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Development of Management Strategies to Improve the Liveweight, Survival and Welfare of Goats during Export by Sea

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Agriculture Western Australia Project DAW.049
Funded by the Meat Research Corporation

Abstract

Losses of goats during live export by sea in the late 1980's early 1990's warranted research for welfare, productivity, and market protection reasons. Intervention by the Australian Quarantine and Inspection Service imposing a 21 day domestication period for harvested feral animals was empirical, and seen by industry to warrant investigation. By monitoring bucks in feedlots before shipment, during the shipping stage, and in quarantine feedlots post shipping, several key features emerged. Old goats had the highest death rates; young goats lost a greater percentage of bodyweight during domestication than older goats; deaths in feedlots were mainly due to salmonellosis (38%), inanition (30%) and coccidiosis (17%); shipboard deaths were primarily due to enteric (salmonellosis) (42%) and respiratory diseases (26%); post shipping deaths were mainly enteric disease (31%), respiratory disease (24%), and inanition (24%). Goats examined in pastoral regions before transport and feedlotting were generally in good health and body condition. The process of feedlotting resulted in rapid spread of pathogens, particularly *Salmonella* organisms, which resulted in deaths during and after shipping. The longer the period in the feedlot, the greater the death rates. Recommendations include that domestication feedlotting be restricted to a 7-10 day period, and that the domestication process actively train goats to eat pellets, and become accustomed to handling. Benefits include the potential for lower pre-shipping costs to producers, higher quality goats offered to buyers, fewer deaths in transit and thereafter, and improved perception of the Australian export product.

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Executive Summary

Rationale for the research
In the late 1980's and early 1990's death rates in goats exported live by sea were unacceptable. The Australian Quarantine and Inspection Service (AQIS) empirically identified a number of risk factors associated with high losses in shipments, and for welfare reasons applied critical controls on the export of goats which included:

- Restricting consignments to approximately 1500 goats
- Requiring that feral goats undergo a 21 day domestication period prior to export; and
- Banning the export of female goats without AQIS approval

The broad aim of this project was to identify causes of death, reduce the mortality and improve welfare and liveweight of goats exported live by sea. A series of secondary aims included identifying an appropriate diet for goats during shipping, determining a suitable pellet formulation, and establishing a suitable pre-shipping domestication period.

Outcomes of the study
By studying goats at the point of capture, before transport or feedlotting, it was established that feral animals are in good health, and adequate body condition. A low level of pathogenic organisms (*Salmonella*, coccidia) were detected in the feral population, but clinical disease was rare.

During feedlotting before shipment, the main causes of death were salmonellosis (38%), inanition (30%), and coccidiosis (17%). Salmonellosis and coccidiosis amplified during the feedlot period, with contamination by these organisms becoming profound by the 14th day, and death rates increasing as the domestication period increased. Treatments are available for these diseases, but are expensive, and difficult to administer effectively. Prevention is to be preferred. Inanition, the refusal to eat in the presence of adequate feed, is a domestication *process* concern. Goats need the opportunity to learn to eat pellets, and adequate time to become accustomed to them. Old goats (more than 6 adult incisors) either need to be excluded from export (the recommendation of this work), or treated separately to ensure that they are eating prior to export. Similarly, young goats tend to lose the greatest percentage of bodyweight during domestication, apparently due to dominance behaviour of older bucks which prevents access to feed. Drafting of bucks into size/age groups should be of benefit in this regard. Treatment of bucks to reduce dominance behaviour without reducing marketability (e.g. immunological castration) has some potential, but current methods require extended periods to become effective. The study recommends that domestication feedlotting be restricted to a 7 to 10 day period, to minimize spread of pathogens, and give adequate time for adaptation to a pellet diet.

During shipping, deaths from salmonellosis (manifested as enteric disease) (42%) continued to be the major cause, with respiratory diseases (26%) being second most frequent. Inanition

appeared to be less of a concern (4%) during shipping, probably because the dominance hierarchy is disrupted by the regrouping of animals. The increase in respiratory diseases may be attributable to dust particles arising from pelleted feed, and the build up of waste gases, particularly ammonia, which irritate and damage the respiratory tract, thereby allowing the establishment of pathogens.

In destination feedlots, major causes of death were: enteric disease, (31%), respiratory disease, (24%), and inanition, (24%). While some causes for enteric disease could be found in the management practices of destination feedlots, particularly a sudden change in feed, the diseases identified were those carried over from pre-embarkation and shipping. Deaths or poor performance at destinations results in a poor reputation for Australian stock, and attendant low prices offered to suppliers.

Implementation period

Time to implement the recommendations will depend on industry and AQIS. All recommendations are achievable with current technology, and it will be a matter of negotiation between the export goat industry and AQIS to modify the code of best practice relating to domestication. Individual export feedlotters could implement relevant recommendations immediately, and establish preferred supplier status with overseas buyers. While some further work may be needed, shipping managers could address the issues of dust and waste gas buildup, and enhance the welfare of goats accordingly. Destination feedlotters could obtain a pellet formulation from Australian suppliers, to minimize the sudden change in diet which currently occurs post shipping.

Beneficiaries of this research

In addressing the issues identified by this work, all sectors of the industry will benefit. End buyers will have a higher regard for the Australian product. A higher price should be negotiable between suppliers and buyers, based on greater survival and better quality animals (e.g. a "preferred supplier" scheme). Shippers could reduce death rates through addressing conditions on board, and present a better animal on conclusion of the voyage. Feedlotters would reduce costs through shorter domestication periods, and at the same time present goats in better condition, of types required by importing countries, and a greater assurance of survival. Suppliers would be more sure of markets, of demand for goats, and of a fair price. The whole process lends itself to a quality assurance program that will protect and benefit the whole export chain. Not the least, the welfare of the goats themselves would be enhanced, with liveweights maintained, and survival maximized.

Acknowledgments

Any task with the Herculean challenge of determining appropriate management strategies for such varied outcomes as improved liveweight, survival, and welfare, is one which cannot be undertaken alone. This work owes much to a myriad of Agriculture Western Australia staff who have been involved in planning, reviewing and challenging the programme, and also to those actually doing the work. None of it has been easy, whether it has been weighing, collecting samples from, and identifying feral goats as they arrive in feedlots; conducting autopsies in unconventional and often difficult conditions; processing and interpreting thousands of specimens; or analyzing reams of data to bring hidden nuances to light through current analytical techniques. The following staff especially deserve mention: Steve Gherardi, for his management of early parts of the program, Susan Godfrey for her consistent input throughout the program, John Creeper for his processing and interpretation of pathology specimens, Jane Speijers for her statistical expertise, Tim Johnson who provided expert technical assistance, Paul Frapple for his oversight and direction, Peter Ross for his field assistance; and Matthew Young, Damian Collopy, Bob Nickels and Roy Butler who accompanied shipments of goats to various destinations to collect and compile relevant data.

The work would not have been possible without the valued co-operation of exporters and shippers, particularly Bob and Trish Grinham of Geraldton who along with David and Margo Stedman of Carnarvon made their feedlots and stock available to us, and Sue Troncone of Heytesbury Pastoral Co. who facilitated travel arrangements, and introduced valuable contacts in Malaysia.

Funds for the completion of this work were provide by the Meat Research Corporation, and their continued interest and input into the project was highly valued.

Others have also made significant inputs into this work, and their contributions have been acknowledged in the body of the report.

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1. INTRODUCTION

The health and welfare of stock shipped live from Australia is paramount to the development of our export industries, and to the protection of our growing international markets. The aim of the project was to reduce the mortality and improve the welfare and liveweight of goats exported live by sea. The rationale for this work was that the potential for expanded exports of live goats had been identified but development of the industry had been hampered by the inability of the industry to provide a consistent supply of a quality product.

In the late 1980's and early 1990's mortalities were high. The Australian Quarantine and Inspection Service (AQIS) had empirically identified a number of risk factors associated with high losses in shipments, and for welfare reasons applied critical controls on the export of goats which included:

- Restricting consignments to approximately 1500 goats
- Requiring that feral goats undergo a 21 day domestication period prior to export; and
- Banning the export of female goats without AQIS approval

The project largely focused then on providing the information to facilitate modifying the AQIS restrictions in anticipation of an expansion of the live goat export industry.

Following the initial Technology Transfer Advisory Group (TTAG) meeting of 26 May 1992, the objectives of the project were redefined as follows:-

- By October 1995, to develop management practices to reduce the ship-board mortality to levels acceptable to AQIS;
- To allow the expansion of the live goat export trade from 1,500 goats per shipment to at least 2,500 by:-
    - i) Determining the requirements and economics for maintenance of liveweight in goats 30-40 kg and increasing liveweight in goats 18-24 kg
    - ii) Identifying the causes of death during shipment;
    - iii) Developing a protocol for domestication and preparation of feral goats for live export; and
    - iv) Developing a protocol for shipment of live goats.

The milestones of the project were modified accordingly with the main emphasis of the project late in 1992 being on determining the maintenance requirements for goats in the two weight ranges, and the value of Vaxstrate (a vaccine directed against sex hormones) in reducing the reproductive and dominance behaviour in bucks.

In 1993, new project managers within Agriculture Western Australia, and the MRC considered that developments in the live goat export industry warranted a modification of the project objectives, believing it was necessary to first identify the causes of death during export before developing cost effective strategies to minimise mortality and improve welfare.

The objectives of the project were re-defined as follows:-

i) Collect and analyze historical information on mortality from ships' Masters' Reports;
ii) Investigate and identify factors that affect mortality and welfare by accompanying shipments of goats;
iii)Examine strategies that will reduce mortality and improve welfare;
iv)Develop a protocol for the preparation and export of goats by sea; and
v) Negotiate the modification of AQIS restrictions.

At the TTAG meeting in September 1994, these objectives were endorsed and it was agreed that the research would concentrate on determining causes of mortality, and whether the domestication period of 21 days was appropriate for shipments of goats to South East Asia.

Market research by Agriculture Western Australia in December 1994, and liaison with Malaysian goat importers in June and October 1995, confirmed the existence of a strong market for live goats in South East Asia. One Western Australian exporter estimated the market could take up to 3,000 goats per month at current prices in order to meet the demand, as local supplies were insufficient. A price of $90 delivered was quoted as achievable for fat score 1 goats in excess of 35 kg liveweight. The exporters interviewed all expressed frustration at the shortage of suitable live goats for export.

Despite a number of major changes in direction over the three years of this project, the results provide a strong base for industry development, and a resolution of the welfare concerns associated with live goat exports.

2. MORTALITIES IN LIVE GOAT EXPORTS - AN INDUSTRY PERSPECTIVE

Whenever stock are exported, details of mortalities occurring during loading, in transit, and during discharge are required to be kept, and records of all voyages submitted to the Australian Maritime Services Association. From these records, high mortalities were observed in the early 1990's, and the Australian Quarantine and Inspection Service applied limitations on the export of feral goats. These limitations were empirically determined, and based on assumptions from data in Masters' Reports. These restrictions are:

- Feral goats required to have a minimum of 21 days domestication period;
- Female goats could not be exported without prior approval;
- Shipment sizes were restricted.

A number of factors apart from those already targeted by AQIS (i.e., domestication period, sex, and shipment size) may influence survival on a voyage, and need to be considered carefully in order to compile a more complete picture.

Because of the empirical nature of these restrictions, doubts were expressed about their usefulness by a section of the goat industry, especially since these measures incurred additional costs. It was therefore an important component of the research to determine the effect of some of these AQIS requirements, and so provide a basis for their continuation or modification.

Masters' reports for 179 shipments carrying 50 or more goats, between 1989 and 1994 have been analyzed. Some 30 different ships were involved, making analysis difficult. However, differences between ships, and daily death rates were evaluated by converting data to a standard format (percentage deaths per day).

An analysis of death rates indicated the following:

- Deaths during loading were low;
- Deaths during discharge were variable, with discharge deaths in the Middle East being higher than those in South East Asia;
- Deaths in transit were variable, by destination and time of year;
- Higher overall death rates were frequently associated with longer voyages;
- Shipment size was not correlated with death rates;

- Comparison of death rates between goats from feral and agricultural sources was not feasible;
- The total number of goats exported has been small in comparison to sheep.

A drop in mortalities was observed after 1991, but the reason for this is not clear, since the AQIS restrictions were not in force at this time. Obtaining accurate data regarding domestication length has been difficult. Because of the nature of feral goat supply, and the requirements of shipping, it is doubted that strict adherence to the 21 day domestication period is either practical or possible. Attributing any reduction in death rates to a 21 day domestication period may result in an inaccurate conclusion.

Detailed analyses of Masters' Reports are provided in Appendix 1

3. PROJECT OBJECTIVES

The broad aim of the project was to reduce the mortality and improve welfare and liveweight of goats exported live by sea. A series of secondary aims were pursued under this major heading, but modified as described in the Introduction. The end point of the research has always been to develop management practices which reduce ship-board mortalities to acceptable levels.

Studies on goats during export are few, and very little information was available regarding the complexities which may contribute to ship-board deaths. Nutrient requirements of goats required evaluation. Little was known about adaptation of goats to pellet diets, or the type (composition) of pellets which were appropriate for goats. Actual causes of death were unknown, and it was imperative that these be determined. A corollary of this was that the health of feral goats in pastoral areas was also unknown. Hence it was important to identify underlying diseases or conditions present in feral goats which could result in poor performance or deaths during domestication or shipping.

The emphasis of this project has covered the following areas:

- Collection and analysis of historical information on mortality from ships' Masters' records;
- Investigating the health of feral goats in their natural setting;
- Identifying the causes of death throughout the shipping process - in the feedlot, on board ship, and in the destination country;
- Determining the requirements and economics for maintenance of liveweight in goats 30-40 kg, and increasing liveweight in goats 18-24 kg; and
- Determining whether behaviour modification in bucks was practical.

Information from this research is intended to provide a foundation from which to:

- Develop a protocol for domestication and preparation of feral goats for live export;
- Develop a protocol for shipment of live goats; and
- Negotiate the modification of AQIS restrictions.

The ultimate success of the project will lie not only in identifying causes of deaths in the shipment process, nor the development of preventative strategies, but in the successful adoption of these practices by the goat export industry, and the modification of AQIS requirements for live goat exports.

4. HEALTH OF FERAL GOATS BEFORE TRANSPORT AND FEEDLOTTING

4.1 The Normal Goat

Much of the study described previously related to feral bucks in holding areas and feedlots, some time and distance from their origin. That is, the goats had already been subjected to the stresses of capture, transport, and confinement to holding paddocks and yards. Under these conditions, some transmission of parasites and bacteria could have already occurred, and goats considered normal may not be truly representative of the feral goat population.

A study of goats as close to their feral situation was conducted in the pastoral region, where small flocks were being mustered as part of the WA Feral Goat Eradication Programme.

Over a period of three days in August 1994, 53 feral goats (27 males and 26 females) were mustered, shot and autopsied using the method described in Appendix 5.1. Total body weight, and weights of rumen, rumen solids, and abomasum were recorded; weights of femur, omentum, and biceps femoris muscle were taken, and the adrenal glands placed in formalin for weighing later. Samples of ileocecal lymph node, and terminal ileum were collected for culture of *Salmonella*. Faeces were also collected for worm egg and coccidial oocyst counts.

4.2 Results

Findings in goats from this study relate only to those in one restricted location, and extrapolation to goats from other sources must be done with caution.

Goats were generally healthy, and in good condition. Bucks were leaner than does, and this was borne out by lower fat reserves in the greater omentum. Body score for bucks averaged 2.7.

The relative size of the adrenal glands of bucks was generally smaller than that observed in bucks autopsied on board ship (adrenal glands increase in size when the animal is under stress).

Worm eggs were found in 17 of the 53 goats autopsied, but all counts were low (under 50 eggs per gram of faeces). Because of the low numbers of worm eggs, larval differentiation was not feasible.

Coccidia were not detected in any faecal samples.

Salmonella organisms were isolated from 3 goats (two with *S. singapore*, and one with *S. onderstepoort*).

Caseous lymphadenitis (Cheesy Gland) was found in 2 goats.

Fibre balls (felt balls, phytobezoars) ranging from 145g to 1100g were found in the abomasa of 5 goats. Bodyweight, and body condition of goats with fibre balls were comparable to those without.

4.3 Discussion

Goats mustered in the wild are likely to be in sound general health. While goats in this study were all in good body condition, this may not always be the case following poor seasons, or after the breeding season, when bucks in particular may be expected to be in low body score.

Isolation of *Salmonella* from three goats indicates that any activity which involves concentration of stock in a small area would potentiate the spread of this organism. The same principle holds for coccidia, although none was isolated from goats in this study group.

Worms, particularly *Haemonchus* spp. are able to spread in conditions of warm moisture, and may pose a threat to other goats, because eggs become infective within 4 days, and egg laying maturity reached within 19 days (Soulsby 1968). Thus, within a relatively short period of time, goats may build up severe worm burdens, if forced to remain in contaminated areas. The infective stages of *Haemonchus* may persist for up to 6 months under mild conditions, allowing carry over of infections in feedlots between shipments. Although speciation of worms was not practical in this study, because of low faecal egg counts, *Haemonchus* and other trichostrongylid worms have been isolated from goats throughout this project.

The role of fibre balls in producing disease is uncertain, and in these goats, substantial fibre balls were found, without any suggestion of loss of body condition, or other disturbance. However, in ship-board studies, a number of goats were observed to die with abomasal ulcers in association with fibre balls. It is possible that under stressful conditions, fibre balls may accentuate processes leading to abomasal ulceration, peritonitis, toxaemia, and death. Fibre balls appear to be dependent on diet, although the plants contributing to accumulation of fibre balls in this population were not identified. Fibre balls may also be the result of swallowing fur during the licking and grooming process, although the composition of the fibre balls found here appeared to be of plant origin. The prevalence of fibre balls in other goat populations is not known.

In summary:

- the general health and condition of goats at the point of capture appears to be satisfactory;
- within this population, which may or may not be representative, there is evidence of disease agents at low level;
- disease agents identified in this population are known to amplify in conditions of confinement (e.g. feedlots) and other stresses (change of diet, transport etc.);
- the presence of fibre balls in this population may provide an indication of the likelihood of abomasal ulceration and complications in subsequent stages of the export process.

4.4 Acknowledgment

This work could not have been conducted without the willing co-operation of Bruce and Ermie Robinson of Yerilla Station, and their help is gratefully acknowledged.

4.5 Reference

Soulsby E.J.L (1968) *Helminths, Arthropods, and Protozoa of Domesticated Animals* (Sixth Edition of Monnig's Veterinary Helminthology and Entomology) Bailliere Tindall and Cassell, London. Pp 235-238.

5. CAUSES OF MORTALITY IN GOATS EXPORTED LIVE BY SEA

5.1 Methodology

Determining why something dies, in this case a goat on board a ship, is a major task, combining the skills of many specialists - such as clinician, pathologist, and clinical pathologist. When a group of goats dies, and continue to die in association with a process or event, the skills of many others interact, including epidemiologists, nutritionists, and statisticians. Even then, there is no guarantee that a diagnosis will be made. In order to maximise the possibility of piecing the whole picture together, information on goats has been collected from the earliest (on entry to the export feedlot) to the latest (in the quarantine feedlot in the destination country) practical times in the export process. As many factors as could be managed have been evaluated, through processes known as cohort, and case-control studies.

Factors under consideration

Because the objective of these studies was to determine causes of deaths in exported bucks, with the view to recommending procedures to industry for reducing deaths, the following factors were examined to determine whether they contributed to deaths:

- Source of goats: did the different original properties produce goats of differing characteristics which in some way affected survival?
- Age of goats: were any particular age groups more likely to survive (or die?)
- Weight changes: did those which survived gain weight in the feedlot and during the voyage, or did they maintain/lose weight?
- Appetite: were the ones which died eating or not?
- Body condition: were thin goats or fatter goats more likely to survive? This question is of considerable importance, because importing countries prefer thin (lean) goats.
- Specific diseases: did a change of diet and transport stress predispose or precipitate underlying diseases? Did *Salmonella* play a major or minor part? Were parasites causing problems that lead to deaths?
- Is the period of domestication in the feedlot influencing survival?
- Is the location on the ship enhancing or aggravating death rates?
- Are there other ship-board factors which complicate the picture? Because goats have travelled on different ships, such differences may be apparent.

Each of these factors has been examined empirically, and where data were sufficient, detailed statistical analyses were conducted.

5.1.1 Sources of Bucks

Bucks were principally from feral sources, and originated from several stations in Western Australia. For any given shipment, bucks could be obtained from more than one station. Bucks would be trucked to a holding feedlot as they were mustered from stations, and bulked up awaiting further selection prior to shipping.

5.1.2 Management in Feedlots

While in feedlots, day to day management of goats was largely dependent on the preferences of the manager. However, goats were usually provided with hay and or access to grazing/browsing. Ostensibly, in the 5 days prior to shipping, goats were provided with a pelleted diet or one comparable to that of the shipping ration. Observations began when advice was received from feedlot managers that goats were being bulked up prior to shipping.

Goats entering the feedlot were identified on the horn base by different coloured cattle paint, and source and date of arrival recorded.

Where practical, goats selected for closer study ("cohorts") were stratified into groups by the time in the feedlot, so that any effects of this period on survival could be evaluated. However, a cohort of one hundred goats was all that could be managed under the constraints of the commercial export process. On voyages when this cohort was stratified by time, representativeness of other factors was often lost. That is, the group was not truly representative of age, weight, or body score.

The process of domestication was usually that of allowing goats to become accustomed to confinement and eating a ration comparable to that fed aboard ship.

5.1.3 Preparation of Animals

A group of goats was selected for more detailed observation, by systematic sampling from the total group to yield 100 goats. These goats were identified initially by eartagging. However, when overseas customers indicated their preference for goats without tags, identification was by numbered collars which were subsequently removed and re-used. Bucks were weighed, body condition scored (Appendix 5.3), and aged by dentition. Samples of faeces were obtained for worm egg and coccidial oocyst counts, and a sub-sample of faeces placed into selective broth for *Salmonella* isolation. Where practical, a second weight and body score was obtained close to the shipping date, to determine weight and condition changes associated with the feedlot period. Findings relating to worm eggs, coccidial oocysts, and *Salmonella* cultures were conveyed back to feedlot managers. Appropriate treatment regimes were discussed with managers when a known pathogen was identified (e.g. *Salmonella*, coccidia, heavy nematode burdens). It is readily acknowledged

that the provision of this information to feedlot managers may have influenced the outcomes being measured, but it was considered unethical for professional, commercial, and welfare reasons to withhold such findings.

Detection of bucks in the study group which were or were not eating was undertaken where practical. The use of marker bars (a bar which delivers dye when bumped, placed over feed troughs to mark the head of goats which eat from the trough) had been found impractical. Goats would not approach troughs fitted with marker bars, unlike sheep which readily accepted their presence. Consequently, feed was dyed each day for two days with a Brilliant Blue solution (36g/L) applied at the rate of 10-15 L/tonne feed (see Appendix 5.4), and those eating identified by the blue staining around the mouth and nose. From these observations, percentages eating and not eating were determined. Because of the difficulty in detecting dye on dark haired goats, the method used may underestimate the actual percentage eating (i.e.. over-estimate the apparent number of non-feeders). The presence of dye may also have rendered feed unpalatable to some goats, thereby also biasing estimates. (This latter possibility is doubted, from the experience of operators performing the dying process, who noted that dying seemed to encourage pellet consumption.)

Where required by AQIS, tips of very long horns were removed, except where to do so contravened requests by the importing country (e.g. for the el Eid ritual slaughter).

5.1.4 Feedlot Deaths

Animals which died during the feedlot period were submitted for necropsy where practical, and the standard necropsy procedure followed (Appendix 5.1). Autopsies were not conducted when feedlots were isolated, making access difficult, or where carcasses decomposed rapidly in hot weather.

5.1.5 Necropsy Procedures and Laboratory Procedures

All goats were necropsied as soon after death as possible. A standardised necropsy procedure (Appendix 5.1) was applied in all cases, designed to provide a complete examination of the carcass so that all gross lesions could be identified and fully documented. At each necropsy the weight of the carcass, greater omentum, biceps femoris muscle, femur, rumen contents and abomasal contents were measured. The rumen contents were filtered through nylon mesh and the solid fraction recorded. Both adrenal glands were sampled into formalin and subsequently weighed in the laboratory. Multiple pH strips were used to measure rumen and abomasal pH. All measurements were entered on a standard necropsy report form (Appendix 5.2).

5.1.6 Bacteriology

Samples for *Salmonella* spp culture were taken from swabs of the gut lumen and transported in strontium chloride B selective transport media. *Salmonella* samples taken on board ship were maintained at 4°C in a portable refrigerator until the ship returned to Australia. Isolation and identification were carried out at Agriculture Western Australia's Animal Health Laboratory and subsequent serotyping and phage-typing was performed by the Western Australian Department of Health.

5.1.7 Parasitology

Faecal samples were collected and analyzed in Agriculture Western Australia's parasitology laboratory as follows. Enumeration of coccidial oocysts was undertaken by performing a separation technique on a standard quantity of faeces. Oocysts were concentrated following flotation in a NaCl/sucrose solution having a specific gravity between 1.1. and 1.3. Floated oocysts were transferred via pipette onto a slide and examined microscopically.

Faecal samples were also assessed by standard methodology to determine faecal egg count for helminth parasites.

5.1.8 Histopathology

Once all procedures on the carcass, as described above had been completed, samples as described in Appendix 5.1 were placed in 10% buffered neutral formalin. On return to Australia, the samples were blocked, embedded in paraffin and 5 micron section stained with haematoxylin and eosin and examined microscopically. Deciding whether *Salmonella* organisms were a primary cause of death was based on histological findings: if the lesions were acute or peracute, *Salmonella* was considered the primary cause of death. Where chronic lesions were observed, in association with the isolation of *Salmonella*, then the organism was considered to have opportunistically initiated a secondary process leading to death.

5.1.9 Voyage Management

Bucks were transported from feedlots to the wharf at either Geraldton (for trips to South East Asia), or Fremantle (for trips to the Middle East). Stock were loaded into pens reserved for goats. However, because pens were not specifically designed to contain goats, escape was common, and redistribution of goats between pens occurred frequently.

Goats were fed twice daily, at times dictated by ship-board routine. Pellets were the principle feed component, although on some voyages, hay or chaff supplements were provided.

Water was provided in troughs which were cleaned daily, and topped up once or twice throughout the day, depending on ship-board routine.

Any bucks which died were subjected to the standard necropsy procedure already described. However, if a carcass was decomposed, or the ship close to port, a necropsy was not conducted. This meant that deaths in the 12 hours before docking, and during unloading, would not be autopsied.

Dyed pellets were fed to bucks over a 1 or 2 day period late in a voyage, either to the study group, or to the whole shipment of goats if this was small enough. An evaluation of goats eating/not eating was performed as described previously. Where possible, liveweights of the study group were obtained at the same time, and on some voyages, faecal samples taken to detect goats shedding *Salmonella* organisms. Ship-board conditions were frequently unsuitable for performing these measurements, and incomplete data sets were common.

Middle East Voyages

Large shipments of goats to the Middle East frequently coincided with religious festivals. Entire bucks (i.e.. full horns, no ear markings or tags, not castrated) are required by customers, and horn tipping reduces their values. Where practical, horn tipping is not carried out on bucks at these times. It is important to note that the value of goats is high at these times, and outstrips the value of Australian live sheep. Likewise, market demand is high, and there is the potential to capture a substantial proportion of that market. (See extract from the *Gulf News*, May 19th 1994 - Appendix 8).

For both shipments to the Middle East, goats were on an exposed deck.

South East Asian Voyages

As with Middle East voyages, shipments frequently coincided with religious festivals. At these times, demand is high, and the goats command a premium price. Similarly, horn tipping reduces the value of goats, and this practice is kept to a minimum. In addition to withstanding the stresses of a sea voyage, goats shipped to Malaysia must also withstand a 10 day quarantine period. Quarantine is enforced, particularly when the arrival of a shipment may coincide with the spread of infectious animal diseases within the country, such as Foot and Mouth Disease. Conditions in quarantine feedlots are quite different from those in Australia, and these require substantial adaptation by goats.

For most journeys to South East Asia, goats were transported on an enclosed deck.

5.2 Results

5.2.1 Causes of death

Deaths were rarely due to a single cause, and a range of factors were observed to be involved. It was important to identify these factors, because manipulation or modification of one or more of these factors may be possible, and thus reduce mortalities in future voyages. Causes of death and their frequencies are given in Table 5.1. A summary of laboratory findings is presented in tabular form in Appendix 8.

Table 5.1 All Causes of death

Disease Diagnosis	Number	Percentage
Salmonellosis	66	27.4
Inanition	28	11.6
Pasteurellosis/Bronchopneumonia	23	9.6
Coccidiosis	14	5.8
Abomasal Ulceration	12	5.0
Septicaemia	9	3.8
Inanition and secondary salmonellosis	8	3.3
Enterotoxaemia	8	3.3
Pasteurellosis/Salmonellosis	6	2.5
Enteritis (parasitic or bacterial)	4	1.7
Trauma	3	1.3
Cardiomyopathy	3	1.3
Pasteurellosis and Abomasal Ulcer	2	0.8
Salmonellosis and Abomasal Ulceration	2	0.8
Abomasal Phytobezoars	2	0.8
Inanition and Coccidiosis	2	0.8
Liver Abscess	2	0.8
Rumenitis	1	0.4
Inanition/Trauma	1	0.4
Inanition/Cardiomyopathy	1	0.4
Peritonitis	1	0.4
Inanition/Phytobezoars	1	0.4
Endometritis	1	0.4
Pasteurellosis and Coccidiosis	1	0.4
Autolysis	13	5.4
No Diagnosis Made	27	11.2
Total	241	100%

5.2.2 Other factors linked with deaths

5.2.2.1 Age of goats: Where age distribution was known, older bucks (i.e.. 8 teeth = full mouth) were over-represented amongst the deaths. That is, more old bucks died than would be expected than by random occurrences. On some voyages, this same trend was apparent in 6 tooth bucks.

5.2.2.2 Weight Changes: Goats which were maintaining or increasing their weight during the feedlot period prior to shipping were more likely to survive than goats which lost weight. Goats which maintained or gained weight during shipping were again more likely to survive than those which lost weight during the voyage.

5.2.2.3 Appetite: From the use of dyed pellets, goats observed to be eating in the feedlot were also found to be eating on board ship, and these goats had a higher survival rate than goats not observed to be eating.

5.2.2.4 Body Condition: The predominant body score of goats which died was low - usually score 1. From assessments of dead goats in study groups (cohorts) it was apparent that many of these goats had been in better body condition at the time of shipping, and had lost condition during the voyage. It is not readily apparent whether the loss of condition preceded the immediate cause of death, or whether weight loss was the result of some other disease process which caused the goat to stop eating.

It was frequently noted that many goats which died in very poor body condition, still had feed in the rumen despite an empty intestine. That is, feed was retained in the fore-gut, and therefore unavailable to the animal. Dye from pellets given on board ship was still apparent in the rumen of some of these goats which died after several days in quarantine. The pathophysiology of this situation also needs to be clarified, and doing so may lead to a simple preventive measure.

5.2.2.5 Domestication:

a) Domestication period:

Because of the small numbers of goats in most shipments, it has not always been possible to attach a statistical significance to findings surrounding differing periods of domestication. However, a number of important features did emerge:

- There was a strong linear relationship between the length of time in the feedlot, and deaths. This relationship was statistically significant, highly so on some voyages and there was very little deviation from linearity - that is, the major determinant of deaths was primarily related to the time in the feedlot, with little confounding effect of other

variables. This trend was evident from 10 days upward, with increasing deaths beyond 10 days.

- Weight loss occurred in all age groups following entry to feedlots. However, the *percentage* weight loss was greatest in young goats (0 teeth). With young goats, this loss appeared to be recovered by the time they boarded ship, and deaths in this age groups were lower than for goats with 6 adult incisors or full mouthed.

- Infectious diseases were amplified with longer domestication periods. *Salmonella* and coccidia activity (excretion) increased with longer domestication. These two diseases were responsible for a large number of deaths, and may have played a part in others[1]. A number of the deaths associated with pneumonia appeared histologically to be linked with *Salmonella.*

- Very short domestication periods (under 5 days) were associated with a low acceptance of pellet rations. However, this did not appear to affect the survival of goats during the voyage.

b) Domestication process:

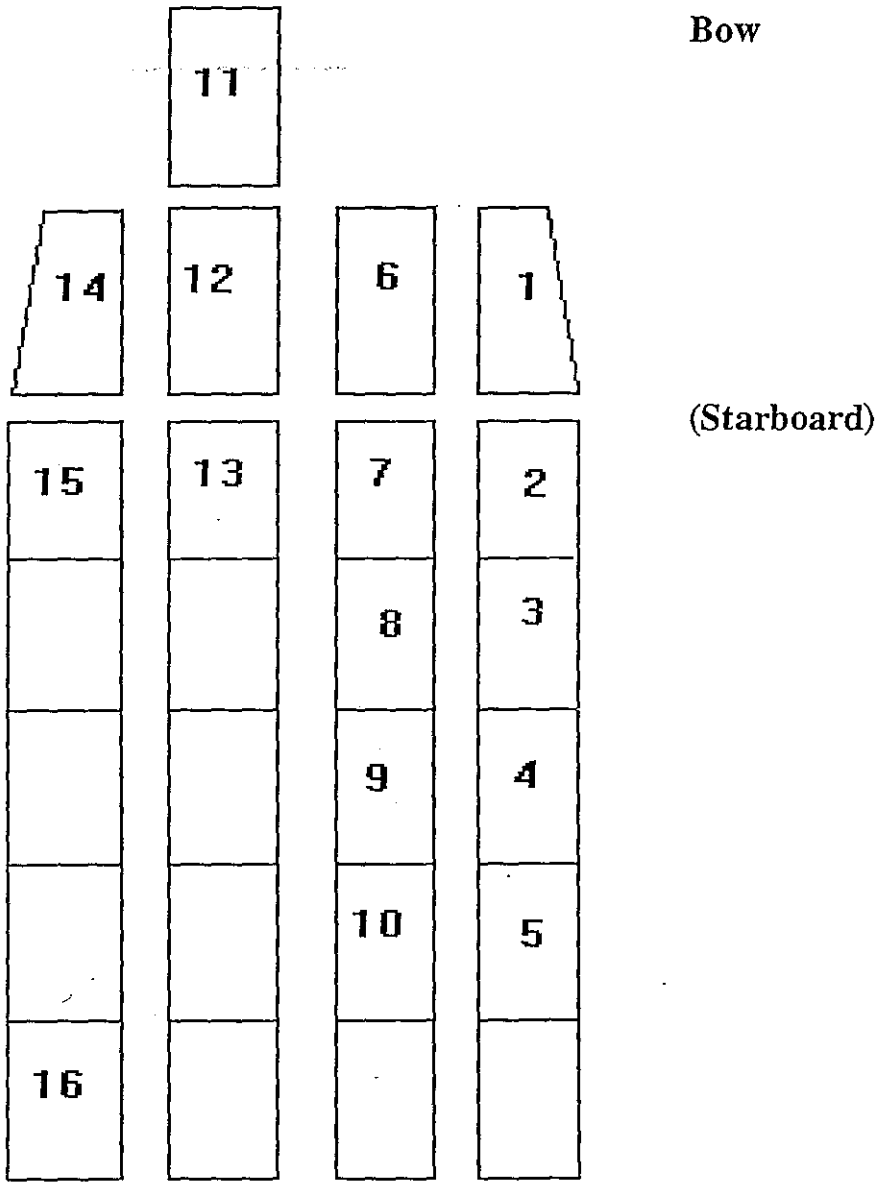
This is singled out simply because it is ill-defined. While the domestication period may be important (as outlined above), the domestication process needs to be examined. Most feral goats are confined to a feedlot for varying lengths of time, and provided with feed and water. Some drafting and handling for medication or other treatment such as horn tipping may occur. However, domestication implies a process of adapting to new circumstances and conditions, rather than a passive enclosure. Many workers emphasize the complexity of this process, and that factors within and beyond the animal interact. Ability to adapt is observed to be greater in younger animals than older ones, and the configuration of the confinement is important. While it is not appropriate to go into detail, it needs to be emphasized that the domestication process *per se* requires further investigation. The greater adaptability of younger animals may be associated with their higher survival rates.

5.2.2.6 Location on ship: Where bucks were transported on exposed decks (on voyages to the Middle East), more deaths occurred in outside pens. Deaths were highest in pens with a northerly aspect during the voyage. The diagram following (Figure 5.1) shows the pen layout on one vessel, the location of goats, and the pens with highest death rates during a voyage to the Middle East. This finding, of highest deaths occurring in outer pens, was observed on both voyages to the Middle East.

[1] Bacteriology samples could not be taken from goats which died on board ship, because of the delay in getting samples back to Australia, and the Australian Quarantine restrictions on biological material.

Figure 5.1

Location of goats on an exposed deck during transport from Fremantle to the Middle East.



Numbered pens contained goats. Shaded pens had greater than 2% deaths.

Location of pens was not observed to contribute to death rates when goats were transported on enclosed decks, which was the case for voyages to South East Asia. Movement of goats between pens on all voyages makes interpretation of this finding difficult.

Other ship-board factors were associated with losses where goats were transported on enclosed decks.

5.2.2.7 Other ship-board factors:

Masters' Reports (Appendix 1) indicate that there are differences in death rates between voyages. The factors involved in these differences are likely to be complex, involving mechanical factors as well as biological ones. Some factors which emerged were:

- On some voyages it was observed that the concentration of waste gases, particularly ammonia and suspended dust particles, was sufficiently strong to make working amongst the pens unpleasant. Workers complained of stinging eyes, painful noses, and difficulty breathing, making working in the area possible for only short periods. Objective measurement of ammonia levels was conducted on one voyage only, and found to reach 30ppm, a level recognized to produce irritation.

- The crew on some vessels reported that when stock on enclosed decks became sick during a voyage, they frequently recovered when placed on an open deck, suggesting that in pens below deck, conditions may be detrimental to recovery once an animal become ill.

- Space available on ships for goats appeared adequate, and usually greater than the minimum recommended by AQIS. However there was a significant relationship between increasing space available, and deaths. In other words, where there was more space per goat, more deaths occurred. This incongruous finding may be related to buck behaviour, in that more space allowed more vigorous butting activity, leading to dominant bucks alienating less dominant bucks from feed and water. While this situation requires further investigation, solutions are not always practical - castration would render the bucks unsaleable in many markets, and the use of chemical castration (e.g. Vaxstrate) requires considerable time before changes in behaviour result.

- Water availability varied. While stock crews made every effort to ensure water was freely available, most troughs in goat pens had to be cleaned and filled by hand. This meant that these activities were done a limited number of times each day, with cleaning restricted to once a day. Troughs quickly became contaminated with faeces, and progressively less palatable to goats. Faecal contamination of water (and feed) is a fundamental means of spread of enteric and other infections. It is unlikely that the full impact of the spread of pathogens by this means would be felt during a short voyage (about 10 days), and illness would continue to be expressed in the period following disembarkation.

5.2.2.8 Specific diseases and conditions: As listed above, some specific diseases or disease agents were identified repeatedly with deaths in goats. In particular, these were *Salmonella* spp. (Table 5.2), inanition, pneumonia, and coccidiosis accounting for over half of the

deaths. Enterotoxaemia ("Pulpy Kidney") accounted for only 3.3% of deaths. No diagnosis could be reached on 11.2% of goats, and a further 5.4% were too decomposed for evaluation.

Table 5.2: Serotypes of *Salmonella* isolated from goats.

Salmonella Serotype	Total
adelaide	27
typhimurium	14
bovis-morbificans	10
muenchen	9
anatum	6
fremantle	6
chester	2
give	2
havana	2
singapore	2
St Paul	2
newport	1
onderstepoort	1
Grand Total	84

As would be expected, many serotypes of *Salmonella* were isolated (see Table 5.2), but the predominant ones were *adelaide*, *typhimurium*, and *bovis-morbificans*. These serotypes are frequently associated with illness in domestic animals, and their presence in the goats, coupled with lesions in internal organs detected through histology, indicate that they have been a significant influence on the disease process leading to the animal's death. As mentioned above, deaths from *Salmonella* related conditions were more common in goats which had been in feedlots for longer periods. It was also noted that the rate of excretion of *Salmonella* in the faeces of goats during domestication could increase dramatically in a very short time: from 7% on first sampling, to 30% when sampling 5 days later.

Coccidia caused deaths through acute enteritis, and in association with other diseases. Goats dying from coccidiosis were generally those in feedlots: 17% of feedlot deaths were the result of coccidiosis, compared to 3% of ship-board deaths. Outbreaks were curtailed by appropriate medication.

Although enterotoxaemia (pulpy kidney) was observed as a discrete entity on some occasions, this condition was not a major cause of deaths.

It is important to note that the pattern of diseases seen differed between feedlotting, on board ship, and in the quarantine feedlot. While enteric disease remained the most frequent diagnosis in all three periods, respiratory disease, which was low in the feedlot, is the second most frequently diagnosed cause of death on board ship, and in quarantine. This may be associated with the elevated ammonia levels discussed previously, and the result of airborne

pathogens which may concentrate in the pen situation, being more readily spread between goats in close confinement. Inanition as a major cause of death appears to diminish during shipping, but is important during feedlotting prior to and subsequent to a voyage. In each case, goats are subjected to significant changes in diet, and following the voyage, the change is very sudden. Changing diets of goats may reasonably be expected to result in rejection of feed, particularly by older stock. Where a feed is not composed of suitable components, or in the correct proportions, rejection following an episode of acidosis is likely. However, other conditions in the quarantine feedlot may also contribute to inanition, and are discussed elsewhere.

Table 5.3 Causes of Deaths of goats in Feedlot or Pre-embarkation trials

Disease	Number	Percentage
Salmonellosis	27	38
Inanition	21	30
Coccidiosis	12	17
Abomasal phytobezoars & ulceration	4	6
Enterotoxaemia	3	4
Pneumonia	2	3
Rumenitis	1	1
liver Abscess	1	1
Total	71	100

Table 5.4 : Causes of Ship-board deaths

Cause of Death	Number	Percentage
Enteric disease	40	42
Respiratory disease	25	26
Abomasal Ulceration	9	9
Septicaemia	7	7
Enterotoxaemia	4	4
Inanition	4	4
Coccidiosis	3	3
Cardiomyopathy	2	2
Peritonitis	1	1
Liver Abscess	1	1
Trauma	1	1
Total	97	100

5.3 DISCUSSION

When investigating causes of deaths in export animals, each shipment is an independent event, with associated events in the past history of the goats having some relationship to the outcome of a shipment, but also some inter-relationship with other shipments. While it may be possible to link immediately preceding events to a single shipment, finding a common thread across several shipments is a complex task, requiring very large numbers of animals and shipments, and a protracted time period. The work conducted in sheep since the early 1980's has started to unlock the situation in live sheep exports, with the uncovering of seasonal metabolic variations which profoundly influence the ability of sheep to survive the export process. The research reported here has identified many important factors associated with deaths in the live goat export process, but should not be considered definitive.

It should be readily apparent that the complexity of the issues encountered requires further research and elucidation, before the antecedents of death in export goats can be fully appreciated. In this study, it was rarely possible to assign an appropriate level of statistical significance to a finding, because of small numbers, even though the biological linkages were apparent, or had been previously described. Many of these limitations are a feature of research in commercial conditions, where practicality or economic reality results in the curtailing of neat scientific procedures.

However, when the results from this research are combined with the known behaviour of diseases, practical animal management and husbandry, and new or innovative technologies, some very definite and practical recommendations to industry are possible.

Detailed technical reports of the seven study voyages are included in Appendices 6.1 to 6.7.

6. MODIFYING THE BEHAVIOUR OF BUCKS USING VAXSTRATE®

6.1 Need for modifying behaviour in bucks

Aggressive behaviour in bucks has been associated with physical injuries during transport, feedlotting and shipping. .Injuries sustained on these occasions may contribute to deaths, reduce the value of animals through visible blemishes, and pose a welfare problem. Aggressive behaviour in bucks increases when crowding, mixing of mobs, or limiting of feed occurs, as in the feedlotting and shipping situations. For these reasons, reduction in this behaviour is desirable.

6.2 Need for non-traditional means of behaviour control

Male sexual and aggressive behaviour is produced by the influence of testosterone on the central nervous system. Reduction of this behaviour in livestock has been managed by castration, and is highly effective. However, in the case of goats for export, castration is either impractical due to time constraints, or undesirable, because importers require entire animals for cultural or religious reasons. Testosterone production may be lowered in other ways, and an effective method has been to immunize against the compounds released by the brain (i.e.. gonadotrophin releasing hormone, GnRH) which stimulate the production of testosterone. Vaxstrate® (Arthur Webster Pty Ltd, Castle Hill NSW) is a vaccine with this action.

6.3 Immunological control of behaviour

Vaxstrate is generally used on beef cattle or ram lambs, but its value had not been investigated in goats. Mature feral bucks were given Vaxstrate twice, either two or four weeks apart, and compared with normal bucks, and bucks castrated at the same time.

Both vaccination regimes were successful in reducing testosterone production, and male sexual/aggressive behaviour. However, the effect was not as profound as that from castration. Further, testosterone levels did not decline for some two to three weeks after vaccination. Aggressive behaviour was not measured until 9 weeks after vaccination, by which time a significant reduction had occurred.

While this technique has potential in the preparation of farmed bucks for export, the time required for the reduction of aggressive behaviour is too long to be of value in the export of feral bucks.

Further details are available in Appendix 4.

7. NUTRITIONAL REQUIREMENTS OF GOATS

7.1 Requirements for maintenance and growth in bucks during the export process

Determination of nutritional requirements of goats during capture, feedlotting and shipping has been a matter of extrapolation from other livestock, such as sheep or cattle, and precise details of requirements for most dietary requirements are unknown. However, work with sheep has indicated that maintenance requirements increase sharply, by 35%, under shipping conditions.

7.1.1 Reasons for investigating feed requirements

Many of the goats which die are in low body condition, despite having access to what appears to be adequate feed. It was therefore important to determine the maintenance and growth requirements of goats of varying bodyweights.

7.1.2 Simulated feedlot and ship-board studies

After domestication for 7 days, goats were grouped into small, medium or heavy groups, and provided with a range of feeding levels. Conditions simulated a feedlot, and after 27 days in the feedlot, goats were transported to a simulated shipping facility. Feed intake was measured daily, and goats were weighed and body scored weekly. Determining which goats were eating was done using dyed pellets (Appendix 5.4).

All goats lost weight during the simulated feedlot period, but gained weight following transfer to the simulated ship. Loss of weight was not related to the amount of feed available. However, amount of feed available did affect weight gains, with greater gains associated with more available feed. This relationship was consistent across all liveweight groups.

The complicating factors in this experiment were water quality, and pellet composition. Water for the simulated feedlot was from a dam, and may not have been of sufficiently high quality for the goats, effectively limiting water intake, and as a consequence, pellet intake as well. Digestive disturbances associated with adaptation to pellets was detected during the feedlot period. The pellet formulation was developed for sheep and may not have contained adequate roughage for goats.

It is regrettable, but this study did not contribute to the understanding of the maintenance requirements for goats, and further studies are necessary.

Details of this work may be found in Appendix 2.

7.2 Goat diets and fibre requirements

7.2.1 Fibre requirements

A "desktop" study was conducted into the fibre requirements of goats. It has long been recognized that goats under range conditions choose a higher fibre diet than sheep, although this requirement had not been widely considered in the preparation of pelleted diets for feedlot and shipping. Literature on goat nutrition was compiled, and a revised pellet ration devised, using lupin straw to increase the roughage content and particle size of pellets. Protein levels were maintained around 14% to minimise the excretion of urea in pens on board ship, thus limiting the production of ammonia from bacterial breakdown. Virginiamycin (a compound derived from *Streptomyces virgineae*, which disrupts the metabolism of Gram positive bacteria, thereby minimizing the risk of rumen acidosis) was incorporated at the rate of 2%. The pellet composition was devised with the kind assistance of Park Feeds, Dalwallinu, who regularly supply pellet feed for livestock export shipments. The assistance and co-operation of Park Feeds is gratefully acknowledged.

7.2.2 Results

Fibre requirement of goats was considered to be in excess of 20% acid digestible fibre, which is higher than that required for sheep, and hence pellets incorporating lupin straw were produced for two voyages. In addition virginiamycin was incorporated at the rate of 2% to restrict Gram positive bacterial growth and hence pH imbalance which may be associated with acidosis and the establishment of *Salmonella* in the gut.

Palatability of the pellets was high, and goats adapted to them without apparent difficulty.

7.2.3 Pellet composition

Composition of pellets for recent voyages were as follows:

Pellets Voyage to South East Asia, November 1994
Moisture 10.2%
Acid detergent fibre 24.2%
Digestible dry matter 72.4%
Est. ME ruminants 10.4 MJ/kg DM
Crude protein 14.4%

Pellets Voyage to South East Asia, June 1995
Moisture 10.3%
Acid detergent fibre 23.4%
Digestible dry matter 73.1%
Est. ME ruminants 10.5 MJ/kg DM
Crude protein 14.3%

Pellets Voyage to South East Asia, September 1995
Moisture 8.7%
Acid detergent fibre 21.9%
Digestible dry matter 73.5%
Est ME ruminants 10.6 MJ/kg DM
Crude protein 13.6%

Appendix 3 compiles the information on fibre requirements for goats.

8. SERVICING THE MARKETS: Deaths in quarantine in Malaysia

8.1 Market Research in Malaysia

Following studies on two shipments of feral goats to Malaysia, reports were received that high percentages of goats were dying during disembarkation, and during the required quarantine period of 10 days. Figures in excess of deaths recorded during voyages were reported. Such reports are damaging to our markets, and lead to downward pressure on prices for Australian goats by overseas importers.

In December 1994, a meeting with Malaysian feedlot managers was held in Perth. Managers confirmed that deaths of 5% to 20% were common, and represented a substantial financial loss, as well as arousing welfare concerns for the goats. Feedlot managers were unable to predict the magnitude of losses beforehand, and could offer no solutions to either preventing deaths, or stopping the occurrences once deaths had started.

It was seen as critical to address the situation with a preliminary investigation in Malaysian feedlots.

It was then arranged for the veterinarian accompanying shipments to Malaysia to continue investigations in a feedlot after arrival, thereby quantifying the size of the losses, and determining the causes of death.

8.2 Activities in Malaysia

For the voyages of June and September 1995, autopsies were conducted on goats dying in quarantine in Malaysia. Methods were as described for ship-board procedures, and where possible, liveweight of study group goats was obtained towards the end of the quarantine period. Because of Australian quarantine restrictions, fresh tissue samples for bacteriology and *Salmonella* isolation were processed by the Veterinary School at the Agricultural University of Malaysia, Selangor. *Salmonella* typing was performed by the Malaysian National Reference Laboratory, Ipoh.

8.3 Causes of deaths of goats during quarantine

Deaths from Salmonellosis and Pasteurellosis, or other related diseases (usually pneumonia) accounted for about 60% of all feedlot deaths in Malaysia. Inanition as seen by empty gastro-intestinal tracts, retained dye in the rumen from feeding up to two weeks previously, or severe diffuse fatty changes in the liver, accounted for 24% of deaths (Table 8.1).

Trauma, which was severe enough to be the cause of death in one goat in the feedlot, underestimates the aggressive behaviour of the goats. Many goats showed bruising of the

thoracic wall or flank and fractured ribs. The continued stress associated with continual aggressive behaviour is likely to be expressed in the longer term by abomasal ulceration.

As with shipping deaths, older goats (6 or 8 adult incisors) were over-represented amongst the goats which died in the quarantine feedlot.

Table 8.1 : Causes of death in the Malaysian Feedlot (cases in which a diagnosis was made)

Cause of Death	Number	Percentage
Enteric disease	11	31%
Respiratory disease	8	24 %
Inanition	8	24 %
Septicaemia	2	6 %
Abomasal Ulceration	2	6 %
Coccidiosis	1	3 %
Cardiomyopathy	1	3 %
Trauma	1	3 %
Total	34	100%

8.4 Feedlot management

Water quality and quantity was reported to be a concern in the quarantine feedlot. Access to water was limited by the location, size, and times of filling of small (60L) troughs, which were provided at the rate of one per 100 goats. Quality of the water was reported by feedlot owners to be poor, based on high coliform counts. Water was pumped to holding tanks from a dam which collected runoff from other animal enterprises on the property, including a cattle feedlot, and sheep grazing areas. The nutrient load of the water was unknown, but runoff from a commercial turf enterprise was also collected by the dam.

Goats were placed in large pens with slatted floors, which had sufficient feed trough length to allow access for all goats. However, the trough was close to floor level, with faecal contamination prompt and frequent. On entry to the feedlot, goats faced a sudden change of feed from the ship-board diet to a pellet diet based on wheat, or palm kernel meal. Because of previous experience with acidosis in goats on these rations, quantities provided were small, and estimates based on numbers of bags fed suggest that maintenance quantities were not being provided. Some access to grazing was provided, although this was infrequent, and again, water was limiting.

Because goats were of mixed ages and sizes, dominance behaviour was common, leading to injuries, and restriction of access to feed/water to the dominant bucks. The space available in quarantine pens was sufficient to allow a space to be cleared in the pen, in which contesting goats could fight undisturbed. Because the pens allowed free movement of goats throughout, dominance contests could not be avoided if one goat attempted to get away. Dominance contests would continue throughout the day, with only short breaks. Goats involved in extended dominance contests would often be found dead subsequently.

Observation in the feedlot in the early morning before sunrise, or after dusk, revealed large numbers of rats which consumed and contaminated feed. However, while rat contamination may have reduced the palatability of feed, diseases associated with rats, such as leptospirosis, were not evident in the goats.

8.5 Discussion

While conditions in the feedlot and husbandry practices were inadequate in some instances, deaths in goats were principally a continuation of those found on board ship. That is, the causes of death in the quarantine feedlot may be reasonably attributed to the underlying condition of the goats themselves, and by inference, on the Australian product.

Trauma resulting from dominance behaviour was noted to increase in the quarantine feedlot. The earlier finding that deaths increased as space per goat increased may be pertinent here, because the quarantine facility offered very spacious conditions, so that a fighting area could be formed in a pen, and butting episodes continue for protracted intervals.

High death rates among aged goats is a consistent finding throughout the export process. It may be appropriate to exclude such goats from export shipments.

Evidence that about a quarter of all deaths may be attributed to inanition is consistent with the findings that only about 65-75% of goats are eating at the time of testing in the feedlot, or on board ship. An option for managers at quarantine feedlots would be to separate out non-feeders for closer attention.

A number of simple preventative measures may be applicable to the situation. These include:

- Excluding older bucks from the export process;
- Keep age and size groups distinct;
- Identify non-feeders, and separate them for closer attention;
- Identify and remove aggressive, dominant bucks to a separate area;
- Move feed troughs so that they are above faecal contamination level;
- Provide potable water in a constant supply system, through long troughs;
- Tailor the pellet mix as closely to the ship-board diet as practical, or revert totally to a hay-based diet for the feedlot period (although this would only postpone the problem);
- Control rats (i.e. feral animals and vermin) in the feedlot;
- Allow access to grazing on a regular basis, and ensure water availability.

8.6 Acknowledgments

The kind assistance of the Veterinary School at the Agricultural University of Malaysia, Selangor, is gratefully acknowledged.

9. TOWARDS AN APPROPRIATE DOMESTICATION PERIOD

As alluded to earlier, adherence to a 21 day domestication period, with a 5 day period of conditioning goats to a shipping diet, may not always be practical when faced with the commercial realities of the shipping trade. For example, if a ship is to be loaded earlier than its forecast date, then procedures at a feedlot may be curtailed. Conversely, if a ship is delayed, the duration of feedlotting will be extended, with attendant costs and ramifications. Added to this, the very nature of the feral goat harvesting process adds an element of uncertainty to the ability to supply exact numbers of goats for domestication by the required shipping date. The seasonality of goat harvesting also complicates the picture. Producers, particularly feedlotters, have indicated that goats readily adapt to feedlot conditions when appropriately segregated (i.e.. draft off does and kids from bucks), and that this adaptation occurs within a few days for most animals.

In the studies reported here, attempts to conduct adequate cohort studies have met with limited success, because of generally small shipment sizes, and small numbers of deaths in cohorts. On the other hand, case-control (i.e.. retrospective) studies have been able to associate death rates with domestication period. There is very strong indication that death rates increase linearly with time in the feedlot, and that other factors, such as age, while playing an important role, are not substantially influencing this finding.

Other factors unrelated to domestication period *per se* appear to be biologically and statistically associated with deaths. In particular, old goats, thin goats, and goats with underlying illnesses represent the groups most likely to die.

Analysis of causes of death have identified salmonellosis as the most common cause, followed by inanition. This pattern was evident in feedlots before embarkation, but the role of inanition was much decreased during shipping, with respiratory disease being the second most frequent cause of death at this time. It is important to note that salmonellosis has also been identified as the major cause of death in sheep exported live by sea. It should be noted that sheep are not required to spend any fixed time in feedlots prior to shipping. Work with sheep found that inanition was the main cause of loss in sheep during shipping, which is contrary to the finding in goats during this study. It is also important to note that in sheep, excretion of *Salmonella* was nil or low on entry to feedlots, but increased with time in feedlots. These workers also demonstrated that sheep which did not eat in the feedlot before shipping had a high risk of developing salmonellosis during shipping. The picture is comparable to that in goats: the longer the confinement, the more animals will shed *Salmonella* organisms, and the more environmental contamination there will be. Goats which do not eat are at a high risk of developing salmonellosis. Other studies have

demonstrated that most sheep which do not eat in the feedlot will eat during shipping[2] and need not be excluded from export. The low percentage of goat deaths due to inanition on board ship (4%) parallels this finding.

The increased importance of respiratory disease as a cause of death on board ship is important to note, and requires further investigation. Specific factors surrounding this finding have not been identified, but inadequate movement of air, and the build up of ammonia are suspected. These issues require addressing separately, and the domestication period is unlikely to contribute to their occurrence, except where Salmonella and other enteric organisms contribute to lung disease.

The preparation of goats during domestication needs to address these issues. The implications for domestication are as follows:

- Enteric disease will be minimized by feedlot hygiene - isolation of feed and water from soil and faecal contamination reduces spread of enteric pathogens;
- Extending the time in feedlots will increase the spread of *Salmonella* and other pathogenic organisms;
- Curtailing time in feedlots may reduce the adaptation to ship-board diets, increasing the risk of inanition and hence salmonellosis;
- Non-feeders or shy feeders in the feedlot probably commence eating on board ship;
- The most appropriate domestication period is less than 14 days, but longer than 5 days.

This study, and the available literature provide no support for a long domestication period. In fact, the weight of evidence is to the contrary: the shorter the domestication period the better. It is regrettable that a definitive length of domestication period cannot be determined from this study, but interpolation of the results, along with published literature, provide some guidelines. By 14 days after entry to a feedlot, excretion of *Salmonella* may exceed 80% of goats, having risen from very low levels. This suggests that by 14 days, environmental contamination is profound, and the risks to animals likewise. Confinement for this period is clearly too long. However, in the present study, more goats which were domesticated for approximately 5 days were observed to be non-feeders than goats domesticated for longer periods, although the domestication *process* may have been inadequate in this case (see Appendix 6.4).

Although more work is required, the implications are that 5 days may be too short, and 14 days are too long. **Until further studies are available to define this period more closely,**

[2] Norris RT, McDonald CL, Richards RB, Hyder MW, Gittins SP, and Norman GJ (1990) Management of inappetent sheep during export by sea. Australian Veterinary Journal 67: 244-247.

it is recommended that the domestication period be not more than 10 days, and not less than 7 days.

It is further recommended that the domestication period be used to facilitate the domestication ***process***, with producers adopting a strategy which actively quietness, and conditions the goats to human contact and handling, in association with strategies to reduce environmental contamination with enteric pathogens, particularly *Salmonella.* This requires the implementation of a Quality Assurance Program based on feedlot hygiene, and animal behaviour modification activities aimed at the outcome of goats adapted to human contact and, ship-board diets and conditions.

10. ACHIEVEMENT OF RESEARCH OBJECTIVES

The research program reported here must be considered a fact-finding mission, not a definitive investigation into the complexities surrounding deaths in feral goats during the mullet-staged process of export. As such, the results have demonstrated adequately that there are factors unique to goats which must be specifically addressed, as well as factors common to other livestock industries which cannot be overlooked. The program has highlighted the following important points, and where further research is required, this is indicated.

10.1 . Goat factors:

- Feral goats are essentially healthy at the point of capture;
- Feral goats may be carrying disease agents at low levels, which amplify during the export process;
- Aggressive behaviour of bucks causes injury and death, and may contribute to the inanition syndrome;
- Aggressive behaviour is directly related to the space available per goat;
- Aggressive behaviour of bucks can be modified in a manner acceptable to the markets, although further work is required on this;
- Older bucks adapt less well to the domestication process, and are more likely to die than younger stock.

10.2 Dietary factors:

- Nutritional requirements of goats are different from sheep, in relation to fibre content of pellets, and further work is required to determine the optimum pellet composition;
- Changes in diet of goats, sudden or otherwise, result in a proportion of goats which will not eat, leading to inanition. Appropriate methods of introduction of goats to a pellet diet are required;
- Water supply, in terms of quality, quantity and placement may influence feed intake, and therefore performance. A definition of potability for goats is required.

10.3 Feedlot factors:

Conditions in feedlots, and the stresses associated with domestication, allow the amplification of pathogens present in goats at the time of capture, or resident in the feedlot leading to infectious diseases.

Some infectious diseases, such as coccidiosis and helminthoses are simply dealt with. However, the control of salmonellosis requires further investigation.

10.4 Domestication

- Domestication needs to be considered as a *process*, not simply a confinement of goats prior to export;
- Long domestication periods aggravate the damage done by infectious diseases.
- Short domestication periods reduce the adaptation of goats to pellet diets;
- An appropriate domestication period is in the range of 7 to 10 days, in order to minimise deaths during shipping. Further work is required to define the domestication process.

10.5 Shipping factors:

- Infectious diseases continue as a major cause of death during shipping, but respiratory illness is much more apparent during this stage. More work is required.
- Configuration of a ship may be important, with protection of goats from environmental conditions a consideration;
- Longer voyages produce more deaths, but not a greater daily death rate;
- Water supply on ships may limit performance, and warrants further investigation;
- Methods of confinement of goats on board ship needs to be researched, to minimise escape and the expression of aggressive behaviour.

10.6 Destination factors:

- The sudden change in diet at the destination quarantine feedlot is detrimental to goat performance;
- Water quality and supply needs to be adequate;
- Feeding regimes should be consistent with those on board ship;
- Husbandry techniques need to be of a high standard;
- Feral animals (rats, birds), may introduce infectious diseases, consume and contaminate feed, thereby reducing the performance of goats; and
- Causes of death in quarantine feedlots in large part are a carry over of illnesses and problems in earlier parts of the export process (i.e. feedlotting and shipping).

More work is required to enhance survival of Australian goats once they arrive in importing countries. Performance during quarantine will be improved by the improvement of goat management at other stages of the export process. It remains important to pursue this aspect of the export process, because as long as there are deaths in Australian goats following importation, the reputation and credibility of Australia as a supplier of quality stock, remains tarnished.

The determination of these factors has provided a clearer understanding of the reasons behind deaths in goats during export by sea, and offers a basis for recommending modifications to current practices, and provides an indication for further work.

11. IMPACT ON THE MEAT AND LIVESTOCK INDUSTRIES

The results of this research will have limited effect on the meat and livestock industries, unless the information is distributed, and where practical, adopted. Its value will be further restricted if the findings here; many of which have only been investigated in an embryonic manner, are allowed to remain incompletely researched. Follow up is imperative.

However, there are a number of findings of immediate value to the meat and livestock industries. Most are highly practical, although not without cost. These findings are those relating to husbandry of the goats, the prevention of infectious diseases, and the appropriate preparation of goats for export.

11.1 Husbandry

The conditions for satisfactory husbandry will vary, and skills in this area will need to be developed across the industry. Experience with other species of stock is helpful, but not sufficient. An understanding of the effects of space restriction on goats is paramount: where goats are confined sufficiently closely to minimise damage from aggression, injuries will be reduced. Where sufficient space is provided to allow for escape of a buck from aggressive conflict, injuries will also be reduced. However, if space is such that aggressive encounters can be vigorous, without adequate room for escape, injuries will be severe, and dominance related deaths continue to occur. Further work is required to establish appropriate space requirements for goats. Until such details are known, it may be appropriate to draft and maintain goats in age and size groups, to limit injuries from this source.

Drafting of goats into groups of comparable body size may minimise the effects of dominance, by removing small animals from the most aggressive group. At this stage, the use of Vaxstrate is not appropriate because of the time required to achieve a suitable response. However, further work along these lines may provide a quick, efficient means of behaviour control, without loss of value to the export market.

Being pro-active in the feedlot, by appropriate handling, drafting, and training of goats would facilitate the domestication process. Reducing the flight distance and alarm response, and ensuring that goats are accustomed to handling are important. Careful introduction of goats to pellet feeds, so that acidosis is avoided, could pay large dividends; alternately, the routine use of virginiamycin at a rate of 2% in pellet formulations may facilitate transition from roughage to pellets. However, at the time of writing virginiamycin is only registered for use in cattle diets, and its use in goat pellet formulations requires further investigation.

11.2 Preventing infectious diseases

Most infectious diseases seen throughout this research can be prevented by fairly simple means. Coccidia can be limited by suitable coccidiostats; *Salmonella* by strict hygiene; intestinal nematodes by anthelmintics and hygiene. It would be unwise to recommend blanket treatment for these diseases, because of the variability expected between goats based on source, and time of year. Goats from each source are likely to have a limited but consistent range of conditions which are open to manipulation, and appropriate treatment at the mustering point offers a means of alleviating illnesses later in the export process. It is in the interests of suppliers to ensure the quality and survival of their product.

An appropriate screening program on entry to feedlots would also offer a cost effective means of addressing the health needs of particular batches of goats. For a given batch of goats, infections may be from two main sources - the goats themselves bringing disease agents into the feedlot, or the disease agent is already in the feedlot, through contamination from previous groups, or in animals (sheep, goats, cattle etc.) which may also occupy or pass through holding facilities. Spread is predominantly through contaminated feed and water, offering the possibility of reduced transmission. By ensuring all feed is isolated from the ground, that all water is from troughs and faecal contamination is minimal, transmission of these diseases will be curtailed. Feedlot hygiene on top of appropriate pre-feedlot treatment should reduce the spread of infectious diseases. The adoption of such hygiene measures throughout the entire export process would be essential. At this stage, development of vaccines for *Salmonella* is not warranted, because of the generally poor response to *Salmonella* vaccines, the variability in serotypes encountered, and the practicalities of control by hygiene.

11.3 Preparation for export

There are a number of requirements in preparing goats for export. These relate to ensuring that an animal is physiologically (and psychologically) prepared for what lies ahead. Husbandry skills also apply to this process.

As alluded to earlier, adaptability to new environments decreases with age, and the effect of this was seen in the higher death rates in older bucks. Therefore, it would be appropriate to select only younger bucks, such as those with 6 or fewer adult incisors. Selecting only those bucks which are actually eating the pellet diet would enhance survival. Selecting bucks with adequate body reserves (e.g. score 3 and above) would allow some room to move, if the stresses of export result in reduced feed intake. Drafting bucks into groups based on size would tend to reduce damage from aggression.

11.4 After sales service

A continued interest in the performance of Australian goats in the destination countries is essential for the ongoing health of these markets. Market research suggests that there is a bigger demand for goats than currently supplied, and if the markets are going to be effectively tapped and maintained, the quality of the product will need to be addressed. Research into the desired product and its uses would allow for the continued development and expansion of these markets.

12. CONCLUSIONS AND RECOMMENDATIONS

12.1 Conclusions

In its simplest form, the conclusions from this research may be summarized as follows.

> *During export by sea, goats die from a variety of causes, related to the spread of infectious diseases, and the failure to adapt satisfactorily to domestication and a pellet diet. Feral goats are generally healthy at the point of harvest, but the domestication process as it is currently applied facilitates the spread of disease agents, notably Salmonella. The domestication process, largely passive, does not sufficiently equip goats to withstand the stresses of export, nor ensure that all goats are consuming sufficient of a pellet diet for maintenance. The time taken to domesticate goats should be between 7 and 10 days. Adaptation is least in older goats, and deaths are concentrated in this group.*

12.2 Recommendations

Most of the recommendations from this research have been discussed throughout the report, and it is unnecessary to go through them in detail again. In summary form, the recommendations are:

12.2.1 For immediate consideration

12.2.1.1 Activities at the Feedlot

- Exclude old bucks (i.e.. those with 8 adult incisors or older) from export;
- Draft bucks into age/size groups;
- Identify non-feeders, or shy feeders, and separate them for closer attention;
- Exclude very thin goats (low body score 1) from export;
- Remove aggressive, dominant bucks to a separate area;
- Ensure feed remains fresh, by preventing faecal contamination;
- Provide a constant supply of fresh water also preventing faecal contamination;
- Maintain hygiene in feedlots, to minimise the spread of infectious disease agents (pathogens);
- Ensure that the domestication process results in a reduced alarm response, reduced flight distance, acceptance of contact/handling by people, and appropriate adaptation to pellet diets;
- Keep the domestication period short (7-10 days), to minimise spread of pathogens; and
- Ensure that feed, including pellets, conforms to the nutritional requirements of goats.

12.2.1.2 Ship-board conditions

- Maintain goats in appropriate groupings, as above;
- Ensure water supply is constant and fresh, as above;
- Ensure adequate air exchange in pens, to minimise concentration of waste gases (ammonia) and pathogens; and
- Where goats are transported on exposed decks, appropriate protection from the elements (sun, rain etc.) should be considered.

12.2.1.3 In destination feedlots

Most recommendations for pre-embarkation feedlots, and ship-board conditions apply here. Further evaluation of the situation in destination feedlots is warranted, and discussion with managers of quarantine feedlots to determine the practicalities of these recommendations under local conditions is necessary.

12.2.2 Recommendations for further studies

- Confirmation by industry of 7-10 days as the appropriate domestication period is needed;
- A working definition of the domestication *process* is required;
- Work on the most appropriate pellet formulation is required;
- Energy requirements of goats during shipping needs to be determined;
- Continued investigations into behaviour modification in bucks is warranted;
- The evaluation of innovative means (e.g. enzymatic breakdown) of reducing ammonia on board ship may be beneficial;
- Co-operative research into the ongoing poor performance of goats following disembarkation is essential for the preservation and development of the export industry.

12.3 A protocol for the domestication and preparation of feral goats for live export

A draft code of practice, developed by members of the goat industry, with assistance from the Meat Research Corporation, was produced following the TTAG meeting held at Agriculture Western Australia, in September 1994. The draft code is included as Appendix 9.

It is necessary to point out the following about the draft code:

- The code has been developed empirically, and is not based on established scientific fact;
- The code is still in a stage of development, because the industry is likewise still developing;
- The code is a recommendation only, and should not be taken as legally binding;
- The code requires the application of extensive research into the practices mentioned, in order to determine the direction of future drafts of the code.

With these provisos in mind, this research would offer the following towards the modification of that code:

- Twenty-one days domestication period is too long, in that the spread of pathogens is facilitated, and higher death rates are associated with periods longer than 10 days. A period of 7 to 10 days should be sufficient to domesticate the goats and accustom them to shipping rations;
- The definition of domestication already expressed in terms of the desired outcome, needs to be further defined and expanded;
- A suitable domestication *process* should be documented and evaluated;
- Feedlot hygiene must be of the highest standard, including the provision of feed and water in a manner which avoids faecal contamination;
- Feral goats with 8 adult incisors and older should be excluded from export;
- Feral goats in poor condition (low body score 1) should be excluded from export;
- Bucks should be drafted and maintained in groups of comparable body size and age;
- On entry to the domestication facility, bucks should be screened, and treated for infectious conditions in an appropriate manner.

It should be noted that the code only relates to the handling of goats in feedlots prior to shipping. It would be in the interest of the goat industry to extend the code to the transport of goats by sea, and also to produce recommendations for importers to consider, once a shipment arrives in the destination country.

Quality Assurance (QA) and product integrity are now the critical components of any industry - and goats for live export are no exception. As major livestock diseases are eradicated from South America and other locations, new competitors loom large on the horizon. It is in the interests of Australia and Australian goat producers to ensure that the product exported from here is of the highest, most consistent quality possible, and that every consignment meets the standard and requirements of the importing country. The results of three years research reported here provide a solid foundation for such an industry.

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