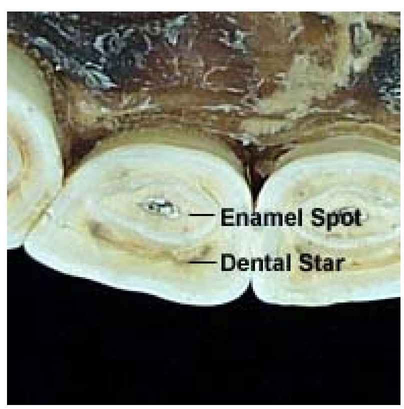


Fig. 2.4 **A dental star and central enamel (enamel spot) with the labial side at the bottom of the picture.**

(Source: Rogue, 2002)

The curvature of the dental arch may also be helpful in determining the age of a horse. In a young horse the lower incisors form a semi-circle while in an older horse it approximates a straight line (Myulle, 1999). In addition, the actual shape of the lower incisors may be of use when estimating the dental age of a horse. The teeth change from an oval shape in a young horse to round in a middle-aged horse and triangular (with the apex toward the lingual side) in an aged horse (Wilson, 2000). However, it has been noted that these changes are a guide only as it is difficult to judge the specific shapes objectively (Myulle, 1999).

Alterations in the timing of the wear patterns mentioned above can be caused by many factors including the composition of feed a horse receives. Hay and grass with high silicate contents will wear teeth down at a faster rate than softer food, however, chewing hay requires much less effort than chewing fresh grass so this will also show in the amount of wear (Loch and Bradley, 2000). Other factors which can influence the wear of the incisors include the angle of the occlusal surfaces in relation to each other, the makeup of the individual teeth, the shape of the teeth, the mechanics of the chewing process and the chewing force of the individual horse (Kreling, 2003). All of these factors can influence the accuracy of the dental age of a horse resulting in this type of aging becoming an "informed guess" (Richardson *et al.*, 1995) rather than an accurate assessment.

2.6.2 Wear

Unusual wear patterns of the teeth may also produce some valuable information regarding the condition and characteristics of a horse (Baker and Easely, 1999). Irregular wear of the incisors and missing teeth can have detrimental impact on both the temperament and chewing activity of the horse, thereby affecting its overall health (Wilson, 2000). Missing or broken teeth can give rise to abnormalities in the opposing set of teeth, with the result being an overgrowth, which can prevent proper mastication, and therefore proper digestion of the available food, leaving the horse in poor body condition (Wilson, 2000). Malocclusions (a misalignment between the upper and lower arcades when the jaw is closed which results in a faulty bite) are considered to be genetic conditions and have been cited as being an important part of a veterinary exam conducted on a horse presenting with weight loss and poor performance (Lowder, 2004; Carmelt, 2007). An undershot bite (sow or monkey mouth) and overshot bite (parrot mouth) are the two most common types of malocclusion (Wilson, 2000). Incorrect nutrition may also be an issue as it can cause insufficient wearing of the incisors which may eventually become extremely elongated and prevent the molars (cheek teeth) from touching, again inhibiting the correct mastication of food and reducing digestive efficiency. However, the majority of these issues can be rectified with proper dental care (Kreling, 2003).

Abnormal behaviours such as crib-biting (where a horse places its upper incisors against an object, pulls back and swallows quantities of air (Butler, 1985) and scraping may also have an impact on the effectiveness and efficiency of the teeth and therefore the health of the horse. These behaviours usually occur when a horse spends large amounts of time in a stable (McGreevy *et al.*, 1995) which is often the case with racehorses and other competition horses. The biting or scraping of objects with the teeth which is involved in this type of behaviour, can wear the incisors down to the sensitive pulp which, when exposed, can become infected (Kreling, 2003). The following discomfort caused by the infected tooth may severely affect the horse's ability to eat and hence its condition. Treatment has often been reported as being difficult and prolonged (Mason and Latham, 2004). Conditions such as crib-biting can generally be identified by severe wear on the upper incisors while scraping can cause the labial edges of both the upper and lower incisors to show wear (Wilson, 2000; Kreling, 2003).

Dentition can enable valuable information to be obtained regarding the approximate age of an animal, its background, previous condition and behaviours. However, dentition is not the only indicator which may allow an insight to the characteristics or conditions of slaughter horses. Other indicators which may enable us to gain information about a horse's previous history are outlined in the next section.

2.7 FOOT AND HOOF CONDITIONS

The state of a horse's foot can add important information regarding the general condition of an animal and may in fact give an indication of the reason a horse was relinquished to an abattoir. As noted by Jeffcott (1990) and Lindner and Dingerkus (1993) the most significant factor affecting wastage in younger racehorses is lameness, indicating that abnormalities which may contribute to or cause lameness could be a reason for relinquishment. Abnormalities in the shape of the hoof may increase the incidence of foot problems and contribute to limb problems and lameness (Moyer, 1999) and it has been noted that the most common cause of lameness in horses involves issues with the foot (Turner and Stork, 1988). Hill and Klimesh (2000) argue that owner neglect can be responsible for issues such as hoof wall breakage, imbalance in the hooves causing lameness and infections which may go unnoticed and become severe. Although the authors note that some common problems, such as poor hoof quality and hoof shape, may have numerous causes (e.g. genetics, poor nutrition and metabolism, disease, specific drugs and trauma) many issues can be managed, if not corrected, with adequate owner, veterinary and farriery attention. Moyer and Anderson (1975), Balch *et al.* (1995) and Stashak *et al.* (2002) support Hill and Klimesh's (2000) view by noting that incorrect care and incorrect preparation and trimming and shoeing of the hoof are key factors in the development of equine lameness. This has been demonstrated by studies such as that by Kobluk *et al.* (1989) who investigated the care and trimming practices of 95 Thoroughbred racehorses and reported that the utilisation of appropriate trimming and shoeing methods could reduce musculoskeletal injuries and enhance performance. Inappropriate trimming and shoeing practices can also alter the loading patterns of the limb which then alters both the medial/lateral strain on the skeletal system and the strain on the tendons and ligaments of the limb (Turner and Stork, 1988). The foot also plays an integral role in the absorption of concussion and both conformational defects and inappropriate shoeing practices can alter the effectiveness of this mechanism which may, again, add to the likelihood of lameness (Turner and Stork, 1988).

Regardless of the breed or use of a horse, forelimb lameness is reported to be more common than lameness in the hindlimbs due to the centre of gravity being located closer to the forelimbs than the hindlimbs (Ross, 2003). The forelimb to hindlimb weight distribution is 60%:40% (70%:30% when a rider is added) and as higher loads are forced on the forelimbs (30% each) it is these limbs that are predisposed to an increased risk of injury (Ross, 2003). The structure of the hoof and forelimb enables it to fulfil its function and is therefore an important aspect in understanding both normalities and abnormalities of the foot.

2.7.1 Structure of the foot

2.7.1.1 External hoof structure

The external structure of a horse's hoof is comprised of the periople, coronary band, hoof wall, sole and frog (Dyce *et al*., 2002). The periople is a band of soft horn which covers the juncture between the skin and hoof wall and functions to limit moisture evaporation from the horn (Deveraux, 2006) and the coronary band is positioned below the periople, runs from one heel to the other and produces horn tubules which allow hoof growth (Gray, 1994). This band produces approximately 70% of the hoof growth (Hill and Klimesh, 2000). The wall (portion of the hoof visible when the horse is standing) is produced by epithelial keratinisation and covers a modified dermis, commonly known as the corium (Dyce *et al.,* 2002). The corium lines the entire hoof and supplies blood to the internal structures (Loch, 1998) and is divided into sub layers according to the underlying structure, such as the coronary corium and sole corium (Hill and Klimesh, 2000). The wall itself does not contain blood vessels or nerves (lacks sensitivity) and is produced continuously and therefore must be worn off or trimmed (Deveraux, 2006). The hoof is arbitrarily divided into the toe (front of the hoof), quarters (sides of the hoof) and heel (Riegel and Hakola, 1996) (Figure 2.5). The hoof wall is the thickest at the toe, as this is the region of greatest friction, and becomes thinner (Pollitt, 1986) and more flexible toward the heels where it expands when weight is placed upon it, therefore aiding the weight bearing mechanism of the foot (McClure *et al*., 1993). At the toe, the angle of the wall is generally reported to be 'ideal' if it is between 48 - 55° (Clayton, 1987; Parks, 2003a) although this figure is greater for hindfeet (Pollitt, 1986). At the heels the wall turns inwards to form the bars of the foot viewed when the underside of the hoof is exposed (Figure 2.5). Like the walls, the bars have a weight bearing function (Gray, 1994).

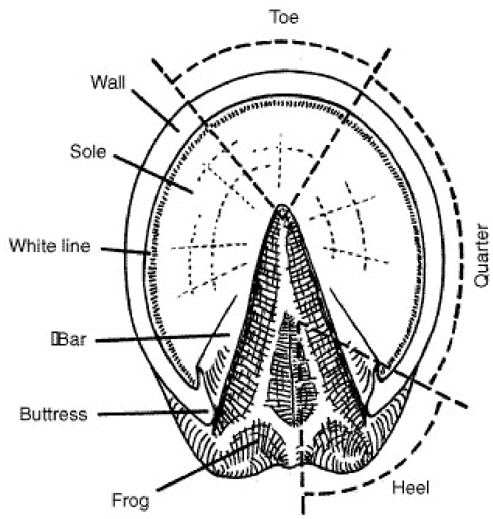


Fig. 2.5 Diagram illustrating the sections (heel, quarter, toe) and underside of the hoof.

(Source: Loch, 1999)

The majority of weight is taken by the wall at the heels and the toe/quarter junction on either side of the hoof (Devereux, 2006). As the wall bears most of the horse's weight is it also the portion of the hoof subject to the most wear and trauma (Butler, 1985). The sole and the frog make up the underside of the hoof. The sole is slightly concave ensuring only the outer edges make contact with the ground and the thickness and concavity of the sole can vary between individual horses making some more prone to puncture wounds and bruising than others (Gray, 1994). The white line (zona lamellatum) is the junction of the hoof wall and the sole and generally appears yellow in colour (Dunivant, 2000). The frog is a spongy, flexible, V-shaped pad and is positioned between the heels of the hoof (Hill and Klimesh, 2000). Its function is to aid in the absorption of shock and the circulation of blood throughout the foot (McClure *et al.*, 2003) although its specific role in weight bearing is considered to be uncertain (Parks, 2003b).

2.7.1.2 Internal foot structure

While the hoof commonly refers to the visible external features, the foot comprises both the hoof and the internal structures such as the bones and tendons (Figure 2.6) (Hill and Klimesh, 2000). As previously mentioned, the hoof wall is not sensitive itself and the internal surface of the wall (the white line) has many “finger-like” (King and Mansmann, 2005) projections or laminae (Gray, 1994). The corium (also referred to as the laminar corium in this portion of the hoof) situated dorsally to the navicular bone, also has laminae, however, as these are supplied with blood and nerves from the corium they are sensitive (King and Mansmann, 2005). The two types of laminae (sensitive and insensitive) interlock tightly (Figure 2.7) and this bond holds the third phalanx in place and allows the wall to grow distally from the coronary band at a rate of 6 - 10mm per month while remaining attached to the third phalanx (Devereux, 2006). The third phalanx (also known as the distal phalanx, coffin bone, pedal bone, P-3 and PIII) is the terminal bone of the horse’s limb and resembles the hoof in shape but is significantly smaller (Gray, 1994). The deep flexor tendon attaches to the third phalanx at the palmar surface of this bone (McClure *et al.*, 1993). Articulating with both the second phalanx (short pastern bone) and third phalanx is the navicular bone, also referred to as the distal sesamoid or shuttle bone, and this bone aids in the anticoncussive mechanisms of the foot (Johnson and Asquith, 2003). Between the navicular bone and the deep flexor tendon is the navicular bursa which is a sac functioning to protect the navicular bone (King and Mansmann, 2005). Distally to the deep flexor tendon lies the digital cushion, or plantar cushion, which extends rearwards and in doing so supports the bulbs of the heel (Gray, 1994) and reduces shock to the foot (Johnson and Asquith, 2003).

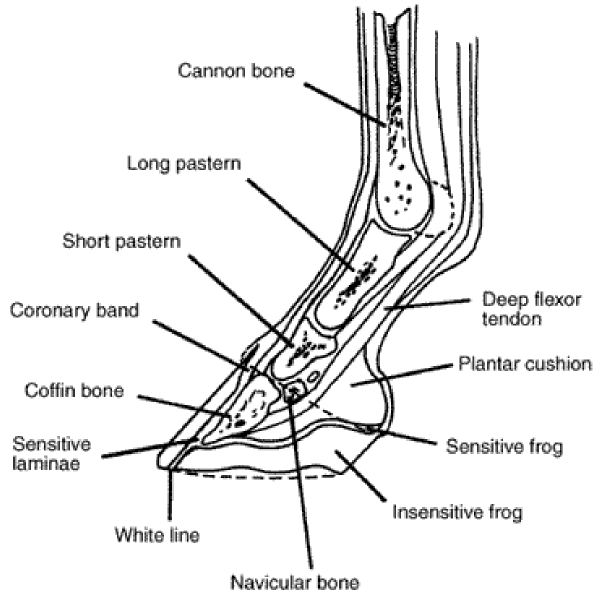
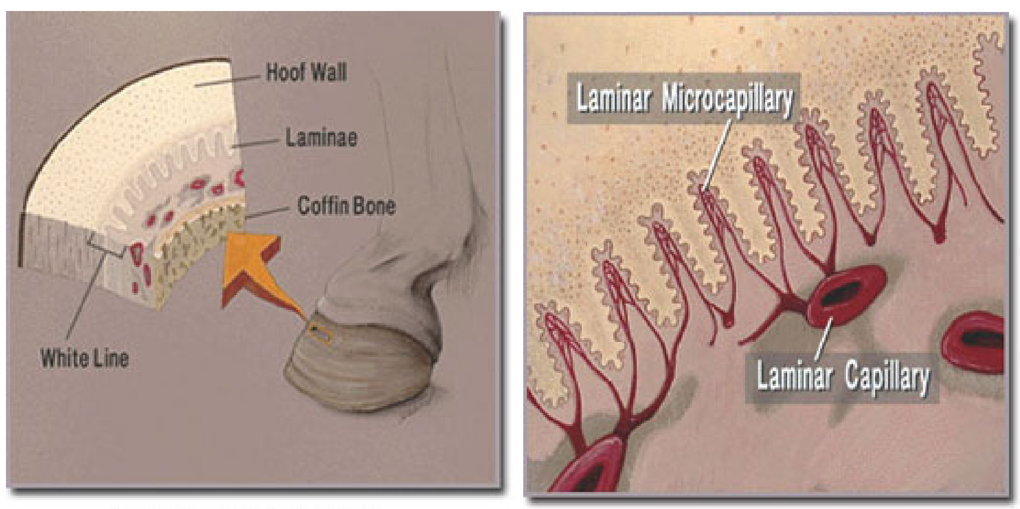


Fig. 2.6 The internal structures of the horse foot.

(Source: Loch, 1999)



Arrangement of laminae of hoof.

Enlargement of laminar microcirculatory blood flow.

(A) (B)

Fig. 2.7 Figure (A) demonstrates the placement of the internal structures of the hoof which form the hoof wall-coffin bone bond and figure (B) shows the interlocking between the insensitive laminae (top left) and blood-rich sensitive laminae (bottom right).

(Source: Adair, 2006)

Understanding the structure and function of the basic components of the horse foot (as described above) was seen to be of paramount importance before investigating the more common foot abnormalities found in horses. These disorders are listed below, along with the signs and symptoms of each abnormality. Where appropriate the applicability of the abnormalities to this study has also been reviewed.

2.7.2 Common foot abnormalities

2.7.2.1 Low or high hoof wall angles

The angle of the hoof wall has traditionally been thought to be of significance and, as previously mentioned, an ideal angle for the dorsal aspect of the fore foot is cited as being between 48° and 55° (Balch *et al.*, 1991; Parks, 2003b). However, as argued by O'Grady (2003a) this does not take into account the individual conformation of the horse. Ideal angles of the hoof are believed to be present if a line drawn along the dorsal surface of the hoof wall is parallel to lines drawn along the surface of the heel and the pastern (Clayton, 1987; Parks, 2003b) so that the 'normal' hoof angle for an individual will depend on its pastern slope. If the hoof/pastern angle is too high it is said to be a broken-forward pastern axis and can cause unnecessary stress on the heel of the hoof while a hoof/pastern angle which is too low (broken-back pastern axis) can cause strain on the digital flexor tendon and third phalanx joint (O'Grady, 2003b). Wright and Douglas (1993) have reported that approximately 73% of a sample group of horses diagnosed with forelimb lameness also had a broken-back pastern axis. To accurately measure the hoof/pastern axis it is necessary for the horse to stand squarely on all feet on a solid level surface (O'Grady, 2003b). Unfortunately, this investigation only has access to the hooves post-mortem so the hoof/pastern axis cannot be measured. However, the dorsal angle of the hoof wall can be measured as can the heel angle and this information may be able to provide further insights into the hoof and foot condition. Kobluk *et al.* (1989) reported that Thoroughbred racehorses with lower hoof angles had significantly more musculoskeletal problems which prevented the horse from racing and training when compared with uninjured horses and that horses with 10 or more wins had higher forehoof angles than those with less than 10 wins. This indicates that a lower hoof angle may predispose the animal to greater injuries and lower their chance of success. Similar conclusions have been made by other investigators. Thompson *et al.* (1993) reported that an increase in the toe angle decreased the strain and possible tearing of the deep digital flexor tendon. Kane *et al.* (1998) found that the odds of a cannon bone fracture were 0.26 times lower when the toe angle was increased by only 3°. While a horse can have a genetic predisposition to a low hoof angle or a long toe this issue can be exacerbated by infrequent or incorrect trimming, limited exercise and little access to hard surfaces which may aid in wearing down the hoof wall and reducing the toe angle (Moyer, 1999).

2.7.2.2 Long toe-low heel (LT-LH)

A long toe formation in a horse is often accompanied by a low or underrun heel. The toe lengthens and grows forward and the heel growth follows the direction of the toe growth (O'Grady, 2003c) As the heel grows forward it becomes parallel to the ground at which point it no longer supports weight and rolls under the foot with accompanying heel pain and soreness in the frog (Ovnieck *et al.*, 2003). It can be identified by measuring the difference in angles between the hoof wall (at the toe) and the heel. A difference of greater than 5° indicates the condition is present (Turner and Stork, 1988). Another indicator can be the heels of the foot which may end a considerable distance before the back of the frog and both the bars and heel buttresses curve in a significantly greater arc when compared to a foot without this condition (Ovnieck *et al.*, 2003). The long toe-low heel (LT-LH) configuration is an issue prevalent in Thoroughbreds although it has been reported as being present in all breeds and types of horses (Moyer, 1999), particularly in those horses with long pastern conformation or those that have not had access to hard surfaces to wear the hooves naturally (Ovnieck, 2003). Even though it is not actually a type of lameness it can cause and contribute to other foot and limb problems such as heel bruising, navicular syndrome, hoof cracks, toe wall separation, deep digital flexor tendon tension and interference injuries (Moyer and Anderson, 1975; Moyer, 1999; O'Grady, 2003b). Kane *et al.* (1998) also found that the odds of suspensory apparatus failure occurring were 6.75 times greater with a 10° increase in the toe-heel angle difference. Importantly, Ovnieck (2003) notes that in the majority of cases the LT-LH condition responds well to specific trimming techniques and regular trimming.

2.7.2.3 Hoof wall defects

Hoof wall defects include cracks, flaring and hoof loss as well as wall stretching and separation and can be caused by genetics and the natural hoof structure, the environment (trimming and shoeing practices, stable management and ground conditions), injury and by specific activities (Moyer, 2003). Poor hoof wall quality may add to the incidence and severity of hoof wall defects and has many causes such as the trimming and shoeing techniques used, the hoof conformation and the weather and can generally be managed rather than corrected (Dabareiner *et al*., 2003). Poor hoof wall quality is often indicated by the occurrence of many partial thickness vertical cracks in the hoof wall (King and Mansmann, 2005). Uneven growth rings may also indicate that a horse has been exposed to a sudden change in environmental conditions or has experienced an episode of illness (Dabareiner *et al*., 2003)

Cracks in the hoof are generally categorised by their location (toe, quarters, heel), depth (superficial, which penetrates only the outer insensitive horn, or deep, which penetrates into the sensitive tissues), length (partial hoof length of full hoof length) and the presence or absence of infection (Curtis, 1999; Moyer, 2003). The site of origin and orientation is also noted with grass cracks being vertical cracks which begin at the distal border, sand cracks also being vertical cracks but originating at the coronary band and horizontal cracks extending horizontally around the hoof wall and are usually caused by an injury to the coronary band or trauma to the hoof wall (Devereux, 2006). Most cracks do not cause lameness although the damage to the underlying wall structure is often found to be more extensive than it appears from the exterior surface (Moyer, 2003). Central toe cracks are often found to be associated with wall separation while heel and quarter cracks are commonly seen in conjunction with long toes and low heels (Moyer, 2003). Hoof cracks can also be caused by owner neglect, foot imbalance, dry or wet hoof walls and excessive hoof growth (Pascoe, 1986; Dabareiner *et al*., 2003).

Flaring, dishing, chipping and breakage of the hoof are all commonly seen in horses that are unshod and are subjected to prolonged shoeing intervals (King and Mansmann, 2005). Flaring is indicated by a hoof wall which shows normal growth from the coronary band but begins to flare out approximately two-thirds of the way down the hoof wall at the quarters (Moyer, 1999) while dishing is flaring occurring at the toe (Hill and Klimesh, 2000). In hooves that flare, chipping (portions of the hoof wall flaking or chipping off) and breakage (portions of the hoof wall breaking off and exposing the underlying structures) can occur (Devereux, 2006). If the broken portion of the hoof does not detach from the hoof wall it can bend at an awkward angle and put pressure on the sensitive structures of the hoof wall during locomotor activities and this may cause lameness (King and Mansmann, 2005). Infection can occur under the damaged wall which may also lead to lameness as can the imbalance caused by portions of a hoof breaking off (Stashak *et al*., 2002).

As the hoof grows in length the mechanical forces which occur during locomotion cause the hoof to be stretched, or widened, at the toe as this is the point of breakover – the last portion of the foot which contacts the ground as the horse locates forward and in any horse which displays this stretching, white line separation and hoof cracks are likely (King and Mansmann, 2005). White line separation or disease (also termed seedy toe) is generally used to describe the separation of the hoof wall and the laminar attachments which occurs at the white line (or junction between the laminae of the hoof wall and sole of the foot) (Dabareiner *et al.,* 2003). Once an opening in the white line appears bacteria or fungi from soil and manure are forced into the interlaminar gap causing cavities between the laminae and hoof wall (DeBowes and Yovich, 1989). Stretching (or thickening) of the white line in the toe region, chronic laminitis, hoof walls which frequently flare and crack and wet or dry hooves may all be factors which predispose a horse to white line separation (Dabareiner *et al*., 2003). The cavities within the hoof wall can often be found between the heel and the quarter and can extend deep into the hoof wall causing pain and lameness (Stashak *et al*., 2002).

2.7.2.4 Sheared heels

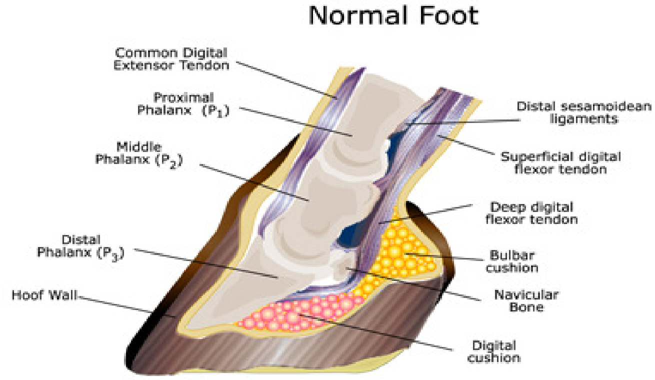
Sheared heels occur due to an imbalance between the medial and lateral bulbs of the heel (Dabareiner *et al.*, 2003) and are generally caused through uneven wear from conformational faults (which create a mediolateral imbalance) or incorrect trimming (Pavord and Pavord; 2002; Deveraux, 2006). Incorrect shoe placement has also been found to cause mediolateral imbalance (Parks, 2003a). This imbalance places uneven strain on the hoof structure and the extra weight which is borne by one side of the hoof can displace the hoof wall upwards, effectively shearing the heels between the bulbs (Hill and Klimesh, 2000). This condition can be identified by a difference of greater than 50mm between the medial and lateral distance of the heel when measured from the heel coronary band to the ground (Turner, 1986a). Sheared heels may be present in one or more hooves of the horse and can be the cause of mild to moderate lameness (Dabareiner *et al.*, 2003) and is generally associated heel soreness or severe infection (Deveraux, 2006).

2.7.2.5 Contracted heels

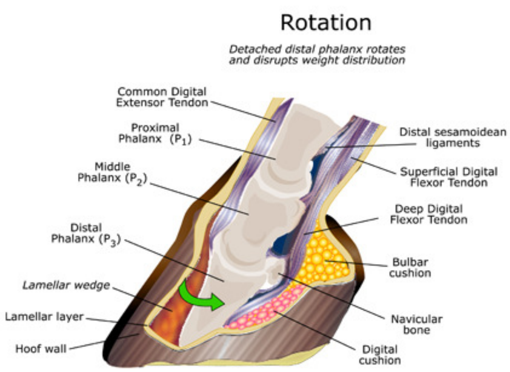
Contracted heels are a narrowing of the heel where the frog width is less than two-thirds (67%) its length and this condition can be present in one or both forefeet (Turner and Stork, 1988) and it is more common in the forefeet than the hind feet (Pascoe, 1986). In comparison, the width of a 'normal' frog is considered to be approximately 50% - 66% of its length (Parkes, 2003b). Contracted heels cause the affected feet to be significantly smaller than they would otherwise be and as the hoof grows more at the heel the appearance of the affected hoof wall is referred to as being steep and boxy (Gray, 1994). Heels have been found to contract due to a lack of frog pressure which can be caused by a genetic predisposition for taller, narrow feet, faulty shoeing, allowing the heel wall to become too long, chronic heel pain preventing the affected limb from bearing weight or lack of exercise (Gray, 1994; King and Mansmann, 2005). If contracted heels are associated with navicular syndrome (see below) they are generally referred to as a symptom rather than as the condition itself (Butler, 1985). King and Mansmann (2005) also note that horses with contracted heels are more likely to be lame than those with other foot abnormalities such as long toe-low heel.

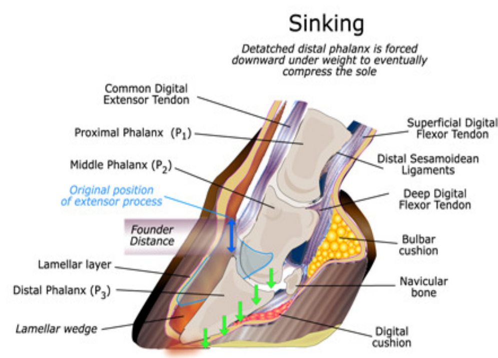
2.7.2.6 Laminitis

Laminitis is a disease which affects the internal structures of the horse's foot (Devereux, 2006) and has been described as one of the most common causes of lameness and disability in both horses and ponies (Eustace, 1992). Laminitis usually occurs in both front feet and may or may not occur in the hind feet (Dyson, 2003). Although an oversimplification of the process, laminitis can be described as the breakdown of the suspensory mechanism of the third phalanx involving the interlocking laminae between the third phalanx and the hoof wall (Pollitt, 2001; Ramey and Pollitt, 2003). If severe enough the breakdown of the laminar attachments combined with the downward weight of the horse, added to the upward pull of the digital flexor tendon, will allow the third phalanx to rotate and, in more chronic cases, sink into the hoof capsule where arteries and veins can be crushed and the solar corium can be damaged (Figure 2.8) (Pollitt, 2001). Unrelenting pain results and if the damage to the laminae is extensive in nature the affected horse may be euthanasied (Stashak and Hill, 2002). Laminitis is frequently found to be a secondary disease (Dyson, 2003). Horses suffering from conditions such as grain overload and inflammatory conditions of the intestinal tract, retained placenta, sepsis, colic, pleuropneumonia and those being administered corticosteroids have been reported to be at greater risk of developing laminitis as a secondary disease (Garner *et al*., 1978; Sprouse *et al*., 1987; Hunt, 1993; Pollitt, 2001, 2003). The developmental phase, where the horse experiences some type of system failure, as mentioned above, and the acute phase, where the first signs of foot pain occur, (Pollitt, 2001) are usually able to be recognised in a live horse. However, when viewing a horse's foot, post-mortem and without dissection, it appears that only indicators of the chronic phase can be recorded. Signs which may indicate the presence of laminitis in the chronic stage can include a 'dropped sole' or a sole which appears convex instead of concave in shape, prolapse of the sole caused by the descending third phalanx pushing through the horny sole, a semi-circular mark or bruise of the sole of the foot which may indicate imminent prolapse, a depression of the coronary band caused by the bone and attachments descending into the hoof capsule and deformed hoof growth where the hoof wall at the heel grows faster than at the toe causing growth rings of the hoof to be unparallel (Figure 2.9) and if left can form into the 'Aladdin slipper' shape (Eustace, 1992; Pollitt, 1995, 2001). The white line at the toe may also become stretched and/or separated at the toe and an infection may be present (Pollitt, 1995).



(A)





(B) **(C)**

Fig. 2.8 The placement of the third phalanx (distal phalanx) in a normal foot (A) compared to a foot displaying rotation (B) and sinking (C) caused by laminitis.

(Source: Orsini, 2006)

Fig. 2.9 Changes in the hoof wall appearance due to laminitis.

The arrow indicates the beginning of the laminitis episode. Growth rings are parallel prior (distal) to the onset of laminitis but are more widely spaced at the heel and converge at the toe following laminitis.

(Source: Pollitt, 1995)

2.7.2.7 Navicular syndrome

Navicular syndrome is believed to be a common cause of chronic forelimb lameness in horses (Turner, 1986a) and is a degeneration and deterioration of the navicular bone (Ramey, 2002). Its causes are much debated (Stashak, 2002) although it is generally believed to be either a vascular or biomechanical issue in the navicular region (Leach, 1993) and is caused by repeated trauma to the navicular bone, the surrounding ligaments, navicular bursa and deep flexor tendon (Devereux, 2006). It is thought that specific types of conformation (mediolateral imbalance, the shape of the navicular bone, narrow feet and small feet for the weight/size ratio of the horse) may increase the risk of the disease occurring (Devereux, 2006). The syndrome itself is not easily correctly diagnosed (Ramey, 2002) and various abnormalities have been found to be connected to the syndrome. These include low heels and the LT-LH condition, contraction in the affected foot and an overall smaller and more upright appearance of the foot (Stashak, 2002). Navicular syndrome may be unilateral or bilateral and the average age of onset is between 7 and 9 years (Devereux, 2006). Specific breeds of horses have been found to be more likely to suffer from navicular syndrome than others and these include Thoroughbreds, Quarter Horses and other warm blood breeds (Ramey, 2002). Specific shoeing principles (Turner, 1988) can be utilised with some success to manage the syndrome. Turner (1986b) reported that of

48 horses diagnosed with the syndrome, 36 were successfully managed with shoeing techniques and the greatest success occurred if the treatment was initiated within 10 months of the onset of the syndrome. Although difficult to diagnose in a horse hoof post-mortem it is mentioned here for the sake of completeness as it is an important cause of lameness in horses.

2.7.2.8 Common injuries

Interference injuries

Any horse which exhibits an abnormal movement, has imperfect conformation or simply travels in a specific gait at speed may suffer from an interference injury however, this type of injury is most commonly seen in trotters and pacers and has been found to be a cause of poor performance and unsoundness (Ross, 2003). An interference injury can be defined as an injury caused on one limb by another and commonly occurs from the knee to the hoof on the forefeet and the fetlock of the hind feet (Stashak and Hill, 2002). There are various forms of contact which occur between the limbs including overreaching (the toe of the hind foot cuts the heel of the forefoot) (Pollitt, 1995), scalping (the toe of the forefoot hits the hind foot at or below the coronary band), speeding cutting (wounds on the hind legs caused by the forefeet) and shin and hock hitting (Stashak and Hill, 2002). Interference injuries can begin as a swelling of the affected area and if not protected from further injury (via protective boots or specialised shoeing: Pollitt, 1995) can escalate to include bruises, cuts, and underlying bone damage (Ross, 2003).

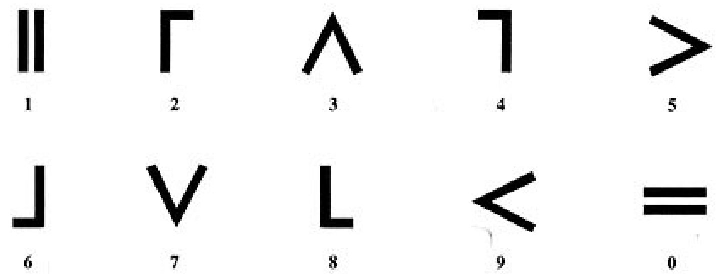
Coronary band injuries

Injuries to the coronet can have lasting effects. If a portion of the coronary band is severely damaged, the result may be chronic scarring and abnormal hoof wall growth and horses with this type of deformity are frequently found to be lame (Pollitt, 1995). However, if the coronet can recover from the injury successfully it may return to generating hoof of normal, or near normal, quality although the hoof below the injury may become compromised and crack (Pollitt, 1995) and this can result in a weakened wall section (King and Massman, 2005). Coronary band injuries can be caused by a variety of factors including accidental contact from the horse's own feet or another horse during contact sports, foreign objects piercing the coronet and lacerations caused by fences and a variety of other materials (Pollitt, 1995).

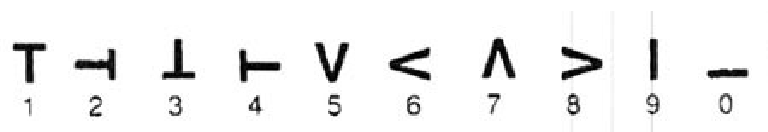
2.8 BRAND TYPE

As part of the process of registering a horse for the racing industry freeze branding is required. Once this occurs, the horse carries an identifiable brand for the remainder of its life. Both Thoroughbreds and Standardbreds are freeze branded which involves the process of applying an extremely cold brand to the skin thereby rendering the new hair that grows in that location white which enables ease of reading (HRA, 2002). Thoroughbred horses are required to have two brands. The first identifies the stud or station where the horse was bred (comprised of letters and symbols) and the other identifies the sequence in which the horse was born, such as 27 over 3 or the 27^{th} foal branded in its birth year (1983, 1993 or 2003) (ASB, 2007). In accordance with each state's Department of Agriculture requirements Australian states and the Australian Capital Territory place the stud or station brand on the near-side shoulder of the horse and the sequence number on the off-side shoulder. In comparison, the Northern Territory and Queensland have the option of placing both brands on the near-side shoulder (ASB, 2007).

Standardbred horses have a slightly more complex branding system, the alpha angle system (Figure 2.10), and this comprises of two lines with four symbols in each line. This system is utilised, instead of normal numbers, so that the brand once applied, cannot be modified in any way. The brand is placed on the off-side of the horse's neck (HRA, 2002). The first symbol is the letter 'S' indicating that the horse is a Standardbred. This is followed by the symbol for the Australian state the horse was born in and the year of birth. The second line comprises the horse's individual registration number. New Zealand freeze brands for Standardbred horses are also comprised of a two line brand with the first having three symbols (the last being a 'Z' to denote the country) and the second line having a four symbol number (HRA, 2007), However, New Zealand utilises a T.V.I (Figure 2.10) system as opposed to the alpha angle system.



The alpha angle symbol used to brand and identify Australian Standardbred horses



The T.V.I system used to brand and identify New Zealand Standardbred horses

Fig. 2.10 The symbols systems used to brand Standardbred horses in both Australia and New Zealand.

(Reprinted with permission of Harness Racing Australia Inc., 2002)

While Standardbred brands are easily identifiable due to the alpha symbol which is utilised, Thoroughbred brands can look similar to brands used on a variety of other horses. The requirements and make up of these more generic brands varies from state to state. South Australian brands are generally composed of one letter and two numbers in any order and may have numerals placed beneath the brand (Primary Industries and Resources, 2007). In comparison, the Northern Territory utilises a three-letter system and stipulates that one letter must be a ‘T’ (Department of Primary Industries, Fisheries and Mines, 2006). Different yet again is the Queensland brand which is a three-piece mark and may or may not be used in conjunction with a symbol brand (Ume, 2007). The locations for the placement of brands also varies with state and can include placing the brand on the horse's quarter, shoulder, thigh, neck, saddle or rib area.

CHAPTER THREE

MATERIALS AND METHODS

3.1 INTRODUCTION

The aim of this investigation was to collect and analysis data regarding the age, brand and conditions, specifically dentition and foot conditions, of horses relinquished to an export abattoir and in doing so provide information regarding the profile of Australian slaughter horses.

3.2 INVESTIGATIVE PROCEDURE

In accordance with University of Queensland requirements the Animal Ethics Committee were informed of the details of the research which would involve the observation of post-mortem horses.

3.2.1 Site and sample

The survey was conducted at an Australian Abattoir. Approximately 180 horses, which are destined for the international human consumption market, are processed every Friday. However, due to the restrictions on the transportation of horses within Australia in response to the outbreak of EI the numbers of horses available for processing during the time period when this research was undertaken had decreased. The number of horses processed weekly varied between 80 and 140 over the period the survey was conducted. We were unable to obtain official data from the Manager regarding the origin of the horses although we were informed that the horses can be transported from anywhere in Australia and that they generally originate from Queensland and New South Wales

3.2.2 Collection

Collection of the data occurred over three months in the summer of 2007/2008. The actual collection dates were as follows: 23 November 2007 (Sample 1), 7 December 2007 (Sample 2) and 18 January 2008 (Sample 3). Two investigators travelled to the abattoir on these dates to record and collect the data. Data collection occurred inside the plant during processing as indicated in Figure 3.1. As the horses entered the plant they were allocated an identification number or head/body number which remained with the carcass as it moved along the processing line. Once the horses were removed from the kill box and inverted on a conveyor belt the front feet were removed, generally dorsal to the fetlock (Figure 3.2 A). At this point, both front feet were collected and tagged with the head/body number for later inspection (Figure 3.2 B). The feet were then placed into large body bags and moved out of the plant to await transportation back to the University. While the feet were being removed, the horse was briefly examined for signs of a brand and this was recorded alongside the head/body number.

Further down the processing line the skin was removed from the carcass followed by the head. Heads were then collected and cleaned (by abattoir staff) and brain tissue was sampled by an AQIS officer. At this point the dentition was examined for age and any signs of malocclusions, missing teeth or wear (Figure 3.2 C). This information was also recorded alongside the head/body number allowing the feet, age, teeth and brands to be identified as belonging to a specific animal at a later date. Once processing was complete, the feet were transported back to the University of Queensland, Gatton campus, where they were stored in a cool room overnight. Measurement and assessment of the feet occurred on the two following days. Upon completion of the assessment, the feet were transported to the University's Pinjarra Hills farm where they were processed in accordance with the legal regulations for the disposal of biohazards.

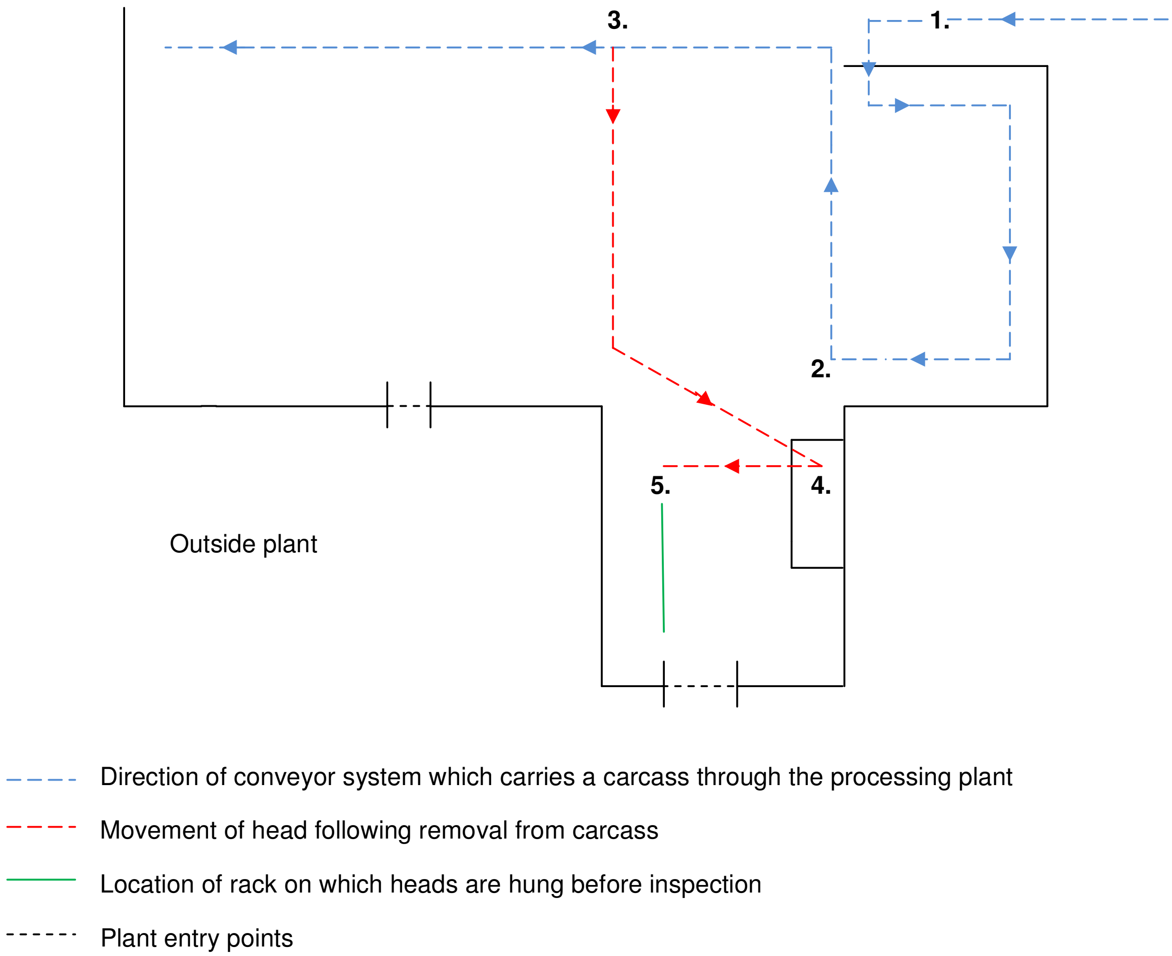


Fig. 3.1 Diagram showing the direction of a carcass through the processing plant and locations of collection and inspection.

The horses entered the plant from the holding yards and moved into the kill box (1). After stunning, they were attached to the conveyor system and bled out. This was followed by removal of the front feet (2). At this point the carcass was inspected for signs of branding. Processing continued and at (3) the skins and heads were removed. The carcass continued down the processing line while the heads were carried to the wash bays (red broken line) (4) and following cleaning were hung (5) and inspected before disposal. Researcher 1 was positioned at point 5 inspecting teeth and assessing brand type while researcher 2 moved between the plant entry and point 2, collecting, tagging and removing feet from the plant.

(A) (B)

(C)

Fig. 3.2 Data collection images.

Image (A) shows the location of both the foot removal and the inspection of the carcass for brands. Image (B) shows an investigator attaching the tags to the feet and image (C) shows the heads awaiting a dentition inspection.

3.2.3 Measurement

The observations, measurements and recording of the data occurred in two stages. The first set of data collection occurred at the processing plant and involved aging the teeth and placing each horse into a dental age category of ≤ 7, >7 -15 and 15+ (see Appendix 2) and checking the dentition for the presence or absence of teeth which exhibited malocclusions, unusual wear (such as crib-biting) and missing teeth. The exact location of the teeth involved was recorded using the modified Triadan system (see Appendix 3) which allocates each tooth within the mouth a specific three-digit number so that the quadrant and position in the mouth (rostral to caudal) could be easily and consistently identified (Floyd, 1991).

The other information which was recorded at the plant was the presence or absence of brands on the carcasses. A Thoroughbred marking was defined as a two-part brand comprising of a station brand or symbol and an age numeral brand with the marks placed upon one or both shoulders. Assessing the appearance of the horse for characteristics typical of Thoroughbred horses (between 15-17 hands, weighing approximately 450-600kg, relatively small head with a straight profile, long neck, back and legs, smallish hooves and fine coats of bay, black, chestnut or gray: Dutson, 2005) was found to be necessary to avoid confusion between Thoroughbred brands and 'other' types of brands. A Standardbred brand was defined as a marking placed upon the off-side neck of the horse, and comprised of either the alpha angle or T.V.I symbols and an 'other' brand was any other type of brand which did not fit a Standardbred or Thoroughbred brand definition. If no markings were visible on the animal, it was classed as having 'no brand'. As previously mentioned, the age, dentition and brand information was recorded along with each horse's head/body number so that all the data could be related back to an individual animal.

The second set of data was collected at the University of Queensland's Gatton campus and involved measurements and observations of the feet following their transportation to the University from the abattoir processing plant. Within 60 hours of the horse's time of death each front hoof was washed and measured. Hoof wall measurements obtained included the sagital toe length (distance from the hairline to the toe on the dorsal aspect of the hoof), hoof width (distance from the medial side of the hoof to the lateral side at the widest point), toe angle, (angle between the lines which best approximates the dorsal slope of the hoof and a line along ground surface measured with a toe protractor) and the heel angle (an angle between a line from the most palmar portion of the bulb of the heel to the heel at the ground surface of the hoof wall and a line along the ground surface (Figure 3.3–3.5). These measurements were used to ascertain the presence or absence of the following abnormalities: long toe-low heel (where the angle of the heel is 5° or more, less than the angle of the toe), contracted heels (where the width of the frog is less than 67% of the frog length) and sheared heels (defined as being a difference of at least 5mm between the medial and lateral heel lengths when measured from the coronary band to the ground: Turner, 1986a). After the hoof wall measurements were obtained the hoof walls and feet were examined for the presence or absence of the following: shoes, flaring at the quarter, dishing at the toe, vertical cracks, sand, grass and horizontal cracks (location, length and depth was measured), chips, breaks (location and length was measured), uneven growth rings, coronary band injuries (location and approximation of the timing of the injury was noted), wall stretching and separation (location was noted), as well as any signs of laminitis, navicular syndrome or other inflammation or injury (location and an approximation of the timing of the injury was noted) (for summary and examples see Table 3.1 and Figure 3.6).

Fig. 3.3 **Measurements obtained from the hoof wall: toe angle (TA), heel angle (HA) and toe length (yellow arrow).**

Fig. 3.4 **Measuring the hoof width.**

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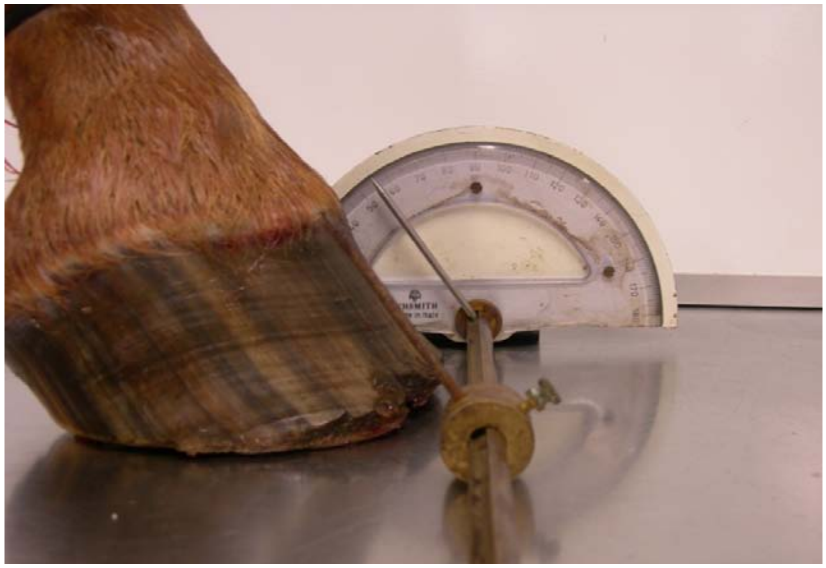
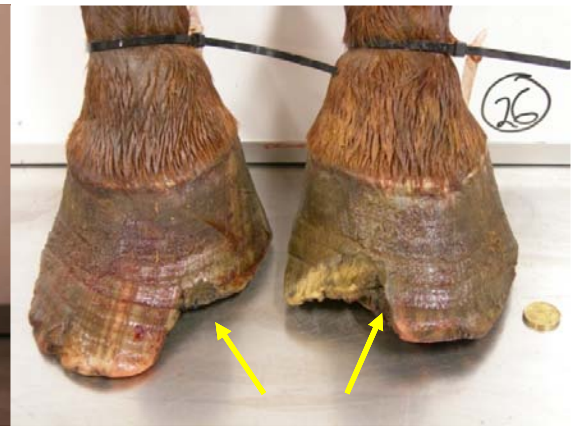


Fig. 3.5 Illustration showing the toe angle being measured with a toe angle protractor.

Table 3.1 Summary of foot variables assessed during data collection

Foot variables assessed and definition of abnormal conditions		
Hoof variables	Presence definition (where appropriate)	Extra information recorded
Hoof width (mm)		
Hoof length (mm)		
Toe angle (°)		
Heel angle (°)		
Presence of Long toe-Low heel	a difference of 5° or more between the toe angle and the heel angle	
Presence of shoes		
Presence of flaring at quarter	straight hoof wall with a notable flaring towards the lower third of the wall	
Presence of dishing at toe	toe shoes convex shape when compared to level instrument (Fig. 2.6)	
Presence of vertical cracks	partial thickness vertical cracks in entire hoof wall (Fig. 2.6)	
Presence of sand cracks	vertical crack originating at the coronary band	length (partial, full), location (toe, quarter, heel), depth (superficial, deep)
Presence of grass cracks	vertical crack originating at the ground surface	as for sand cracks
Presence of horizontal cracks	horizontal crack in the hoof wall	as for sand cracks
Presence of chips	portions of the outer hoof wall missing - no underlying structure exposed	
Presence of breakage	portions of the hoof wall breaking and exposing the underling structure	length (mm), location (toe, quarter, heel)
Presence of uneven growth rings	rings surrounding the hoof (parallel to the ground) no longer evenly spaced	
Presence of coronary band injuries	injury to the coronary band - may/may not be accompanied by abnormal hoof wall growth	location (toe, quarter, heel), injury recent (bloody, weeping, open) or past (scarring present, healing occurring, hair growth returning)
Presence of contracted heels	the frog width being less than 2/3 of the frog length (mm) (Fig. 2.6)	
Presence of sheared heels	a difference of 5mm or greater between the medial and lateral heel bulbs	
Presence of wall stretching	any widening of the area around the white line (Fig. 2.6)	location (toe, quarter, heel)
Presence of wall separation	separation or a cavity of the hoof wall at the white line zone	location (toe, quarter, heel)
Presence of laminitis	dropped sole, prolapsed sole, 'laminitic' growth rings	
Presence of inflammation/ injury	any other abrasions, cuts, wounds or inflammation	location on hoof or foot, injury - recent or past (as for coronet injuries)

Dishing



Breakage

Chipping and partial vertical cracks

Contracted heels

Hoof wall stretching

Grass crack and flaring

Fig. 3.6 Examples of hoof conditions.

3.2.4 Statistical analysis

Data was entered into an Excel spreadsheet (Microsoft Excel, 2007) and pivot tables were used to check errors occurring in the translation between the raw data and the database. Descriptive statistics were generated, in the form of totals and percentages, which gave an overview of the trends of the age, dentition conditions, hoof conditions and brands present.

Using the entire horse as an experimental unit (as opposed to individual hooves) the differences in age, week and brand on specific foot and hoof conditions were analysed using the SAS® version 8.2 © 2001 software and the chi-square (χ^2) test of association. The chi-square test was used to investigate patterns of associations between the independent variables and to evaluate whether two variables, such as age and grass cracks, were related or unrelated (D'Agostino *et al*., 2006). The null hypothesis (H_o) assumed that the two groups showed no association while the alternative hypothesis (H_1) was that H_o was false (Thrusfield, 2005). A significance level (α) of <0.05 (5%) was used and H_o was rejected if the p-value was less than α (Siegel and Castellan, 1988). Chi-squared tests of association can be used when degrees of freedom are greater than one, no more than 20% of cells in the cross tabulation tables have an expected frequency of less than five and no cell in the table has an expected frequency of less than one (Siegel and Castellan, 1988). It was expected that some of the observed frequencies, or number of subjects, in each cell would be less than one making the chi-square result unreliable in these situations so the significance value was tested using an exact test (Siegel and Castellan, 1988). Following this, logistic regression models that tested simultaneously for the effects of brand, age and sample time were fitted. The conclusions drawn from these models were not greatly different from those drawn from the simple tests of association and the logistic regression models were not effective in some circumstances due to the sparseness of several data sets, so the results which follow are based on the data generated from the chi-square test of association. A general linear model was used to calculate the means and standard errors of the continuous data collected as well enabling analysis of associations of hoof length, width and toe angle with age, brand type and sampling period.

CHAPTER FOUR

RESULTS

4.1 INTRODUCTION

The following results from this investigation have provided data regarding the profile and characteristics of horses processed through a export abattoir, specifically in relation to the age of the horses, their breed (Standardbred or Thoroughbred as indicated by the neck and shoulder brands, respectively) and ascertained what information can be gained regarding the condition of the teeth and feet of the horses. The ability to assess other information concerning different characteristics and conditions (gender, soundness and body condition) was also investigated during abattoir visits. Additionally, the possibility of further background information (original location of the horse, time spent in transport, whether the horses were domestic or feral) being provided by abattoir staff was also gauged.

Each of the following sections contains the results of the descriptive analysis of the data, followed, where appropriate, by a more in-depth analysis of the occurrence of variables and the associations between the different variables. A total of 340 horses were processed over the three collection dates and the data from 333 horses has been utilised in the analysis below.

4.2 BRAND TYPE

Of the 340 horses processed over the three collection periods, 7 (2.1%) were found to have brands which were neither Standardbred nor Thoroughbred. Other than these brands there were no factors which the horses had in common. The location and type of brands differed as did the size and type of the animals (ponies, Arabian horses and stock horses). Due to this diversity, it was decided that this group could not be collapsed and joined with the ‘no brand’ (NB) group because of the lack of common property or mutual identity (Siegel and Castellan, 1988), so it was retained as an ‘other brand’ (OB) group. However, further analysis showed that the small number of individuals in the OB group, and therefore the small cell frequency, was influencing the data to an extent which made the exclusion of the group from the sample necessary. Descriptive analysis without this group indicated that Thoroughbreds (TB) accounted for 40.0% (133 horses) of the total number of horses while Standardbreds (SB) accounted for 12.9% (43 horses) of the sample. The remaining 47.1% (157 horses) had no visible brand (NB).

4.3 AGE

The dental ages of the horses were recorded via a visual examination and the horses were categorised as being ≤ 7 years, >7-15 years and >15 years. Due to the small sample size of only 14 horses in the >15 year age group it was collapsed and the categories for horse ages became ≤ 7 years and >7 years. Prior to this taking place it was noted that, in relation to the brands of the >15 age group, 10 horses had no brand, 4 had a Thoroughbred brand and none of the group had a Standardbred marking.

Of the remaining two age categories 199 horses or 59.8% were recorded as being ≤ 7 while 134 horses (40.2%) were >7. Of the NB horses 59.8% were ≤ 7. The majority of both the TB and SB horses were also 7 and under (60.9% and 55.8% respectively).

4.4 DENTITION

Of the 333 horses which had their teeth examined only 8 (2.4%) showed signs of malocclusion and all horses with this type of an abnormality had an overshot jaw (parrot mouth). Three of the horses displaying this were Thoroughbreds with the remainder having no visible brand and 7 of the 8 horses were in the 7 and under age group.

A total of 11 horses had broken or chipped teeth all of which were located on the upper and/or lower incisors. Seven horses had breaks or chips located on their lower incisors (301 - 403), 3 had breaks or chips on the upper incisors (101- 203) while 1 horse was found with all four central incisors chipped. A total of 7 (63.6%) of the horses with this abnormality carried a Thoroughbred brand, 3 (27.3%) had no visible brand and 1 (9%) horse was a Standardbred.

Four horses were found to have teeth missing completely and in all cases it was either the central or intermediate incisors which were absent and the teeth appeared to have been absent for a period of time as the growth of the opposing tooth or teeth was accentuated.

Unusual wear was found in 23 (6.9%) of the horses with 8 of these wear patterns fitting the descriptors for crib-biting (TB = 3, SB = 1, NB = 4) and 6 fitting the pattern for scraping (TB = 3, SB = 1, NB = 2). The remaining 9 horses had unidentifiable wear patterns. Of these 23 horses which displayed unusual wear patterns 2 (8.7%) were Standardbreds, 9 (39.1%) were Thoroughbreds and 12 (52.2%) had no visible brand.

4.5 FOOT CONDITION

4.5.1 Descriptive analysis of foot conditions

Over 55% of the horses had hooves which were flared at the quarters and nearly 80% of the hooves examined had chips missing while 40% had some degree of breakage. These breaks ranged in length from 7 mm to 135 mm with a mean of 49.4 mm and a standard error of 1.77 (Table 4.1). A total of 32.4% of the hooves collected were found to have some form of stretching or widening, which occurred at the toe in 46% of cases. Grass cracks were the most prevalent type of crack found in the hooves as 28.5% of the horses exhibited this condition. The majority of these cracks (72.0%) were located at the toe of the hoof and were of partial length only (95.0%). Coronary band injuries were present in 16.8% of the feet examined and these injuries were located at the heel (53.1%), quarter (24.2%) as well as at the toe (18.2%). The majority of these injuries (78.8%) were classified as having occurred in the past due to the scarring and regrowth which was visible. Other varying types of injuries were present in 15.3% of the hooves examined. These injuries were located at the fetlock in 69.2% of cases, as well as the heel (21.5%) and pastern, (9.2%) with the majority (81.5%) of these injuries classed as recent. No horses were observed to have navicular syndrome and only 1 horse (0.3% of the total population) displayed signs of laminitis (Table 4.2). Analysis of the hoof variables indicated that the mean hoof width was 132.7 mm (SE ± 0.69), mean hoof length was 89.4 mm (SE ± 0.47) and mean toe angle was 51.8° (SE ± 0.22).

Table 4.1 Summary of the descriptive analysis of foot variables

Descriptive analysis of foot variables (continuous data)					
Variable	Mean	SE	Minimum	Maximum	Median
Hoof width (mm)	132.6	0.69	95	209	130
Hoof length (mm)	89.4	0.47	49	126	89
Toe angle (°)	51.8	0.22	25	69	52
Breakage length (mm)	49.4	1.77	7	135	46

Table 4.2 Summary of the descriptive analysis of the foot conditions

Descriptive analysis of foot conditions		
Condition	Presence of condition	
	Number	%
Long toe-Low heel	**23**	**6.9**
Shoes	**15**	**4.5**
Flaring at quarter	**196**	**58.9**
Dishing at toe	**34**	**10.2**
Vertical cracks	**37**	**11.1**
Sand cracks	**3**	**0.9**
Grass cracks	**95**	**28.5**
Located at toe	--	72.6
Located at quarter	--	21.5
Located at heel	--	1.5
Located at toe and quarter	--	4.4
Partial length	--	95.6
Full length	--	4.4
Superficial depth	--	35.6
Deep depth	--	64.4
Horizontal cracks	**14**	**4.2**
Located at toe	--	57.1
Located at quarter	--	28.6
Located at heel	--	14.3
Partial length	--	100
Superficial depth	--	64.3
Deep depth	--	35.7
Chips	**262**	**78.7**
Breakage	**136**	**40.8**
Uneven growth rings	**78**	**23.4**
Coronary band injuries	**56**	**16.8**
Located at toe	--	18.2
Located at quarter	--	24.2
Located at heel	--	53.1
Past injury	--	78.8
Recent injury	--	21.2
Sheared heels	**1**	**0.3**
Contracted heels	**29**	**8.7**
Hoof wall stretched	**108**	**32.4**
Located at toe	--	46.4
Located at quarter	--	28.2
All of hoof wall stretched	--	25.4
Hoof wall separated	**45**	**13.5**
Located at toe	--	52.8
Located at quarter	--	32.1
Located at heel	--	13.2
Laminitis	**1**	**0.3**
Inflammation / Injury	**51**	**15.3**
Located at fetlock	--	69.2
Located at heel	--	21.5
Located at pastern	--	9.2
Past injury	--	18.5
Recent injury	--	81.5

4.5.2 Associations between conditions and variables

Chi-squared tests were conducted to ascertain if any associations were present between brand type, age and sample period themselves. No association was found between sample date and age or brand and age however, a strong association (χ^2 = 74.86, p<0.001) was found between the sample period and the brand type, specifically in relation to SB horses. Standardbred horses represented a low percentage of the total population in samples 1 and 2 (8.8% and 0.8%, respectively) however, this increased to 40.3% of the population in sample 3 (Sample 3 TB = 33.7%, NB = 26.0%).

Chi-squared tests were also conducted to test the effects of brand, age and sample period on the appearance of various foot conditions and these results are presented in tables 4.3 and 4.4.

Table 4.3 Results of the χ^2 test of association for foot conditions and age

Association of foot conditions and horse age			
Presence of Condition	Age group		Exact P-value
	≤ 7	> 7	
Long toe-Low heel	5.0%	9.7%	0.12
Shoes present	5.5%	3.7%	0.60
Flaring at quarter	61.8%	54.5%	0.21
Dishing at toe	9.5%	11.2%	0.71
Vertical cracks	8.0%	15.7%	0.03*
Grass cracks	25.6%	32.8%	0.17
Horizontal cracks	3.5%	5.2%	0.58
Chips present	83.4%	71.6%	0.01*
Breakage present	38.2%	44.8%	0.26
Uneven growth rings	22.6%	24.6%	0.69
Coronary band injury	14.1%	20.9%	0.13
Contracted heels present	7.5%	10.4%	0.43
Hoof wall stretched	34.2%	29.9%	0.47
Hoof wall separated	12.1%	15.7%	0.41
Injury or inflammation	15.1%	15.7%	1.00
Number in sample	*199*	*134*	

. As the asymptotic and exact P-values were similar, the more correct exact values were used in this analysis. In the above table * p<0.05, ** p<0.01, *** p<0.001.

Table 4.4 Results of the χ^2 test of association for foot conditions and brand type

Association of foot conditions and brand type

Condition	Brand type			Exact P-value
	NB	SB	TB	
Long toe-Low heel	5.1%	9.3%	8.3%	0.54
Shoes present	2.5%	14.0%	4.5%	0.00**
Flaring at quarter	56.1%	44.2%	66.9%	0.02*
Dishing at toe	12.1%	0.0%	11.3%	0.06
Vertical cracks	11.5%	0.0%	14.3%	0.04*
Grass cracks	28.7%	9.3%	34.6%	0.00**
Horizontal cracks	5.1%	0.0%	4.5%	0.36
Chips present	77.1%	76.7%	81.2%	0.67
Breakage present	39.5%	34.9%	44.4%	0.49
Uneven growth rings	23.6%	14.0%	26.3%	0.24
Coronary band injury	14.6%	30.2%	15.0%	0.04*
Contracted heels present	8.9%	11.6%	7.5%	0.71
Hoof wall stretched	31.2%	39.5%	31.6%	0.57
Hoof wall separated	17.2%	7.0%	11.3%	0.14
Injury or inflammation	12.1%	27.9%	15.0%	0.04*
Number in sample	*157*	*43*	*133*	

As the asymptotic and exact P-values were similar, the more correct exact values were used in this analysis. In the above table * $p<0.05$, ** $p<0.01$, *** $p<0.001$.

Following analysis it became apparent that there was a significant effect on the foot condition caused by the sample date, particularly with respect to LT-LH, flaring at the quarter, dishing at the toe, uneven growth rings, the presence of both chips and breaks and contracted heels ($p<0.001$). However, beyond indicating that a wide variation in foot condition was found over the sample period it was determined that little more information could be gathered from the available data and more research would be needed before conclusions could be confidently reached. For this reason it was decided that the analysis and discussion pertaining to the associations between sample period and foot condition should be placed in an appendix (see Appendix 1).

Associations were also found between foot condition and age with vertical cracks being significantly higher ($\chi^2 = 4.72$, $p<0.05$) in the 7 and under age group than in the older (> 7) group. An association was also found between the presence of chips and age (χ^2=6.61, p<0.05) as a greater proportion of horses in the 7 and under group were found to have chips when compared with the over 7 group (Figure 4.1).

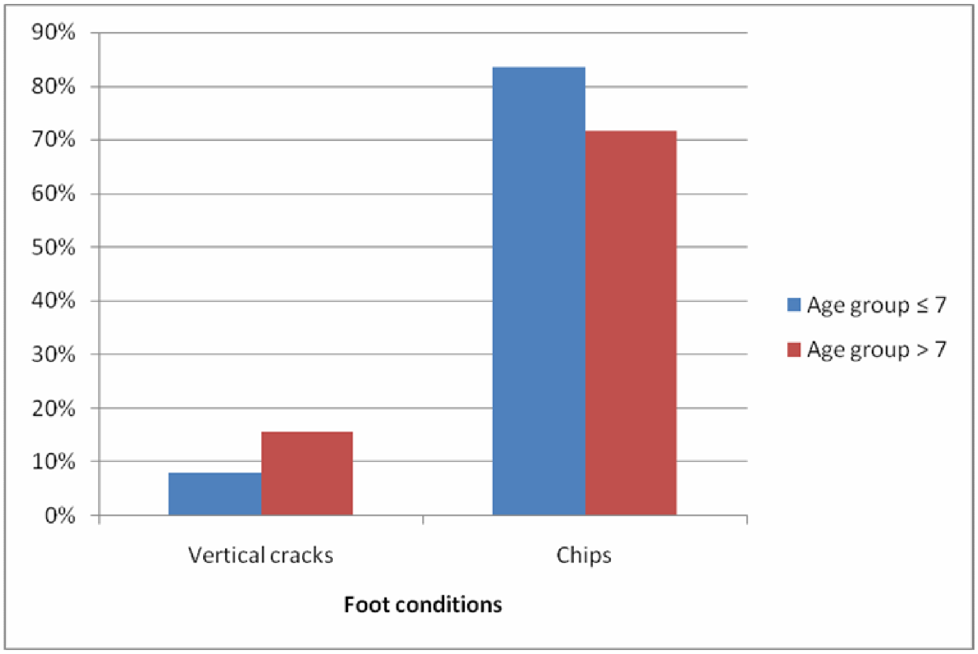


Fig. 4.1 Summary of associations between foot condition and age group (*p*<0.05).

The above figure shows that there was little association between foot condition and age group. However, the chi-square test did indicate that the younger age group had significantly fewer vertical cracks and higher numbers of chips than the older group (p<0.05).

Foot condition tested against brand type also demonstrated some significant associations. Flaring at the quarter was found to be more strongly associated with TB horses (66.9%) and horses with no brand (56.1%) when compared to horses that carried an SB brand (44.2%) (χ^2 = 7.90, p<0.05). This was also found to be the pattern of association with grass cracks. The number of these cracks that were present was significantly higher in TB (34.6%) and NB horses (28.7%) than SB horses (9.3%) (χ^2 = 10.91, p<0.01). However, an association (χ^2 = 6.36, p<0.05) was found between SB horses and coronary band injuries as 30.2% of this group had an injury in the coronary band area while this type of injury was found in only 14.6% of NB horses and 15.0% of TB horses. A similar significant association (χ^2 = 6.51, p<0.05) was discovered with 'other' injuries of the fetlock, pastern and heel. Nearly

30% of SB horses examined were found to have an injury in one of the above locations while it was present in less than 15% of both NB's and TB's (Figure 4.2).

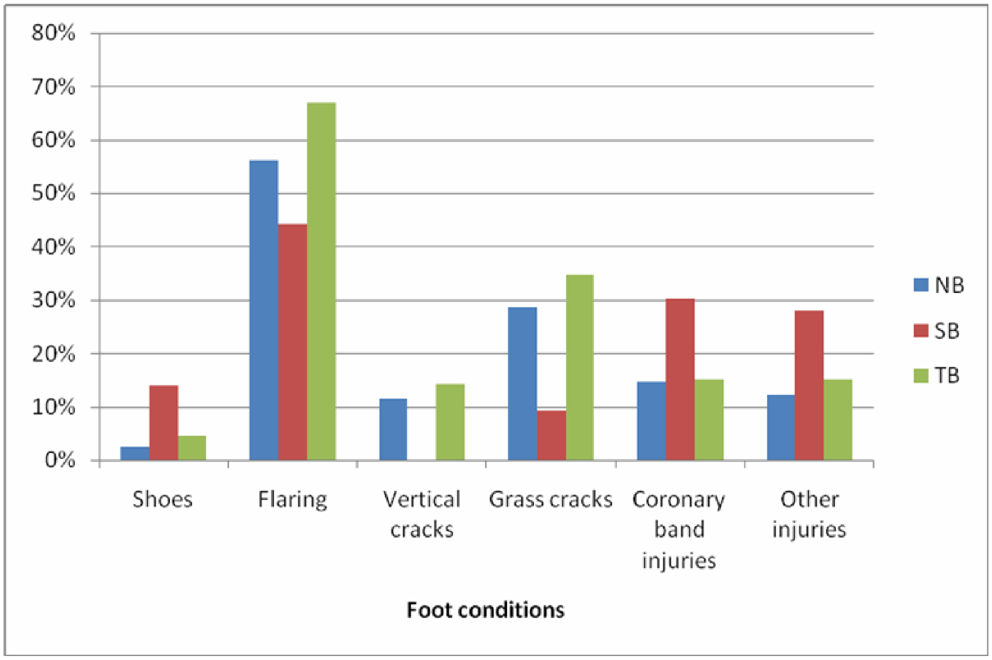


Fig. 4.2 Summary of associations between foot condition and brand type ($p<0.05$).

The above graph indicates that significantly more SB horses presented with shoes ($p<0.01$) and both coronary band injuries and injuries to the fetlock, heel and pastern ($p<0.05$) than either NB or TB horses. However, in comparison to NB and TB horses, SB horses had significantly fewer levels of flaring ($p<0.05$) and both vertical cracks ($p<0.05$) and grass cracks ($p<0.01$).

Further investigation was then conducted on the associations between the continuous variables (hoof length, hoof width and toe angle) and sample collection period, age and brand type. This analysis showed that the mean hoof width did not vary with sample period nor with dental age but width did differ with brand type. The mean hoof width of a TB horse was significantly greater than that of a SB horse ($p<0.001$). The mean length of the hooves did not differ with either brand or age however, a correlation was found between length and sample date with the hooves collected in sample 2 being longer than those in samples 1 or 3 ($p<0.001$). The mean toe angle was calculated and this variable also differed with sample date. The mean toe angle of the hooves collected in sample 1 was significantly lower than the mean calculated from the hooves collected in samples 2 or 3 ($p<0.001$).

Many of the above associations appeared to indicate that the hooves were lacking recent hoof care or farrier attention so this relationship was further investigated. Six indicators, which are generally associated with an overgrown or untrimmed hoof were selected (LT-LH, shoes present and needing replacement, flaring at the quarter, dishing at the toe, hoof wall breakage and hoof wall stretching) and the total number of horses which had one or more of these indicators was calculated. A total of 268 out of the sample of 333 (80.5%) of the horses examined had one or more of the indicators which were associated with overgrown and untrimmed hooves. A total of 42.2% of the horses examined were found to have only one indicator, 32.5% had two indicators and 25.3% of the horses presented with three or four of the indicators (Figure 4.3). No horses were found to have five or six of the overgrown hoof indicators. There were no associations found between the age of the horse or the brand type and the number of horses requiring farrier attention however, an association was discovered between sample period with sample 1 having significantly fewer horses (p<0.001) requiring attention than either samples 2 or 3.

Fig. 4.3 Examples of overgrown and untrimmed hooves.

The above photos are examples are hooves which were lacking farrier attention and were found to have 4 of the 6 indicators which can be associated with overgrown and untrimmed hooves. These indicators included flaring at the quarters, dishing at the toe, hoof wall breakage and hoof wall stretching.

4.6 COLLECTION OF OTHER FURTHER INFORMATION

During visits to the abattoir the possibility of collecting further information for future studies was assessed. The collection of data regarding the general body condition of horses was found to be possible both in terms of the abattoir restrictions on the movement of people and the speed of processing. However, the scoring of body condition of a horse generally utilises both observation and palpation of the horse (Henneke *et al*., 1983; Carroll and Huntington, 1988) and while the visual observations can be made, tactile access to the horses prior to processing is not possible.

A soundness score is another variable which could be successfully assessed during processing. An observer positioned outside the processing plant would have the opportunity to assess the soundness of the horses as they are moved through the yards. It would also be possible to collect information regarding the sex of the horses during processing as the carcasses are inverted and held on a conveyor belt for a short period of time before further processing.

CHAPTER FIVE

DISCUSSION AND CONCLUSION

5.1 INTRODUCTION

The objective of this survey was to determine various characteristics and conditions of horses relinquished to an Australian abattoir via an assessment of the dentition, feet, age and brand type.

5.2 PREVALENCE OF THOROUGHBRED AND STANDARDBRED HORSES

Anecdotal evidence has suggested that a large majority of horses processed through an export abattoir are surplus to the requirements of the racing industry (Animal Liberation, 1998; Animals Australia, 2007). However, this study has found that only 52.9% of the horses carried brands which indicated they were of Thoroughbred or Standardbred origins, with the remainder of the sample population having no visible brand. While this figure is substantial, and may indicate wastage issues within the racing industry, it is lower than expected.

Although it was not possible to determine the exact proportion of horses which were of domestic origin, as compared to feral, observations of body type and hide condition made by the investigators agreed with the estimates from AQIS that approximately 90% of the horses processed are of domestic origin (Roberts *pers.comm.*). This indicates that the majority of the NB group was comprised of domestic horses rather than those of feral origins. It is possible that some of the NB horses were surplus to the requirements of the racing industry and were discarded before being branded and registered, as observations indicated that a number of horses fitted the typical Thoroughbred conformation guidelines but carried no brand. However, it seems unlikely that this would account for all of the horses within the NB category, so it may be that more horses than anecdotal evidence suggests are sent to abattoirs from the domestic recreational riding industries. Hayek (2004) noted that a horse processed through a knackery may be relinquished as it is no longer financially viable for the animal to be maintained in drought conditions. It is possible that the outbreak of EI as well as the current and continued drought may have increased financial strain on owners with a corresponding increase in the numbers of NB horses processed.

5.3 AGES OF RELINQUISHED HORSES

The results of our observations on the dental ages of horses processed through the abattoir found that 40% were aged over 7 years. According to research conducted in the United States (McGee *et al.*, 2001) horses, which are no longer viable working animals, due to their age, are more likely to be sold to a slaughter plant than younger animals that can fetch higher prices at auction. The results of our survey did not agree with these findings as the majority of horses observed (59.8%) were 7 years of age or younger and only 14 horses (4.1%) were classified as being aged (over 15 years). In comparison, McGee *et al.* (2001) reported that 211 (16.0%) horses could be allocated to the aged or geriatric category. One argument for retaining the export slaughter industry is that it provides a humane way of disposing of aged, and therefore unwanted, horses. Our research indicated that this is not a strong argument in regards to our sample population due to the lack of aged horses. However, other research questions do arise from these findings such as why relatively high percentages of horses 7 and under are being processed and what are the reasons for their relinquishment.

5.4 DENTITION CONDITION

Malocclusion occurred in 2.4% of our sample population. In all cases the malocclusion was a ‘parrot mouth’ or overshot bite, which was expected as an overshot bite is reportedly the most frequently occurring type of malocclusion found in horses (Wilson, 2000). However, Wilson (2000) also notes that malocclusions are one of the most commonly found types of dental problems so the low numbers present (2.4%) was surprising. As malocclusions are generally considered to be of genetic origin (Kreling, 2003) our results indicate that this type of dental trait was uncommon in our sample population.

A total of 3.3% of the horses assessed were found to have broken or chipped teeth. Unfortunately, it was not possible to ascertain if the horse had arrived at the abattoir with chipped or broken teeth or if the teeth had been damaged during the processing as only post-mortem inspection was feasible. However, due to the severity of the chips and the very rough and uneven surfaces it seems likely that the damage occurred during processing.

By investigating the unusual wear patterns (crib-biting and scraping) of the horses it was possible to ascertain that 4.2% of horses processed had spent a considerable amount of time in a stabled environment. As these types of behaviours are often difficult to correct (Mason and Latham, 2004) and may indirectly affect the health and performance of the horse, it is possible that they were the main factor influencing the relinquishment of the horses.

5.5 FOOT CONDITION

Our results demonstrated a high prevalence of flaring at the quarter (58.9%), chipping (78.7%), breakage (40.8%) and hoof wall stretching (32.4%), all of which are common indicators of hooves which are lacking farrier attention (Hill and Klimesh, 2000; Dabareiner *et al.*, 2003). Further investigation into the actual number of horses that required attention revealed that 268 out of the 333 horses (80.5%) had been subjected to varying degrees of inattention and that 57.8% of the horses had two or more indicators which highlighted that attention was required. Our research indicates that this type of overall hoof condition is 'typical' in horses relinquished to a slaughterhouse. One possible explanation for this could be that an animal which has been identified for slaughter is likely to be set aside until it can be sold at an auction or transportation can be arranged to the abattoir. It seems unlikely that an animal which is about to be slaughtered would receive costly farrier attention. The frequency of this type of condition could also have been exacerbated by the recent outbreak of EI in Australia, as transporting a horse beyond its place of residency was not possible from late August 2007 until mid November 2007. In this situation, a horse, which was destined for an abattoir, would have a considerable delay until transportation could be arranged.

5.5.1 Associations with age

The results of this investigation have revealed that there was little association between the ages of the horses relinquished and the frequency and pattern of occurrence of variables as most hoof conditions were found in similar numbers across the two age groups. Despite this, an association did exist between the horse age and the presence of chips with more horses in the 7 and under age group having chipped hooves than those in the over 7 group. However, relatively high numbers of hooves which were found to have chips in both age groups (83.4% in the ≤ 7 group and 71.6% in the > 7 group) and this is more likely to be correlated with the high number of unshod horses in the study, as opposed to the age of the horses, as it has been reported that both chips and breaks are commonly seen in horses exercised or turned out without shoes (King and Mansmann, 2005).

Our results also found that the horses in the older group (> 7) had a higher likelihood of presenting with partial vertical cracks than horses in the younger group. This condition indicates a decrease in the quality of hoof wall that can be caused by a variety of factors including environmental changes (e.g. prolonged dry conditions or dietary changes) (King and Mansmann, 2005). The horses relinquished over the November 2007 – January 2008 period were exposed to dry climatic conditions but this would have affected the horses equally and not been dependent upon the age of the animal. However, the older the animal the greater the likelihood that it would have experienced prolonged periods of drought as well as other environmental changes.

5.5.2 Associations with brand type

Several associations were found between a variety of foot conditions and the brand type of the horses, most of which involved the SB group when compared to the NB and TB groups. The SB group were found to have higher numbers of shod horses, less flaring at the quarters and fewer grass cracks when compared to either the TB or NB horses. It seems likely that some of these associations are related as the higher proportion of shod horses may have decreased the amount of flaring present. As previously mentioned flaring is often found in horses exercised or turned out without shoes so an increase in shod horses would equate to a likely decrease in the presence of flaring. Due to the large variety of factors which may contribute to the occurrence of grass cracks (e.g. foot imbalance, excessive hoof growth and thin, dry or wet hoof walls: Pascoe, 1986; Dabareiner *et al.*, 2003; Moyer 2003) it is difficult to ascertain exactly why the SB group had fewer grass cracks than either of the other groups. However, it does appear that overall the SB group presented with largely different hoof conditions than either of the other two groups and this could be due to the different activities of the horses (harness work as opposed to riding) and possible differences in the husbandry and management techniques used which are likely to be similar for the majority of SB horses.

Keane and Munroe (2003) noted that coronary band injuries as well as injuries of the heel are common in horses which are driven in harness and Ross (2003) reported injuries in trotters can frequently be found on the coronary band, heel, pastern, shin and hock. The associations found in this investigation agree with this literature. SB horses were found to have significantly more coronary band injuries and injuries occurring to the fetlock, pastern and heel than the TB or NB groups of horses, most likely due to the type of activity undertaken by these animals.

5.6 STUDY ACHIEVEMENTS

As previously mentioned the primary goal of this study was to assess the viability and practicability of collecting data regarding the physical characteristics and conditions of horses relinquished to an abattoir. It was hoped this would allow analysis of or extrapolations from the data collected to give information regarding the more typical characteristics and conditions of these horses. This was achieved and as such this study was successful and is the first to describe characteristics of Australian horses relinquished to an abattoir for the human consumption market. Information regarding the brand type of the horses, age, dentition and foot conditions was successfully collected and this study ascertained that there is a greater prevalence of foot conditions when compared to dentition conditions. Further inspection of the slaughter process revealed that other factors such as the sex, body condition and soundness could also be assessed in future studies once additional resources are available to enable a larger number of researchers to be on-site to record the data.

5.7 PROPOSALS FOR FURTHER RESEARCH

Of interest to future studies would be the life histories (origins, recent distances travelled, husbandry and environment) of individual horses prior to relinquishment. This information, when combined with physical observations, would provide a broad overview of horses relinquished to abattoirs, particularly if both Australian abattoirs were included in any future research. It is important that a survey of the overall profile of horses relinquished to slaughterhouses (specifically gender, age and dental condition, foot condition, body condition, soundness and brand type: McGee *et al.*, 2001) be undertaken as this would allow more information to be gathered regarding the identification of welfare and wastage issues and the reasons for relinquishment. Such a large undertaking was outside the scope of this study. However, if access to vendor declarations, which accompany slaughter horses from their point of origin to the processing plant, could be gained (possibly by modifying the declarations to maintain owner / transporter anonymity) it would be possible to gain some of the above mentioned information, specifically gender, brand type and age, from this paperwork rather than needing large numbers of investigators for observational purposes. Access to these declarations would also remove some of the speculation which is currently inferred from physical characteristics with regard to possible reasons for relinquishment. Future studies may also extend the data collection locations to include knackeries and by doing so gain information pertaining to the condition of all horses relinquished for slaughter in Australia.

Three sample periods were utilised to provide an appropriate sample size for this study. However, there were still some surprisingly small numbers in several categories, particularly within the SB group. A study with a broad scope, such as the one mentioned above, would need to be conducted over a prolonged period of time, possibly 6 - 12 months, as this would account for variations which may be caused by seasonal environmental patterns in the conditions of the horses as well as seasonal equine industry patterns in relation to the timing of horse relinquishment. A longer survey would also dampen the impact any unforseen occurrences, such as an EI outbreak, might have on the data and subsequent analysis.

As previously mentioned, the two front feet of the relinquished horses were collected in this survey as the majority of issues affecting feet and lameness are present in the front feet (Ross, 2003). Collecting and labelling all four feet would give investigators the opportunity to ascertain more information regarding the foot conditions of horses relinquished to abattoirs and may provide more data on possible reasons for relinquishment, particularly if conducted in association with an examination of soundness. However, if a large-scale survey is to be undertaken it may be that an exhaustive forensic investigation of all four feet is not realistic due to abattoir conditions and the time/financial constraints of the study. It may be possible to overcome this issue by developing a scale of foot condition (McGee *et al.*, 2001) similar to the five-point body condition scale (Carroll and Huntington, 1988). When taken in conjunction with soundness, a scale of foot condition would give a fast and repeatable overall evaluation of the foot condition.

The results from this investigation show that it is possible to gain valid information regarding the condition and characteristics of horses relinquished to an abattoir. Our study demonstrated that approximately 60% of the horses relinquished to the abattoir for the human consumption market are aged 7 and under and over half were easily identifiable as originating from the racing industry. The majority of horses (80.5%) presented with hooves that were in need of care and farrier attention and changes in the type of horses processed differed greatly over time. Future studies should be concentrated on a broad range of conditions and characteristics from horses relinquished to both Australian abattoirs and conducted over a significant period of time so as to ascertain if the results found in this study are genuine and repeatable or if they were influenced by endogenous and exogenous factors affecting this particular sample population. This study has provided valuable data on the conditions of abattoir horses and the results from both this and future investigations will aid in gaining a better understanding of the characteristics, condition, welfare and wastage issues associated with horses which are relinquished to Australian abattoirs.

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APPENDIX 1

ASSOCIATIONS BETWEEN SAMPLE PERIOD AND FOOT CONDITIONS

A. 1 INTRODUCTION

The results of the descriptive analysis and χ^2 test of association demonstrated that there are significant associations between the sample collection period and the various foot conditions as indicated below.

A. 2 RESULTS

There was a significant association between the LT-LH condition and the sample week (χ^2 = 24.82, p<0.001) with 19.5% of the hooves examined in sample 3 having this condition compared to 2.4% and 3.8% in samples 1 and 2, respectively (Table A.1.1). Other variables which were found to have a significant association with the sample period were flaring at the quarter (χ^2 = 39.49, p<0.001), dishing at the toe (χ^2 = 28.02, p<0.001), uneven growth rings (χ^2 = 57.13, p<0.001), the presence of both chips (χ^2 = 70.40, p<0.001) and breaks (χ^2 = 17.66, p<0.001) and contracted heels (χ^2 = 20.42, p<0.001). The associations appeared when samples 2 and/or 3 were compared with sample 1 (Figure A.1.1). Flaring at the quarter was significantly worse in sample 2 (77.9%) than in samples 1 or 3 (39.2% and 58.4% respectively) and dishing at the toe of the hoof exhibited a similar pattern with 20.6% of the hooves examined in sample 2 having this condition compared with only 0.8% in sample 1 and 7.8% in sample 3. The presence of chips and breaks exhibited a different pattern of association and their presence was found to be significantly higher in both samples 2 and 3 when compared to sample 1. In samples 2 and 3 it was found that over 90% of the horses had chips compared with 54.4% in sample 1. Approximately half of the horses examined in samples 2 and 3 were found to have breaks in the hoof wall while this figure was only 26% in sample 1. A similar association was found for uneven growth rings and contracted heels.

Other weaker associations were uncovered between the sample collection period and condition. Horizontal cracks were found to be more prevalent in sample 2 (9.2%) than in samples 1 (0.0%) and 3 (2.6%) and the presence of an injury or inflammation was significantly higher in sample 3 (27.3%) than in sample 1 (10.4%) or 2 (13.0%).

Table A.1.1 Results of the χ^2 test of association for foot conditions and sample period

Association of foot condition and sample period				
Presence of Condition	Sample period			Exact P-value
	1	2	3	
Long toe-Low heel	2.4%	3.8%	19.5%	0.00***
Shoes present	5.6%	1.5%	9.1%	0.04*
Flaring at quarter	39.2%	77.9%	58.4%	0.00***
Dishing at toe	0.8%	20.6%	7.8%	0.00***
Vertical cracks	7.2%	13.7%	13.0%	0.21
Grass cracks	20.0%	36.6%	28.6%	0.01*
Horizontal cracks	0.0%	9.2%	2.6%	0.00**
Chips present	54.4%	93.9%	92.2%	0.00***
Breakage present	26.4%	51.1%	46.8%	0.00***
Uneven growth rings	0.8%	36.6%	37.7%	0.00***
Coronary band injury	9.6%	19.1%	24.7%	0.01*
Contracted heels present	0.0%	12.2%	16.9%	0.00***
Hoof wall stretched	28.8%	31.3%	40.3%	0.23
Hoof wall separated	7.2%	17.6%	16.9%	0.03*
Injury or inflammation	10.4%	13.0%	27.3%	0.00**
Number in sample	*125*	*131*	*77*	

As can be seen from the above table there were a large number of variables which displayed a significant association with the sample period. In fact, the only variables which did not appear to change in prevalence over time were hoof wall stretching and vertical cracks, demonstrating the wide variation present. As the asymptotic and exact P-values were similar, the more correct exact values were used in this analysis. In the above table * $p<0.05$, ** $p<0.01$, *** $p<0.001$.

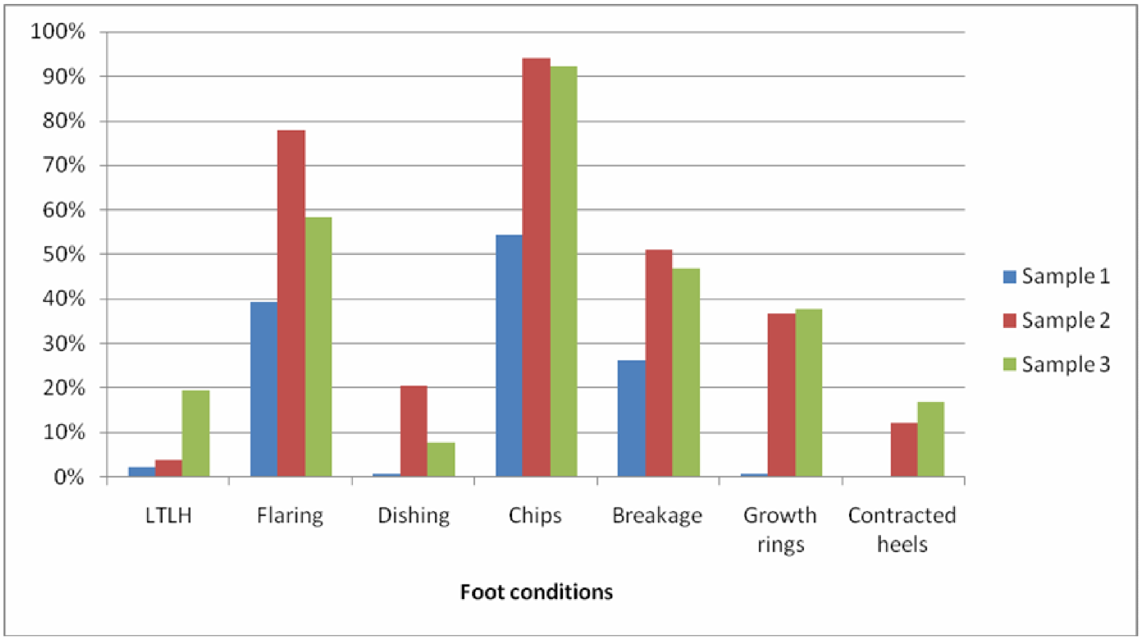

Fig. A.1.1 Summary of associations between foot condition and sample period (p<0.001).

Figure A 1.1 summarises the strongest associations (p<0.001) found between foot condition and sample period. All variables show a greater prevalence of the conditions in samples 2 and/or 3 when compared to sample 1.

A. 3 DISCUSSION AND CONCLUSION

As shown above various associations were found using the χ^2 test of association on the foot conditions and the sample collection period. A significant association was also discovered between the brand type of the horses and the sample period and this difference appeared to centre on SB horses. In the first sample period 8.8% of the horses observed were branded with typical SB markings. This dropped to 0.8% in sample 2 and rose to 40.3% in sample 3. Due to the lack of background information on each horse (e.g. origin, reason for relinquishment) it is difficult to determine the cause of such a pattern, however, it may be that some type of seasonality in the removal of horses from a particular sector of the equine racing industry does exist. For example, there may be a surplus of unwanted SB horses at a particular time each year. However, the unexpected low number of SB horses in sample 2 may have influenced the results.

The sample period against foot condition data revealed that the occurrence of the LT-LH condition and the occurrence of 'other' types of injuries were greater in sample 3 than samples 1 or 2. However, dishing at the toe, horizontal cracks and grass cracks were greater in sample 2 than samples 1 or 3. In contrast, hoof wall separation, coronary band injuries and mean hoof length were greater in samples 2 and 3 than sample 1 as was flaring at the quarter, chips, breakage, uneven growth rings and contracted heels. A similar pattern was also found between the association of horses which required farrier attention and the sample period with fewer horses requiring this type of attention in sample 1 than in samples 2 or 3. Overall, the pattern which developed regarding the foot condition and sample period indicated a general worsening of the foot condition over the collection period (Figure A.1.2). One possible explanation for this pattern could be that horses were transported from different (sample 1) or similar (samples 2 and 3) locations throughout NSW and QLD. It is also possible that a backlog of horses caused by the EI transport restrictions may have significantly extended the amount of time a horse waited until it could be relinquished, thereby worsening the condition of a hoof which may have required attention.

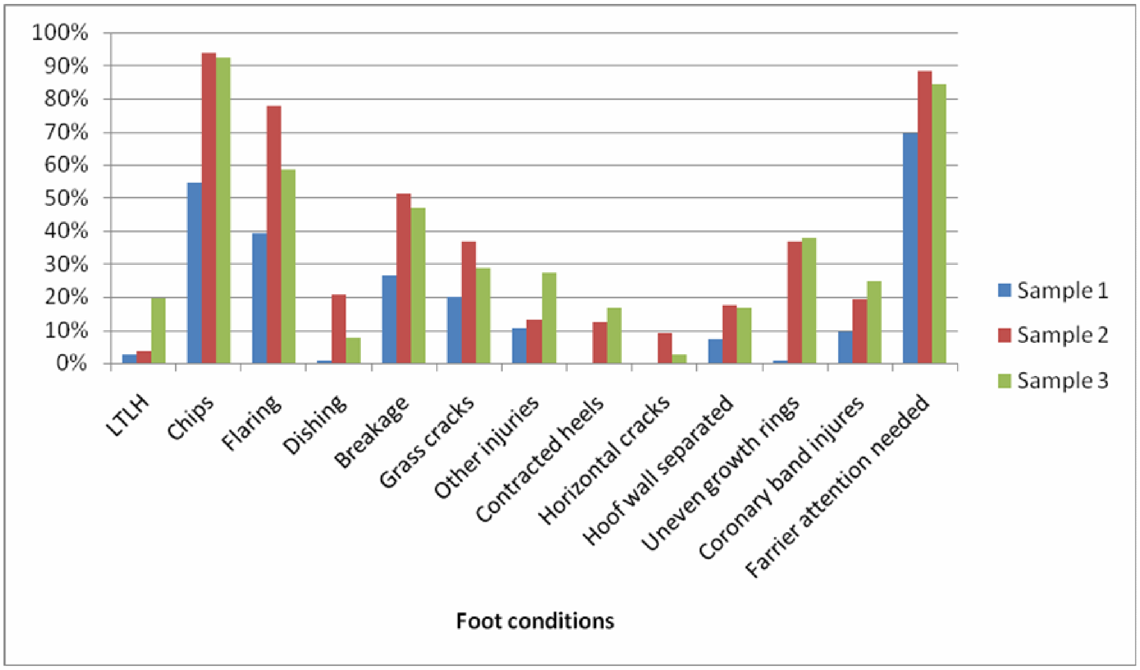

Fig. A.1.2 Graph indicating the changing pattern of foot conditions over the sample period.

Figure A.1.2 demonstrates the worsening condition of the feet over the sample period with each foot or hoof variable having a greater prevalence in the second and third sample period when compared to sample period one (p<0.05).

The only association which opposed this pattern was the mean toe angle measurement and this was significantly lower in sample 1 than in either samples 2 or 3. An increase in toe angle would generally indicate an improvement as low toe angles have been found to be associated with an increased risk of fractures, strain and injuries involving the deep digital flexor tendon (Kobluk *et al.*, 1989; Thompson *et al.*, 1993). However, the mean toe angle calculated for this study was 52° (SE ± 0.22) which agrees with the literature reports that the ideal angle for the forefoot of a horse is between 48° and 55° (Balch *et al.*, 1995; Parks, 2003b).

The results of the χ^2 test of association between the sample period and various foot conditions demonstrated that, on a sample-by-sample basis, wide variations were found across many of the variables that were measured. However, the collection procedure was not fully controlled to cater for such an eventuation due the low numbers of horses available for processing in the transport restricted post-EI climate, the samples not being equally separated in time (two weeks between the collection of samples 1 and 2 and six weeks between the collection of samples 2 and 3), and the untraceable, and likely inconsistent origin, of the horses relinquished. While it is evident that there was a wide variation in the foot condition of the sample population over the collection period, the causes of such a pattern are unclear and the associations found may indicate an inherent variability or a seasonal or equine industry-driven trend. It may be possible to develop an 'ideal' study to assess for seasonal effects by collecting data from horses relinquished to an abattoir from a known and comparatively localised region taken over successive (monthly or quarterly) periods with relative control. Given the currently undeterminable reasons causing the association between foot condition and the sampling period this is an area in which future research could and should be directed.

APPENDIX 2

AGING TEETH

Table A.2.1 Descriptors for aging teeth

Category	Age	Description
Young	1	Horse has full set of deciduous teeth and 4 cheek teeth (3 premolars + 1 molar)
	2	Horse has full set of deciduous teeth and 5 cheek teeth (3 premolars + 2 molars)
	2.5	Lower central deciduous incisor shed
	3	Lower central permanent incisor erupted
	3.5	Lower intermediate deciduous incisor shed
	4	Lower intermediate permanent incisor erupted
	4.5	Lower corner deciduous incisor shed
	5	Lower corner permanent incisor erupted / corner incisors in mesial wear
	6	Corner incisors in labial wear
	7	Corner incisors in occlusal wear / Cups disappear from lower central incisors
	General	Incisor profile - straight line
		Curvature of dental arch formed by lower incisors is semi-circle
		Shape of occlusal surface oval
		Corner upper incisor is wider than long
Middle-aged	8	Cups disappear from lower intermediate incisors
	9	Cups disappear from lower corner incisors
	9 to 15	Central enamels (remnants of the infundibulum) remain
	General	Incisor profile - protruding and moving toward horizontal
		Shape of occlusal surface trapezoid
		Corner upper incisor is about as long as it is wide
Aged	15+	No central enamels (remnants of infundibulum) remain
		Incisor profile - teeth angle nearing horizontal
		Curvature of dental arch formed by lower incisors is a straight line
		Shape of occlusal surface triangular
		Corner upper incisor is longer than it is wide

(Source: Baker and Easely, 1999; Wilson, 2000

APPENDIX 3

MODIFIED TRIADAN SYSTEM

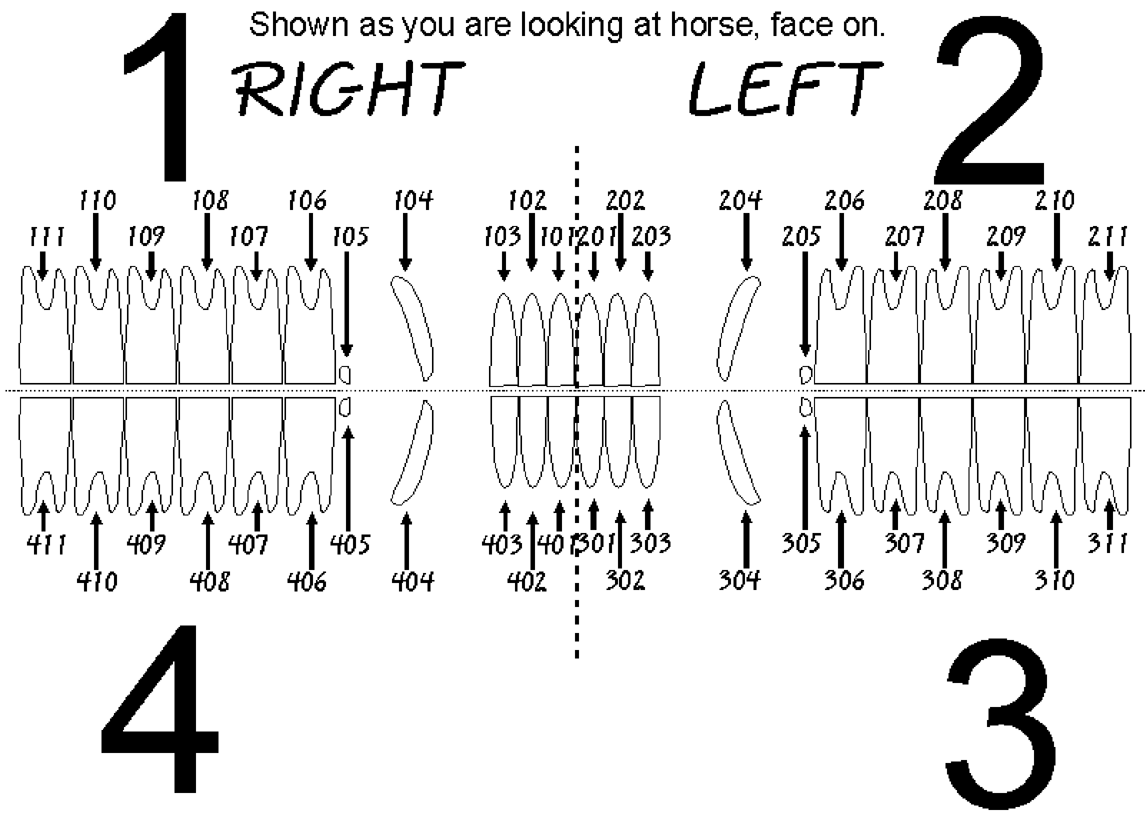

Fig. A.3.1 Modified Triadan system for teeth nomenclature

(Source: Floyd, 1991)