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Reducing Feedlot Costs by *Pre-*Boosting: A Tool to Improve the Health and Adaptability of Feedlot Cattle

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Reducing Feedlot Costs by *Pre-Boosting*: A Tool to Improve the Health and Adaptability of Feedlot Cattle

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in conjunction with the
Cooperative Research Centre
for the Cattle and Beef Industry

MEAT QUALITY CRC

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Authorship and Acknowledgements

[1]Fell, L.R., [2]Walker, K.H., [2]Reddacliff, L.A. and [3]Davies, L. (1997) Reducing Feedlot Costs by Pre-Boosting: A Tool to Improve the Health and Adaptability of Feedlot Cattle. Final Report - Project DAN.069, Meat Research Corporation, Sydney, NSW, Australia. (May 1997).

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Abstract

Bovine Respiratory Disease (BRD) is known to cause production losses and increased costs in feedlots when feeder steers adapt poorly to their new conditions on arrival at the feedlot. It was hypothesised that better weaning management, together with pre-feedlot vaccination, could contribute to solving this problem.

Some 200 male beef calves (Angus x Hereford and Hereford) were separated from their mothers at 7-9 months of age and allocated to one of three main weaning treatment groups. The groups were matched for liveweight and any negative disease history. The treatments were (1) yard weaning with hay or silage (2) yard weaning with hay or silage plus a novel handling procedure to train the animals to be able to find a grain ration in a trough, (3) paddock weaning without supplement or handling according to common industry practice. Experimental vaccines against the major BRD pathogens were given to half of each group 1-2 months prior to entry into a large commercial feedlot. Performance in the feedlot was monitored up to slaughter after approximately 90 days on feed with extensive serology to monitor disease transmission and detailed clinical and postmortem examination. This experiment was repeated over three production cycles in order to refine the treatments which, collectively, were known as *pre-boosting*.

The *yard-weaned* and *yard-trained* cattle had a significantly higher weight gain in the first month and over the 90-day feeding period than the *paddock-weaned* control groups. There was no difference between the groups in pre-feedlot weight gain. The *yard-trained* groups were not significantly different from *yard-weaned*. The vaccination treatment also significantly improved the weight gain in the first month and over 90 days. The combination of yard weaning and vaccination produced the highest weight gains overall. There was consistently lower morbidity in the *yard-weaned* groups compared to *paddock-weaned* controls. The morbidity in *yard-trained* groups was more variable, but overall it was intermediate compared with these two. Mortalities did not occur in *pre-boosted* cattle in phases 1 and 3, but during an acute IBR episode after 11 weeks on feed in phase 2, the *pre-boosting* treatments were less effective.

A method of weaning in small yards, coupled with the appropriate use of effective BRD vaccines 1–2 months before feedlot entry (i.e. *pre-boosting*) are recommended for feeder steers to minimise sickness and improve productivity in the feedlot. Associated benefits are reduced risks of antibiotic residues or animal welfare problems. This procedure was clearly cost-effective there being an increase in gross margin of up to $33 per head while costs increased by $5-15 per head. Benefits to the beef industry were estimated to be $8 million by 2001.

Executive Summary

This project addressed the problem of respiratory disease in feedlot cattle and the failure of feeder steers to quickly and successfully adapt to the changed conditions they encounter when they enter the feedlot. This is part of a larger issue: the need to meet product quality specifications more reliably and economically without risk of antibiotic residues or the threat of animal welfare concerns.

Previous MRC research (DAN.064) had shown that most clinical respiratory disease occurred in the first 4-6 weeks after arrival at the feedlot and there was huge variation between pens in morbidity and mortality. This suggested that multiple changes during the early weeks of adaptation in the feedlot and the lack of a specific, effective immune response which protected the mixed-source animals against new respiratory infections were the main predisposing reasons for this problem.

The two strategies chosen to investigate and address this problem were (1) better management of feeder steers at the time of weaning and (2) vaccination prior to feedlot entry with new experimental vaccines which protected against the major pathogens implicated in respiratory disease.

Each year, during the autumn of 1993, 1994 and 1995, some 200 male beef calves were separated from their mothers at 7-9 months of age and subjected to various weaning treatments at EMAI. After a further grow-out period of 6-9 months on pasture at EMAI, these steers were transferred to a large commercial feedlot near Quirindi, NSW, where they were fed for about 90 days before slaughter. One to two months before entering the feedlot, selected animals were given specific vaccination treatments also. The combination of the weaning management plus the pre-feedlot vaccination is referred to as ***pre-boosting***.

Prior to feedlot entry, measurements were made of the disease status, weight gain, responses to stress and the behaviour of these cattle. Health, weight gain and behaviour were closely monitored during the feedlot phase in order to determine the effects of the ***pre-boosting*** treatments and gain an understanding of the causal mechanisms involved. Offal and carcases were examined immediately after slaughter for effects of disease and meat quality attributes.

Ultimately, two types of yard weaning treatment were thoroughly tested, with and without the experimental vaccines, so that the most cost-effective combination could be determined. These experimental yard weaning procedures were compared with a control group which was paddock-weaned according to the common industry practice for *Bos taurus* cattle at the present time.

The two types of weaning treatment were: (1) yard weaning for 10 days with good quality hay or silage, but minimal handling of the cattle during this time and (2) the same yard weaning plus a novel handling procedure to train the animals to be able to

find a grain ration in a trough. The groups were known as *yard-weaned*, *yard-trained* and *paddock-weaned* controls.

The vaccination treatments, which were administered at times ranging between 77 and 13 days prior to feedlot entry, consisted of experimental vaccines against Pestivirus, Infectious Bovine Rhinotracheitis virus (IBR), Parainfluenza 3 virus (PI_3) and Pasteurelleae (P. *haemolytica* and P. *multocida*). These were experimental vaccines, not yet commercially available, but they were prototypes of vaccines which are now in an advanced stage of commercial development.

The experimental animals came from two main sources. About 60% were bred at EMAI while the remainder came mostly from one commercial property in the southern highlands of NSW. In the first year some cattle also came from another commercial property in the same area. The majority were Angus x Hereford calves, but there was a significant number of Herefords also and a small number of other crosses. In the feedlot they were placed in a single pen, together with a similar number of comparable commercial-in-contact cattle, which were provided by the feedlot to ensure that a typical behavioural and infectious challenge occurred.

The *yard-weaned* and *yard-trained* cattle had a significantly higher weight gain in the first month and over the 90-day feeding period than the *paddock-weaned* control groups. This difference was small in phases 1 and 2, but was a 21% advantage after 90 days on feed in the third and final phase. There was no difference between the groups in pre-feedlot weight gain. The *yard-trained* groups were not significantly different from *yard-weaned*, indicating that there was no advantage of the additional training to find grain in a trough.

The vaccination treatment also significantly improved the weight gain in the first month and over 90 days. This difference was only about 8% overall, but it was consistent. The combination of yard weaning and vaccination produced the highest weight gains in phases 1 and 3 (the phase 2 data were confounded in this respect and had to be ignored). In phase 3 the *yard-weaned, vaccinated* group was approximately 60% higher in early weight gain than the *paddock-weaned, unvaccinated*, control group, with all the other groups falling in between, but significantly different from either extreme.

The disease patterns observed throughout the project were representative of the patterns seen in other studies (e.g. DAN.064). In each phase there was extensive transmission of Pestivirus and BRSV in the period between induction into the feedlot and the first weighing and sampling at around day 35. Transmission of IBR also occurred during this period in phase 1 and phase 3. Phase 2 was quite different in that there was virtually no IBR transmission up to day 37, but extensive transmission after this, resulting in a severe respiratory disease episode in weeks 11 and 12 with associated mortality. The transmission of PI_3 mostly occurred prior to feedlot entry. As expected, the history of exposure to infection and the previous management experience of the cattle populations were major factors affecting the disease outcomes.

There was consistently lower morbidity in the *yard-weaned* groups compared to *paddock-weaned* controls. The proportion of *yard-weaned* animals pulled because of sickness was 2.0%, 4.1% and 5.9% or less than half that of *paddock-weaned* animals (5.4%, 10.2% and 22.7%) in each of the three phases. The *yard-trained* groups were generally intermediate between these two.

Mortalities did not occur in *pre-boosted* cattle in phases 1 and 3 (there was one only in the *paddock-weaned, unvaccinated* group in phase 1). During the IBR disease episode which occurred in phase 2 after 11 weeks on feed there were some deaths in all groups. Neither yard weaning nor yard training protected against this. The only sub-group in which there were no deaths was the vaccinated group from the EMAI source. This suggests that the *pre-boosting* treatments were more effective against early respiratory disease than they were against an acute IBR episode occurring after a few months on feed.

There were many significant differences between the different sources of commercial-in-contact cattle and between the two sources of experimental cattle. These were interesting and could be related to the prior handling of the cattle in several cases, but being incidental to the design of the experiment, they must be interpreted with some caution.

There were significant treatment effects on the feeding activity of the cattle during the first two weeks in the feedlot. Both *yard-trained* and *yard-weaned* groups adapted to the ration in the feed bunk more quickly than control or commercial-in-contact cattle. There were significant differences in the stress responses of the cattle (measured by cortisol in blood) at different times, but no significant differences between treatment groups.

Behavioural testing of weaner animals during the yard training procedure enabled certain animals (8-17% of the group) to be identified as "shy" or lacking the normal level of confidence when placed in an intensively managed situation. These animals had higher stress responses and performed significantly worse in the feedlot than the remainder of their group in both morbidity and weight gain. This showed that it should be possible to develop a behavioural test to identify the animals which will have most difficulty adapting (and therefore become cost burdens in the feedlot) well before they are purchased for feedlot-finishing. It appeared that these particular animals would perform better in a pasture-finishing situation.

The extensive nature of the results obtained, including the information on stress and behaviour, provided some clues as to the causal mechanism whereby yard weaning and vaccination had these beneficial effects on weight gain and health. The learned feeding behaviour and taming of flighty animals during yard weaning were considered to have played only a minor role, whereas the strengthening of social bonds between animals seemed likely to be a major component of the mechanism whereby yard-weaned animals coped better with adaptation to the feedlot environment. The effect of the *pre-feedlot vaccination* coupled with the better coping ability of *yard-weane*d animals resulted in a lower level of subclinical disease and a better growth rate as a consequence of this.

These findings should impact particularly on the weaning and marketing practices of the Southern beef breeding sector of the industry. Yard weaning is not currently widely practiced and calves are often weaned directly into saleyards where they encounter considerable stress from mixing and handling. An increasing awareness of the value of yard-weaned on-property, feeder steers that can adapt quickly in the feedlot should contribute to the adoption of value-adding practices such as these. Integrating better feeder steer management with the next stage of intensive feedlot finishing forms part of an emerging best practice for quality trading alliances between steer suppliers, feedlotters and the beef-consuming public.

The overall **conclusion** was that the method of weaning beef calves and whether or not they receive pre-feedlot vaccination against respiratory disease can certainly influence the subsequent health and weight gain of these animals in the feedlot. Clearly, a simple method of yard weaning which has been detailed here resulted in better weight gain and reduced incidence of respiratory disease than a fairly typical paddock weaning regime. It was also noted that additional training of calves to eat grain from a trough during weaning did not give a better result than straight yard weaning with hay or silage. A definite benefit in weight gain and respiratory health also resulted from the use of experimental vaccines 1-2 months prior to feedlot entry. The two procedures were synergistic in their effect in that the combination of the two produced the best overall result.

It was also concluded that these treatments would be cost-effective under a range of industry circumstances. Economic analysis showed that, in comparison to the gross margins for control animals, all treatments improved the gross margins per head when compared to the control. The best in terms of the highest improvement in gross margin were the yard-weaned, unvaccinated and the yard-weaned, vaccinated treatments where, using projected income levels and price levels, an improvement of $33 per head was achieved to the feedlot. Farmer costs of $5.50 per head for yard weaning alone or, perhaps $15 with vaccination, must be deducted from the feedlotter benefit because the feedlotters would have to offer a premium of at least this much for the cattle to make it worthwhile.

The economic analysis also showed that, with adequate extension and a positive response from feedlotters to offer premiums for producers to wean their cattle, a benefit to the industry of $8 million could be achieved by the year 2001.

This leads to the following general **recommendation** designed to increase the likelihood of producing feeder steers which adapt well when introduced to the feedlot, are equipped to combat the BRD infectious challenge and can therefore be expected to perform well in terms of both health and weight gain:

1. Use a method of weaning in small yards which has at least the major characteristics of the yard weaning procedure used in this project.

2. Use appropriate vaccines against respiratory disease (when these become commercially available) prior to feedlot entry to ensure that a protective immunity exists on arrival at the feedlot.

Main Research Report

Background and Industry Context

When this project commenced five years ago, the beef feedlot industry in Australia was in a very rapid growth phase that was just beginning to trigger many changes in the cattle supply sector of the beef industry. A critical issue was the ability of feeder steers to adapt quickly and easily to the feedlot without major setbacks in health or weight gain. It was apparent from consultation with feedlot managers and from disease surveillance that many cattle being purchased for the feedlot failed to make a smooth transition to the more intensive system.

An earlier MRC project entitled Diseases of Feedlot Cattle - DAN.064 (Dunn et al 1993) had determined the rate and significance of disease and deaths in feedlot cattle and was examining the infectious causes of Bovine Respiratory Disease (BRD) which had been identified as the major reason for deaths and sickness in the feedlot. It was found that fever at the time of entry to the feedlot and BRD accounted for 66% of all cases of disease. Furthermore 78% of all cases occurred in the first four weeks after arrival at the feedlot with huge variation between pens in morbidity and mortality.

This suggested that multiple changes during the early weeks of adaptation in the feedlot and the lack of an effective immune response which specifically protected the mixed-source animals against new respiratory infection were the main predisposing reasons for this disease. The two strategies chosen to investigate and address this problem were (1) better management of feeder steers at the time of weaning and (2) vaccination prior to feedlot entry with new experimental vaccines which protected against the major pathogens implicated in respiratory disease.

The method of weaning was considered to be important because there have been studies which showed that calves were more amenable to training at this time than at any other stage of their development (Boissy and Bouissou 1988; Boivin et al 1992a,b). Weaning in yards provided many opportunities to expose the calves to situations similar to those they would experience on arrival at the feedlot. It was hypothesised that this would reduce the amount of maladaptation and distress which animals experienced during adaptation to the feedlot and speed up the process of adjustment.

Vaccination against respiratory disease in feedlot cattle world-wide has typically been carried out at the time of induction into the feedlot. This has two major disadvantages: (1) the animal stress at that time may render the vaccination ineffective and (2) there is insufficient time to develop effective immunity before exposure to new infection in the feedlot pen. The US experience, particularly with the Texas A&M University Ranch to Rail Program, now seems strongly in favour of vaccination prior to feedlot entry (McNeill et al 1995: USDA Cattle on Feed Evaluation, 1995)

Good progress has been made to develop Australian vaccines against respiratory disease, particularly since 1993 when the Cooperative Research Centre for the Cattle and Beef Industry (Meat Quality) began its research and development program. It is expected that the first commercial vaccines will be available by the end of 1997. Our project, utilising experimental or prototype vaccines under development at the NSW Agriculture Elizabeth Macarthur Agricultural Institute, has been an integral part of a larger strategy to introduce effective new vaccines to the feedlot industry.

Other industry developments occurring during the course of our project have also enhanced rather than diminished its importance. A report on Input Requirements for the Feedlot Industry - MRC Project M.544 (1995) cited an improvement in total efficiency as the main requirement of the "now-maturing industry". One of three strategies to achieve this was "an improvement in the cattle supply production system" with backgrounding to be one of the main elements of this. The package of procedures examined in our project, for which we coined the term "pre-boosting", is an integral component of any backgrounding system for feedlot cattle.

Most of the major feedlots now buy their cattle direct from breeders with whom they have a record of past performance whereas five years ago they operated predominantly with a saleyard buying system. Clearly communication between breeders and feedlotters has been steadily improving. Successful trading alliances and the Eating Quality Standards beef grading system depend on those sectors being closely linked. Projects like MRC's Storelink and the Beef Trading Information System are aimed at further strengthening the exchange of information as a basis for developing value-based marketing. In this new environment, both the breeder and the feedlotter are more likely to recognise the benefits of any new procedures that improve the performance of their animals.

The need to combat maladaptation and distress and reduce the prevalence of disease also has other implications for the feedlot industry. Disease prevention, by decreasing reliance on the use of antibiotics, reduces the risk of antibiotic residues in beef. A significant complementary benefit should be an improvement in animal welfare which is an important public perception and public relations issue affecting the industry as a whole. Finally there are large cost savings (treatment and wasted feed) and increased production returns to be garnered from successful disease prevention.

The industry issues to be addressed were summarised in our original submission in the following manner. This project was designed to address:

1. The major industry changes which accompany the expansion of feedlotting, where improving meat quality to meet market specifications (while reducing costs of production) is the major economic issue,

2. The disease problems in feedlots which can blow out costs and wreck production schedules and can lead to antibiotic residue problems,

3. The animal welfare aspects of feedlot production, particularly during the initial adaptation to the feedlot environment.

These issues are clearly as important at the completion of our project as they were at the beginning. Achieving more consistent meat quality to hit targets for product specifications more reliably while reducing losses due to stress and disease – these are still major industry objectives. This project was designed to play a part in providing the technology to achieve those goals. Our milestone reports have already made a small contribution; this report sets out the complete overview of results and conclusions which are pertinent to the meeting of those industry goals.

Project Objectives

The primary objective as originally formulated was to apply new ***pre-boosting*** treatments to weaner steers at EMAI and determine the effects on subsequent feedlot performance, particularly the health and adaptability of the cattle. At the same time the benefits and costs of these treatments were to be analysed and the promulgation to industry of a cost-effective ***pre-boosting*** strategy was to be initiated.

In the schedule of the final contract for this project the objectives were stated as follows:

1. By November 1993, to determine the likely costs of different levels of ***pre-boosting*** to identify best-bet directions for the feedlot industry.

2. By June 1996, to determine the effect of ***pre-boosting*** cattle in relation to animal health, growth performance and carcase quality.

3. By October 1996, to determine and optimise the benefits and costs of different levels of ***pre-boosting*** to the feedlot industry.

4. By December 1996, to transfer the technology of a cost-effective ***pre-boosting*** package to the beef industry.

Methodology

Some 200 male beef calves each year were separated from their mothers at 7-8 months of age and subjected to various weaning treatments at EMAI during the autumn of 1993, 1994 and 1995. After a further period of 6-9 months on pasture at EMAI, these steers were transferred to a large commercial feedlot where they were fed for about 90 days before slaughter. About one month before entering the feedlot selected animals were given specific vaccination treatments also. The combination of the weaning management plus the pre-feedlot vaccination is referred to as ***pre-boosting***.

Prior to feedlot entry, measurements were made of the disease status, weight gain, responses to stress and the behaviour of these cattle. Health, weight gain and behaviour were closely monitored during the feedlot phase in order to determine the effects of the ***pre-boosting*** treatments and gain an understanding of the causal mechanisms involved. Offal and carcases were examined immediately after slaughter for effects of disease and meat quality attributes.

Three levels of experimental weaning treatment were tested, with and without the experimental vaccines, so that the most cost-effective combination could be determined. These experimental weaning procedures were compared with a control group which was paddock-weaned according to the common industry practice for *Bos taurus* cattle at the present time. The treatments at weaning were as follows:

1. *(Control)* Paddock weaning with no supplementary feed and no handling for 21 days after complete separation of the calves from their mothers.

2. Yard weaning for 10 days with good quality hay or silage, but minimal handling of the cattle during this time.

3. Yard weaning with good quality hay or silage plus a novel handling procedure to train the animals to be able to find a grain ration in a trough (see later).

4. Yard weaning with good quality hay or silage, plus the novel training procedure, plus a conditioned immunostimulation treatment carried out at the end of the yard weaning using Equistim® (Virbac Aust. Pty Ltd, Peakhurst, NSW) and flavoured water (see later).

The vaccination treatments, which were administered at times ranging between 77 and 13 days prior to feedlot entry, consisted of experimental vaccines against Pestivirus, Infectious Bovine Rhinotracheitis virus (IBR), Parainfluenza 3 virus (PI_3) and Pasteurelleae (P. *haemolytica* and P. *multocida*).

More detailed methodology is described below and in the individual milestone reports (appendices 1, 2 and 3).

Experimental Animals

Most of the animals used were bred either at EMAI or at Braidwood Station (B. Hall, Braidwood, NSW) This provided a useful comparison between the two different sources of cattle. It had originally been intended to source all animals from EMAI, but there were not enough male calves available.

In phase 1 (1993 weaning) there were 206 calves, predominantly Angus x Hereford, which were weaned in May. There were 131 from EMAI, 25 from Braidwood Station and 50 from Araluen (J. Reynolds, Neringla, Araluen, NSW). Amongst the EMAI animals there were 20 with one-quarter Brahman blood in phase 1. In phase 2 (1994 weaning) there were 200 calves, again mostly Angus x Hereford, weaned in April. Of these, 131 came from EMAI and 69 from Braidwood. In phase 3 (1995 weaning) there were 209 calves weaned in May; 110 of these were Angus x Hereford from EMAI and 99 were Herefords from Braidwood.

The calves were 7-9 months of age at weaning (EMAI 7-8 months, Braidwood 8-9 months in phases 1 and 2 and 8-10 months in phase 3) with an average liveweight of 242 kg (phase 1), 182 kg (phase 2) and 217 kg (phase 3).

The EMAI calves had been examined and tagged at birth, castrated at 3 months of age and run on irrigated pasture up to weaning. They had received 5-in-1 vaccination and drenching for parasite control and had become used to quiet handling. The Braidwood calves were marked at 6 months of age and also received 5-in-1 vaccination and drenching for parasite control, but had somewhat less handling and had been run in larger paddocks and were clearly less accustomed to human contact.

Experimental Design

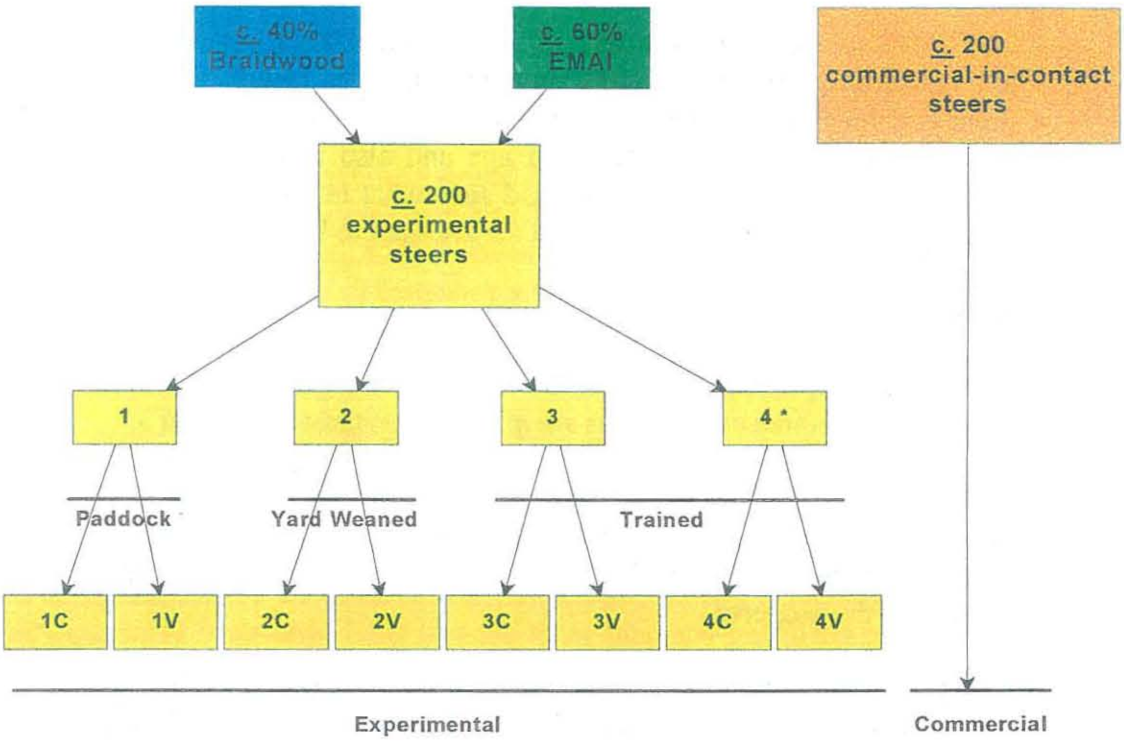
The generic experimental design is illustrated in Figure 1. Full details of the design for each of the three experiments are given in appendices 1, 2 and 3.

The Braidwood and EMAI steers were separated from their mothers on the same day, the difference being that the Braidwood steers had to be trucked for about five hours (250 km) to the EMAI weaning yards whereas the EMAI steers were only trucked 10 km within the property.

The four main treatment groups were closely matched for liveweight, breed and source of cattle. Group 1, which is also referred to as the **paddock-weaned** group, was the weaning control group, being similar to the common industry weaning practice for *Bos taurus* animals at the present time. Groups 2, 3 and 4 received the three levels of yard weaning treatment which were described above. Group 2 is also referred to as the **yard-weaned** group, while groups 3 and 4 are referred to as the **trained** groups because of the novel handling procedure which both groups received. The additional immunostimulation treatment did not give promising results and was difficult to manage in the first two experiments (see appendix 4) so it was abandoned in phase 3.

After weaning the eight sub-groups were formed, again matched for liveweight, breed and source of cattle, by splitting the animals from each group into vaccinated (V) and control (C) groups. Although care was taken to allocate Braidwood and EMAI cattle equally to avoid confounding the effect of source with experimental treatments, in phase 2, there was a design problem when most Braidwood animals had to be excluded from the vaccine control groups because of prior exposure to Pestivirus. The effects of this were fully detailed in the milestone report for phase 2 (appendix 2).

Figure 1. The generic experimental design used for all three phases of the project.



In phases 1 and 2, the cattle entered the commercial feedlot (Caroona Feedlot, Australian Meat Holdings Pty. Ltd., Quirindi, NSW, Australia) 8-9 months after weaning in February of the following year. For the period between the end of weaning and feedlot entry the cattle were grazed as a single group, except for a 2-week period immediately following vaccination with live Pestivirus when the vaccinated animals were kept separate from the unvaccinated controls.

In phase 3, the cattle entered the feedlot 6 months after weaning in November of the same year. In this case the paddock-weaned cattle were grazed separately from the yard-weaned groups between the end of weaning and the day they were loaded for transport to the feedlot. This change was made deliberately because of the likely effects of social facilitation (i.e. untrained animals copying from their trained "mates") at the feedlot in phases 1 and 2.

Figure 1 also indicates that a similar number of commercial-in-contact animals were put into the same feedlot pen as the experimental animals. The purpose of this was to provide both an infectious challenge for the experimental animals and also a behavioural challenge somewhat like that normally experienced by cattle entering a commercial feedlot.
The commercial cattle were purchased by the feedlot from a variety of sources and this enabled some analysis of source effects on health and weight gain within the commercial group, but that analysis was incidental to the main controlled experiment. Details of the different sources and the effects were given in the milestone reports (appendices 1, 2 and 3).

Weaning Methods

The EMAI calves were yarded with their mothers in the late afternoon and drafted onto a truck to be transported about 10 km to the weaning yards where they were kept in a large holding yard with water overnight. The Braidwood calves were handled in the same way except that they were held overnight at the property of origin and transported 250 km to the weaning yards early next morning.

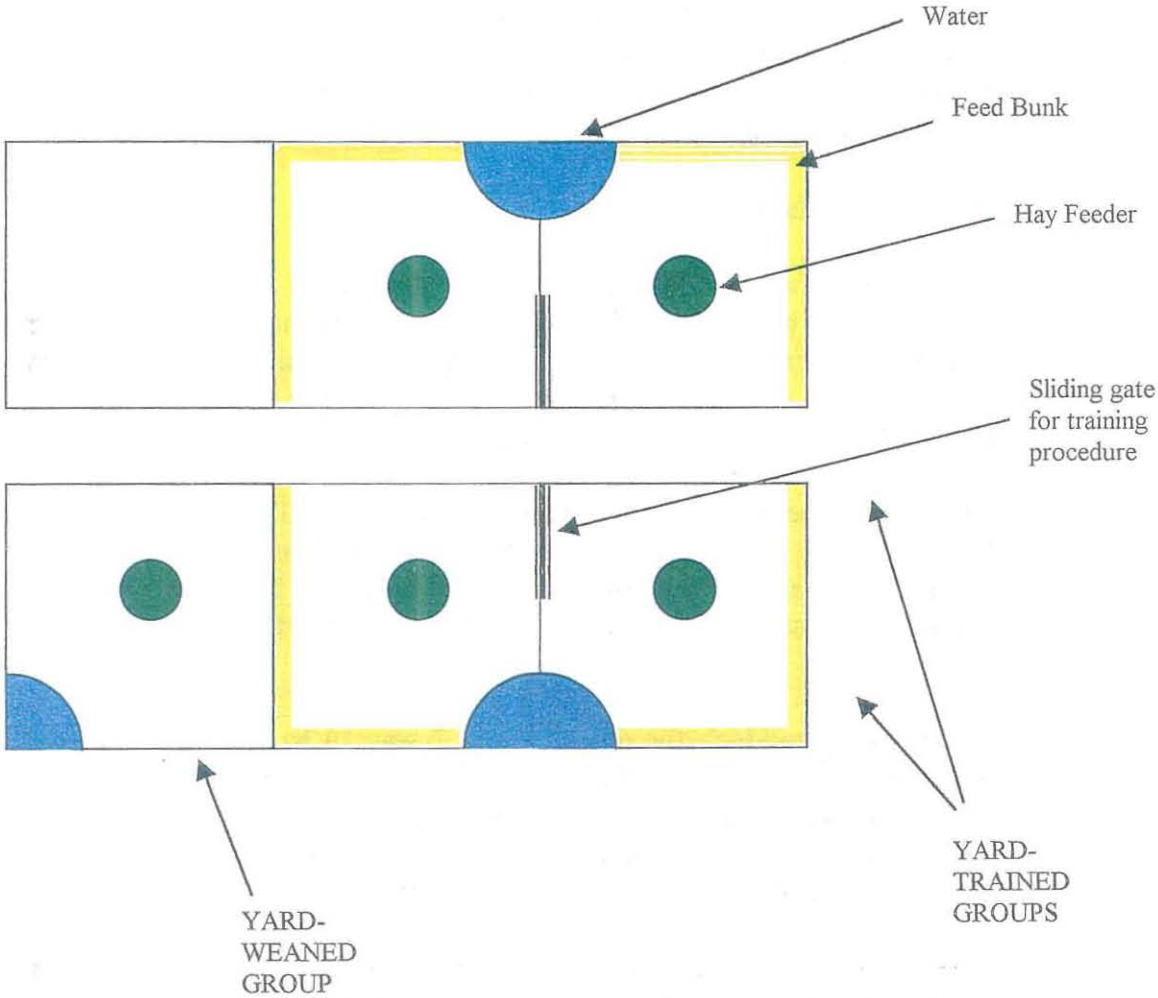
On that day the calves were weighed, sampled and allocated to different groups for the experiment. The 50 paddock-weaned control animals were then transported to a paddock several km away from the weaning yards. Both the yard-weaned and the paddock-weaned calves were kept well out of sight or sound contact with their mothers.

The weaning paddock for phases 1 and 2 was 16 ha containing reasonable quality native pasture (autumn-saved) with some rye grass and clover. In phase 3, similar pasture was provided, but in a 3 ha. paddock. The weaning period was designated as 21 days after which the treatment groups were re-united (except for the paddock-weaned calves in phase 3 which were kept separate until feedlot entry - see earlier).

For yard weaning each group of 50 calves was kept for about 10 days in a 14 x 14 m yard (4 m^2/hd) which had solid (opaque) sides made of 1.2 m high density rubber belting (re-used from a coal mining operation). A diagram of the layout of the yards is given in Figure 2. The trained groups alternated between two adjacent pens whereas the yard-weaned group remained in the same pen for the whole weaning period The hard, sloped pen surface ensured that, even with several days of wet weather, there was only shallow mud. Each yard had a concrete water trough in one corner, a round bale feeder in the centre and a feed bunk on two sides made from the same rubber belting as the side fences. After 10 days the calves were released into a nearby paddock and brought back into the yards overnight for two more sessions of training over the next week.

The standard feeding procedure during yard weaning was to supply each pen with one round bale per day of good quality pasture hay (phases 1 and 2) or forage sorghum silage (phase 3). There was very little feed wastage using this procedure.

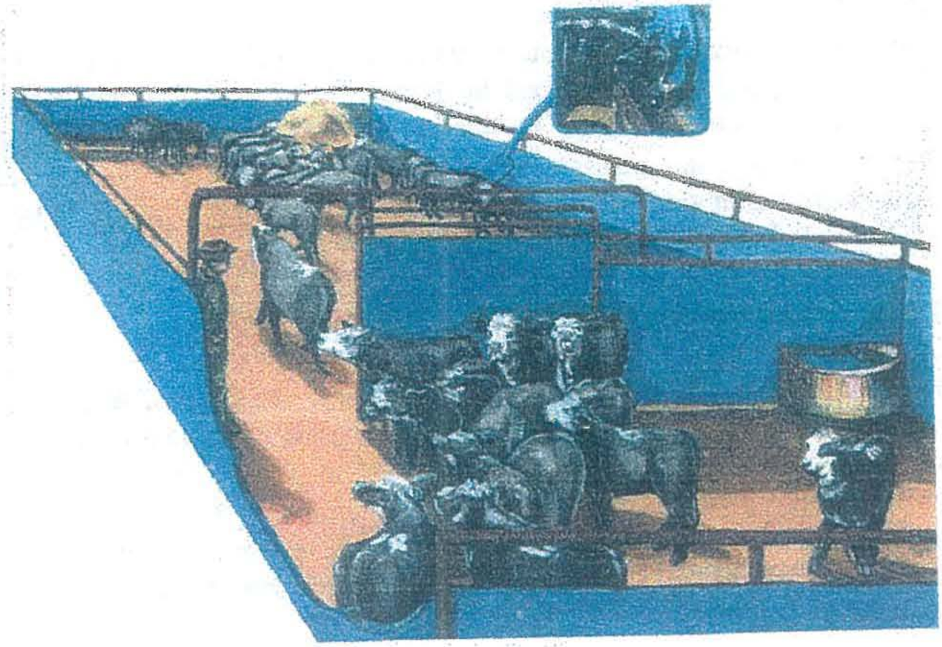
Figure 2. Diagram of weaning yards used for all three phases of the project.



For the purpose of educating the calves to eat grain, a supplement of 1 kg/hd/day of whole lupins and oats (40:60) was provided in the feed bunk once daily as part of the following training procedure which is illustrated in Figure 3.

Each morning at the same time an active learning procedure was conducted for one hour (phase 1) or 45 minutes (phases 2 and 3) with group 3 and group 4. This was done from the first morning that the calves were in the yards up to the day they were released. The procedure consisted of covering any remaining hay in the feeder and supplying new hay and the small amount of grain to an empty pen adjacent to the pen in which the calves were held. Then an adjustable gateway was opened to provide the calves with access to the pen with the new feed in it. A person stood quietly to one side of the gateway, thus requiring the calves to reduce or suspend their normal flight distance in order to get through the gate to the feed.

Figure 3. An artist's impression of the training (and confidence testing) procedure applied during weaning in all three phases of the project.



The gate opening was set according to the temperament and previous handling experience of the animals so that, on the first day of training, it was expected that about half of them would go through the gate of their own volition in the 45 minutes allowed. At the end of that training period the remaining animals were quietly pushed through the wide-open gate, with no obstruction, into the pen with the feed. Each day that this procedure was repeated more animals would go through the gate in the time allowed and more of them would go directly to look for the grain in the trough. After 5-7 days it was expected that all calves would have found their way through the gate and most would seek out and consume the small quantity of grain immediately. This was the case with every group except group 4 in phase 3 (see later).

Confidence Testing and Temperament Testing at Weaning

The training procedure described above also served as a method of measuring a particular behavioural characteristic of each individual animal in the trained groups during the weaning process. The Confidence Score for each animal was the number of days on which the animal succeeded in passing through the gate into the next pen of its own volition. The only animals that scored zero on confidence were six from group 4 in phase 3.

The idea of this test was based on previous work described by Fell and Shutt (1989), Fell et al (1991) and Fell (1992) using a motivational-choice open-field test to assess confidence in sheep. The test sets up an approach-avoidance conflict situation in which the animal's motivation to move towards the new feed in the adjacent pen is pitted against its natural flight distance from the person who is standing at one side of the gateway.

Another measurement of animal temperament, which was used in phase 3 only, was the Flight Speed Test developed by Burrow et al (1988) which measures the time taken by an animal to move a set distance after exiting a weighing scale into an open yard. Some additional assessments of temperament were also made (in phase 3) of the behaviour of animals when restrained in a crush along the lines used by Hearnshaw et al (1979) and discussed by Burrow (1997).

Experimental Vaccination

In attempting to achieve maximum immunity at the time of feedlot entry, the final vaccination was aimed to occur 2-4 weeks prior to induction. In the case of live vaccines (Pestivirus, PI_3) the single vaccination would ideally be given at this time. Killed vaccines (IBR and Pasteurelleae) require two injections at least two weeks apart so the first vaccination needed to be at least a month before feedlot induction. The actual timing was as listed below, the variations from year to year essentially being logistical issues.

All experimental vaccines were administered by subcutaneous injection at EMAI between day -77 and day -13 from the day of induction into the feedlot.

In phase 1 there were three separate injections. Pestivirus (killed, adjuvanted) was given on days -77 and -41 plus a live booster on day -31, IBR (killed, adjuvanted) was given on days -77 and -41, PI_3 (live) was given on day -31 and Pasteurella (inactivated) was given on days -41 and -31.

In phase 2 there were four injections. Pestivirus (live, unmodified) was given on day -27, IBR (killed, adjuvanted) was given on days -70 and -48, PI_3 (live) was given on day -22 and Pasteurella (inactivated) was given on days -70 and -48.

In phase 3 there were two injections, beginning only one month before feedlot entry. Pestivirus (live, unmodified) was given on day -13, IBR (killed, adjuvanted) was given on days -32 and -13, PI_3 (live) was given on day -13 and Pasteurella (inactivated) was given on days -32 and -13.

Determining Liveweight Gain and Health Status

The experimental cattle were on feed for approximately three months (84 or 91 days in phase 1, 94 days in phase 2 and 85-100 days in phase 3). The commercial-in-contact animals were fed for 85 days in phase 1, but up to 200 days in phases 2 and 3.

All experimental and commercial-in-contact animals were weighed at induction into the feedlot, after approximately one month on feed (day 37, 39 and 37 for phase 1, 2 and 3 respectively), and near the end of the feeding period (day 84, 92 and 78 for phase 1, 2 and 3 respectively). Carcase weights were also recorded.

Experimental animals were also weighed before and after weaning (days 1 and 21 after separation from their mothers) and, in phase 1, at intervals between weaning and feedlot entry. Those animals born at EMAI also had birth weight recorded.

The protocol for disease surveillance and sample collection was the same as for the previous MRC Feedlot Diseases project (DAN.064). The five forms used (1-history, 2-induction, 3-sick animals, 4-autopsy record and 5-slaughter) were described by Dunn *et al* (1993) in their Final Report.

Rectal temperature of all animals was recorded at every weighing, at feedlot induction and whenever an animal was pulled, i.e. taken to the feedlot hospital pen. Blood samples were collected on all these occasions, faecal samples and nasal swabs were collected from sick animals, including all pyrexic (high temperature) animals, but not from bullers or lame animals.

Serology was performed on blood samples collected from all experimental and commercial-in-contact animals prior to weaning (for allocation to groups) and at all times they were weighed, on induction into the feedlot, after approximately one month on feed (see above), and near the end of the feeding period (see above). Additional serology was performed on samples taken from all animals that were pulled from the pen because of sickness or sent for salvage slaughter.

At slaughter all organs were examined for the presence and severity of lesions and the pleura of each carcase was assessed for any signs of respiratory disease.

The laboratory methods for bacteriology, histopathology and virology were as described by Dunn *et al* (1993).

Determining Physiological Responses to Stress

Blood samples were collected for hormone assay from all experimental animals at the same time as weighing, before and after weaning (days 1 and 21 after separation from their mothers) and at the time of induction into the feedlot. Additional samples were collected during weaning and before shipping to the feedlot in phase 1. Plasma cortisol concentration was determined by standard radioimmunoassay methodology as described by Fell *et al* (1985).

Blood samples were collected for differential cell counts from half of the animals in each group before and after weaning (days 1 and 21 after separation from their mothers) in phases 1 and 2. The differential counts were performed using a Technicon H-1 laser cell counter (Bayer Diagnostic, Pymble, NSW).

Observations of Cattle Behaviour

The observations which were critically important to this project were the recordings of feeding activity at the feed bunk during the first 2-3 weeks on feed. A large amount of additional behaviour recording including patterns of resting behaviour and social interactions (agonistic, affiliative etc.) was performed as part of another research project also within the Beef CRC Health and Welfare program. This will not be reported here except where the results may shed some light on possible causal mechanisms for the treatment effects described here.

The feed bunk area was monitored continually (24 hour/day) during the critical early period of adaptation in which the cattle began to establish their feeding behaviour. This was achieved by means of four video surveillance cameras strategically mounted on 6m high poles above the feed bunk linked to a time-lapse video recorder in the central observation tower and the provision of appropriate infrared lighting for clear viewing during the night without any disturbance to the cattle. In phases 1 and 2, this surveillance was maintained from the afternoon of day 0 (the day of induction) to the morning of day 11 on feed. Video surveillance in phase 3 was on days 0-4, 8-11 and 15-18 (from day -2 to day 15 for the commercial-in-contact cattle).

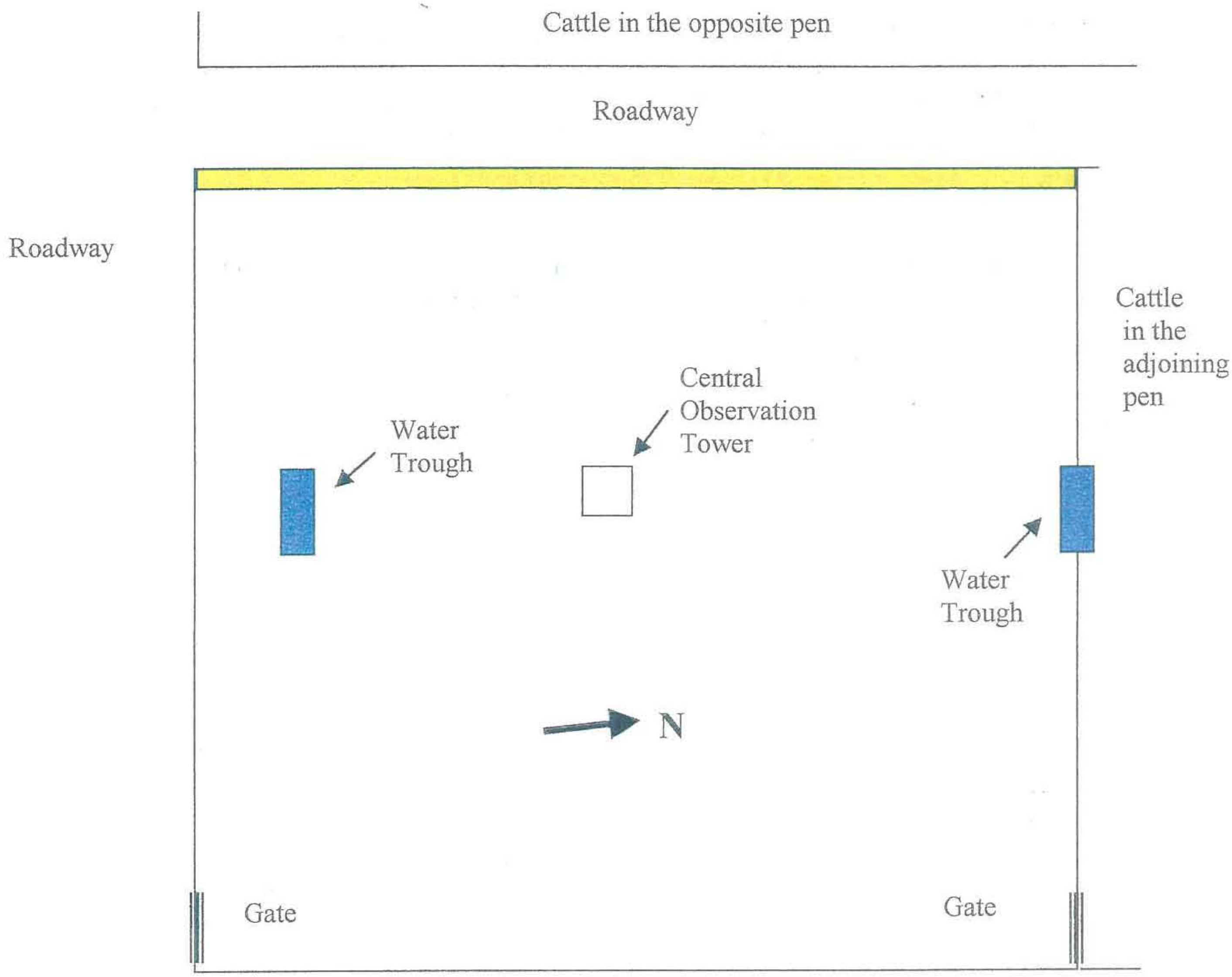
In order to identify individual animals at the feed bunk to properly compare the feeding behaviour of the experimental groups it was necessary to survey the feed bunk on horseback every 15 minutes during daylight hours. A combination of these records and the video surveillance provided a comprehensive account of the feeding behaviour of all animals during their adaptation to the feedlot pen.

In phase 3 there was detailed observation over 9 days (days 1-3, 9-11 and 16-18) of 24 focal animals which had been selected prior to feedlot entry on the basis of their temperament. One group of 12 animals consisted of the highest confidence animals from the trained groups (supposedly ideal feedlot temperament) and the other group of 12 animals were those that had the lowest flight speed and were the most agitated in the crush during routine weighing (supposedly unsuitable feedlot temperament). All their behaviours were recorded at 15 minute intervals throughout daylight hours.

Feedlot Environment

Figure 4 is a diagram of the feedlot pen at Caroona. The pen area was 4,350 m^2 with a slope of 2.5% from east to west and the pen surface was generally very good.

Figure 4. Diagram of the feedlot pen at the AMH Caroona feedlot that was used for all three phases of the project.



Weather conditions were dry and warm during phases 1 and 2 (February - April), but cool and wet during the first month of phase 3 (November - January). Conditions were quite dusty at times during phase 2. The pen surface was muddy during most of intensive behaviour observations in phase 3, but it was not unduly boggy at any stage.

In phase 1 there were 205 experimental and 177 commercial-in-contact steers (i.e., 11 m^2/hd) and the commercial cattle were put into the pen 3-4 days after the experimental cattle arrived. In phases 2 and 3 the commercial cattle were put into the pen three days before the experimental cattle arrived. There were 196 experimental and 187 commercial-in-contact steers in phase 2 (i.e., 11 m^2/hd) and 209 experimental together with 155 commercial-in-contact steers in phase 3 (i.e., 12 m^2/hd). There was a 66m continuous length of feed bunk space in the pen and two water troughs as shown in Figure 4.

Economic Analyses

An economic analysis of the results from each phase of the project can be found in the milestone reports (appendices 1-3). The assumptions used and the general approach taken are described in these appendices and an overall summary of the economic analysis is given at the end of the Results and Discussion.

Statistical Analyses

All the data on weight gain, feeding, stress and behaviour was submitted to analysis of variance using REG version 94.10 which is a generalised least squares program developed and operated by NSW Agriculture.

The non-parametric health data was analysed by Chi-square and Fisher's Exact Test using the statistical program included in Epi Info version 6.1.

Results and Discussion

The results are presented and discussed in the following sections: weight gain, health, interaction between health and weight gain, feeding activity, stress and behaviour and economic analysis.

This report is an overview of all three phases of the project. The summary statements of results and data are contained in a series of Tables which are intended to provide the 'big picture' about the effects of these experimental treatments on respiratory disease and animal productivity in the feedlot. The more detailed results from each phase can be found in the individual milestone reports which are included as appendices 1-3.

WEIGHT GAIN

Tables 1a-d were designed to provide an summary of the treatment effects on weight gain. All statistically significant differences have a probability of 0.05 or better (individual probabilities are not given in the text). The summary statements in Table 1a are based on separate statistical analyses for each phase as these were not three replicates (in the statistical sense); they were intended to be progressive refinements. The three phases were stages in the development of a pre-boosting procedure.

In our interpretation we suggest that more weight should be given to the results of phase 3 than to the previous phases for two reasons. Firstly, we were more experienced at applying the pre-boosting treatments by that stage and, secondly, this was the only experiment in which the paddock-weaned control cattle were kept separate from the pre-boosted cattle between weaning and entry into the feedlot. From the results of phases 1 and 2 it appeared likely that the experimentally treated cattle were assisting their "mates" from the untreated groups by what is known as social facilitation after arrival in the feedlot. We believe (based on feeding activity measurements – see later) that this applied to a lesser extent when the control cattle were not part of the same social group as the treated cattle prior to feedlot entry. Therefore phase 3 was the most realistic and appropriate comparison between treatment and control groups because it considered them as separate social groups..

The inclusion of commercial-in-contact cattle in this summary is not primarily for the sake of a comparison with experimental cattle. That was not part of the experimental design (see earlier). The commercial cattle were similar in age and weight, but were not exactly matched with experimental groups, they received growth promotants which the experimental cattle did not and every individual animal did not have to be accounted for in the final weighing as was the case with experimental cattle. The reason for their inclusion was that they provided a full pen and a realistic behavioural and infectious challenge for the experimental treatment groups and their results provide the context within which the treatment effects can be assessed.

Weight Gain Prior to Feedlot Entry

The groups were matched according to liveweight at weaning. Pre-weaning growth rate was recorded only for the EMAI calves and there were no significant differences between treatment groups in this regard. The calves had been run as a single group since birth. There was no record of birthweights for the animals introduced from other properties.

The average liveweight at weaning in phase 1 was 242 kg with the EMAI calves (7-8 months) averaging 226 kg and the introduced calves (Braidwood and Araluen, 8-9 months) averaging 262 kg. During weaning (from day 1 after separation from their mothers until day 21) the yard-weaned animals lost an average of 3.6 kg, while the yard-trained animals (with the grain supplement) gained 1.3 kg and the paddock-weaned animals (on good pasture) gained 9.2 kg. These small differences no longer existed at the next weighing two months later and there were no significant differences between the treatment groups in weight at induction into the feedlot or in pre-feedlot growth rate.

The average liveweight gain from the end of weaning to feedlot entry nearly nine months later was about 0.3 kg/day. Most of this occurred in December–January following good summer rain. There had been minimal liveweight gain during a very dry period from weaning until late spring.

In phase 2 the weaning age was similar (EMAI 7-8 months, Braidwood 8-9 months), but the average liveweight was 182 kg (EMAI = 172 kg, Braidwood = 212 kg) due to the drought which had become established by that time. During weaning (day 1 to day 21) there was close to zero weight gain in all groups and again there were no significant differences between the treatment groups in weight at induction into the feedlot or in pre-feedlot growth rate.

The average liveweight gain from the end of weaning to feedlot entry nearly nine months later was about 0.4 kg/day, but this was only achieved (in the drought) by putting the weaners on irrigated pasture during the spring and summer.

In phase 3 the weaning age was similar (although some Braidwood calves were 10 months of age) and the average liveweight was 217 kg (EMAI = 196 kg, Braidwood = 240 kg). There was a slight weight loss in all groups during weaning.

The average liveweight gain from the end of weaning to feedlot entry, which in this case was only six months later, was about 0.4 kg/day and, again, this was achieved by the use of irrigated pasture at times.

It can be concluded, therefore, that the effects of the weaning treatments on subsequent feedlot performance were not due to differences in pre-feedlot growth.

Weight Gain in the First Month in the Feedlot

In phase 1 the yard-weaned and yard-trained groups were not significantly different with regard to early growth rate. However, the paddock-weaned control group had a significantly lower weight gain than either of the pre-boosted groups (see Table 1b). This period showed evidence of compensatory gain (weight gain >2 kg/day) which could have been related to the setback to growth during the previous winter and/or the growth spurt which had occurred in the two months prior to feedlot entry.

In phase 2 it was the yard-trained group which showed the best early weight gain and the yard-weaned group did poorly, particularly the Braidwood animals (see Tables 1b and 1c). This was clearly not related to sickness nor was it related to early feeding behaviour (see later sections). We can provide no explanation for this result which seems to be an aberration when compared with the overall trends. It shows that there are factors other than those being considered here which can affect feedlot performance.

The phase 3 result was similar to phase 1 in that yard-weaned and yard-trained groups were not significantly different from one another, but they were significantly better than the paddock-weaned controls (see Table 1b). Phase 3 showed the biggest difference in favour of the pre-boosted groups which was probably mainly due to the fact that the control animals were kept separate from pre-boosted animals for the entire period from weaning until shipping to the feedlot thus reducing the opportunities for social facilitation.

The overall mean for all three phases (although not statistically testable) gives an indication of the consistency of the treatment effects. It was (in kg/hd/day): 1.757 for yard-weaned, 1.760 for yard-trained and 1.603 for the paddock-weaned controls. This is shown graphically, along with a summary statement, in the overheads reproduced in appendix 5.

This represents an overall improvement of 10% in early growth rate due to the pre-boosting treatments. This effect was due to the yard weaning, not to the additional training, there being no extra benefit in the yard-trained group. It is not a large effect, but it is reasonably consistent throughout these experiments. The improvement due to yard weaning was 26% in phase 3 (see Table 1b). As previously mentioned, we attach more weight to the phase 3 result because that experiment was the closest to the real industry situation.

There was a significant positive effect of the vaccination treatment on early weight gain also in phases 1 and 3 (see Table 1d). Design problems prevented any conclusions being drawn about vaccination in phase 2 (see next section). The combination of yard weaning and vaccination produced the highest weight gain in the first month in the feedlot in phase 1 and phase 3 (Table 1d). These results are discussed more fully in the next section.

Table 1a. Summary statements regarding the WEIGHT GAIN treatment effects over all three phases.

Note that the comparison between experimental and commercial-in-contact cattle is not part of the experimental design. It is included here only because the interaction between the two groups may affect the results in the experimental cattle.

		Experimental	Commercial-in-contact
ADG (First Month)	Phase 1	YARD WEANED = YARD TRAINED > PADDOCK WEANED	Appreciably lower than experimental groups (due to sickness)
	Phase 2	YARD TRAINED > YARD WEANED but both = PADDOCK WEANED	Similar to PADDOCK WEANED group
	Phase 3	YARD WEANED = YARD TRAINED > PADDOCK WEANED	Similar to YARD WEANED group
ADG (90 day feeding)	Phase 1	No significant treatment effects, but YARD WEANED highest	Appreciably lower than experimental groups (due to sickness)
	Phase 2	No significant treatment effects, but YARD TRAINED highest	Appreciably higher than experimental groups (due to HGP)
	Phase 3	YARD WEANED = YARD TRAINED > PADDOCK WEANED	Appreciably higher than experimental groups (due to HGP)
ADG (90 days) deads included	Phase 1	No significant treatment effects, but YARD WEANED highest	Appreciably lower than experimental groups (due to sickness)
	Phase 2	No significant treatment effects, but YARD WEANED highest	Appreciably higher than experimental groups (due to HGP)
	Phase 3	YARD WEANED = YARD TRAINED > PADDOCK WEANED	Appreciably higher than experimental groups (due to HGP)

Table 1b. WEIGHT GAIN means of the main weaning treatment groups over all three phases.
YW = yard weaning, YT = yard training, PW = paddock weaning (i.e. CONTROL)

		Experimental	Commercial-in-contact
ADG (First Month)	Phase 1	YW = 2.19 [a] YT = 2.08 [a] PW = 1.92 [b]	Combined = 1.35
	Phase 2	YW = 1.54 [a] YT = 1.74 [b] PW = 1.67 [ab]	Combined = 1.67
	Phase 3	YW 1.54 [a] YT 1.46 [a] PW 1.22 [b]	Combined = 1.53
ADG (90 day feeding)	Phase 1	YW = 1.74 [a] YT = 1.71 [a] PW = 1.68 [a]	Combined = 1.32
	Phase 2	YW = 1.52 [a] YT = 1.59 [a] PW = 1.53 [a]	Combined = 1.73
	Phase 3	YW 1.45 [a] YT 1.39 [a] PW 1.20 [b]	Combined = 1.53
ADG (90 days) deads included	Phase 1	YW = 1.74 [a] YT = 1.71 [a] PW = 1.65 [a]	Combined = 1.08
	Phase 2	YW = 1.50 [a] YT = 1.47 [a] PW = 1.48 [a]	Combined = 1.68
	Phase 3	YW 1.45 [a] YT 1.39 [a] PW 1.20 [b]	Combined = 1.51

[ab] Within a cell, means which have unlike superscripts are significantly different ($p < 0.05$)

Weight Gain over approximately 90 Days on Feed

The treatment effects on weight gain over the entire feeding period were not significant in phases 1 and 2 although the yard-weaned group was the highest in every case when the dead animals were included in the weight gain calculation. However, both the yard-weaned and yard-trained groups grew significantly faster than the paddock-weaned control group in phase 3 (see Table 1b).

The overall means (shown graphically in appendix 4) were (in kg/hd/day):
yard-weaned = 1.503, yard-trained = 1.490 and paddock-weaned = 1.407. This represents an overall improvement of 7% in weight gain over 90 days due to the pre-boosting treatment. Clearly this was due to the yard weaning *per se*. The improvement due to yard weaning was 21% in phase 3 (see Table 1b). The overall weight gain for commercial-in-contact cattle was 1.530 kg/hd/day (with hormonal growth promotants etc.) which shows that the experimental results are quite typical of commercial practice.

There were appreciable differences in weight gain between different source groups of cattle (see Table 1c). Details of the breed, weaning method and previous handling of each of these source groups are summarised in Table 2. These differences are interesting, but because they are incidental to the design of the experiment, it would be imprudent to regard them as genuine effects of the particular handling procedures recorded here. We know too little about the previous history of these animals to draw any firm conclusions.

The difference between EMAI and Braidwood cattle was significant in phase 3 and also in phase 2 when dead animals were included. This did not influence the main treatment effects because EMAI and Braidwood cattle were divided equally across all treatments, but it is necessary to ask whether the treatment effects apply equally to the two different sources of cattle. In phase 3 this is clearly the case. Even though the Braidwood cattle had substantially lower weight gains than EMAI cattle, there was no significant interaction between source and the yard weaning treatments, i.e. the yard weaning benefit applied to both groups.

There was a serious design problem with the results from phase 2 such that the differences between sub-treatment groups that are shown in Table 1d (in smaller font) should be ignored. When the animals were allocated to vaccinated and unvaccinated groups, it was discovered that almost every Braidwood animal was Pestivirus positive, so the Braidwood source was represented in the unvaccinated groups by only one animal. In other words the effects of vaccination treatment and source of cattle, which were significant, were thoroughly confounded in phase 2 so that it is impossible to determine either of these effects. Therefore nothing further can be said about the interaction between source and treatment effects in phase 2. Further details are given in the phase 2 milestone report (appendix 2).

Table 1c. WEIGHT GAIN means of the various source groups over all three phases.

See key with information about individual source groups in Table 2

		Experimental	Commercial-in-contact
ADG (First Month)	Phase 1	EMAI = 1.99 [a] BWD = 1.96 [a] ARAL = 2.02 [a]	TP = 1.39 SP = 1.18 WY = 1.60 DS = 0.96 FE = 1.24 WS = 1.65
	Phase 2	EMAI = 1.70 [a] BWD = 1.65 [a]	RW = 1.67
	Phase 3	EMAI = 1.49 [a] BWD = 1.39 [b]	Mob 1 = 1.23 Mob 2 = 1.29 Mob 3 = 1.41 Mob 4 = 1.73 Mob 5 = 1.78 Mob 6 = 1.21
ADG (90 day feeding)	Phase 1	EMAI = 1.67 [a] BWD = 1.62 [a] ARAL = 1.65 [a]	TP = 1.32 SP = 1.20 WY = 1.41 DS = 1.23 FE = 1.37 WS = 1.41
	Phase 2	EMAI = 1.59 [a] BWD = 1.52 [a]	RW = 1.73
	Phase 3	EMAI = 1.45 [a] BWD = 1.33 [b]	Mob 1 = 1.46 Mob 2 = 1.39 Mob 3 = 1.28 Mob 4 = 1.60 Mob 5 = 1.43 Mob 6 = 1.18
ADG (90 days) deads included	Phase 1	EMAI = 1.65 [a] BWD = 1.62 [a] ARAL = 1.65 [a]	TP = 1.22 SP = 1.20 WY = 1.38 DS = 1.18 FE = 1.37 WS = 1.15
	Phase 2	EMAI = 1.55 [a] BWD = 1.41 [b]	RW = 1.68
	Phase 3	EMAI = 1.45 [a] BWD = 1.33 [b]	Mob 1 = 1.46 Mob 2 = 1.39 Mob 3 = 1.28 Mob 4 = 1.60 Mob 5 = 1.43 Mob 6 = 1.18

[ab] Within a cell, means which have unlike superscripts are significantly different ($p < 0.05$)

Table 1d. WEIGHT GAIN means of the sub-treatment groups over all three phases.
YWV = yard weaned vaccinated, YWU = yard weaned unvaccinated, YTV = yard trained vaccinated, YTU = yard trained unvaccinated, PWV = paddock weaned vaccinated, PWU = paddock weaned unvaccinated (i.e. CONTROL)

		Experimental	Commercial-in-contact
ADG (First Month)	Phase 1	YWV = 2.22 [a] YWU = 2.04 [b] YTV = 2.11 [a] YTU = 2.02 [b] PWV = 2.06 [b] PWU = 1.84 [c]	Combined = 1.35
	Phase 2	YWV = 1.50 YWU = 1.58 YTV = 1.72 YTU = 1.76 PWV = 1.65 PWU = 1.69 (confounded, see text)	Combined = 1.67
	Phase 3	YWV = 1.62 [a] YWU = 1.46 [b] YTV = 1.48 [b] YTU = 1.44 [b] PWV = 1.45 [b] PWU = 0.99 [c]	Combined = 1.53
ADG (90 day feeding)	Phase 1	YWV = 1.60 [a] YWU = 1.48 [b] YTV = 1.53 [a] YTU = 1.47 [b] PWV = 1.58 [a] PWU = 1.43 [b]	Combined = 1.32
	Phase 2	YWV = 1.43 YWU = 1.61 YTV = 1.57 YTU = 1.61 PWV = 1.52 PWU = 1.54 (confounded, see text)	Combined = 1.73
	Phase 3	YWV = 1.46 [a] YWU = 1.43 [a] YTV = 1.44 [a] YTU = 1.35 [b] PWV = 1.27 [b] PWU = 1.13 [c]	Combined = 1.53

ADG (90 days) deads included	**Phase 1**	YWV = 1.60 [a] YWU = 1.48 [b] YTV = 1.53 [a] YTU = 1.47 [b] PWV = 1.58 [a] PWU = 1.41 [b]	Combined = 1.08
	Phase 2	YWV = 1.39 YWU = 1.56 YTV = 1.40 YTU = 1.54 PWV = 1.46 PWU = 1.54 (confounded, see text)	Combined = 1.68
	Phase 3	YWV = 1.46 [a] YWU = 1.43 [a] YTV = 1.44 [a] YTU = 1.35 [b] PWV = 1.27 [b] PWU = 1.13 [c]	Combined = 1.51

[abc] Within a cell, means which have unlike superscripts are significantly different ($p < 0.05$)

However, the effect of vaccination was quite clear-cut in phase 1 and phase 3. The only significant difference between treatment groups for 90 day weight gain in phase 1 was between vaccinated and unvaccinated animals (see Table 1d). In phase 3 the overall vaccination effect was also significant.

Ignoring the phase 2 result the overall mean weight gain (in kg/hd/day) was 1.479 for vaccinated animals and 1.381 for unvaccinated animals which is a difference of about 8% in favour of vaccination (see graph in appendix 5). Again this is not a large effect, but it is consistent across all treatment groups in both phase 1 and phase 3.

It can be seen from Table 1d that the combination of yard weaning and vaccination produced the highest weight gains in phases 1 and 3 (the phase 2 data should be ignored for the reasons given above). In phase 3 the yard-weaned, vaccinated group was approximately 60% higher in early weight gain than the paddock-weaned, unvaccinated, control group, with all the other groups falling in between, but significantly different from either extreme.

Both of the yard-weaned groups and the yard-trained, vaccinated group had significantly higher weight gains than other groups over 90 days and were almost 30% ahead of the paddock-weaned, unvaccinated, control animals.

The overall means (see also appendix 5) for weight gain over 90 days (in kg/hd/day) showed yard-weaned, vaccinated (1.532) as the best group followed by the yard-trained, vaccinated animals (1.484). Then follows yard-weaned, unvaccinated (1.453), paddock-weaned, vaccinated (1.421), yard-trained, unvaccinated (1.410) with the paddock-weaned, unvaccinated control group well behind (1.279).

Our conclusion from these results was that yard weaning (as described in this report) and vaccination (with experimental vaccines), 1-2 months before entry to the feedlot, were each capable of significantly improving weight gain in the feedlot (at least up to 90 days on feed). The combination of these two treatments (yard weaning plus vaccination) produced the highest weight gains in this study. Possible mechanisms which could explain these treatment effects are discussed in a later section of this report.

HEALTH

The data on animal health are also summarised in a Table series. Tables 3a-e were designed to provide an overview of the situation with regard to respiratory disease, as this was the prime focus of the research. Other health details which are important to the overall conclusions are also discussed in this section. Further details regarding each phase of the research can be found in the appendices.

Disease Pattern

Table 3a gives a brief summary of the pattern of the pathogenic challenge in these particular cattle populations for each of the three phases. This provides the context within which treatment effects on disease can be interpreted.

Graphs showing the time course of seroconversion for Pestivirus, IBR, PI_3 and BRSV are given in the individual phase reports (see appendices) and will not be repeated here. These show clearly the dynamics of pathogen transmission and the effects of vaccination. The extensive serology carried out in this project has provided the information that is essential to understanding the disease pattern and treatment effects.

In each phase there was extensive transmission of Pestivirus and BRSV in the period between induction into the feedlot and the first weighing and sampling at around day 35. Transmission of IBR also occurred during this period in phase 1 and phase 3. Phase 2 was quite different in that there was virtually no IBR transmission up to day 37, but extensive transmission after this, resulting in a severe respiratory disease episode in weeks 11 and 12 with associated mortality. This pattern of "late respiratory disease" with IBR had been recognised in this feedlot prior to our experiments.

As expected the previous exposure to infection and the previous experience of the various cattle populations were major factors affecting the disease outcomes. Although it was an aside to the main experimental design, the variety of sources used for commercial-in-contact cattle make for some interesting comparisons in this regard. Details of all the source groups are summarised in Table 2.

Table 2. Summary details of the various sources of cattle[1]

SOURCE GROUP	Vendor's Location	Group History	Description of Cattle	Weaning Method	Shipping and Feedlot Induction
			Experimental		
EMAI (phases 1,2,3)	Research Property Camden, NSW	Single group since birth	Quiet 110-130 head each phase, mostly Angus x Hereford, some other crosses (20 ¼ Brahman in phase 1)	See experim-ental design	Medium distance, quiet handling, inducted next day
Braidwood (BWD) (phases 1,2,3)	Property Braidwood, NSW	Single group since birth	30 (phase 1), 66 (phase 2) Angus x Hereford (flighty) and 99 Herefords in phase 3 (very flighty)	See experim-ental design	Medium distance, quiet handling, inducted next day
Araluen (ARAL) (phase 1)	Property Araluen, NSW	Single group since birth	50 Angus x Hereford in phase 1 only, flighty animals unused to handling	See experim-ental design	Medium distance, quiet handling, inducted next day
			Commercial-in-contact		
TP (phase 1)	Property Northern NSW	Single group since birth	18 Angus x Hereford cross	Not known	Short distance, inducted after several days rest
SP (phase 1)	Property Northern NSW	Single group since birth	18 Angus x Hereford cross	Not known	Short distance, inducted after several days rest
WY (phase 1)	Saleyards Wodonga, Vic.	Mixed groups at saleyards	54 of mixed breeds including Murray Grey, Shorthorn, Angus and Hereford	Not known	Saleyards, long distance, but inducted after 1 week rest
DS (phase 1)	Saleyards Dandenong Vic.	Mixed groups at saleyards	52 of mixed breeds including Murray Grey, Shorthorn, Angus and Hereford	Not known	Saleyards, long distance, inducted next day
FE (phase 1)	Property Northern NSW	Single group since birth	6 Shorthorns from local property	Not known	Short distance, inducted next day
WS (phase 1)	Saleyards Wodonga, Vic.	Mixed groups at saleyards	29 of mixed breeds including Murray Grey, Shorthorn, Angus and Hereford	Not known	Saleyards, long distance, inducted next day
RW (phase 2)	Backgroun ding Property Tumbarum ba, NSW	Mixed groups before back-grounding	165 Angus from the property plus 22 Herefords from 2 other properties run together through previous winter with hay	Not known	Long distance, inducted next day

Mob 1 (phase 3)	Property Coonabara bran, NSW	Single group since birth	27 Shorthorns from a mob of 94 which had been fed lucerne hay in the paddock throughout a severe drought	Small paddock with hay	Short distance, inducted a few days after arrival
Mob 2 (phase 3)	Property Barraba, NSW	Single group since birth	32 Hereford, 6 Angus, 1 Murray Grey and 1 Hereford cross from larger group drought fed with lucerne hay	Yard weaning with hay	Short distance, inducted a few days after arrival
Mob 3 (phase 3)	Property Carroll, NSW	Single group since birth	20 Shorthorns from a mob of 80 weaners used to creep feeding and then drought fed with hay	Creep feeding then small paddock (no hay)	Short distance, inducted a few days after arrival
Mob 4 (phase 3)	Property Breeza, NSW	Single group since birth	35 Shorthorns from a mob of 110 weaners drought fed with lucerne hay and wheat straw	Yard overnight then small paddock with hay	Short distance, inducted a few days after arrival
Mob 5 (phase 3)	Property Spring Ridge, NSW	Single group since birth	20 very well grown Angus from a mob of 100 yearlings which had reasonably good pasture and had not been hand fed	Self-weaned at pasture	Short distance, inducted a few days after arrival
Mob 6 (phase 3)	Property Quirindi, NSW	Single group since birth	11 Murray Grey and 1 Angus from a mob of 20 which had been drought fed with lucerne hay	Small paddock with hay	Short distance, inducted a few days after arrival

[1] The commercial-in-contact cattle were inducted into the feedlot pen 3 days after the experimental cattle in phase 1, but 3 days before the experimental cattle in phase 2 and phase 3.

In phase 1 the experimental cattle were a single source in that they had run together for nine months from the end of weaning until feedlot entry. They proved resistant to the infectious challenge whereas the multi-source, commercial-in-contact cattle in the same pen had high morbidity and mortality. Groups of cattle sourced from distant saleyards and immediately inducted into the feedlot pen fared the worst.

During the IBR disease episode in phase 2 and also during exposure to early respiratory infection in phase 3, the Braidwood source of animals proved to be much more susceptible to clinical disease than the EMAI source. The reasons for this are not clear, but it shows that both genotype and pre-weaning history could be important mitigating factors which can interact negatively with the beneficial effects of the pre-boosting treatments.

Mortality

The summary statements concerning health treatment effects (mortality, morbidity and slaughter lesions) over all three phases are given in Table 3b and data for the main treatment groups are in Table 3c. A number of deaths that were clearly not due to respiratory disease have been excluded from this Table (for easier interpretation). These are detailed in the page of numbered footnotes to Table 3c.

Despite the obvious infectious challenge which existed during the early adaptation period in phases 1 and 3, the only respiratory disease mortality in experimental cattle was one paddock-weaned, unvaccinated animal in week 5 of phase 1. This good result was not necessarily due to the pre-boosting treatments *per se*, which were applied to 75% of those animals, but it probably also reflects the advantage of running these animals together for some months prior to feedlot entry and the additive benefits of good handling and shipping procedures.

The commercial-in-contact cattle in phase 1 represent the extreme opposite case in that small groups had been mixed, first at saleyards and then in the feedlot pen, and some had been transported more than 800 km. Of these, the group that was rested in a paddock at the feedlot for a week before induction (WY) fared considerably better than the group that was inducted into the pen immediately after arrival at the feedlot (WS) (see Table 3d).

In phase 2, when the IBR disease outbreak occurred after 11 weeks on feed, the commercial-in-contact cattle which had been backgrounded as a single group during the previous winter, had fewer mortalities than the experimental cattle (see Table 3c). The situation with the experimental cattle is quite complicated; in summary, the predominant effect is due to the source of the cattle.

The vaccinated animals that were sent for salvage slaughter (3 yard-trained, 1 yard-weaned, 1 paddock-weaned) were all from the Braidwood source. There were also three deaths from the EMAI-source cattle (2 yard-trained, 1 yard-weaned), but these were unvaccinated animals. Therefore it is possible that the vaccine had protected EMAI cattle, but not Braidwood cattle. The efficacy of vaccines is known to be influenced by an animal's susceptibility to stress. Observed differences in behaviour between Braidwood and EMAI cattle (see later) suggested that the Braidwood cattle were less quiet and more likely to be adversely affected by the intensive feedlot situation, even after they had been yard weaned or trained.

Closer consideration shows that this result is not at all conclusive. The probability of the three EMAI deaths being in the unvaccinated group was not statistically significant and the probability of the five Braidwood deaths being from the vaccinated groups was very high anyway because these animals were disproportionately represented in the vaccinated groups (see earlier explanation of the design problem in phase 2).

Table 3a. Overview of the Disease Pattern over all three phases.

		Experimental	Commercial-in-contact
DISEASE PATTERN **Overview of the pathogenic challenge and the cattle population**	**Phase 1**	Extensive PESTIVIRUS, BRSV and significant IBR transmission in the first 5 weeks. LOW MORTALITY in 'single-source', well-handled and shipped cattle population (put into the feedlot pen 3 days earlier than commercial cattle).	Extensive PESTIVIRUS, BRSV and significant IBR transmission in the first 5 weeks. HIGH MORTALITY in multi-source cattle population, especially those shipped from distant saleyards and immediately inducted.
	Phase 2	Extensive PESTIVIRUS and BRSV transmission in the first 5 weeks. Late IBR transmission with respiratory disease and associated mortality. HIGH MORTALITY (11 weeks on feed) in well-handled cattle (into feedlot pen after commercial cattle). Mostly in Braidwood source cattle.	Extensive PESTIVIRUS and BRSV transmission in the first 5 weeks. Late IBR transmission with respiratory disease and associated mortality. MODERATE MORTALITY in single-source, backgrounded, well-handled and shipped cattle population.
	Phase 3	Extensive PESTIVIRUS, BRSV and some PI_3 transmission in the first 5 weeks. IBR transmission 30% in the first 5 weeks; 100% by slaughter after 13 weeks on feed. LOW MORTALITY in well-handled cattle population (put into the feedlot pen 3 days after the commercial cattle).	Extensive PESTIVIRUS, BRSV and some PI_3 transmission in the first 5 weeks. IBR transmission 30% in the first 5 weeks; 100% by slaughter after 13 weeks on feed. LOW MORTALITY in multi-source (local), well-handled cattle population (87% of which had been intensively weaned and drought fed).

Table 3b. Summary statements regarding the main HEALTH treatment effects over all three phases.

		Experimental	Commercial-in-contact
Mortality (number dead)	**Phase 1**	Single death in PADDOCK WEANED UNVACCINATED group	4.5% mortality from confirmed early respiratory disease
	Phase 2	4.1% mortality, but none in EMAI VACCINATED groups	2.1% mortality in late IBR respiratory disease episode
	Phase 3	No mortality attributed to respiratory disease	No mortality attributed to respiratory disease
Morbidity (% sick pulls)	**Phase 1**	YARD WEANED less than half that of PADDOCK WEANED	High morbidity especially in saleyard cattle inducted immediately on arrival at feedlot
	Phase 2	YARD WEANED less than half that of PADDOCK WEANED	Higher morbidity in early period associated with poor adaptation to feed
	Phase 3	YARD WEANED less than one third that of PADDOCK WEANED	Sick pulls concentrated in the first 5 weeks. Mob 2 over-represented
Resp-iratory lesions at slaughter	**Phase 1**	Insignificant number – early acute disease with low morbidity	Significant lesions due to severe early acute disease with high morbidity
	Phase 2	High prevalence of minor lesions due to late IBR disease episode	High prevalence of minor lesions due to late IBR disease episode
	Phase 3	Significant lesions due to severe early acute disease with high morbidity	Insignificant number due to extended period before slaughter

Table 3c. HEALTH means of the main weaning treatment groups over all three phases.

YW = yard weaning, YT = yard training, PW = paddock weaning (i.e. CONTROL)

		Experimental	Commercial-in-contact
Mortality (number dead)	Phase 1	YW = 0 [a] YT = 0 [a] PW = 1 (week 5) [a] 1/205 [1]	Combined = 8 (weeks 2,3,4,5,6) 8/177
	Phase 2	YW = 2/49 [a] YT = 5/98 [a] PW = 1/49 [a] (weeks 11,12) 8/196 [2]	Combined = 4 (weeks 11,12) 4/187 [3]
	Phase 3	YW = 0 YT = 0 PW = 0 0/209 [4]	Combined = 0 0/154 [5]
Morbidity (% sick pulls)	Phase 1	YW = 2.0 [a] YT = 4.0 [a] PW = 5.4 [a]	Combined = 41.2
	Phase 2	YW = 4.1 [a] YT = 10.2 [a] PW = 10.2 [a] [6]	Combined = 15.5
	Phase 3	YW = 5.9 [a] YT = 17.3 [ab] [7] PW = 22.2 [b]	Combined = 9.1
% Respiratory lesions at slaughter	Phase 1	YW = 2.0 [a] YT = 2.0 [a] PW = 9.1 [b]	Combined = 31.0
	Phase 2	YW = 44.7 [a] YT = 44.2 [a] PW = 54.2 [a]	Combined = 58.1
	Phase 3	YW = 27.5 [a] YT = 36.5 [a] PW = 22.7 [a]	Combined = 4.7 [8]

[ab] Within a cell, means which have unlike superscripts are significantly different ($p < 0.05$).

Footnotes for Table 3c

❶ 1 additional death due to wire in rumen (week 7).

❷ 3 additional deaths due to colonic perforation (weeks 1,3,4).

❸ 3 additional deaths due to colonic perforation (week 4), hair balls (week 6) and perioesophageal cellulitis (week 6).

❹ 1 salvage slaughter with chronic tracheo-bronchitis, but microbiologically negative (week 11). This was from the EMAI source (PWV).

❺ 2 salvage slaughter, both unwell, but cause unconfirmed (weeks 1 and 16). These were from the Mob 2 source.

❻ Pulls due to early respiratory disease (i.e. excluding the salvage slaughter in weeks 11 and 12) were 4.6% (6/9 from the BWD source). The groups were YW = 0, YT = 5.1% and PW = 8.2%.

❼ Excluding the 6 animals which totally failed in the training procedure and incurred 117% pull rate, YT = 10.2%.

❽ Only 86 of 154 animals checked and this was up to 153 days after completion of the trial.

Table 3d. HEALTH means of the various source groups over all three phases.
See key with information about individual source groups in Table 2

		Experimental	Commercial-in-contact
Mortality (number dead)	**Phase 1**	EMAI = 1/126^{a} (week 5) BWD = 0/30^{a} ARAL = 0/50^{a}	TP = 2/18^{a} (w 3,5) SP = 0/18^{a} WY = 1/54^{a} (w 5) DS = 1/52^{a} (w 2) FE = 0/6^{a} WS = 4/29^{a} (w 3-6)
	Phase 2	EMAI = 3/130^{a} (all UNVACC) (w 11, 12) BWD = 5/66^{a} (all VACC'D) (w 11, 12)	Combined = 4/187
	Phase 3	EMAI = 0/110^{a} BWD = 0/99^{a}	Mob 1 = 0/27^{a} Mob 2 = 0/32^{a} Mob 3 = 0/20^{a} Mob 4 = 0/35^{a} Mob 5 = 0/20^{a} Mob 6 = 0/12^{a}
Morbidity (% sick pulls)	**Phase 1**	EMAI = 4.1^{a} BWD = 0.0^{a} ARAL = 6.0^{a}	TP = 33.3^{a} SP = 83.3^{bc} WY = 27.8^{a} DS = 76.9^{b} FE = 16.7^{a} WS = 100.0^{c}
	Phase 2	EMAI = 4.6^{a} BWD = 16.7^{b}	Combined = 15.5
	Phase 3	EMAI = 3.6^{a} BWD = 29.3^{b}	Mob 1 = 7.4^{a} Mob 2 = 25.0^{b} Mob 3 = 5.0^{a} Mob 4 = 0.0^{a} Mob 5 = 0.0^{a} Mob 6 = 8.3^{a}
Resp-iratory lesions at slaughter	**Phase 1**	EMAI = 3.6^{a} BWD = 0.0^{a} ARAL = 4.2^{a}	TP = 25.0^{a} SP = 18.8^{a} WY = 25.0^{a} DS = 44.0^{a} FE = 60.0^{b} WS = 21.8^{a}
	Phase 2	EMAI = 50.4^{a} BWD = 22.0^{b}	Combined = 58.1
	Phase 3	EMAI = 33.0^{a} BWD = 28.3^{a}	Combined = 4.7

^{abc} Within a cell, means which have unlike superscripts are significantly different ($p < 0.05$).

Table 3e. HEALTH means of the sub-treatment groups over all three phases. YWV = yard weaned vaccinated, YWU = yard weaned unvaccinated, YTV = yard trained vaccinated, YTU = yard trained unvaccinated, PWV = paddock weaned vaccinated, PWU = paddock weaned unvaccinated (i.e. CONTROL)

		Experimental	Commercial-in-contact
Mortality (number dead)	Phase 1	YWV = 0/25 [a] YWU = 0/26 [a] YTV = 0/49 [a] YTU = 0/50 [a] PWV = 0/28 [a] PWU = 1/28 [a] (w 5)	Combined = 8 (weeks 2,3,4,5,6) 8/177
	Phase 2	YWV = 1/25 [a] YWU = 1/24 [a] YTV = 3/50 [a] YTU = 2/48 [a] PWV = 1/25 [a] PWU = 0/24 [a]	Combined = 4 (weeks 11,12) 4/187
	Phase 3	YWV = 0/25 [a] YWU = 0/26 [a] YTV = 0/52 [a] YTU = 0/52 [a] PWV = 0/27 [a] PWU = 0/27 [a]	Combined = 0 0/154
Morbidity (% sick pulls)	Phase 1	YWV = 4.0 [a] YWU = 0.0 [a] YTV = 4.0 [a] YTU = 4.0 [a] PWV = 7.1 [a] PWU = 3.6 [a]	Combined = 41.2
	Phase 2	YWV = 4.0 [a] YWU = 4.2 [a] YTV = 14.0 [a] YTU = 6.3 [a] PWV = 16.0 [a] PWU = 4.2 [a]	Combined = 15.5
	Phase 3	YWV = 12.0 [a] YWU = 0.0 [a] YTV = 21.2 [b] YTU = 13.5 [a] PWV = 25.9 [b] PWU = 18.5 [a]	Combined = 9.1

Resp-iratory lesions at slaughter	**Phase 1**	YWV = 0.0 [a] YWU = 4.0 [a] YTV = 0.5 [a] YTU = 2.6 [a] PWV = 4.2 [a] PWU = 13.0 [a]	Combined = 31.0
	Phase 2	YWV = 44.2 [a] YWU = 45.2 [a] YTV = 43.6 [a] YTU = 45.6 [a] PWV = 52.0 [a] PWU = 55.6 [a]	Combined = 58.1
	Phase 3	YWV = 22.0 [a] YWU = 31.6 [a] YTV = 30.5 [a] YTU = 42.3 [a] PWV = 20.8 [a] PWU = 24.6 [a]	Combined = 4.7

[abc] Within a cell, means which have unlike superscripts are significantly different ($p < 0.05$).

This equivocal evidence of an interaction between vaccine efficacy and the source of the cattle may need to considered in future vaccine development work. The time interval between the last IBR vaccination and the disease outbreak was 125 days and the IBR titres had fallen in the period between induction and day 37. However, we have no way of knowing whether these titres were protective or not against disease due to IBR infection.

Neither yard weaning nor training prevented mortalities in the event of this late onset IBR challenge. It is to be expected that the major benefits of these treatments, e.g. on early feeding behaviour (see later), would be seen during the early adaptation period. These treatments might be expected to be most effective in preventing early respiratory disease, as was shown in phases 1 and 3.

In conclusion, the main finding was that mortality due to early respiratory disease in a typical feedlot infection situation did not occur in pre-boosted cattle in the course of this research. This implies that the pre-boosting treatments were beneficial in terms of mortality as well as in improving weight gain.

The IBR outbreak in phase 2, however, shows that the pre-boosting treatments cannot be guaranteed to provide protection against all forms of respiratory disease. The likely reasons for this limitation are that the benefits of yard weaning did not persist beyond the early adaptation period and the vaccine was not effective in animals from a particular source after 11 weeks on feed. The vaccines used in this project were experimental and for IBR were in a killed (inactivated) form. It is expected and feasible (e.g. by the use of modified live virus IBR products) that they will have been improved by the time the commercial vaccine development is completed and available to the industry.

Morbidity

The morbidity data summarised in Tables 3c-e are expressed as the percentage of sick animals within a group. Animals pulled for other reasons (lame or bulling) are excluded from these Tables (for easier interpretation), but the complete data set is given in each of the milestone reports (see appendices).

The major finding was the consistently reduced morbidity in the yard-weaned groups compared to the paddock-weaned controls (see the summary statements in Table 3b). The number of yard-weaned animals pulled because of sickness was less than half that of paddock-weaned animals in all three phases. However, only in phase 3 was this statistically significant ($P < 0.05$ Fisher's exact test – see Table 3c).

The commercial-in-contact cattle showed the wide variation in morbidity that has been recorded previously in commercial feedlots (see MRC DAN.064). In phase 1 a collection of high-risk animals had very much higher morbidity than experimental cattle; the backgrounded cattle in phase 2 had only slightly higher morbidity than other groups; and in phase 3 the more intensively weaned, previously drought fed, local cattle had lower morbidity than all Braidwood experimental cattle. In phase 1 the lowest morbidity was in groups that were either local or were rested before feedlot induction and the highest morbidity was in the Victorian saleyard groups that were inducted immediately after arrival at the feedlot. This difference was significant.

There was a significant source effect again in experimental cattle in phases 2 and 3, the Braidwood group accounting for the great majority of sick animals (see Table 3d). This was most apparent in phase 3 when six Braidwood animals completely failed in the training procedure. All animals had completed the training procedure in phases 1 and 2. This is discussed more fully in the next section of the report. It is worthy of note, however, that the exclusion of those six animals reduces the morbidity of yard-trained cattle in phase 3 from 17.3% to 10.2% (see footnotes to Table 3c). Therefore, a small number of animals whose behaviour or temperament was not suited to feedlot conditions contributed disproportionately to the overall morbidity.

In view of the overall beneficial effect of yard weaning, it is important to consider whether this benefit applied equally to cattle from the two different sources. Clearly it did not, in that the majority of yard-weaned animals that became sick were from the Braidwood source. However, there still appeared to be a treatment effect of yard weaning on the Braidwood cattle. For Braidwood cattle only, the morbidity in phase 2 (due to early respiratory disease) was 0% for yard-weaned, 9% for yard-trained and 19% for paddock-weaned and in phase 3 the overall morbidity was 12% for yard-weaned, 22% for yard-trained and 28% for paddock-weaned.

In all phases there was higher morbidity recorded in vaccinated animals than in unvaccinated animals, but this difference was not significant in any treatment group. This would be at odds with the finding that weight gain was consistently better in vaccinated groups (see earlier), suggesting that the level of sub-clinical disease had been reduced by the vaccine treatment. Although not a clear cut result, this may reflect on the criteria used by the pen riders to identify the animals to be pulled because it is possible that the vaccinated animals that were pulled were not really sick, but were exhibiting some side effects of a successful immunological defense against infection. The weight gain of pulled vaccinated animals, however, was no different from the weight gain of other pulls (see later section).

In phase 2 the morbidity picture is complicated by the disease outbreak occurring in weeks 11 and 12. Exclusion of the salvage slaughter animals allows a clearer picture to be seen of the early respiratory disease in the main treatment groups. Prior to the first salvage slaughter, there were no pulls from the yard-weaned group compared with 5.1% of yard-trained and 8.2% of paddock-weaned (see footnote to Table 3c).

In conclusion, the consistently lower morbidity in yard-weaned cattle shows that this practice was beneficial in reducing the incidence of clinical disease in cattle exposed to respiratory infection in a commercial feedlot. In view of the beneficial effect of yard weaning on weight gain (see earlier), it seems likely that this practice has resulted in a lower level of sub-clinical disease also.

The effect of yard training is not so clear. While it appeared to be similar to yard weaning in its effect on cattle from the EMAI source, it was clearly not as beneficial as yard weaning in its effect on the rather more temperamental Braidwood cattle. It is possible that the psychological conditioning resulting from the training procedure may have even been a negative reinforcement for these animals if it was actually stressful to them at the time of weaning. Even relatively minor unpleasant experiences can have long-term conditioning effects (Grandin 1989) so there is a fine line between negative and positive reinforcement with this type of training. Further research is needed to determine whether there could be adverse consequences from a training procedure such as this. In the meantime a note of caution is warranted regarding the use of this kind of approach-avoidance training procedure with more flighty animals.

Respiratory Lesions at Slaughter

In phase 1 there was an insignificant number of low grade respiratory lesions in the experimental groups of cattle, but a high incidence of more severe lesions (grades 3 and 4 signifying up to 50% consolidation of the lungs) in the commercial-in-contact animals, consistent with the much higher morbidity and mortality in that group. As shown in Tables 3c and 3e, the paddock-weaned, unvaccinated group had significantly more lesions than any of the pre-boosted groups. This supports the general finding that the beneficial effects of these treatments were associated with a reduction in sub-clinical disease.

The late IBR disease episode in phase 2 resulted in a high prevalence of minor, recent respiratory lesions, predominantly fibrinous pleuritis, in both experimental and commercial-in-contact animals. The paddock-weaned group was again the highest (see Table 3c).

There was a significant incidence of respiratory lesions at slaughter in experimental cattle in phase 3. The result for commercial-in-contact cattle is misleading because only about half of the animals were checked and these were slaughtered at various intervals up to 153 days after the trial was over (see Table 3). In this case the yard-trained groups were the highest. Within the EMAI source, the vaccinated animals had appreciably fewer respiratory lesions than the unvaccinated animals (26% cf. 40%) which is consistent with the beneficial effects of vaccination.

Liver Lesions at Slaughter

These are not shown in the Table because they were not regarded as part of the respiratory disease picture. However, the prevalence of liver lesions may reveal a metabolic disturbance that occurred during the adaptation to the feedlot ration.

In phase 1 there was a modest prevalence of liver lesions which averaged approximately 5% in unvaccinated animals and 10% in vaccinated and commercial-in-contact animals. This difference was not significant and no particular importance was attached to it, but the results in phase 3 did show a significantly higher incidence of liver lesions in vaccinated animals (31%) than in unvaccinated animals (17%) or in commercial-in-contact cattle (7%). No explanation for this difference can be offered at this stage. A higher feed intake during the first week in the feedlot can be ruled out as a possible cause because there was no difference between vaccinated and unvaccinated animals in their feeding activity (see later section). In phase 2 there was a very low prevalence of liver lesions in experimental cattle (1%) and a high prevalence in commercial-in-contact cattle (60%) due to previous exposure to liver fluke.

INTERACTION BETWEEN HEALTH AND WEIGHT GAIN

It was apparent throughout each phase that sick animals suffered a setback in terms of weight gain. This was to be expected, but the magnitude of the effect and the extent to which these animals can catch up over a 90 day period are two issues worthy of closer examination.

Results for all three phases are summarised in Table 4. In this case the dead animals are not included, so the real cost of the sickness is underestimated to some extent. Those animals which had been pulled as sick had a considerably lower weight gain in the first month and generally this was a significant difference (see Table 4 for details). The average difference over all groups was 29% (1.294 cf. 1.672). This difference applied to both vaccinated and unvaccinated animals.

Table 4. Summary of HEALTH effects on WEIGHT GAIN over all three phases.

<table>
<tr><th></th><th></th><th>Experimental</th><th>Commercial-in-contact</th></tr>
<tr><td rowspan="3">ADG (First Month)</td><td>Phase 1</td><td colspan="2">Healthy = 1.87 [a]
Sick = 1.33 [b]
Bullers = 1.60 [c]
Multiple = 0.82</td></tr>
<tr><td>Phase 2</td><td>Healthy = 1.70 [a]
Sick = 1.58 [a]
Bullers = none</td><td>Healthy = 1.74 [a]
Sick = 1.27 [b]
Bullers = 2.13 [c]</td></tr>
<tr><td>Phase 3</td><td>Healthy = 1.46 [a]
Sick = 1.07 [b]
Bullers = none
Multiple = 1.12</td><td>Healthy = 1.59 [a]
Sick = 1.22 [b]
Bullers = 1.38 [ab]
Multiple = 0.80</td></tr>
<tr><td rowspan="3">ADG (90 day feeding)</td><td>Phase 1</td><td colspan="2">Healthy = 1.46 [a]
Sick = 1.31 [b]
Bullers = 1.38 [ab]
Multiple = 1.14</td></tr>
<tr><td>Phase 2</td><td>Healthy = 1.58 [a]
Sick = 1.47 [a]
Bullers = none</td><td>Healthy = 1.79 [a]
Sick = 1.55 [b]
Bullers = 1.41 [b]</td></tr>
<tr><td>Phase 3</td><td>Healthy = 1.38 [a]
Sick = 1.30 [a]
Bullers = none
Multiple = 0.99</td><td>Healthy = 1.61 [a]
Sick = 1.52 [a]
Bullers = 1.03 [b]
Multiple = 1.17</td></tr>
</table>

[abc] Within a cell, means which have unlike superscripts are significantly different ($p < 0.05$)

After 90 days on feed this margin was reduced to 9% (1.564 cf. 1.430) indicating that the animals affected by early respiratory disease are capable of making up a fair amount of the lost ground over this period. However, in two of the comparisons shown in Table 4, there was still a significant difference between sick and healthy animals even after 90 days. Those animals which were multiple pulls (and yet did not die) performed very badly in several cases.

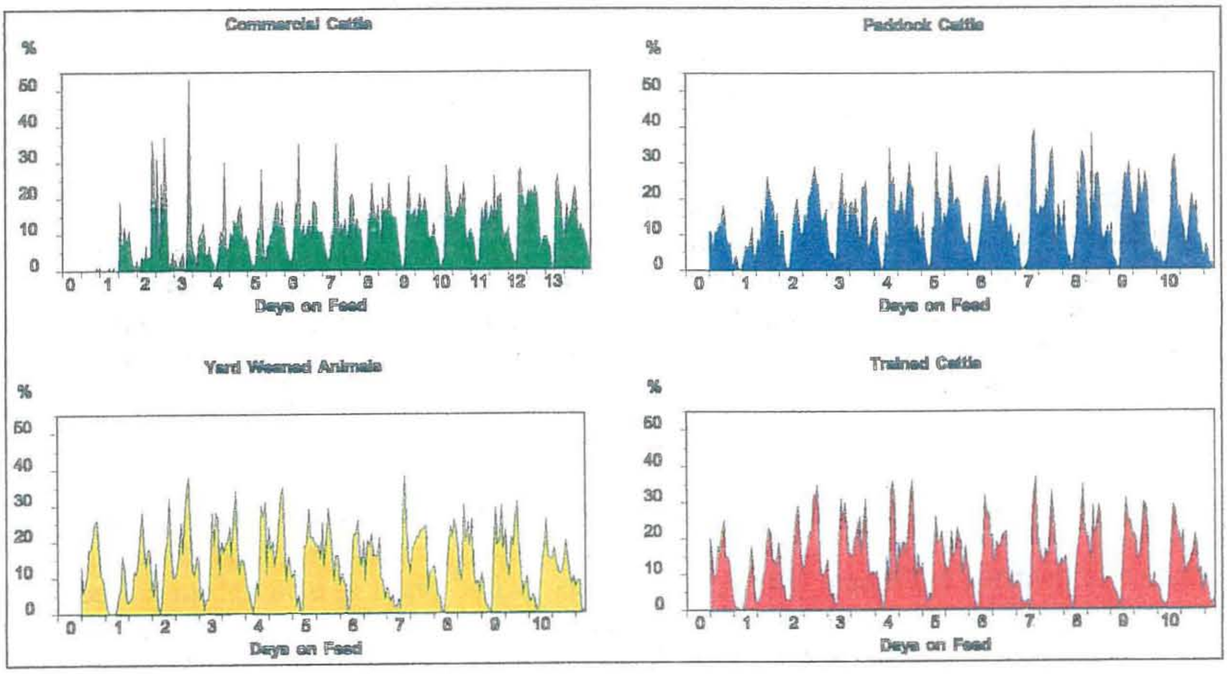
FEEDING ACTIVITY

The time it takes for an animal to begin feeding at the feed bunk and establish a regular feeding pattern is an important aspect of adaptation to the feedlot and it was the major behavioural measure in this project. The new system of recording we used enabled an unprecedented amount of data on early feeding behaviour of cattle to be obtained. The details which were included in the individual milestone reports (see appendices 1-3) will not be repeated here, but the consistent differences and significant treatment effects will be summarised so that conclusions can be drawn.

The biggest difference in feeding activity was between the experimental cattle and the commercial-in-contact cattle, the latter taking much longer to make their first visit to the feed bunk or to establish a routine of regular meals. This was very apparent whether the experimental cattle were put into the feedlot pen three days before the commercial cattle, as in phase 1, or the experimental cattle entered the pen three days after the commercial cattle, as in phase 2. It was less apparent in phase 3 when all commercial-in-contact animals had been previously hand-fed because of drought.

A general picture of the group feeding activity, day and night, is given in Figure 5 which is taken from phase 2.

Figure 5. The proportion of animals in each treatment group that were feeding at the feed bunk at the time of each 15 minute scan over the first 10 days in the feedlot in phase 2.



In phase 2 it can be seen that the commercial cattle did not visit the bunk on day 0 (the day of induction), nor half of day 1, so about 20 bales of lucerne hay were put into the bunk on the afternoon of day 1, twice on day 2 and then each morning through to day 7. This accounted for the spikes of activity shown for the commercial cattle in Figure 5. Meanwhile, most of the experimental animals began feeding as soon as they arrived in the pen after induction. The activity was least for the paddock-weaned group and it gradually increased over the first seven days. A pattern was soon established with two peaks that coincided with the delivery of feed at 0800 and 1300 h each day. This is just one example, but it is reasonably typical of the early feeding activity observed throughout the project.

In phase 1 the commercial-in-contact cattle had to compete with already established experimental animals and it was obvious that they were not actively feeding for several days, but we did not collect individual animal data from commercial animals so no statistical comparison could be made. In phase 2 the commercial-in-contact animals had significantly lower feeding activity than experimental animals on day 0 (the day of induction) and days 2-7 (see appendix 2). From day 8 to the morning of day 11 the difference was not significant.

Because the commercial cattle were very attracted to hay (having been fed hay throughout the previous winter), the provision of hay on days 1-7 may have delayed the establishment of their bunk feeding pattern. In phase 3, with cattle that had also been previously hand fed, the commercial-in-contact animals had significantly lower feeding activity only on the day of induction and were equal to the paddock-weaned experimental animals over days 1-4 (see appendix 3).

A general lack of feeding activity on day 1 (the day after induction), with very little difference between treatment groups on that day, was evident in all three phases. There appeared to be more time spent resting on that day which suggested that the animals were too tired to give much attention to feeding after the physical and psychological effort of induction and shipping to the feedlot.

A significant difference between the yard-trained or yard-weaned groups and the paddock-weaned controls was not clearly evident in phase 1, but it was quite evident in phases 2 and 3 (see appendices). The biggest difference was on the day of induction in phase 3 when the paddock-weaned group had less than half the feeding activity of the yard-treated groups. We assumed that this was due to a lesser amount of social facilitation because this group had been kept separate from the treated groups after weaning.

The yard-trained animals showed a slightly higher level of feeding activity than yard-weaned on most occasions, but this difference was generally not significant. It appeared that the additional training of animals to find grain in a trough produced only marginal benefits within a single social group of cattle. It is likely that the example set by the better trained animals was of some assistance to those from the same social group which had been only yard weaned. There was no difference in feeding behaviour between vaccinated and unvaccinated cattle except for two days in phase 1 which appeared to be an aberration.

The significantly better feeding activity of yard-treated cattle was only apparent up to day 4. However, there were some days between day 8 and day 18 when one of these groups showed higher activity again. It was concluded that the superior feeding behaviour of yard-treated animals was not long-lasting and probably did not persist beyond 7-10 days on feed. A detailed analysis of feeding behaviour in its own right is beyond the scope of this report, but will be the subject of a supplementary publication in due course.

At the end of the Results and Discussion section the possible causal mechanisms for the main treatment effects are discussed and the relative importance of these short-term differences in feeding behaviour is discussed further.

STRESS AND BEHAVIOUR

The physiological responses to stress around the times of weaning and feedlot induction were measured by cortisol assay in all three phases. There were also some effects of handling stress on haematological parameters observed in phase 1. These indicators of stress can be compared with the additional behaviour measurements by which animal confidence was assessed in yard-trained animals in all phases and animal temperament of all animals was assessed by other means in phase3.

Stress Response (Plasma Cortisol)

It is notoriously difficult to monitor chronic stress in animals because the indicators which can be measured are so sensitive to acute change, but it has been possible in this project to monitor the responsiveness to handling stress of a sufficiently large number of animals to see some consistent effects. The details are given in the appendices. The typical pattern of hormonal stress responses to the weighing and sampling procedure before and after weaning and the feedlot induction procedure is shown in Figures 6 and 7 which refer to phases 1 and 3.

In all three phases there was a significantly higher cortisol response to the feedlot induction than to any other handling experience. The plasma cortisol concentration was more than twice as high at induction than it was at the beginning or the end of weaning. The procedures were quite different, the induction following shortly after the stress of transport and involving a hydraulic crush mechanism and additional ear tagging and generally a faster throughput of cattle. Between phase 1 and the subsequent phases there were some changes made to the crush design and the induction procedure which appeared to reduce the behavioural stress, but these changes had no effect on the mean cortisol level.

There were no significant differences between treatment groups in the plasma cortisol response at feedlot induction. In phase 2 the EMAI source of cattle had an appreciably lower cortisol response at induction than Braidwood cattle, but due to large between-animal variation, this difference was not significant.

Figure 6. Mean plasma cortisol concentration before and after weaning and at feedlot induction for the main treatment and source groups in Phase 1.

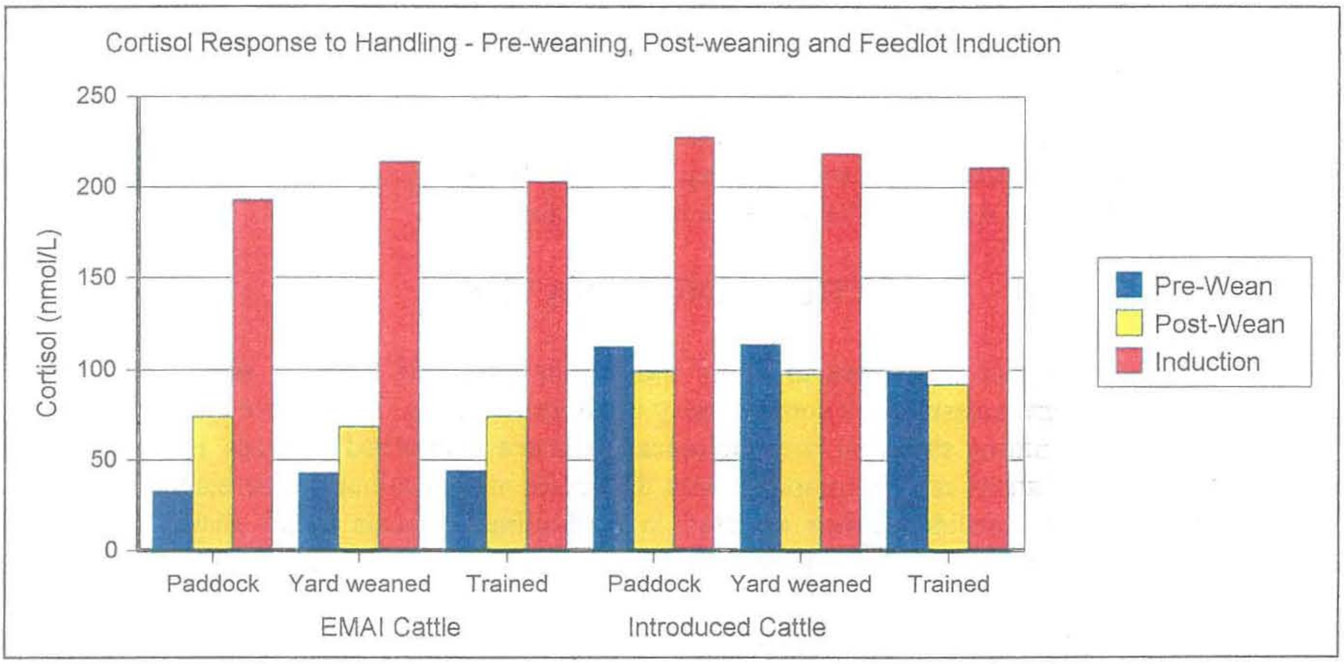
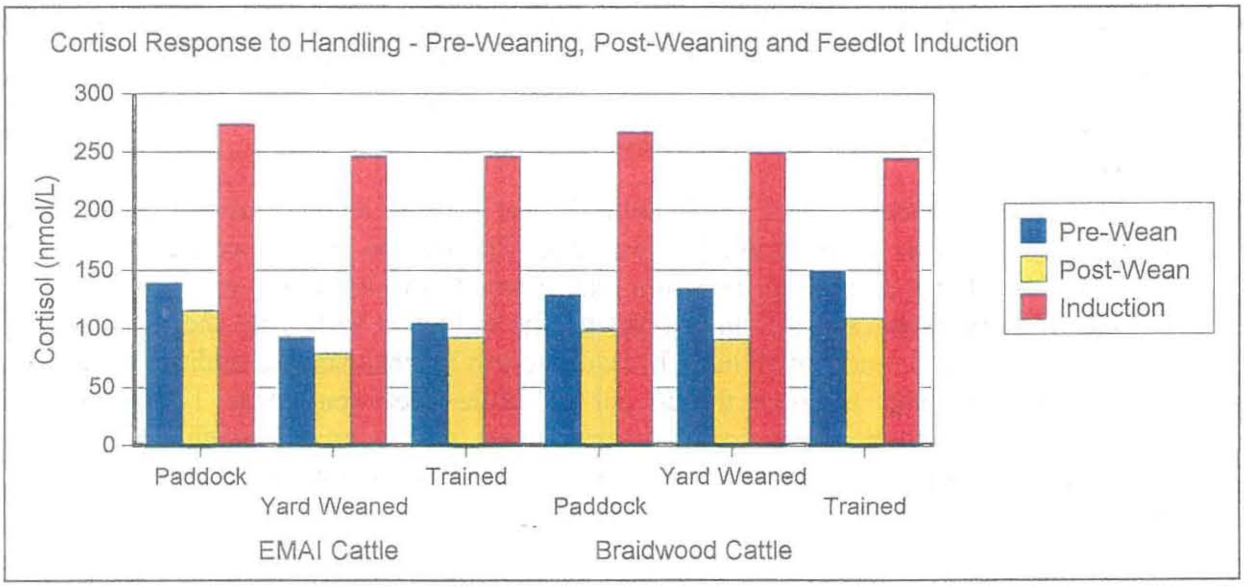


Figure 7. Mean plasma cortisol concentration before and after weaning and at feedlot induction for the main treatment and source groups in Phase 3.



In all three phases the Braidwood (or Braidwood plus Araluen cattle in phase 1) showed a larger drop from the start of the weaning treatment (the day after separation from their mothers) to the end of weaning (21 days later) than did the EMAI cattle. In phase 1 only, the EMAI cattle did not show this drop, but in all other cases it occurred, in all treatment groups, suggesting that the re-handling three weeks after weaning was less stressful than the initial handling. It made no difference whether the calves had been yard weaned or paddock weaned during this time. Although the yard weaned or trained animals appeared to be less reactive to humans and to handling generally by the end of weaning, this was not reflected in their cortisol response. The paddock-weaned groups did have the highest cortisol response at induction in all three phases, but the difference was not significant.

From these mean cortisol values we can see some consistency in the responses at different times, but no effects of any of the treatments. The individual animal values were a bit more useful when they were related to the animal's temperament (see later).

Stress Response (Haematology)

Some further evidence that the yard weaning treatments had reduced the responsiveness of animals to handling stress was obtained from the differential white cell counts performed before and after weaning in phase 1. Both the proportion of white blood cells that were neutrophils and the neutrophil : lymphocyte ratio were significantly lower on day 21 than on day 1 of weaning in the yard-weaned and yard-trained groups, but were only very slightly reduced in the paddock-weaned group. The reduction in proportion of neutrophils was 25.8 to 22.3 in yard-weaned, 26.6 to 18.2 in yard-trained and 20.6 to 19.6 in paddock-weaned cattle. The equivalent reductions in the neutrophil : lymphocyte ratio were 0.48 to 0.33, 0.48 to 0.26 and 0.33 to 0.29 respectively. This suggests that the yard-treated animals were less sensitive to the stress of handling and sampling than their paddock-treated counterparts were after weaning. However, a repeat of this study in phase 2 did not show significant differences before and after weaning in the numbers of these white blood cells.

Confidence and Temperament Testing at Weaning

The procedure for training animals to find grain in a trough during yard weaning was also used to measure a behavioural attribute which we called confidence. The confidence test was intended to measure the outcome of two opposing motivational systems: the desire to locate and eat an appetising feed pitted against the reluctance to reduce flight distance because of fear of humans. Those animals which found their way past the person and through the gate to get to the fresh hay and grain with the least delay were ranked as the most confident while those that took the longest to get through to the feed were the least confident animals.

The test was repeated each morning for 10 days and the majority of animals in each group had passed through the gate after the third or fourth day in each phase. The dynamics of this behavioural testing will be discussed in much more detail in a separate publication. For the purposes of this study the test was used to identify those animals which might be considered unsuitable for feedlot conditions because they were "shy feeders" or too easily frightened by humans, horses or vehicles. Those animals which passed through the gate only once (or not at all in phase 3) were classified as shy.

There were 10 shy animals in phase 1 from the 99 head in the two yard-trained groups. In phase 2 there were 8 classed as shy out of 98 and in phase 3 there were 18 out of 104. In phase 3 these included six animals that were unable to get through the gate at any stage. These were the only animals in the entire project that failed to complete the training procedure. Therefore there were 10%, 8% and 17% of the cattle which were distinguished by this test as being appreciably inferior in confidence compared to the rest of their group.

The performance of these shy animals was compared with the rest of their group (known as confident animals) in each phase and the results are summarised in Tables 5a-b. In every case the shy animals had appreciably lower weight gains than the others and this difference was significant in each case except for the 90-day weight gain in phase 1. The shy animals also had a very much higher pull rate in phase 2 and phase 3, these differences being highly significant. In phase 1 there were relatively few pulls (none amongst shy animals) and the difference was not significant.

The cortisol data showed clearly that these shy animals were more responsive to stress than the main group. In every case the mean cortisol response from handling before and after weaning and at feedlot induction was significantly higher for shy animals. This provides some evidence of an association between the susceptibility to stress of individual animals and their health and weight gain in the feedlot situation.

Additional measures of temperament were made in phase 3. The flight speed test was carried out on all animals both before and after weaning. Individual flight times ranged from 0.6 to 2.9 seconds. The group means for flight speed were not significantly different between treatments either on day 1 before weaning or on day 21 after weaning. The flight time was slightly lower for all groups after weaning which does not provide any evidence that the yard weaning treatments had quietened the animals. There was a highly significant (Pearson) correlation coefficient of 0.62 between the two flight speed recordings showing that this measurement was reasonably repeatable under these conditions which were not ideal for flight speed measurement because of the involved blood and saliva sampling which accompanied the weighing.

Table 5a. Summary of the weight gain, health and stress responses of different TEMPERAMENT groups over all three phases.

ADG (First Month	**Phase 1**	Confident group > Shy group
	Phase 2	Confident group > Shy group
	Phase 3	Confident group > Shy group Calm group > Nervous group
ADG (90 day feeding)	**Phase 1**	Confident group > shy groups, but the difference was not quite significant
	Phase 2	Confident group > Shy group
	Phase 3	Confident group > Shy group Calm group > Nervous group
ADG (90 days) deads included	**Phase 1**	Confident group > shy groups, but the difference was not quite significant
	Phase 2	Confident group > Shy group
	Phase 3	Confident group > Shy group Calm group > Nervous group
Morbidity (all pulls)	**Phase 1**	No significant differences between groups
	Phase 2	Confident group significantly lower morbidity than the Shy group
	Phase 3	Confident (or calm) groups significantly lower morbidity than the Shy (or Nervous) groups
Plasma Cortisol (at weighing)	**Phase 1**	Shy group > Confident group
	Phase 2	Shy group > Confident group
	Phase 3	Shy group > Confident group

Table 5b. The mean weight gain, health and stress responses of different TEMPERAMENT groups over all three phases.

ADG (First Month	**Phase 1**	confident (89) = 2.02 [a] shy (10) = 1.77 [b]
	Phase 2	confident (90) = 1.71 [a] shy (8) = 1.44 [b]
	Phase 3	confident (86) = 1.47 [a] shy (18) = 1.30 [b] calm (12/208) = 1.46 [a] nervous (12/208) = 0.95 [b]
ADG (90 day feeding)	**Phase 1**	confident (89) = 1.72 [a] shy (10) = 1.65 [a]
	Phase 2	confident (90) = 1.62 [a] shy (8) = 1.44 [b]
	Phase 3	confident (86) = 1.43 [a] shy (18) = 1.22 [b] calm (12/208) = 1.47 [a] nervous (12/208) = 1.13 [b]
ADG (90 days) deads included	**Phase 1**	confident (89) = 1.72 [a] shy (10) = 1.65 [a]
	Phase 2	confident (90) = 1.62 [a] shy (8) = 1.41 [b]
	Phase 3	confident (86) = 1.43 [a] shy (18) = 1.22 [b] calm (12/208) = 1.47 [a] nervous (12/208) = 1.13 [b]
Morbidity (all pulls)	**Phase 1**	confident (89) = 9.0 [a] shy (10) = 0 [a]
	Phase 2	confident (90) = 7.8 [a] shy (8) = 50.0 [b]
	Phase 3	confident (86) = 9.6 [a] shy (18) = 50.0 [b] calm (12/208) = 0 [a] nervous (12/208) = 41.7 [b]
Plasma Cortisol (at weighing)	**Phase 1**	confident (89) = 98.7 [a] shy (10) = 124.7 [b]
	Phase 2	confident (90) = 148.7 [a] shy (8) = 208.5 [b]
	Phase 3	confident (86) = 153.8 [a] shy (18) = 178.2 [b]

[abc] Within a cell, means which have unlike superscripts are significantly different ($p < 0.05$)

For the 104 animals which were confidence-tested (the yard-trained groups) there was a highly significant (Pearson) correlation coefficient of 0.57 between the flight speed and confidence score (which was the number of days on which an animal passed through the gate). This shows (from the R^2 of 0.32) that just over 30% of the variation in flight speed was accounted for by the variation in confidence and vice versa. This is reassuring in the sense that two different measures of "temperament" would be expected to show a significant association, but it also shows that these two tests are measuring different aspects of the animal's behaviour. Much larger numbers of animals will be needed to properly compare these two tests. Burrow et al have a large amount of data concerning the suitability of the flight speed test as a tool for breeding programs aimed at improving animal temperament and resultant meat quality in *Bos indicus* cattle (Heather Burrow, personal communication).

The main purpose of using the flight speed test in phase 3 was to select the animals for the focal animal groups. The other criterion used to select these animals was an assessment of crush behaviour (see methods). The focal group designated as the "nervous" group was chosen on the basis of unruly behaviour in the crush and fast flight speed. This group was also chosen from the paddock-weaned animals so that there was no benefit of extra handling at weaning. The focal group designated as "calm" was chosen on the basis of high confidence score, slow flight speed and quiet behaviour in the crush. This group was chosen from the yard-trained animals so that it also had the benefits of the weaning method.

The nervous group had significantly lower weight gain (35% lower in the first month) and significantly higher morbidity and also higher cortisol responses than the calm group (see Tables 5a-b). A close examination of the morbidity data showed that only one of these nervous animals that had been pulled was demonstrably sick with respiratory disease. The others were either lame or inappetent without any identified cause of disease. Therefore this result does not demonstrate any relationship between immune competence or disease susceptibility and behaviour. It suggests that the nervous animals are more likely to be injured during handling or to be inappetent.

The detailed behavioural study of these focal animals is outside the scope of this project and will be reported separately. Suffice it to say that, in all measures of behaviour in the feedlot, the nervous cattle were disadvantaged. They spent significantly less time resting and feeding and were more agitated generally. Over a period of 18 days there was no sign of any improvement in these behaviours, either.

These results clearly demonstrate that it is possible to identify animals at the time of weaning which will be amongst the worst performers in the feedlot in terms of weight gain (at least up to 90 days) and risk of being pulled. However, there were too few shy or nervous animals involved to draw any definite conclusions, particularly with regard to any association between such behavioural measurements and susceptibility to disease.

It is important to note that this work does not deliver - nor was it ever intended to deliver - a reliable or cost-effective method for identifying the troublesome animals routinely at weaning. These results indicate that such a method could be developed, but much larger numbers of animals would need to be studied and other types of test would need to be investigated. The doubt about whether the approach-avoidance principle used here to measure confidence might have adverse consequences (by negatively reinforcing a stressor) also needs to be resolved.

POSSIBLE MECHANISMS FOR THE MAJOR TREATMENT EFFECTS

These treatments, carried out during weaning or 1-2 months prior to the feedlot production phase, clearly influenced weight gain from the time the cattle first arrived in the feedlot (6-9 months after weaning) and throughout a substantial part of their 90-day feeding period. The specific yard weaning treatment also clearly influenced the incidence of disease in the feedlot as measured by the number of pulls. The extensive nature of the results obtained in this project, including the information on stress and behaviour, served to provide some clues as to the causal mechanism that could be operating to bring about these effects.

Possible mechanisms for the effect of weaning treatment include the following:

(1) The learned feeding behaviour resulting from yard weaning and training;

(2) Taming and quietening of temperamental animals during yard treatments;

(3) Strengthening of social bonds between animals during yard treatments;

(4) Familiarity with yard structure and pen surface;

(5) Direct stimulation of the immune system due to yard weaning;

(6) Others, not yet defined.

Perhaps the most obvious consequence of the weaning treatment which might be expected to bring about improvements in early weight gain is the learned feeding behaviour. On the basis of our data, however, it is highly unlikely that this could be a major causal mechanism. Firstly, the effect was too short-lived to be responsible for the longer-term gains we have seen. Secondly, the yard-trained groups did not perform better than yard-weaned, despite having excellent early feeding behaviour as a result of their learning at weaning. We conclude that this could only be a small part of the mechanism responsible for these effects.

There was some evidence of a reduced sensitivity to stress after yard weaning and some training and quietening of behaviour having occurred, but the magnitude of this effect was quite small. Also, there was ample evidence that a wide spectrum of temperaments still existed amongst the yard trained groups and that this was reflected in feedlot performance. Therefore, the taming or quietening of animals is also highly unlikely to be a major causal mechanism, although it could certainly play some part.

The social behaviour of calves during weaning and in the feedlot has been the subject of a parallel study being carried out to develop indices of animal welfare for feedlot cattle. Marked differences have been seen between yard-weaned and paddock-weaned cattle in the number of affiliations (the formation of pair-bonds and the frequency of allogrooming) and the incidence and pattern of agonistic interactions. This will be reported separately when the analysis is complete. It can be hypothesised, however, that the biggest difference between the animals from each of these weaning treatment groups lies in the quality of their social interactions. Cattle are highly social animals (Kilgour and Dalton 1984) and their ability to cope well with stress and thrive in the feedlot environment may depend on some aspects of social behaviour which have not been clearly defined. This cannot be ruled out as a major component of the beneficial effects attributed to yard weaning in this project. Further research is needed to understand this issue and perhaps to exploit it further for the benefit of animal production.

It is difficult to say what role the animal's previous exposure to the physical structures of the yard (other than those concerned with learned feeding behaviour) might play in its adaptation to the feedlot pen. It could be profoundly important or it could be a relatively minor role like the first two factors discussed here. The fact that paddock-weaned cattle appeared to fare relatively worse in phase 3 when they were denied the social attachment to yard-weaned cattle suggests that the physical yard factor was not playing as big a part as was the social factor. Further controlled experiments would be necessary to understand this better.

A direct effect on the immune system is purely speculative and these results add nothing which could illuminate that possibility. When the approach-avoidance type of testing was applied to sheep (Fell et al 1991), there was an indication that changes in immune competence were paralleled by changes in confidence. However, the higher morbidity of shy animals in this study cannot be attributed to any differences in the immune system of those animals. The matters remains an interesting and potentially fertile area for future investigation.

The explanation for the effect of vaccination on weight gain is presumably the reduced subclinical disease experienced by treated animals compared to the controls even though this was not supported by the morbidity data based on the number of animals removed from the pen. It is possible there could be a direct effect of vaccination on growth rate by virtue of some immunological-neuroendocrine interaction (Husband 1996), but it seems most likely that this would involve the extent of subclinical disease. Metabolic shifts away from growth-related processes are well known to be associated with disease stress at all levels (Elsasser et al 1997). There was no effect of vaccination on the early feeding behaviour, but unfortunately we know nothing about the feed intake during bouts of sickness, nor about the efficiency of feed conversion, both of which could be affected by the animals' level of coping during adaptation to the feedlot.

The overall conclusion is that the main reasons for the beneficial effects of both yard weaning and vaccination are to do with improvements in the animal's coping mechanisms when exposed to an adaptive challenge and a simultaneous infectious challenge during the early stages of a feedlot production regime. We still know very little about the immunological/neuroendocrine processes whereby better social coherence in the group can improve the adaptation of cattle to feedlots, particularly when combined with the effective use of protective vaccines. However, we now have a greater comprehension and awareness of the main factors which seem to be operating in this complex situation and this provides some clear directions for improved industry practice and also for future research.

ECONOMICS

Economic analyses for individual phases are fully reported in each of the phase reports contained in the appendices. As systems were developing and there were confounding livestock health problems in phase two, the following report is based primarily on the results from phase three with due regard for the consistency of results over all three phases.

Economic benefits were assumed to occur in a number of possible ways. These were:

- Faster weight gains in the feedlot.
- Lower livestock health costs due to less sick pulls in the feedlot.
- Less deaths in the feedlot.
- A higher proportion of finished stock making the higher priced target market.
- Higher growth rates can mean reduced times to finish cattle and increased throughput per annum for the feedlot.
- Faster turn-off time can lead to earlier payments and lesser interest charges on the investment in cattle.

Results showed (Tables 1a-d earlier in this report) that for phase 3 there was a significant improvement in weight gain for both yard weaning and training treatments compared to paddock weaning. This occurred both in the first month and for the 90 day feeding period. There was also a significant improvement in weight gain in phase 1 for yard weaning and training treatments in the first month of entering the feedlot. It has been assumed in the analysis that higher weight gain groups have consumed the same amount of feed as other treatments. In practice it is likely that higher weight gain groups have actually consumed more feed so that differences in gross margin performance may in fact be slightly overstated.

There were lower livestock health costs due to fewer sick pulls. In all three phases the percentage pulls due to sickness in the yard-weaned treatments was less than half of that in the paddock-weaned situation. It should be noted that in phase 3 the yard-weaned unvaccinated group did not have any animals pulled for sickness (see phase 3 report Table 9) and as a result there was no cost penalty applied in the calculations shown in Table 16 of the phase 3 report. Considering the overall picture in all three phases, this would appear to be a slight aberration and a cost of at least $2.50 per head for sick pen costs would be a reasonable estimate when the costs of other categories are examined.

There were actually lower sick pen costs for unvaccinated animals than for vaccinated animals (see Table 3e), but weight gain was consistently better in vaccinated groups, suggesting that the level of sub-clinical disease was reduced by vaccine treatment.

Due to the low occurrence of deaths in experimental groups, no significant differences in deaths can be attributed to treatments. There were no mortalities in phase 3 and sporadic mortalities in other phases. However, there were no deaths in any EMAI vaccinated treatments. A small difference in the percentage of deaths can have a moderate impact on the returns, however, the sensitivity analysis in phase 3 (see appendix 3, p.37) estimated a difference in average gross margin per head of $11 when death percentage was varied from .01% to 2%.

It is very difficult to place an estimate on the value of getting a higher proportion of stock into a target market. The value to the feedlot will depend on the target market, the price penalties or premiums and the tightness of specifications in making this market. Improvement in weight gains from treatment animals were only modest and it was considered that there would only be limited gains in this category. Premiums are paid for heavier cattle in some situations. In an example where cattle attract a 3 cents per kg dressed premium for being in excess of a target weight, the improvement in returns per head, where carcase weight is 200 kg, is $6.00. If an additional 5% make the premium grade the improvement in average gross margin per head is $0.30. The higher the carcase weight, the greater the bonus will be.

It must be noted that, in phase 3 (see appendix 3, Table 11, p.32), there was actually a premium price paid of 1 to 3 c/kg liveweight for the lighter control animals compared with the other treatments. This was because at the time of valuation, a premium was being paid for smaller carcases that suited the local markets. It is anticipated that this situation is unlikely to occur regularly in the future, but it must be acknowledged that market conditions can also prevail such that heavier animals attract a discount rather than a premium.

The phase 3 report (see appendix 3, Table 16) shows an improvement in gross margin of $33.43 for the yard-weaned unvaccinated treatment using a yardstick purchase price of $1.20/kg and a sale price equivalent to $1.30/kg liveweight. This improvement would reduce to $30.93 if sick pen costs of $2.50 as discussed above are allowed. The gross margin improvement for the yard-weaned vaccinated treatment was similar at $33.16.

Faster turn-off was not a factor in this study. Stock were fed for a set period and all gains were made through increased liveweight performance.

To calculate the likely benefit to the industry from these pre-boosting treatments, any costs borne by the farmer in carrying out the treatments must be subtracted from the superior gross margin performance during the feedlot stage. In fact farmers would need to be convinced they are to receive the premium necessary to at least compensate them for the costs incurred to justify the expenditure. Feedlotters will claim however, that in a market where there is choice, farmers may have little choice but to carry out the treatments if they wish to sell their cattle to the feedlot. Warranty, quality assurance and value-based trading are clearly issues at this point.

A summary of the difference in gross margin returns compared to paddock weaning (from the phase 3 report, Table 16) and the costs incurred by farmers (phase 3 report, Table 7) is shown in Table 6.

Table 6. Summary of difference in gross margin per head in feedlot stage (assuming feedlot purchase price is $1.20 per kg liveweight and sale price is $1.30 per kg liveweight) **and treatment costs incurred at farm level ($ per head)** (assuming vaccine cost of $9.08 - as this vaccine is only in the development phase it is impossible to determine the market price).

	Paddock Weaned Unvacc.	Paddock Weaned Vacc'd	Yard Weaned UnVacc.	Yard Weaned Vacc'd	Yard Trained UnVacc.	Yard Trained Vacc'd
Difference in gross margin	Control	11.36	33.43	33.16	21.28	30.05
Cost of treatment	0	9.48	5.5	14.98	9.28	18.76
Net benefit	0	1.88	27.93	18.18	12.00	11.29

The results in Table 6 show that under the price assumptions used there was a net benefit from all treatments. The yard weaning treatments showed the highest returns. To test the sensitivity of the results and allowing for price fluctuations it is estimated that the differences in gross margins should range under most price scenarios from $10 to $30 per head. The lower end results are most likely if it is proven that much of the improvement in growth rate was due to higher feed consumption.

Benefits to the industry of adopting a yard weaning strategy will depend on the adoption rate by producers. Adoption will in turn be determined by the quality of any extension program and the willingness of feedlots to acknowledge the value and negotiate a premium for yard weaned cattle. In order to attract producers to yard weaning, the costs must be matched by the premiums available. It is estimated that the cost of yard weaning is $5.50 comprising $5.00 per head feed (silage) costs and $0.50 in labour. At purchase weights averaging 290 kg, the premium required to cover costs is 1.9 cents. If vaccination is carried out in conjunction with yard weaning, the premium required to cover producer costs would be 5.2 c/kg. In reality an additional bonus is probably required to encourage producers to adopt a yard weaning strategy, unless other management advantages make the procedure worthwhile. Other advantages could include having quieter cattle, especially heifers, and having cattle that are trained for drought feeding should drought occur.

Feedlot capacity in Australia is currently 854,000 head (March 1997 Survey of Cattle in Feedlots conducted by ALFA and AMLC) of which 51% is currently utilised. Utilisation has increased from 40% to 50% from December 1996 to March 1997 and has the potential to increase still further if price prospects improve. Assuming an average feeding rate of 150 days on feed the current annual turn-off rate from accredited feedlots is 800,000. Table 7 on the next page provides estimates of the benefit that yard weaning technology could give to the industry given a range of numbers of yard-weaned cattle entering the feedlots per annum and a range of improvements in gross margins per head.

Adoption will take a considerable time to achieve. With adequate extension and feedlot incentives to producers a total of 400,000 yard-weaned cattle could be available to feedlots in by the year 2001. At an improvement in gross margin of $20 per head, this benefit to the industry would be $8 million dollars. As adoption increases the future gains would increase.

Table 7. Australian benefit per annum given number of cattle yard weaned and a range of improvements in gross margins.

	Improvement in gross margin per head ($'m)				
Numbers of yard-weaned animals in feedlots	$10	$15	$20	$25	$30
200,000	2	3	4	5	6
400,000	4	6	8	10	12
600,000	6	9	12	15	18
800,000	8	12	16	20	24
1,000,000	10	15	20	25	30
1,200,000	12	18	24	30	36

Impact on Meat and Livestock Industry

The results reported here should impact most on the weaning and marketing practices of the Southern beef breeding sector of the industry. Yard weaning is not currently widely practiced and calves are often weaned directly into saleyards where they encounter considerable stress from mixing and handling. The fact that the feeder steer market is becoming an increasingly important outlet for these producers should encourage adoption of methods which have now been shown to improve the animals' adaptability to feedlots. Yard weaning is a more integral part of the management of *Bos indicus* cattle in the Northern sector. However, this work has already stimulated similar trials being conducted by Drs Holroyd and Petherick in Queensland. In recent years, buyers of feedlot cattle have shown an increasing interest in the adaptive ability and disease-resistant qualities of genetically appropriate feeder steers that are also properly prepared and can be sourced directly from breeding or backgrounding properties. These findings should increase their resolve in this direction.

The principles on which these treatments were based will not be new to many people in the industry. It is apparent, however, that the industry has not yet been too successful at applying these principles in a consistent way in practice.

Two likely reasons for this is are offered below:

1. It requires the right combination of many small details to make an effective management practice and an overall quality assurance plan is essential.

2. The benefits of more effective pre-treatment of feeder steers were not clearly defined or recognised by all stakeholders, nor has there been an obvious economic incentive to improve this aspect of the beef supply chain.

This project, the practical application of which has already been described in a preliminary way by Fell et al (1997), has a direct bearing on both of these issues.

The findings should provide a useful guide to the combination of weaning and vaccination treatments which will be effective in many different industry situations. This is because such controlled trials help to reveal the underlying mechanisms and this provides a basis for extrapolating to other situations. It should also make the benefits of a weaning/vaccination package more visible and encourage the recognition and adoption of management procedures which add value at this point in the production chain.

However, the way in which this work is followed up will have a large bearing on its eventual impact in the industry. Much more industry experience will be required to validate these findings under a wide range of seasonal conditions, types of cattle and feedlot requirements and environments. We have only compared two basic methods of weaning (paddock and yard, with some variations). The effects of other methods such as weaning in small paddocks with supplement, on-the-fence weaning, creep feeding before weaning etc. cannot necessarily be predicted from our work. Our results suggest, however, that other methods which do not have the intense socialisation benefit of yard weaning may not be as effective.

The Storelink project, initiated and managed by the MRC, provides an ideal opportunity to monitor the benefits and pitfalls of the many different variations of weaning practice that could be used in the industry. We believe that our results could be used both to guide practices developed in Storelink groups and to help in interpretation of the results that producers are obtaining within the project.

Finally, it is the contribution to the Australian Beef Eating Quality Assurance Program that will be the measure of the value of this work to the industry. There is good reason to believe that producing feeder steers which adapt better, remain healthy and grow well in the feedlot will play a useful part in assuring the quality of the product onto the consumer's plate. Integrating feeder steer management with the next stage of intensive feedlot finishing forms part of an emerging best practice for a quality trading alliance between steer suppliers, feedlotters and the beef-consuming public.

Conclusions

It was concluded that the method of weaning beef calves and whether or not they receive pre-feedlot vaccination against respiratory disease can certainly influence the subsequent health and weight gain of these animals in the feedlot. Clearly, a simple method of yard weaning which has been detailed here resulted in better weight gain and reduced incidence of respiratory disease than a fairly typical paddock weaning regime. It was also noted that additional training of calves to eat grain from a trough during weaning did not give a better result than simple yard weaning with hay or silage. A definite benefit in weight gain also resulted from the use of experimental vaccines 1-2 months prior to feedlot entry.

It was also concluded that these treatments would be cost-effective under a range of industry circumstances. Economic analysis showed that, in comparison to the gross margins for control animals, all treatments improved the gross margins per head when compared to the control. The best in terms of the highest improvement in gross margin were the yard-weaned, unvaccinated and the yard-weaned, vaccinated treatments where, using projected income levels and price levels, an improvement of \$33 per head was achieved to the feedlot. Farmer costs of \$5.50 per head for yard weaning alone or, perhaps \$15 with vaccination, must be deducted from the feedlotter benefit because the feedlotters would have to offer a premium of at least this much for the cattle to make it worthwhile.

The economic analysis also showed that, with adequate extension and a positive response from feedlotters to offer premiums for producers to wean their cattle, a benefit to the industry of $8 million could be achieved by the year 2001.

Recommendations

In order to increase the likelihood of producing feeder steers which adapt well when introduced to the feedlot, are equipped to combat the infectious challenge and can therefore be expected to perform well in terms of health and weight gain, the following is recommended:

1. A method of weaning in small yards which has at least the major characteristics of the yard weaning procedure used in this project. These characteristics are listed below in what we believe to be their order of importance *.

2. The use of appropriate vaccines against respiratory disease (when these become commercially available) administered prior to feedlot entry to ensure that a protective immunity exists on arrival at the feedlot.

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* Characteristics of the yard weaning procedure used in this project listed in what we believe to be their order of importance (the first four, however, being essential):

1. Well-built, weaner-proof yards with good quality water.
2. Pen stocking density of $4m^2$/head for 180-260 kg calves.
3. Round bale feeder with good quality hay or silage *ad libitum.*
4. Kept in yards for 5-10 days.
5. Some human presence each day, but not for specific training.
6. Reasonably sloped, non-bog surface (e.g. shale or coal dust)
7. Solid opaque pen sides made from 1.2 m rubber belting

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Financial Statement

This summary statement sets out the income from Meat Research Corporation funds in each year of the project and the total expenditure by NSW Agriculture in the execution of the project divided into the major categories of expenditure.

It is intended to be an overview to provide the reader with a good indication of the amount of funds spent in the project and the way the money has been used. The final reconciliation of accounts will occur after June 30 1997.

Income from Meat Research Corporation ($)

July 1992 – June 1993	114,248
July 1993 – June 1994	151,940
July 1994 – June 1995	120,240
July 1995 – June 1996	66,640 [1]
July 1996 – December 1996	30,460 [2]
TOTAL	**483,528**

[1] This includes an additional $20,000 due to difficulties caused by severe drought.

[2] This includes a final payment of $27,360 (on receipt and acceptance of the Final Report by the Corporation)

Expenditure by NSW Agriculture ($) [1]

Capital Items (weaning Yards at EMAI)	28,000
Salaries (Heather Vallance 1992-97 and temporary assistance each year, particularly during feedlot operations)	177,000
Operating costs	
Laboratory – health testing	157,000
Laboratory – other	30,000
Behaviour recording	14,000
Cattle production and feedlot operations	24,128 [2]
Supplementary feeding costs at EMAI	14,040
Technology transfer (video, displays, publications)	12,000
TOTAL	**456,168** [3]

[1] These are the Principal Investigators' reasonable approximations of the expenditure division between categories as a final reconciliation of accounts will occur after June 30 1997.

[2] This includes an additional $20,000 due to difficulties caused by severe drought.

[3] This does not include a final payment of $27,360 (on receipt and acceptance of the Final Report by the Corporation).

Appendices

Appendix 1

Progress Report on Completion of Phase 1, September 1994

Appendix 2

Progress Report on Completion of Phase 2, September 1996

Appendix 3

Progress Report on Completion of Phase 3, January 1997

Appendix 4

A Note on the Effects of the Additional Immunostimulation Treatment and the Reasons for Abandoning this Procedure

Appendix 5

A Diagrammatic Overview of the Research and Summary of Combined Data from all Three Phases (A Set of Overheads)

Appendix 1

Progress Report on Completion of Phase 1, September 1994

Meat Research Corporation Project DAN.069

Reducing Feedlot Costs by Pre-Boosting: A Tool to Improve the Health and Adaptability of Feedlot Cattle

Progress Report on Completion of Phase 1

prepared by

Lloyd Fell and Keith Walker

with economic analysis by Kim Fraser

Elizabeth Macarthur Agricultural Institute, Camden, NSW

September, 1994

Summary of Phase 1

Angus/Hereford weaners were divided between 8 treatment groups (25 animals/group) which differed in various aspects of pre-feedlot management and their health and performance for 90 days on feed in a large commercial feedlot was determined. The experimental cattle were run as a single group from the end of the various weaning treatments and were mixed with a similar group of commercial in-contact cattle in one pen at the feedlot. The experimental herd consisted of a control group (supposedly current industry practice) and 7 levels of treatments known as pre-boosting which included vaccination against Pestivirus, IBR, PI3 and Pasteurella at least 1 month prior to feedlot entry, yard weaning with supplementary hay, additional handling and training to eat from a trough, and non-specific immunostimulation given shortly after weaning.

All experimental groups (including the control) adapted very quickly to the feedlot, got onto feed much quicker than is normally expected and had unusually high weight gains during the adaptation phase (day 1-37). Their growth rate returned to normal for the rest of the feeding period. The experimental groups had a very low incidence of disease (1/205 deaths and 8 pulls) despite a severe infectious challenge from the commercial in-contact cattle which had 8/177 deaths and over 100 pulls (these were not typical, but high risk animals, many from saleyards).

It appeared that the control group performed better than an industry average for 2 reasons: they had more pre-feedlot handling than is normal (to obtain additional data) and they benefited from social facilitation in the feedlot (i.e. they learned from their herd mates). This tended to reduce the benefits of the pre-boosting treatments.

However, there were some benefits found for all pre-boosting treatments. The major treatment effect appeared to be the experimental vaccination. Weight gain to day 37 was significantly improved by all treatments, but weight gain overall was only significantly improved by those treatments which included vaccination. Small benefits due to the training procedures were seen during the adaptation phase, but these were not evident over the total feeding period.

The economic analysis showed that all pre-boosting treatments produced higher returns in the feedlot, but this was cost-effective for only three of the treatment groups. These were the vaccinated only group, the yard weaned (with hay), and the yard weaned plus vaccination group. The yard weaned, trained, immunostimulated and vaccinated group also gave an appreciably increased gross margin compared to the control, but in this analysis the treatment proved too costly.

In the next phase of this 3-phase project the pre-boosting treatments have been somewhat simplified and refined, the control group will be given less handling and the behavioural challenge at the feedlot will be increased to provide a better test of whether the more elaborate pre-boosting treatments are providing any cost-effective benefits. At this stage the vaccination looks promising as does the simplest yard weaning procedure.

METHODS

The experimental design was essentially as outlined in our original submission.

Some 215 calves (predominantly Angus x Hereford) were weaned at 7-8 months of age at EMAI (in May 1993) and allocated to 4 main experimental groups (matched for body weight) of 50 animals per group (plus spares). Later, each group was divided into vaccinated and non-vaccinated sub-groups so that there were 8 treatment groups in all (25 animals per treatment) designated as follows:

Group 1	Treatment 1	Control
	Treatment 2	Control, Vaccinated
Group 2	Treatment 3	Yard Weaned
	Treatment 4	Yard Weaned, Vaccinated
Group 3	Treatment 5	Yard Weaned/Trained
	Treatment 6	Yard Weaned/Trained, Vaccinated
Group 4	Treatment 7	Yard Weaned/Trained/Immunostimulated
	Treatment 8	Yard Weaned/Trained/Immunostimulated, Vaccinated

Treatments 2-8 constitute different levels of what we term: **pre-boosting**. The details of each treatment are as follows:

Control - Weaned into a large paddock with adequate pasture, minimal animal handling, no supplementary feeding. In Phase 1, the amount of human handling was abnormally high (to obtain additional data) which evidently advantaged this group compared to typical commercial cattle (see later).
Vaccinated - Experimental vaccines against Pestivirus, Infectious Rhinotracheitis virus (IBR), Parainfluenza 3 virus (PI3) and Pasteurellosis (P. haemolytica and P. multocida) given at least 1 month before entry into the feedlot. The types of vaccine and time of administration (days from feedlot entry) were: Pestivirus (killed, adjuvanted) at days -77 and -41 plus a live booster at day -31; IBR (killed, adjuvanted) at days -77 and -41; PI3 (live) at day -31; Pasteurella (killed, adjuvanted) at days -41 and -31.
Yard Weaned - Weaned into specially-constructed weaning yards (50 animals in a 200 m^2 square pen with solid sides) with reasonable quality meadow hay provided in a round bale feeder (1 bale per day) for 10 days - then released into the paddock.
Yard Weaned/Trained - As yard weaned, but with a novel behavioural training procedure (known as confidence testing) conducted for 1 hour each day for days 1-7 and day 11 (after weaning). Calves were also returned to the pen, overnight, for a repeat of this procedure next morning, on days 14 and 18 after weaning. The training procedure involved access to a 40:60 lupins/oats ration supplied in feed bunks at a rate of 1kg/head/day.
Yard Weaned/Trained/Immunostimulated - As yard weaned/trained, but with a subcutaneous injection of Equistim® (1 ml/100kg) on day 20 after weaning accompanied by 24 h access to sweetened drinking water (containing 1% sucrose). Access to the sweetened drinking water was repeated 1 day prior to shipping to the feedlot.

All animals received appropriate 5-in-one vaccination and drenching for internal parasites.

The 206 steers which went to the feedlot came from 3 different properties (EMAI - 131, Araluen - 50 and Braidwood - 25). These different origins were split almost equally between the 4 main experimental groups. The calves from Araluen could not be evenly divided between vaccinated and non-vaccinated treatments, however, because their high incidence of previous exposure to Pestivirus disqualified many of them from the latter treatment group.

The experimental groups were run as one herd on pasture at EMAI from day 21 after weaning until shipping to Caroona feedlot 8 months later (at 15-16 months of age) in February 1994. There were 206 steers shipped to the feedlot - to ensure a minimum of 50 per treatment group. A herd of 205 was successfully inducted into the feedlot, 1 animal being accidentally killed during the induction procedure. Another steer died due to misadventure (ingestion of wire) during the trial and was subsequently excluded (see later).

The 205 steers were fed in one pen of 4,350 m^2 together with 177 steers of similar age and weight purchased by the feedlot for the purpose of providing a realistic behavioural and infectious challenge for the experimental animals. The feedlot-owned cattle were designated as **commercial, in-contact** to distinguish them from the **experimental** (EMAI) group. The commercial, in-contact cattle arrived 3-4 days after the experimental animals, after which there were 382 animals in the pen (11 m^2/head) with 66 m of feed bunk space. Dry, warm weather and a well-designed pen ensured that pen conditions were excellent for the cattle throughout the trial.

The experimental animals were slaughtered at Aberdeen after 84 days (101 head) or 91 days (102 head) on feed, the subdivision into 2 groups being essentially random. The commercial, in-contact cattle were slaughtered at Toowoomba after 84 or 85 days on feed.

Intensive **behavioural observation** and other measurements of stress were carried out throughout the yard weaning treatments and during the adaptation phase in the feedlot. Continual (24 hour/day) surveillance was maintained at the feed bunk on days 1-11 (with the aid of video recording) and daily measurements of feeding were also made on days 16-17 and 44-45 (after the change from starter to feeding ration). Agonistic and social behaviour and standing, lying etc. was also recorded at frequent intervals.

Other measurements of stress included plasma cortisol assays for each animal on 5 different occasions and differential blood cell counts on half the animals on 3 occasions. This can be compared with the detailed serology obtained from all animals (particularly the sick animals during the feedlot phase) and with extensive records of the behavioural attributes of individual animals.

The large amount of individual animal data which is still being analysed will not be discussed here. This report is confined to group comparisons to determine the main findings at this stage of the project.

RESULTS

The effect of the experimental treatments must be measured against the appropriate EMAI control group. The commercial, in-contact cattle provided another comparison, but the purpose of that group was to create a realistic behavioural and infectious challenge for the experimental cattle and it is not an appropriate "control". There were several different breeds and different sources of cattle and the group was not necessarily representative of the commercial feeder steer population - it was seen as a "high risk" group. Even if it had been representative, a comparison with the experimental herd would be biased in favour of the commercial cattle because the normal management system naturally removes the worst performers whereas all experimental animals had to be included in the final production result. However, the feedlot-owned cattle serve as an example of one possible commercial situation and data from this group are analysed at the end of this report.

Production

Carcass Gain

Figure 1 shows that there were some positive effects of the pre-boosting treatments on weight gain, particularly during the early adaptation phase, but these were not large differences over the entire feeding period.

In the adaptation phase (days 1-37), all experimental treatments gave higher weight gains than the control (11-20% improvement) and the overall treatment effect was significant ($p<0.05$). In the rest of the feeding period (days 37-84), only treatments 2, 4 and 8, which were all vaccinated groups, retained higher weight gains than the control and the overall treatment effect for this period was not significant ($p>0.05$).

Overall weight gain showed a significant positive effect of pre-boosting ($p<0.02$), but this was due to the performance of treatments 2, 4 and 8. The other treatment groups, although higher than the controls, were not significantly so ($p>0.05$). Therefore the major treatment effect in this experiment appeared to be the vaccination, although the other treatments may have also made a contribution, particularly during the early period of adaptation.

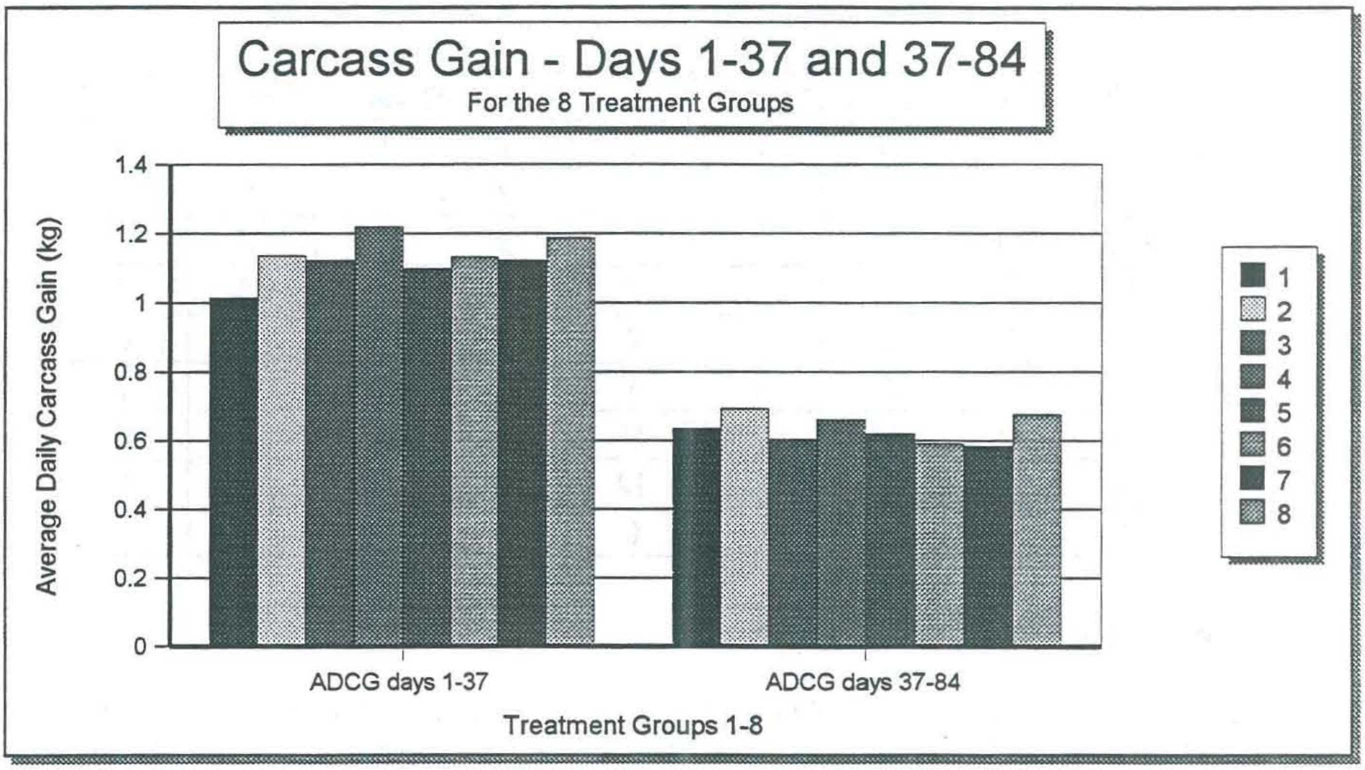
The superior performance of treatments 3, 5 and 7 over the control group during the adaptation phase and the reversal of this situation after day 37 does suggest that yard weaning improved the adaptability of the animals on arrival in the feedlot, but does not show any advantage of the additional training which was given in treatments 5 and 7. Also, the effect of vaccine alone in treatment 2 was equal to the effect of the yard weaning in this experiment.

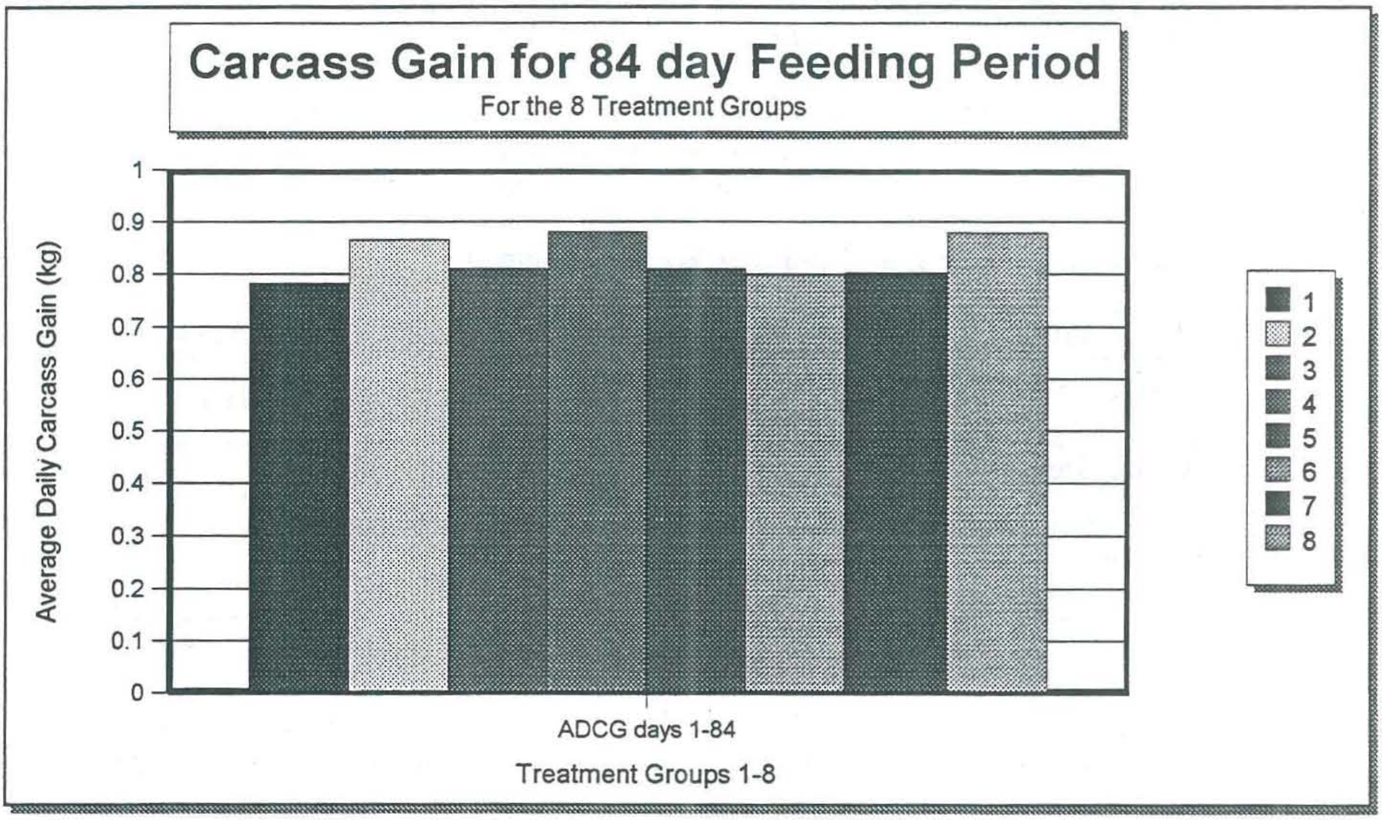
A comparison of these experimental groups with the commercial in-contact cattle is given later.

Carcass Quality

There were no significant differences between the treatments in classification scores based on carcass weight or fat depth. The control groups 1 and 2 and also treatments 5 and 6, which

FIGURE 1 Effects of Pre-Boosting Treatments on Weight Gain





were the worst-performed of the pre-boosted groups overall, tended to have lower carcass scores and higher fat scores (see Table 1).

Table 1 Distribution of Carcass and Fat Classifications across Treatment Groups

CLASS	Treat. 1	Treat. 2	Treat. 3	Treat. 4	Treat. 5	Treat. 6	Treat. 7	Treat. 8
WGT 1	1	0	0	0	1	0	0	0
WGT 2	4	2	2	4	2	4	4	4
WGT 3	10	12	8	5	9	8	7	7
WGT 4	8	3	12	9	7	9	10	7
WGT 5	3	8	4	4	4	3	3	6
WGT 6	1	3	0	1	2	0	1	1
FAT 1	12	12	14	11	10	11	12	17
FAT 2	15	15	12	12	15	13	13	8
FAT 3	0	1	0	0	0	0	0	0

Estimated Feed Consumption

Round-the-clock surveillance of cattle behaviour for the first 11 days and subsequent daily observations revealed considerable between-animal variation, but no significant differences between the experimental groups in the extent or intensity of feeding behaviour. Neither the frequency of visits to the feed bunk nor the time spent feeding was significantly different between the 4 main experimental groups (see Table 2).

This is also seen in the upper graph of **Figure 2** which gives mean feeding activity scores for each group on days 1-5, 7, 9 and 11. There were some differences between the trained and untrained groups in feeding behaviour for the first few days, however (see later).

Table 2 Behaviour Scores for Estimating Feed Consumption

BEHAVIOUR	Group 1	Group 2	Group 3	Group 4
Feeding Activity Score	44.1	43.3	44.2	44.1
Feeding Duration Score	15.6	15.2	15.5	14.3
Feeding Preference Score	4.2	4.5	4.3	4.2

Assuming that there is a reasonable relationship between these measurements and actual feed intake, on an individual animal basis (which is the subject of another investigation at Trangie), it appears that there were no differences between the groups in estimated feed consumption. In the individual animal analysis it will be possible to rank animals according to their feeding activity and also their weight gain to give an estimated "efficiency" score. However, arrangements are also in hand to measure feed intake directly on some of the animals during phase 2 of this project.

Health

Mortality

There was only 1 death which occurred 35 days after induction, that animal being from the control group 1. On induction it had been IBR and Pestivirus negative, but when first pulled on day 32 it was IBR and Pestivirus positive and S. dublin was also present. Clinically prior to death it had severe dyspnoea from severe interstitial emphysema and at postmortem was IBR positive and concluded to have Pasteurella septicaemia and pneumonia, IBR and necrotic laryngitis.

This result, combined with the high incidence of respiratory disease which occurred in the commercial in-contact cattle (see later), leaves no doubt about the infectious challenge to which the experimental cattle were subjected.

The steer previously mentioned that was excluded from the trial because of death by misadventure (ingestion of wire) came from treatment 4. It was diagnosed as having septicaemic traumatic reticulo-pericarditis and no viruses or bacteria could be isolated.

Morbidity

The number of animals pulled was very low (particularly compared to the commercial in-contact cattle - see later) and therefore no differences between treatment groups could be discerned. In the first week 8 animals were pulled, 1 was re-pulled in the second week, and there were 5 animals pulled in the rest of the feeding period. Of the first 8 pulled, 2 were not found to have clinical symptoms and 3 were pulled because they were lame.

The low incidence of disease was presumably not due to a lack of infectious challenge, but may have been related to the unusually good adaptability of all experimental groups (even the control group) which was evident from the high weight gains and excellent feeding behaviour during the adaptation phase (see later).

Lesions at Slaughter

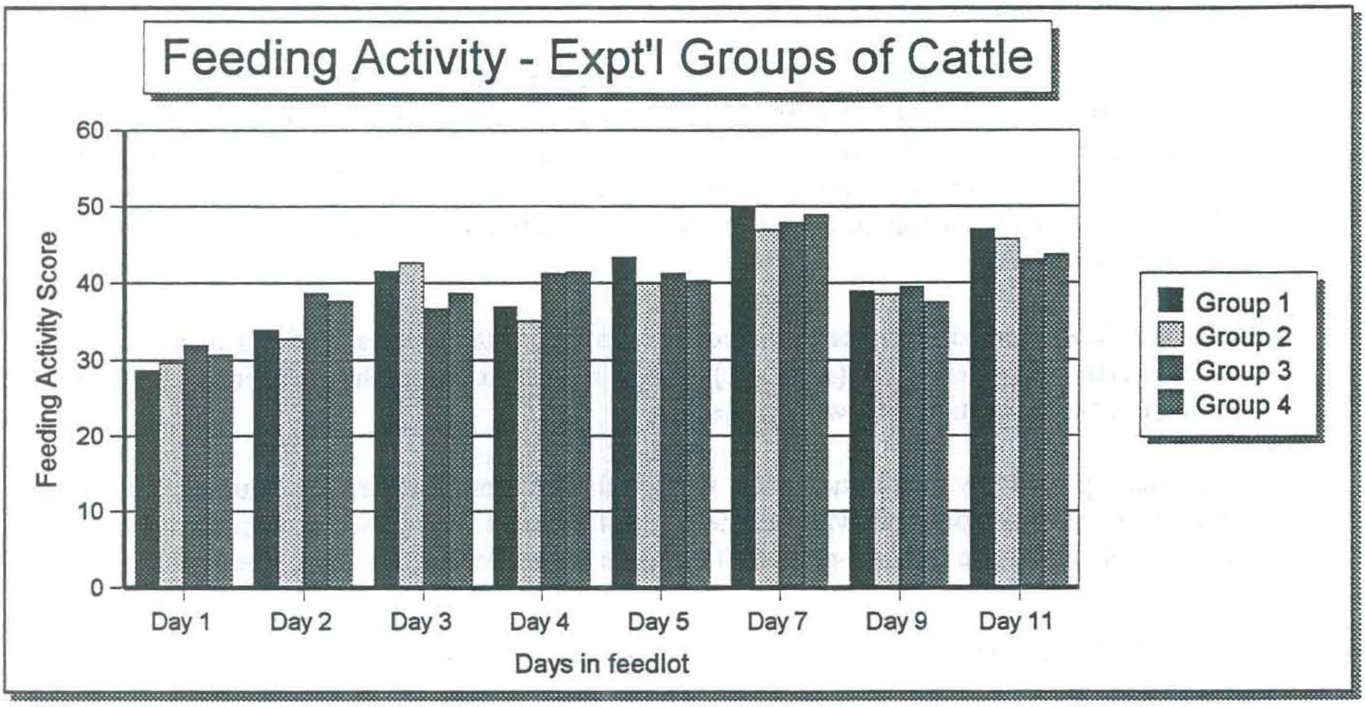
The only lesions found at slaughter were in the respiratory system and these were minimal focal lesions in a single lung lobe (grade 1). There were 7 in total - 5 from the control group 1 and 2 from the control group 2 - i.e. 3.4% overall. This compares with 31.7% grade 2- 3 lesions in the commercial in-contact cattle which were sent for slaughter (see later).

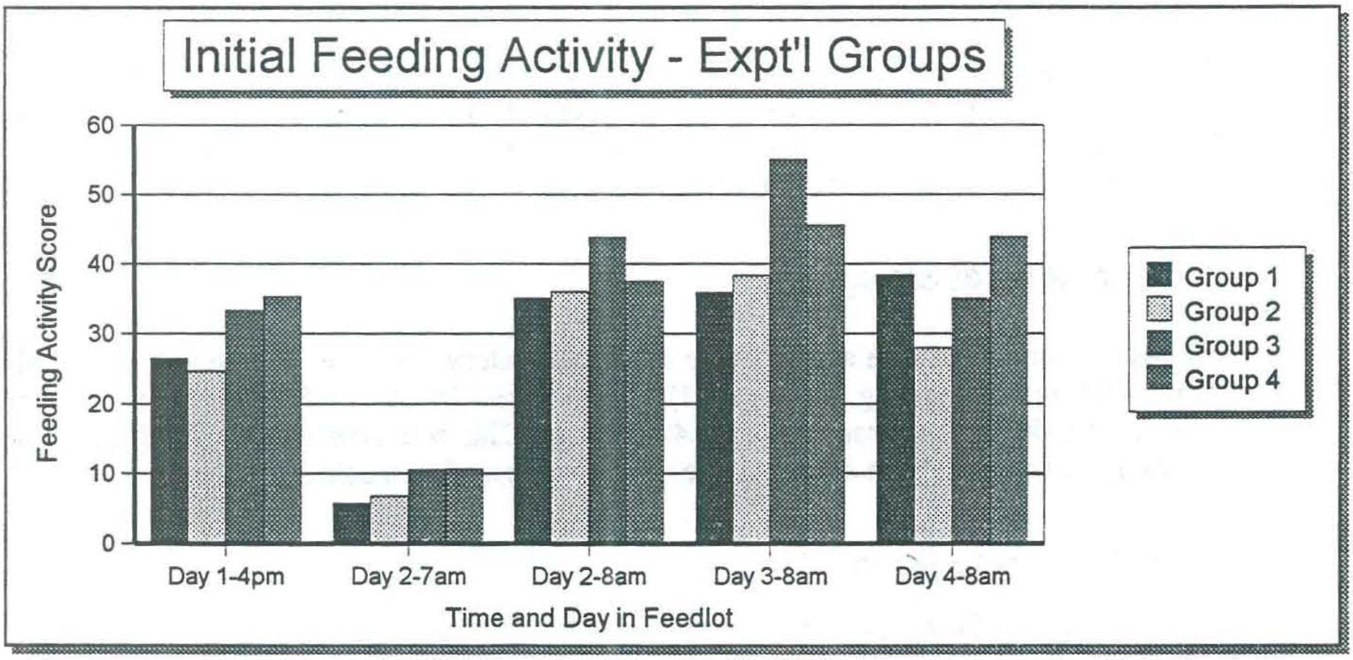
Behaviour and Stress

Feeding Behaviour

As already indicated there were no significant differences between groups in overall measures of feeding behaviour, but there was considerable between-animal variation which will be useful in future analyses of individual animal adaptability and responses to stress. The upper graph in **Figure 2** shows the average feeding activity score (which is a composite of frequency and duration of feeding) on a daily basis.

FIGURE 2 Measures of Feeding Activity for the Main Experimental Groups





The very high level of feeding by experimental cattle from day 1 was an outstanding feature of this trial. Very few animals had not eaten within 24 h and feeding activity was close to a stable maximum level by day 4 when the other cattle arrived in the pen after which there was some disruption due to the mixing of the groups.

The trained groups (3 and 4) did show significantly greater feeding activity than untrained groups ($p<0.05$) at critical times on the first 4 days (see lower graph of **Figure 2**). These were the first afternoon (first feed delivery), the next morning prior to feed delivery and immediately after feed delivery on the first 3 mornings.

It was apparent that social facilitation played a major role in the adaptation of cattle to the feed bunk. The experimental cattle were a stable social group that had been running together for 8 months. They had the pen to themselves until day 4 and untrained animals quickly learned from trained animals during this time. The implication of this is that any advantage enjoyed by trained animals was very short-lived. It also suggests that it may only be necessary to train a few "trendsetter" animals within a stable social group to obtain the benefits of pre-feedlot training.

The value of other behaviour data which was collected extends beyond this immediate project. **Figure 3** shows the distribution of feeding durations and **Figure 4** shows the preference for different feeding positions at the bunk by individual animals and by the herd as a whole.

Figures 5 and 6 give a comparison of the feeding activity of the experimental and commercial groups. Feeding by the commercial animals showed a gradual increase continuing for 14 days at least (to day 17), but was substantially less than that of experimental animals throughout the adaptation phase, particularly during the peak periods after feed delivery which occurred at 0800 and 1300 h each day. This may have been partly due to the greater social facilitation evident in the experimental group, but a major factor appeared to be the territorial advantage which they had established by being in the pen 3 days earlier than the commercial cattle.

In phase 2 it is planned to introduce the commercial animals a few days before the experimental group in order to increase the degree of behavioural challenge and thus provide a stiffer test of whether there are benefits from any pre-boosting behavioural treatments.

Cortisol Responses

There were 5 sampling times of which 4 are shown in **Figure 7**. Time of sampling is a highly significant effect ($p<0.01$) entirely due to the far greater stress response which occurred at the feedlot induction compared to any previous handling situation.

There was a significant interaction between time of sampling and both origin of cattle and experimental group. The cattle from Braidwood (and to a lesser extent from Araluen) showed greater stress responses than the EMAI cattle (which were obviously more quiet), but those animals also showed more benefit from training and the Braidwood cattle in group 4 tolerated the feedlot induction far better than other cattle. Individual animal variation in this stress response will be checked against other individual attributes in future analyses.

FIGURE 3 Distribution of Feeding Durations Days 1-11

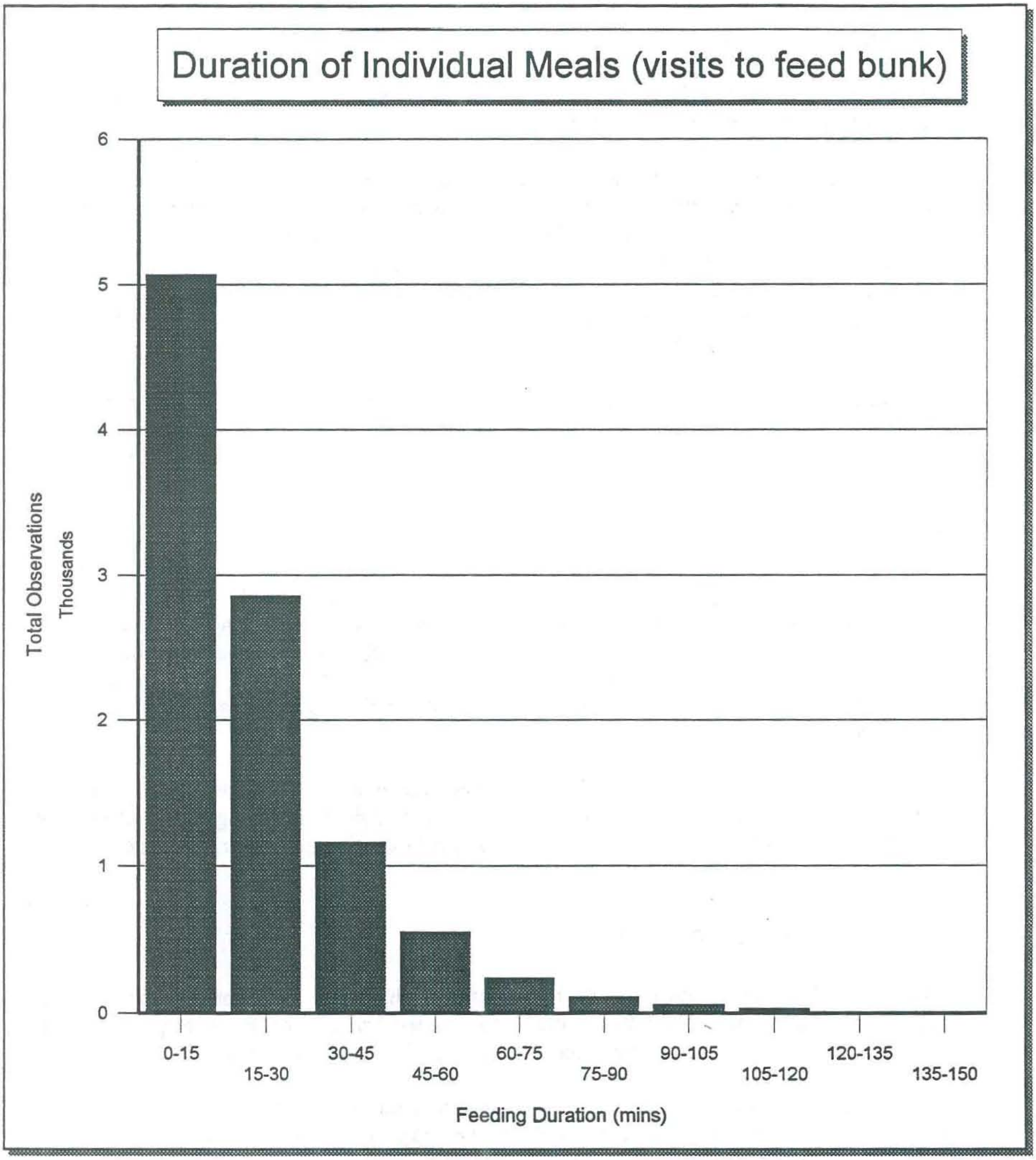
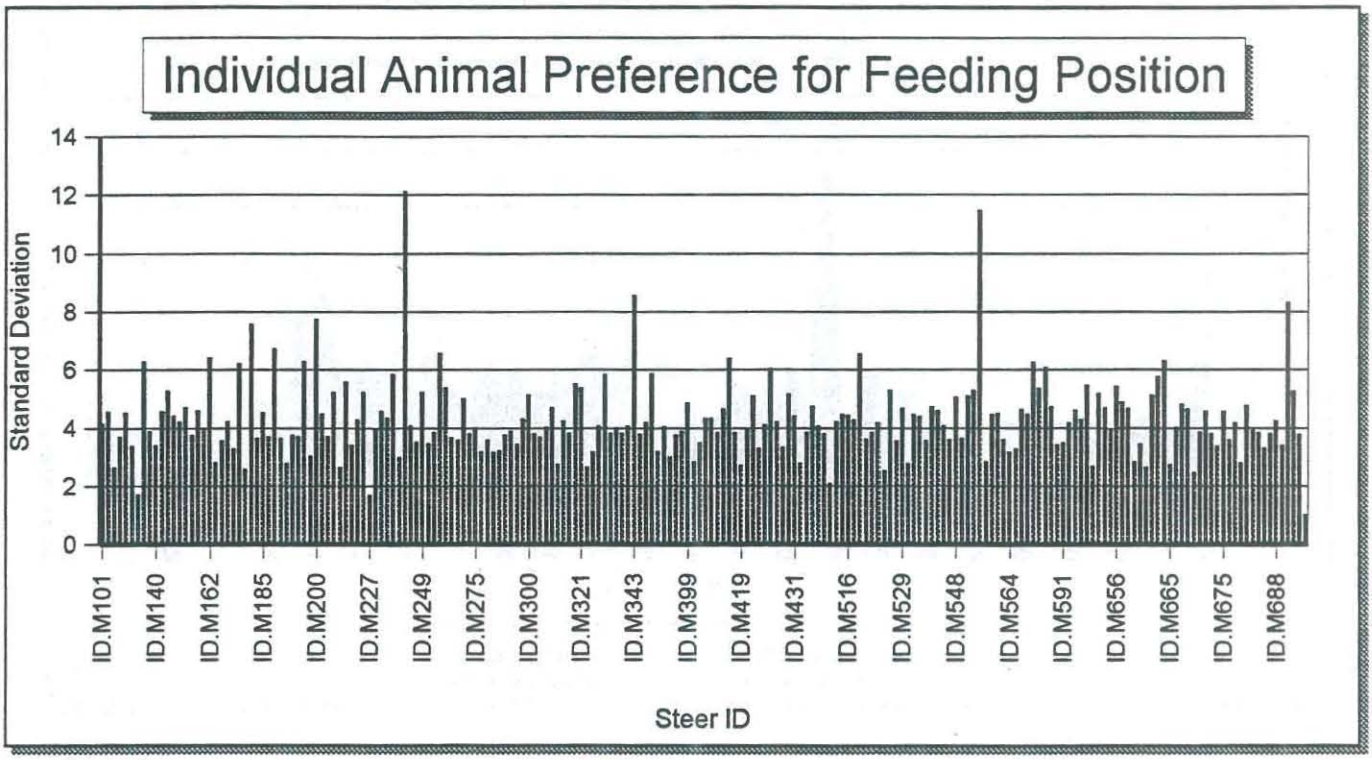


FIGURE 4 Animal Preference for Feeding Positions in the Pen



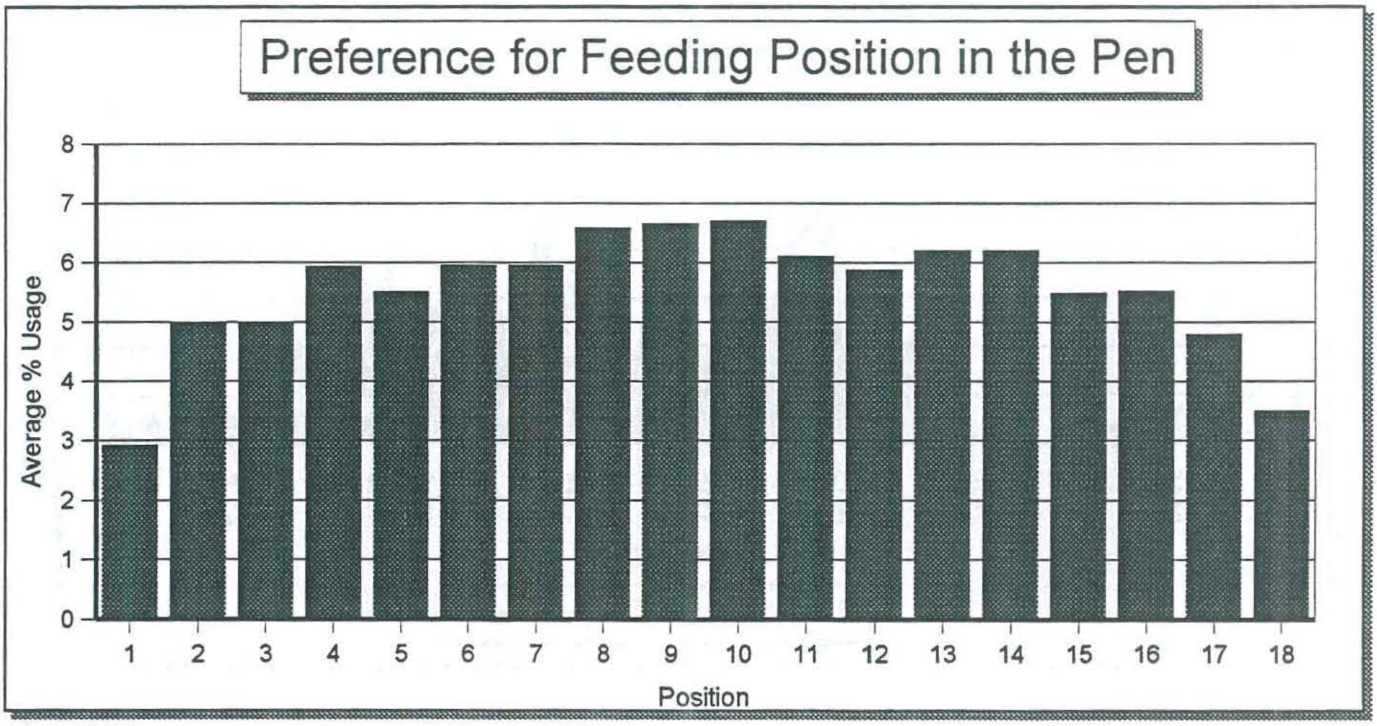
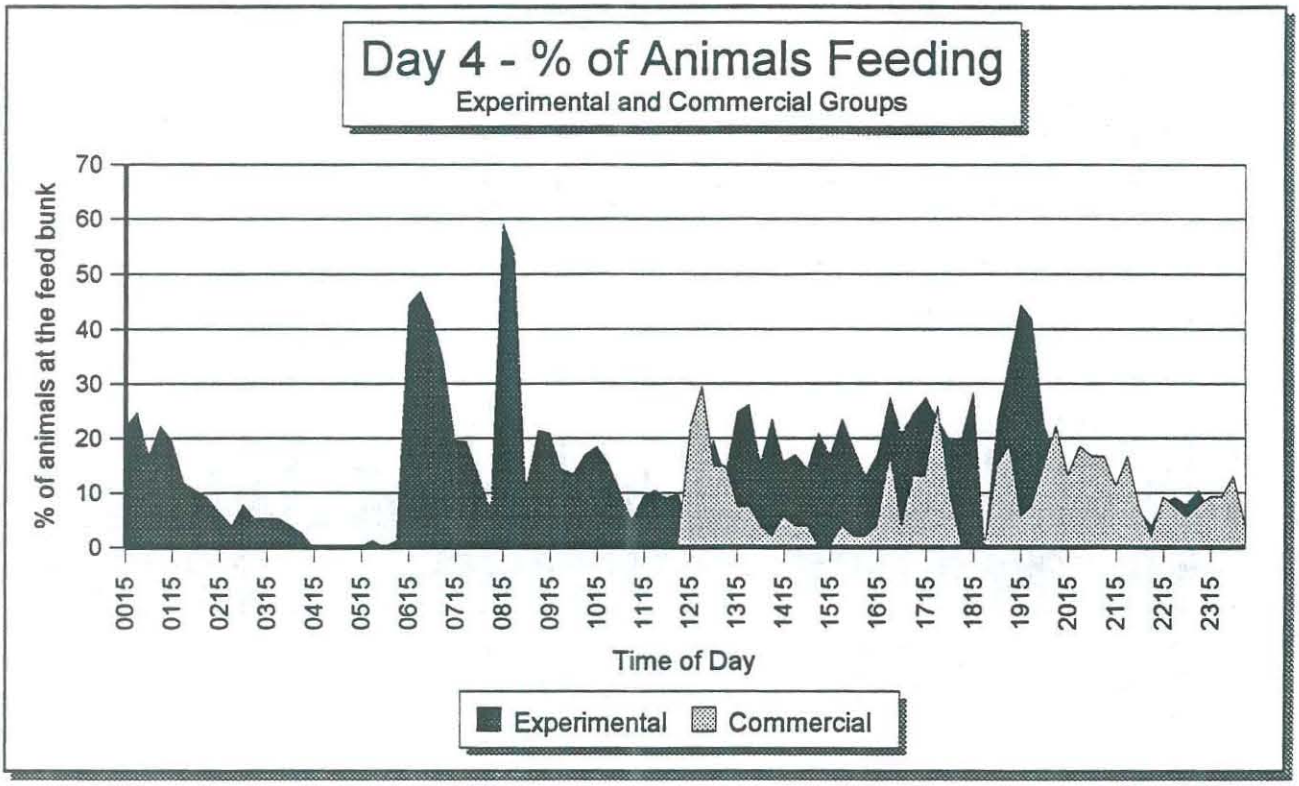


FIGURE 5 Feeding Activity by Experimental and Commercial Groups



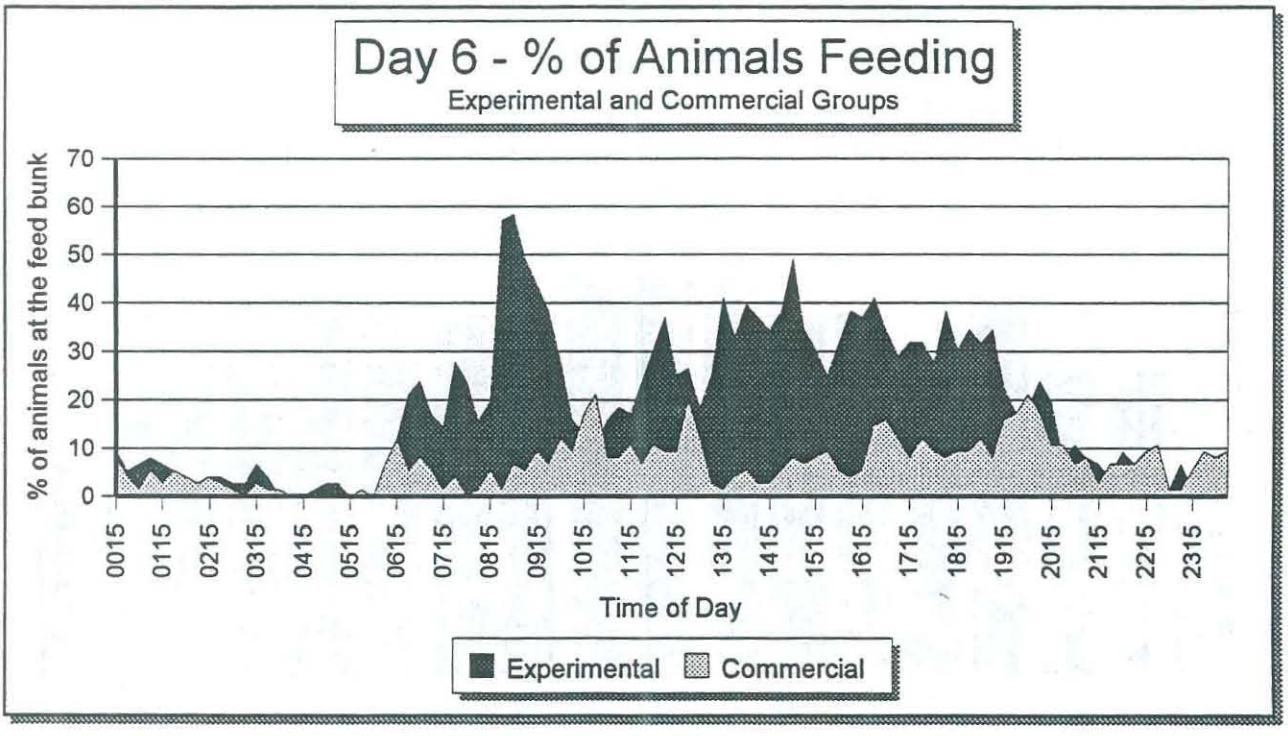
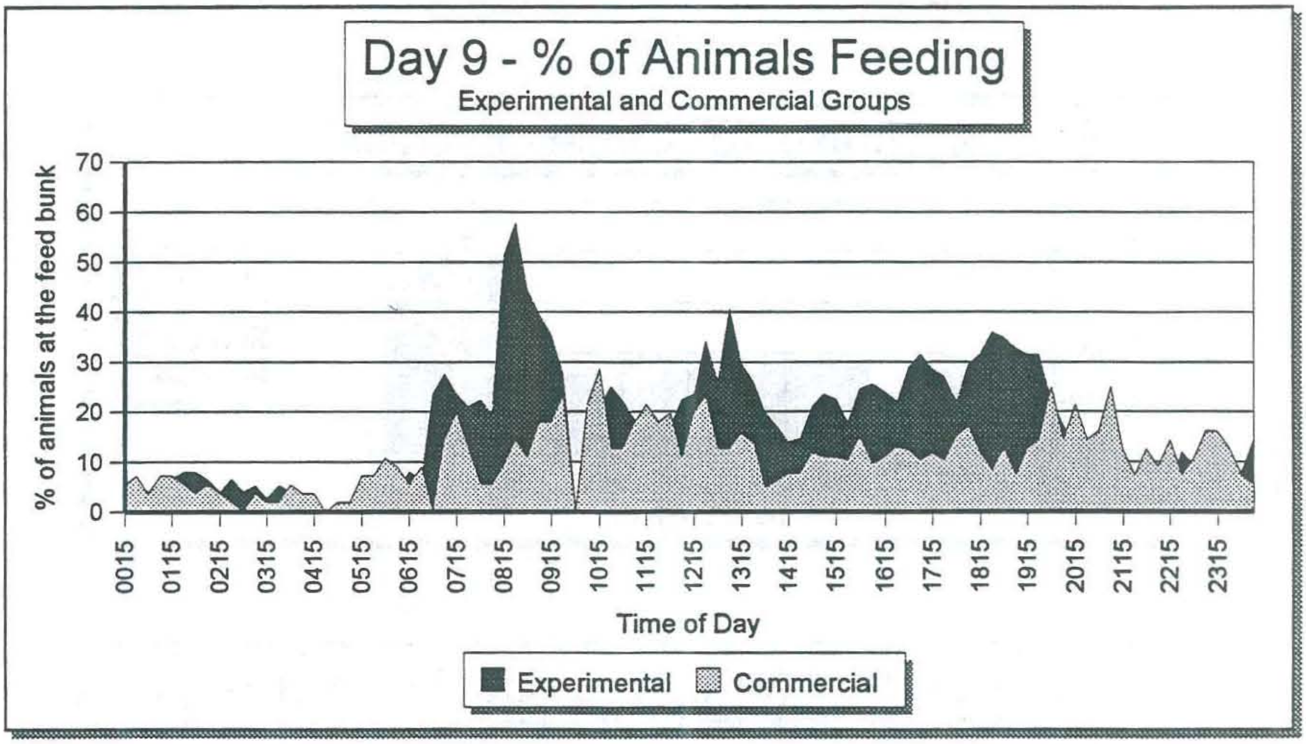


FIGURE 6 Feeding Activity by Experimental and Commercial Groups



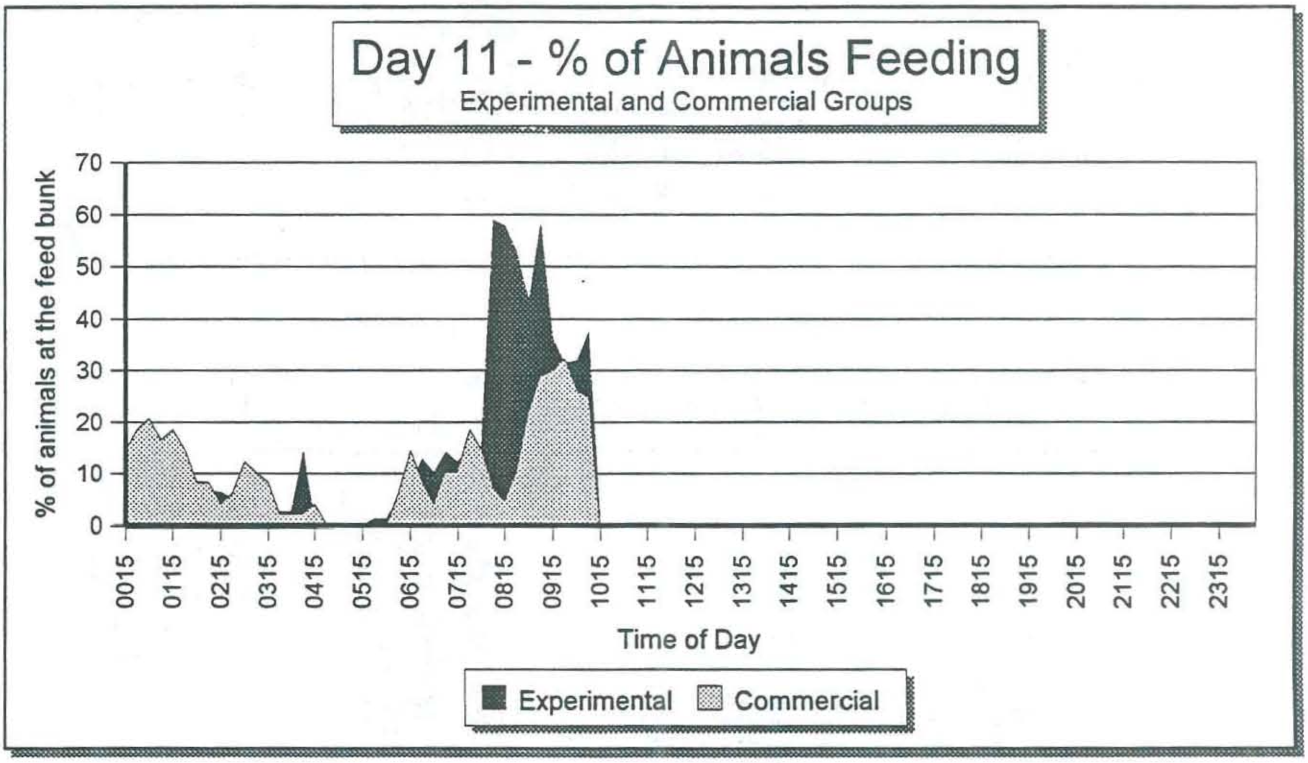
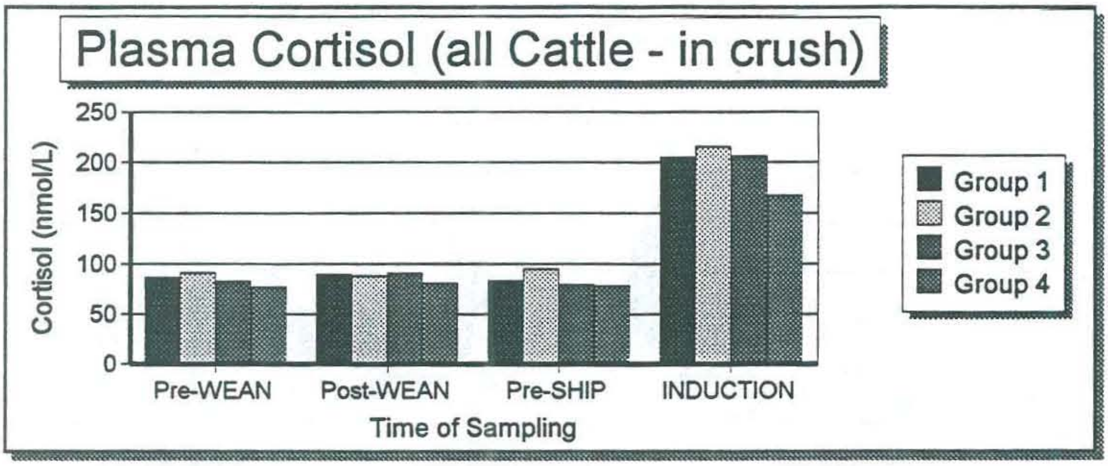
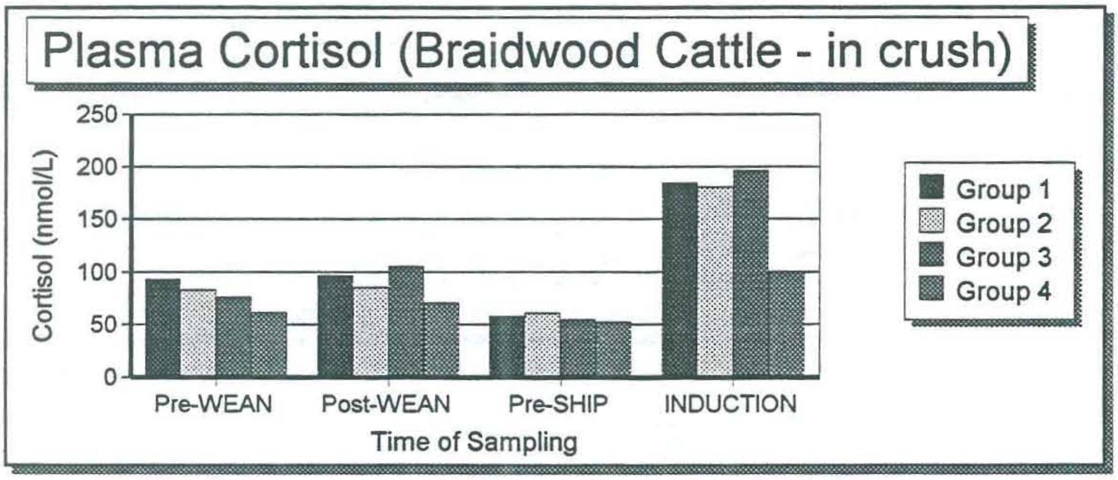
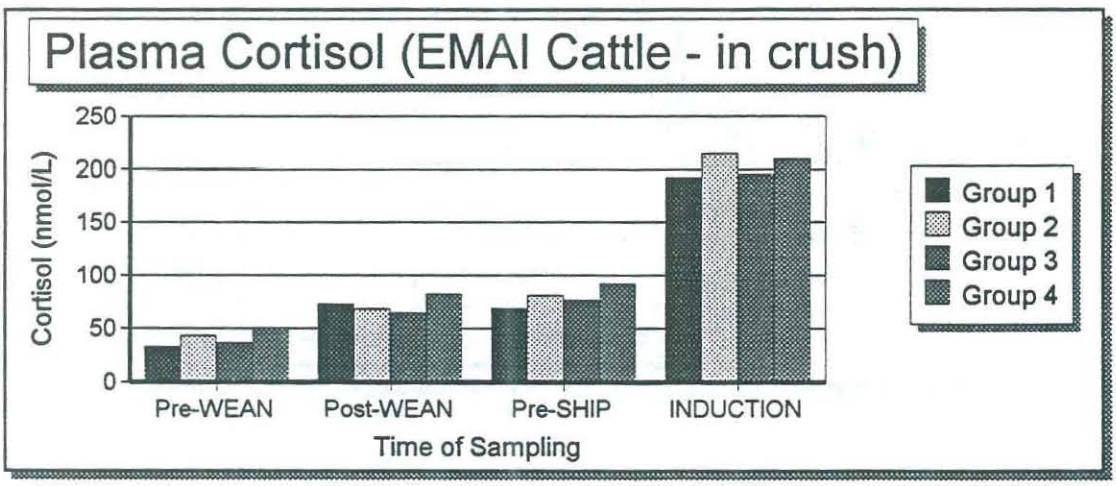


FIGURE 7 Plasma Cortisol Concentration for the Experimental Groups







Commercial in-contact Animals

The commercial in-contact cattle were purchased by the feedlot in order to fill the pen and to provide the experimental cattle with exposure to the disease profile that may be expected in mixed groups of cattle from different sources. The first group to be introduced (3 days after the EMAI cattle) consisted of 142 animals. These animals had been sourced either directly from property, as in the case of TP (n=18) and SP (n=18), or had been purchased from saleyards. The saleyard cattle, WS (n=54) and DS (n=52), were from a number of individual properties and had been mixed at the saleyards. The WS (Wodonga Saleyards) cattle had also spent one week at the feedlot on pasture before being inducted into the feedlot pen. The DS (Dandenong Saleyards) cattle were inducted shortly after arrival at the feedlot. Another group of cattle introduced to the pen on the following day consisted of 35 animals. Once again cattle had been sourced directly from property, FE (n=6), and from saleyards, WOS (n=29). The WOS (Wodonga Saleyards) cattle were again from a number of property origins and had been mixed at the saleyards. These cattle were also inducted shortly after arrival at the feedlot.

The performance of commercial in-contact cattle was inferior to the experimental cattle in several respects. This is despite the fact that 16/177 head had been removed from the commercial group (8 dead, 8 excluded) by the time they went to slaughter (which would be expected to improve their result). Average daily carcass gains achieved by the commercial in-contact cattle both to day 37 and over the entire feeding period (**Figure 8**) were significantly lower than both the control group of experimental cattle and the pre-boosted groups ($p<0.001$). **Figure 8** also shows that, up to day 37, the EMAI control group (vaccinated plus non-vaccinated) had a significantly lower average daily carcass gain than the pre-boosted cattle ($p<0.05$).

Figure 9 shows the variation in performance of the commercial in-contact cattle from the different sources. At day 37 there were highly significant differences ($p<0.001$) between a number of the different sources. However, by the end of the feeding period, these differences had largely disappeared.

Figure 10 shows a comparison between the commercial in-contact cattle and the experimental cattle in terms of the number of animals pulled for each of the categories: sick, lame and buller and also the total number of animals pulled. For sick, buller and total the commercial cattle had substantially higher numbers of pulls ($p<0.001$). For lame the numbers were low and the groups were not significantly different.

Also in **Figure 10** is shown the variation due to origin, within the commercial cattle, in the number of pulls. The two saleyard sources that had cattle inducted into the feedlot directly after transport, DS and WOS, had significantly higher numbers of animals pulled for sickness ($p<0.001$). There were no differences between the groups in the level of lameness. Two of the origins (SP and WOS) had higher numbers of animals pulled for bulling ($p<0.01$).

There were 8 deaths in the commercial in-contact group during the feeding period. Of these, 5 were in groups which came straight from saleyards (4 WOS, 1 DS). These deaths occurred from 2-5 weeks after induction. Detailed diagnostic examination revealed IBR infection and Pasteurella pleuropneumonia in all cases with some incidental Salmonella infection. A high incidence of respiratory lesions was found in the remaining animals at slaughter also (51/161 or 31.7%) and these were all grade 2 or 3 (consolidation up to 50% of the lung) - see the Table below).

Origin	TP	SP	WS	DS	FE	WOS
Respiratory lesions	4/18	3/18	14/54	22/52	3/6	5/29

These data from the feedlot-owned cattle were a bonus in the experiment, showing the kinds of effects which saleyard mixing and long transport immediately before induction can have on the health and performance of cattle in a feedlot. They are not typical of results that would be expected at this feedlot, but have been used to calculate the economic consequences of a "poor" - compared to an "average" - commercial situation (see the economic analysis which follows).

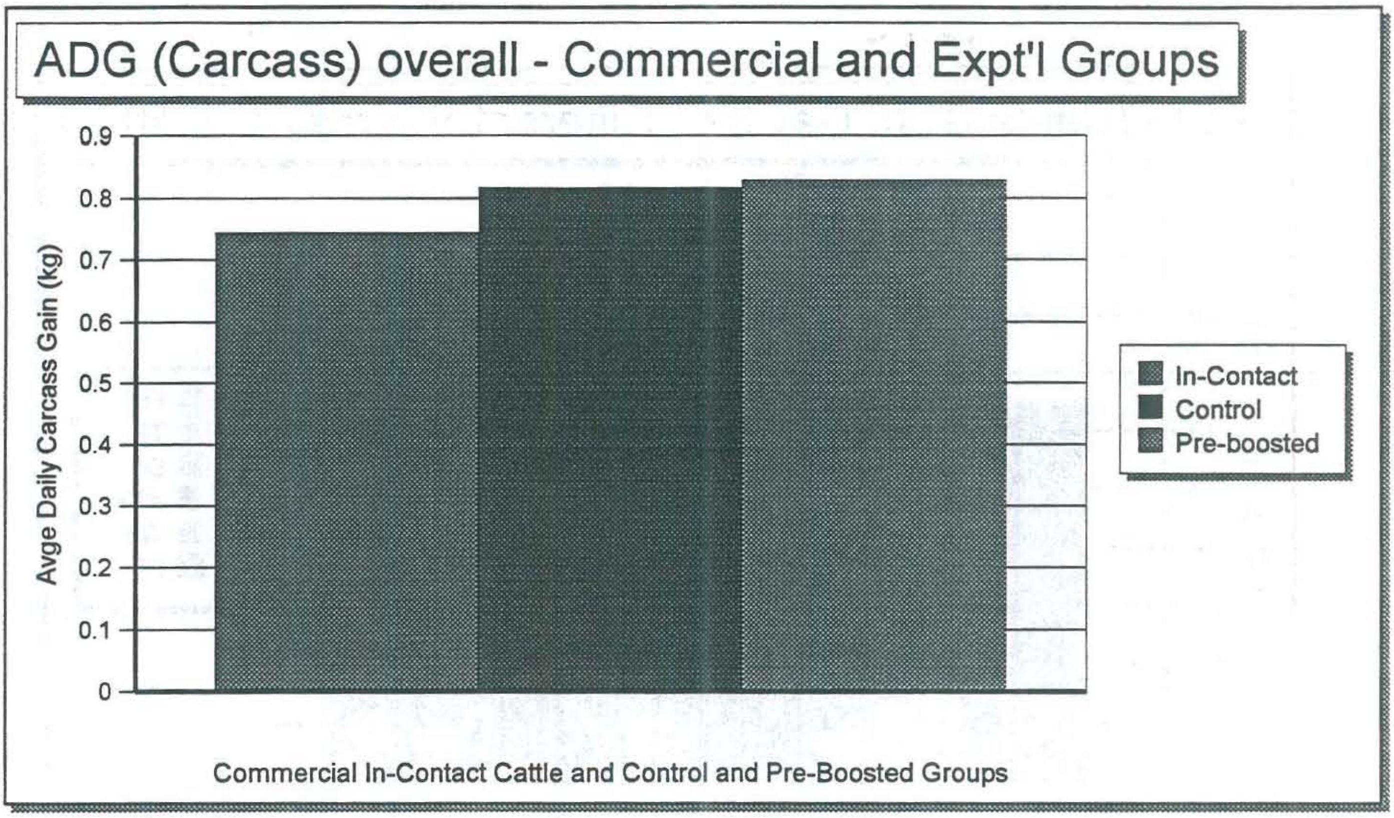
These results are a further indication that the EMAI control group performed substantially better than might be expected from a typical commercial grouping of cattle, particularly considering their low incidence of disease in the presence of a severe infectious challenge. This would be consistent with their superior growth rate and feeding behaviour during the adaptation phase. There are two likely reasons for this. Firstly, the EMAI control group was subjected to considerably more handling (for the purpose of additional measurements) than would be expected in a normal commercial situation. Secondly, the social facilitation mentioned earlier would have advantaged the EMAI control group compared to a normal commercial group.

The effect of this good performance by the control animals has been to reduce the apparent benefits of the pre-boosting treatments. Despite this, some benefits have been found. In the next phase of the project, steps have already been taken to reduce the amount of handling for all EMAI cattle to more adequately test whether there are any benefits to be gained from the specific weaner training procedures.

Combining data from all animals, there was an interesting suggestion that the time of seroconversion, particularly for Pestivirus, was related to weight gains, i.e. animals which were positive at induction had better growth rate (see **Figure 11**). However, it also happened that this effect was confounded with the experimental versus commercial comparison so it can only be taken as a guide for future investigation. This has implications for considering whether vaccination should be carried out before induction or not.

As this work continues it should be possible to estimate the cost of disease more accurately by looking at its effects on production as well as the treatment costs etc. **Figure 12** shows the weight gains of all healthy and sick animals of different types for the adaptation phase and the rest of the feeding period.

FIGURE 8 Carcass Weight Gain of Commercial and Experimental Groups



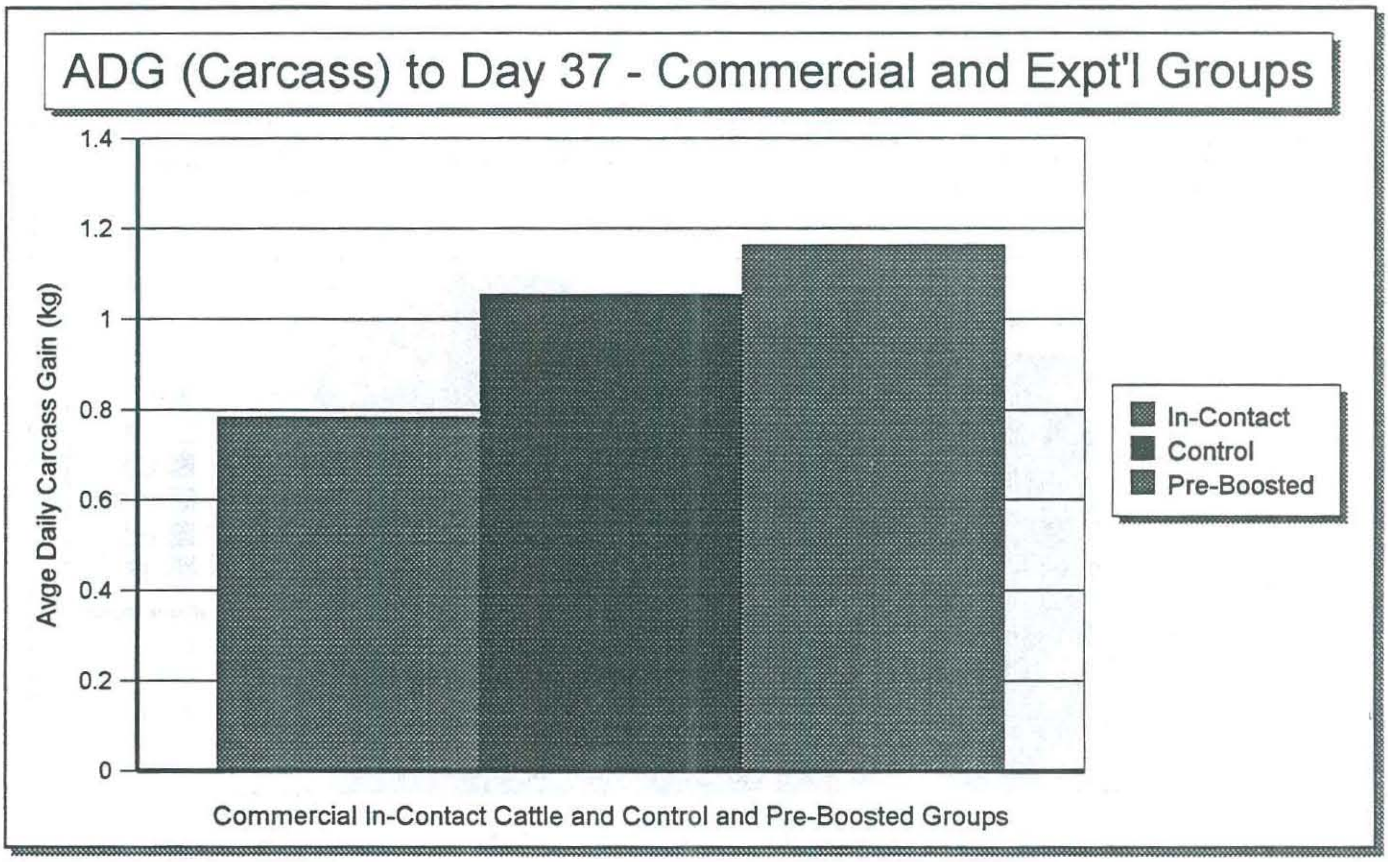
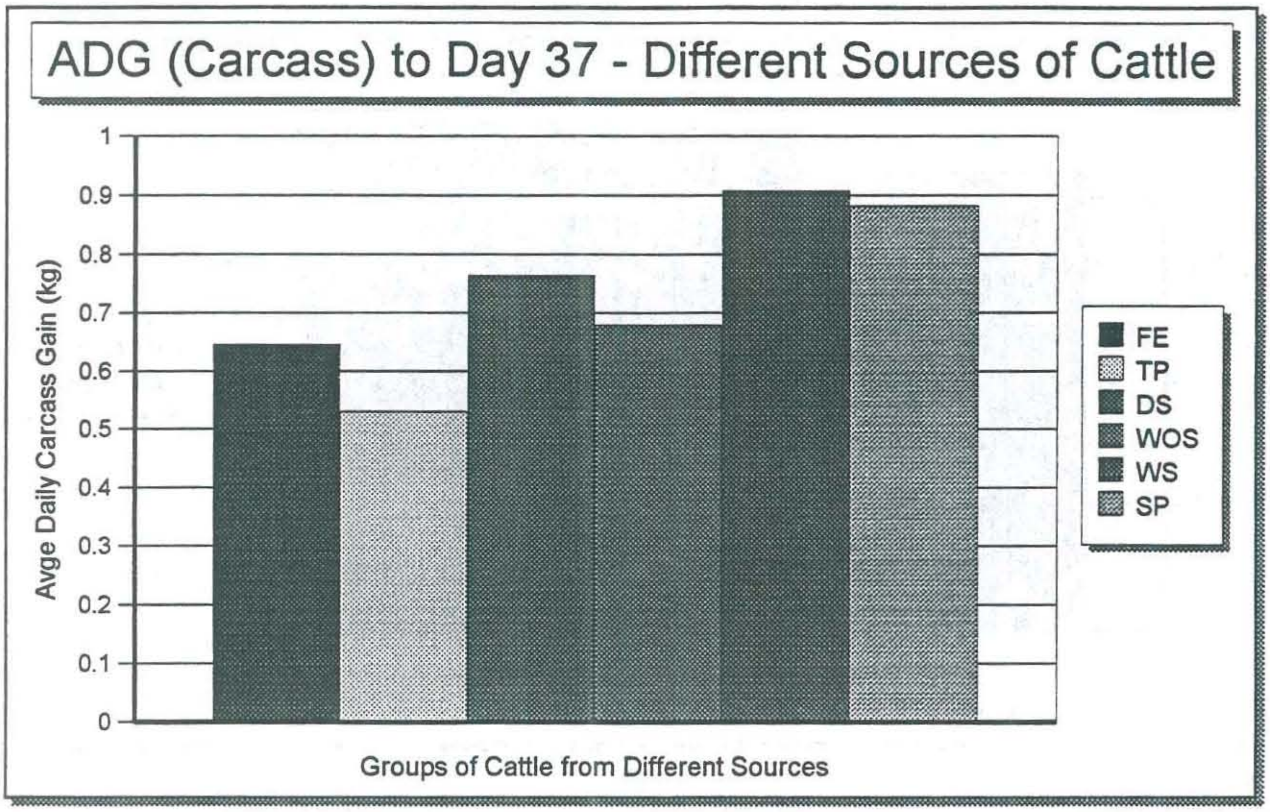


FIGURE 9 Variation in Weight Gain of Commercial Cattle from Different Sources



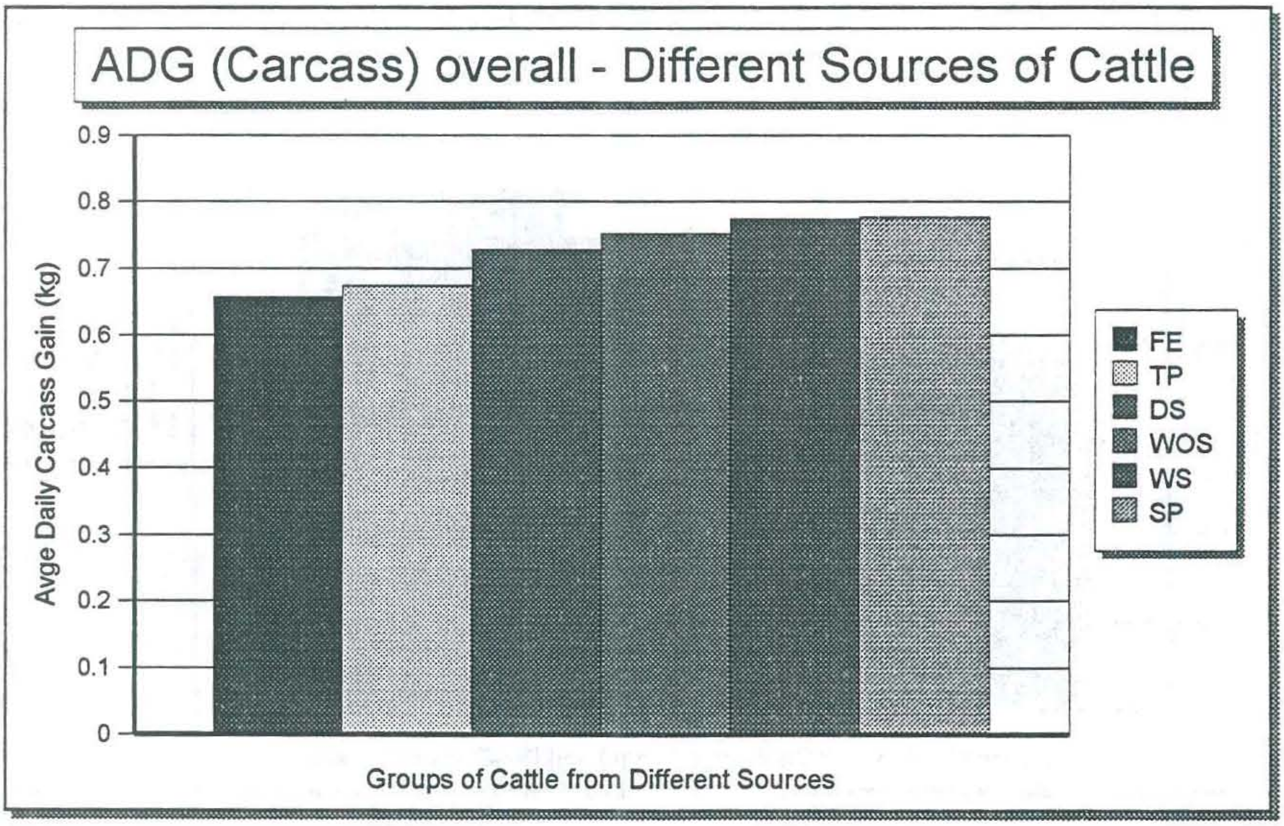
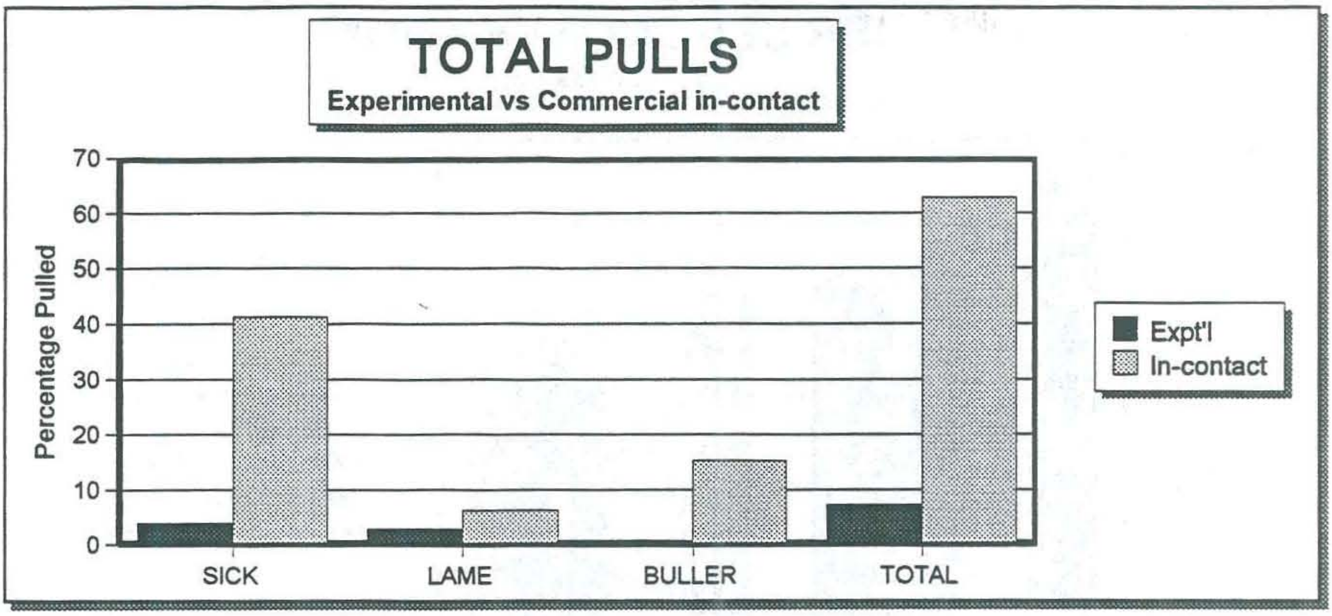
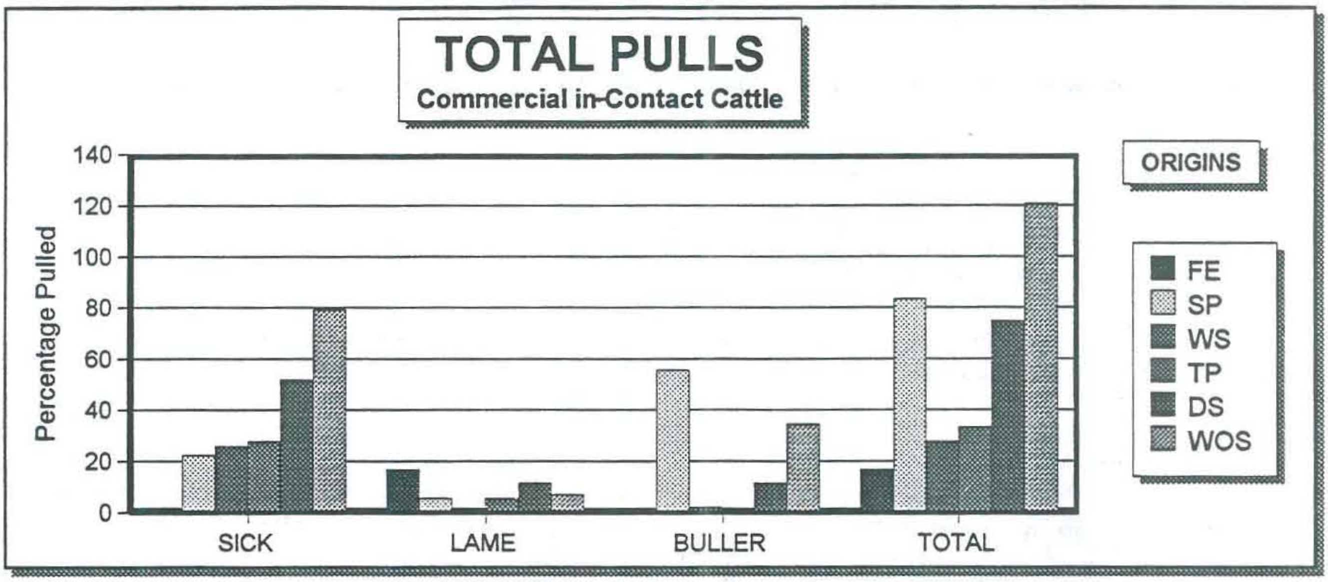


FIGURE 10 Comparison between Commercial and Experimental Cattle for Numbers of Animals Pulled for Different Reasons





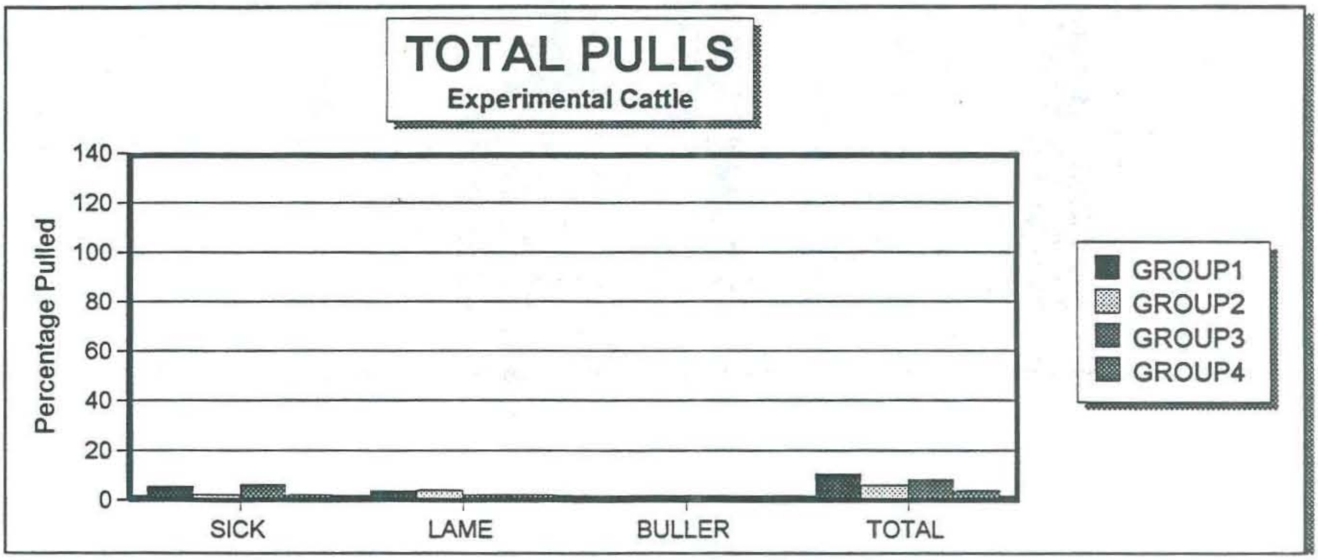
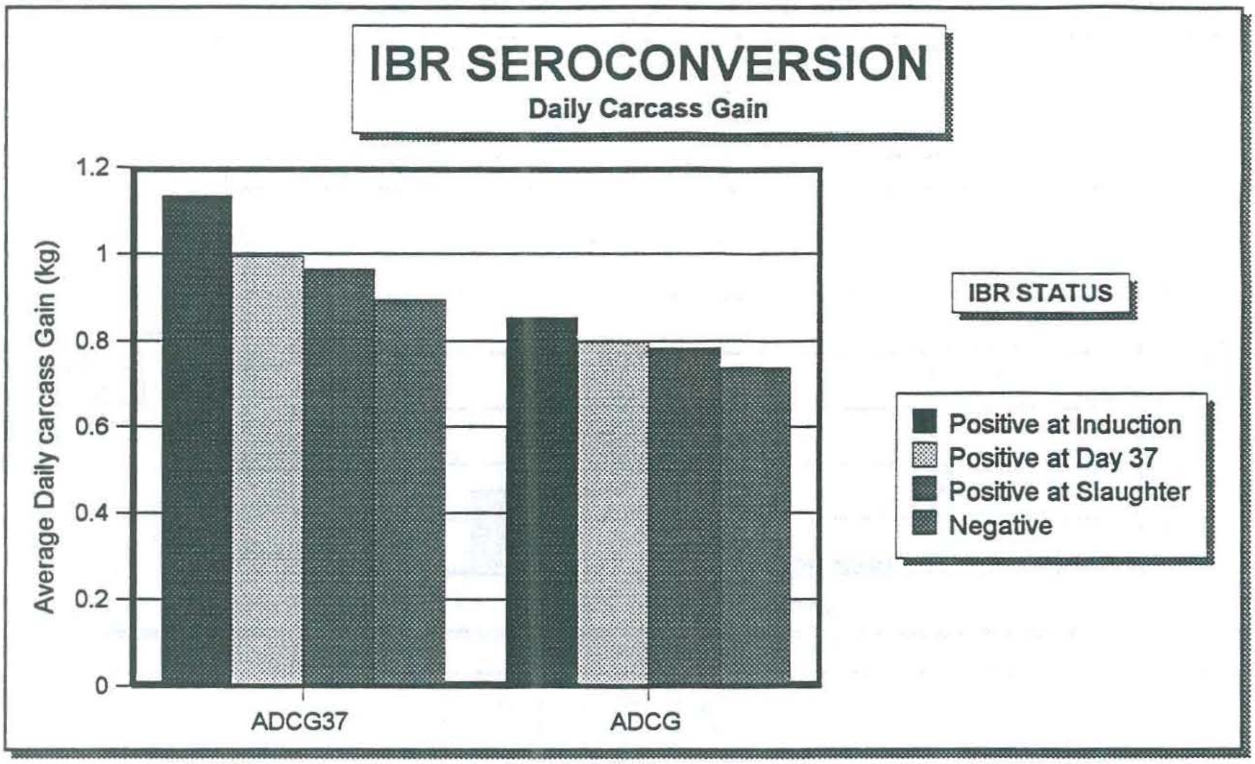


FIGURE 11 Time of Seroconversion in relation to Weight Gain



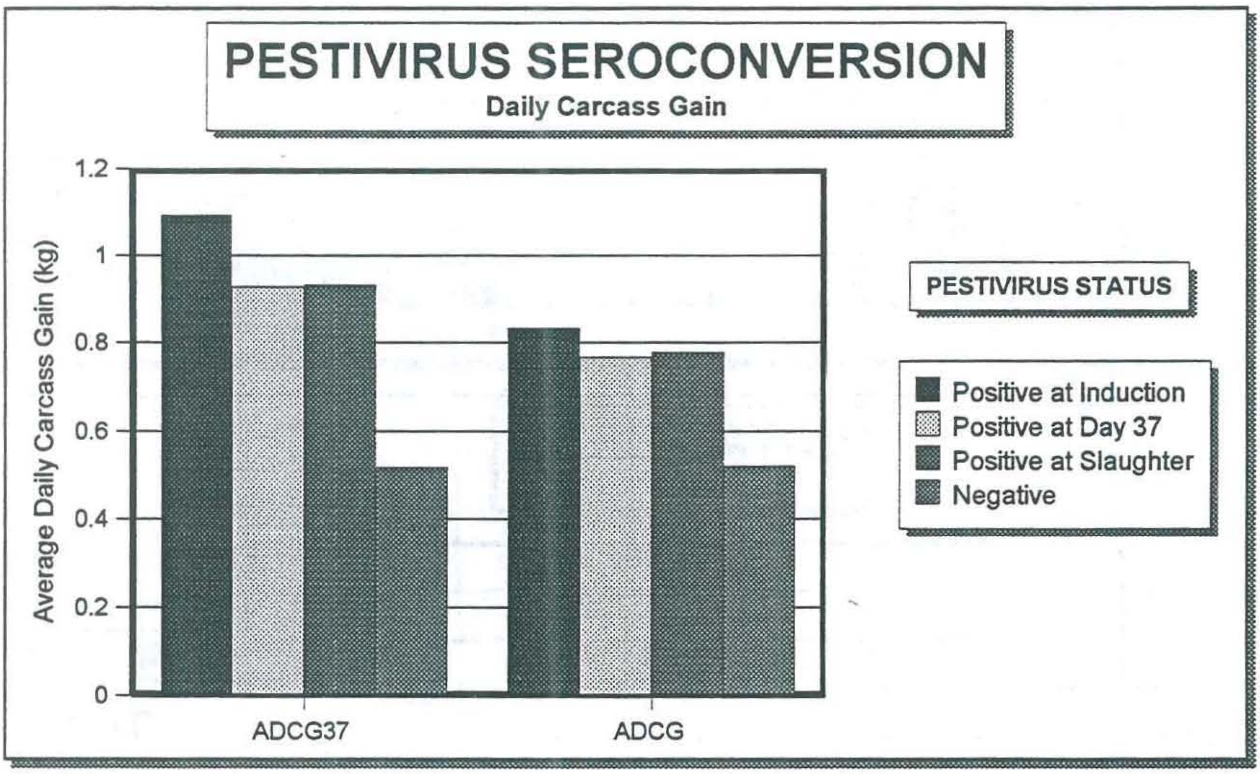
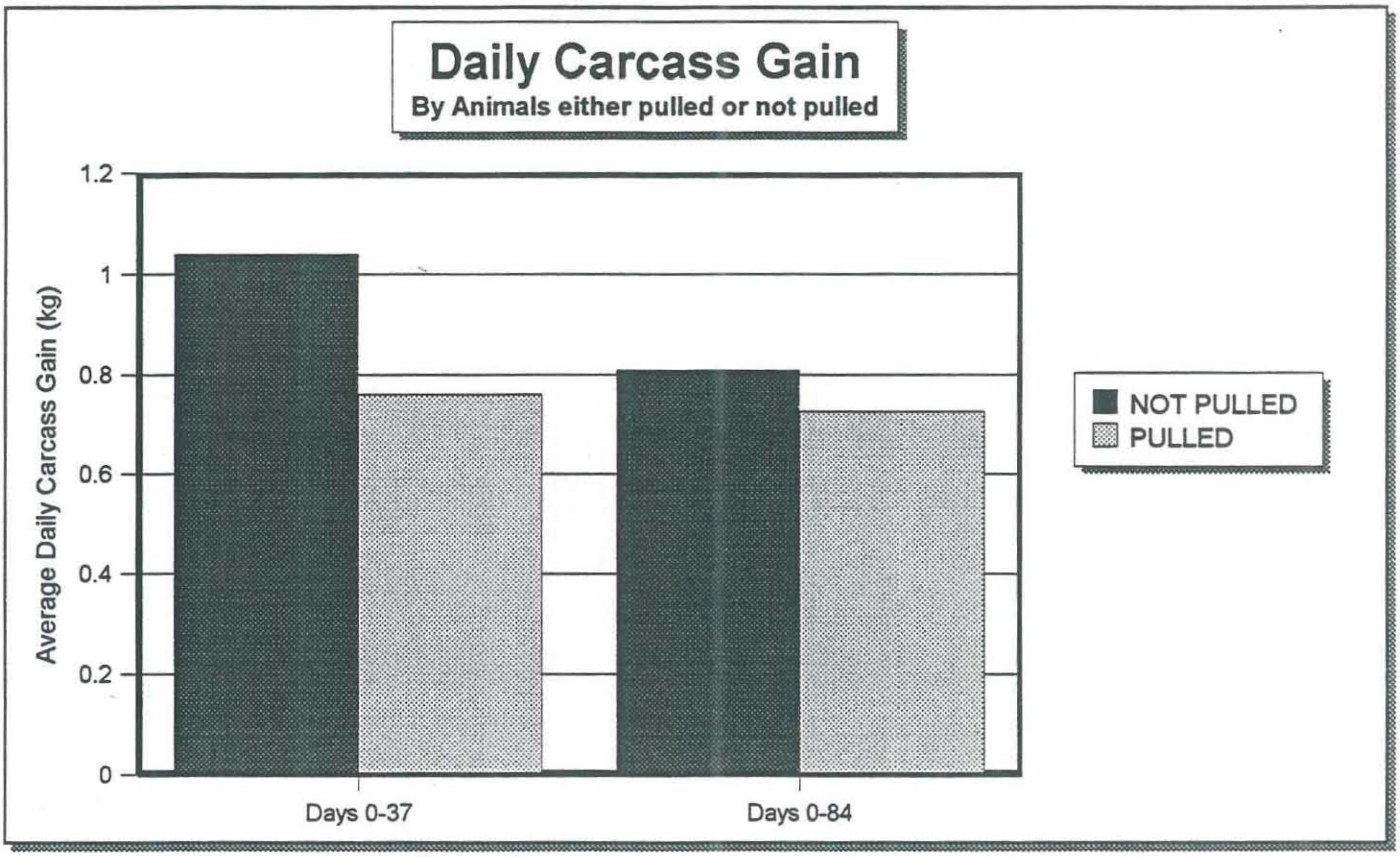
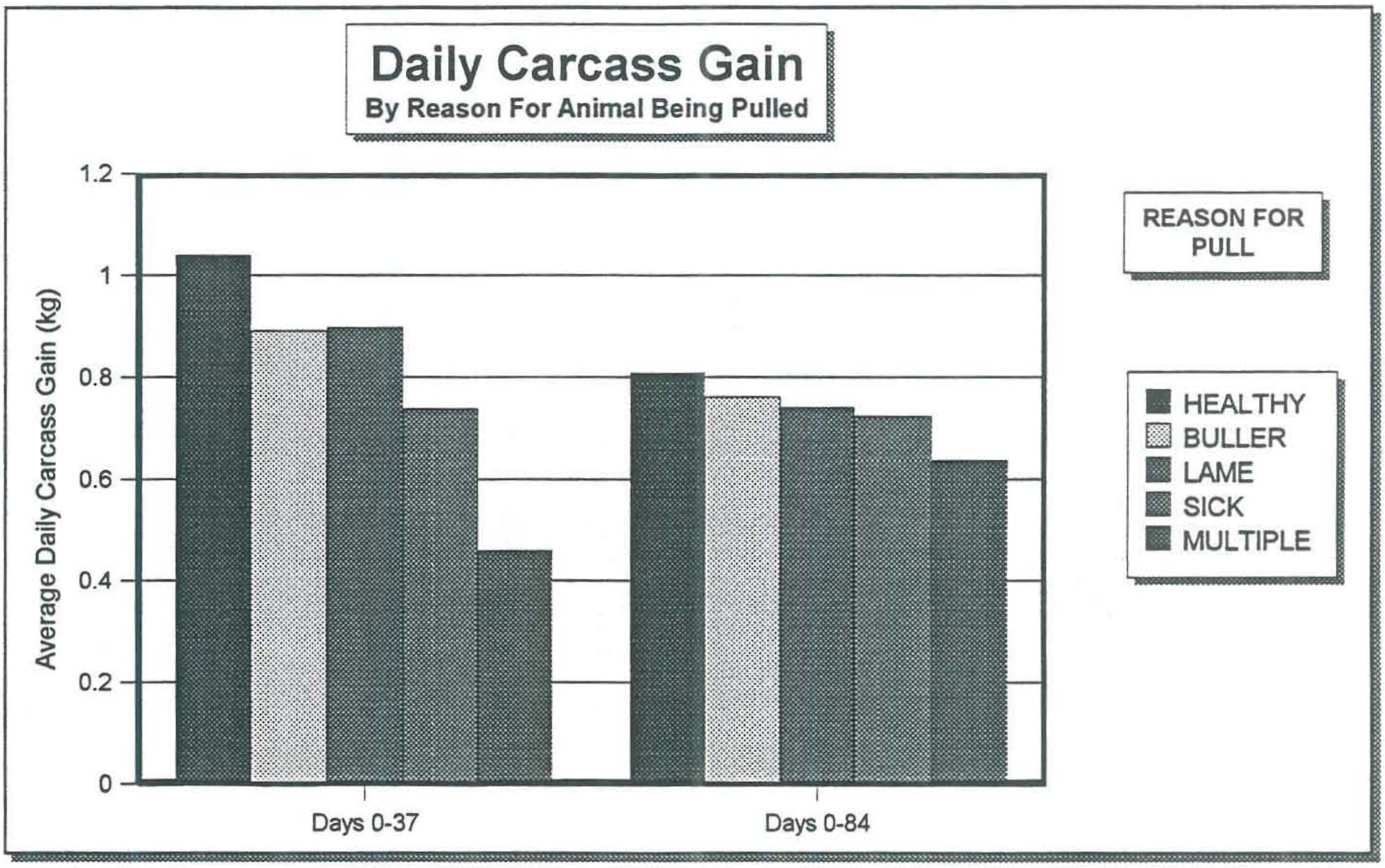


FIGURE 12 Weight Gains in Sick and Healthy Animals and those Pulled for Different Reasons





Meat Research Corporation Project DAN.069

Reducing Feedlot Costs by Pre-Boosting: A Tool to Improve the Heath and Adaptability of Feedlot Cattle

Economic Analysis of Phase 1

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(with thanks to Ian Patrick, Research Economist, NSW Agriculture, Gunnedah for preliminary economic analysis)

September, 1994

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1. Pre-boosting operations

1.1 Pre-boosting operations trialled

There were eight trial groups which tested five pre-boosting operations. These pre-boosting operations were vaccination, feeding hay, feeding grain (lupins and oats), feeding sugar and Equistim, and training the cattle.

1.2 Assumptions used for the economic analysis

Labour

Labour was costed in at $10/hour. The labour required for each operation was estimated by the researchers on the project. The time was then split over the number of animals involved in each operation and a cost per head was calculated (see Table 1).

Table 1. Labour cost for the different activities

Operation	Time per day	Frequency	Labour cost	No. of animals	Cost per animal
Vaccinating	2 hrs	twice	$10/hr	100	$0.40/hd
Feeding hay	0.25 hrs	10 days	$10/hr	50	$0.50/hd
Feeding grain	0.25 hrs	10 days	$10/hr	50	$0.50/hd
Providing sugar and equistim	1 hr	once only	$10/hr	50	$0.20/hd
Training	1 hr	10 days	$10/hr	50	$2.00/hd

Vaccines

Two vaccines were given to four of the groups: a bacterial vaccine and a viral vaccine both given twice to the cattle. It was estimated that it took two hours to vaccinate the group of 100 cattle. Vaccines were priced at $1.34/hd (bacterial vaccine) and $7.74/hd (viral vaccine). These prices were based on similar vaccines to other agents which are currently commercially available for cattle in Australia.

Feeding hay

Five kilograms of hay was fed every day for ten days to six of the groups. The price of hay was taken as the normal cost of small bales of lucerne hay (25 kg) at around $3.50/bale. It was estimated to take around 15 minutes to feed the hay out to fifty cattle.

Feeding grain

Lupins (0.40 kg/hd/day) and Oats (0.6 kg/hd/day) were fed to four of the groups every day for ten days. The grain cost $350/t and $150/t to buy during the trial. Feeding the grain was estimated to take around the same amount of time as feeding the hay out at fifteen minutes a day.

Providing sugar and Equistim

Sugar was placed in the drinking water along with Equistim once. Sugar cost around $0.03/head. Equistim is not currently available commercially, however its price was equated to its probable market price. Around 1 ml per 100 kg liveweight was required and it was costed at $10/ 2 ml, or $11.50/head. It was assumed to require about 1 hours labour to provide the sugar and Equistim to the cattle.

Training

Training involved a simple arena test procedure - mainly observing the cattle from close quarters for around an hour a day for ten days.

Summary Costs and Assumptions

The above assumptions are summarised in the Table 2 below.

Table 2. Assumptions and Costs involved in Pre-Booster Trials

Inputs		Rate	Cost	Head	Cost/hd	Totals
1. Vaccines	bacterial viral labour	once only	$1.34/hd $7.74/hd $10/hr	100	$1.34 $7.74 $0.40	$9.48/hd
2. Feed hay	5 kg/hd/day 0.25 hrs/day	10 days	$3.50/bale $10/hr	50	$7.00 $0.50	
3. Feed lupins Feed oats	0.4 kg/hd/day 0.6 kg/hd/day 0.25 hrs/day	10 days	$350/t $150/t $10/hr	50	$1.40 $0.90 $0.50	$2.80/hd
4.Sugar Equistim	 1 ml/100 kg lw 1 hour	once only	$0.30/hd $10/2 ml $10/hr	50@ 280kg	$0.03 $11.50 $0.20	$11.73/hd
5. Training	1 hour/day	10 days	$10/hr	50	$2.00	$2.00/hd

1.3 Costs for each pre-boosting groups

The eight pre-boosting trial groups had the costs as indicated below in Table 3.

Table 3 Costs per head involved in the pre-boosting trial groups

Group	1	2	3	4	5	6	7	8
Vaccine ($/hd)		9.48		9.48		9.48		9.48
Feed hay ($/hd)			7.50	7.50	7.50	7.50	7.50	7.50
Feed grain ($/hd)					2.80	2.80	2.80	2.80
Sugar+Equistim($/hd)							11.73	11.73
Training ($/hd)					2.00	2.00	2.00	2.00
TOTAL ($/hd)	0.00	9.48	7.50	16.98	12.30	21.78	24.03	33.51

1.4 Returns to the pre-booster

The analysis assumes there are no extra overhead costs incurred with the different treatment levels as opposed to the control, that is there are no other yard facilities required to undertake the pre-boosting operations. It is assumed that cattle breed is unimportant, that there is no preferred type of cattle which would accept the pre-boosting treatments better than others. If these assumptions are incorrect, then the costs involved in these pre-boosting operations could be higher.

To undertake the operations involved in group 8 the producer would have to receive $33.31/head more for his weaners to make it worthwhile. Assuming a sale weight of between 300 kg and 320 kg, this comes back at $0.11-$0.10/kg lw extra price, or effectively an 8% price premium (see Table 4).

Table 4. Extra returns required to cover pre-boosting costs

Group	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Pre-boosting costs ($/hd)	0.00	9.48	7.50	16.98	12.30	21.78	24.03	33.51
Extra price c/kg assuming 300kg	0	3	2.5	6	4	7	8	11
%price increase from $1.40/hd	0%	2%	2%	4%	3%	5%	6%	8%

2. Feedlot operations

The assumptions used for the economic analysis of the pre-boosting trial groups are presented below in Table 5. As far as possible actual values were used for each group, so as to realistically reflect what the commercial situation would have been. Two extra groups were also used for comparison: a commercial average and a commercial poor.

2.1 Animal assumptions

Purchase weight

The cattle were weighed upon entry to the feedlot and an average purchase weight for each group was used in the economic analysis.

Starter ration - intake and days on

The cattle were fed for 28 days on starter ration. Their intake was not able to be measured and therefore an average value for all groups was used of 8.5 kg/day/head.

Finisher ration - intake and days on

The cattle were fed on finisher ration until they were sold. As the cattle were sold on different days the exact number of days each group was on this ration was used, so the feed cost could be accurately estimated.

Weight gain and Sale weight

All cattle were weighed at slaughter and these weights were subtracted from the entry weights to estimate the weight gains for each group (kg/head/day). Similarly in the calculation of the sale value per head, the actual sale weights for each group were used.

Table 5 - Animal assumptions used in the economic analysis

Group	1	2	3	4	5	6	7	8
Purchase weight (kg/hd)	310	313	316	303	319	309	315	311
Starter intake (kg/hd/day)	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5
Starter days on	28	28	28	28	28	28	28	28
Finisher intake (kg/hd/day)	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1
Finisher days on	56	56	56	56	56	56	56	56
Total days on feed	88.1	88.3	87.2	88	87.9	87.2	86.5	86.8
Extra finisher days	4.1	4.3	3.2	4.0	3.9	3.2	2.5	2.8
Weight gain (kg/hd/day)	1.425	1.575	1.475	1.602	1.473	1.453	1.460	1.60
Proportion sick %	7%	11%	0%	12%	12%	4%	0%	8%
Proportion deaths %	4%	0%	0%	0%	0%	0%	0%	0%
Sale weight (kg/hd)	436	449	444	447	448	436	441	448

Proportion of sick animals
The number of animals which became sick in the feedlot was recorded for each group and these values were used.

Proportion of deaths
Only one death occurred in the eight groups (in group 1 - control). Hence a death rate of 4% was used for this group, and a death rate of 0% was used for the others. It is important to note here that because one animal died out of 25 in the control group, the mortality was around four times higher than the more usual 1%.

Commercial animal assumptions
Two commercial production levels were assumed to allow the pre-boosting trial groups to be compared to the commercial situation. The assumptions for the "commercial poor" group were based on the results of the worst of the commercial in-contact group of the cattle in this experiment. The assumptions for the "commercial average" were based on the average of this group for average daily weight gains; and on a 1% death rate (a commonly accepted industry average). These assumptions are presented in Table 6.

Table 6. Animal Assumptions for Commercial Average and Commercial Poor Group

Assumptions	Commercial Average	Commercial Poor
Weight gain (kg/hd/day)	1.35	1.18
Sickness (%)	0.25	0.5
Death (%)	0.01	0.045

2.2 Economic assumptions

The economic assumptions used in this analysis are summarised below in Table 7.

Table 7 - Economic assumptions

Assumptions	All Groups							
Purchase price	$1.20/kg liveweight							
Starter ration cost	$130/tonne							
Finisher ration cost	$150/tonne							
Sick pen cost	$30/head							
Interest rate	10% per annum							
Sale cost	$5/head							
	Separate Group Values							
	1	2	3	4	5	6	7	8
Sale price ($/kg lw)	1.4	1.42	1.42	1.43	1.41	1.41	1.41	1.43

Purchase price
A purchase price of $1.20/kg liveweight was assumed for each group.

Sale price
The actual sale values for the cattle as paid by the processor were used.

Sale cost
A sale cost of $5.00/head was used to cover transport costs to move the cattle from the feedlot to the abater.

Sick pen cost
The sick pen was estimated to cost around $15/head for medicine and $15/head for veterinary services and labour to move the cattle around, a total of $30/head.

Animal death cost
It was assumed that if an animal died it was at the end of its time in the feedlot. Hence the cost was its purchase cost, and the starter and finisher rations. It could be suggested that this overestimates the feed cost as many animals would die at the start rather than the end of their time in the feedlot. However, it is likely that an animal that dies would be in the sick pen for some time before death, and therefore these costs were assumed to even out.

Starter and finisher ration costs
Starter ration was assumed to cost $130/t ($0.13/kg). Finisher ration was assumed to cost $150/t ($0.15/kg). Both these prices were estimated from the feedlot trial.

Interest rates
Interest rates were assumed to be 10% per annum, or 3% per quarter, (close to the overdraft rate). The purchase cost, feed costs and sick pen costs were all multiplied by the quarterly interest rate to allow for an opportunity cost on the money invested in the cattle.

2.3 Returns to the feedlot operators for the eight pre-boosting trial groups
Given the above animal and economic assumptions, the marginal returns (not allowing for overheads) for each group of cattle, are presented below in Table 8 and Figure 1.

Table 8. Costs and returns calculated for the eight pre-boosting trial groups ($/head)

Group	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Purchase cost	372	375	379	363	382	371	378	373
Starter ration	30.94	30.94	30.94	30.94	30.94	30.94	30.94	30.94
Finisher ration	64.01	64.22	63.05	63.90	63.79	63.05	62.30	62.62
Sick pen cost	2.13	3.21	0	3.6	3.6	1.26	0	2.40
TOTAL COST	481	485	484	473	493	478	483	481
SALE VALUE	581	608	603	609	601	584	595	608
Gross margin	101	123	118	136	108	106	111	127
Gross margin compared to control		22	18	36	7	5	11	26

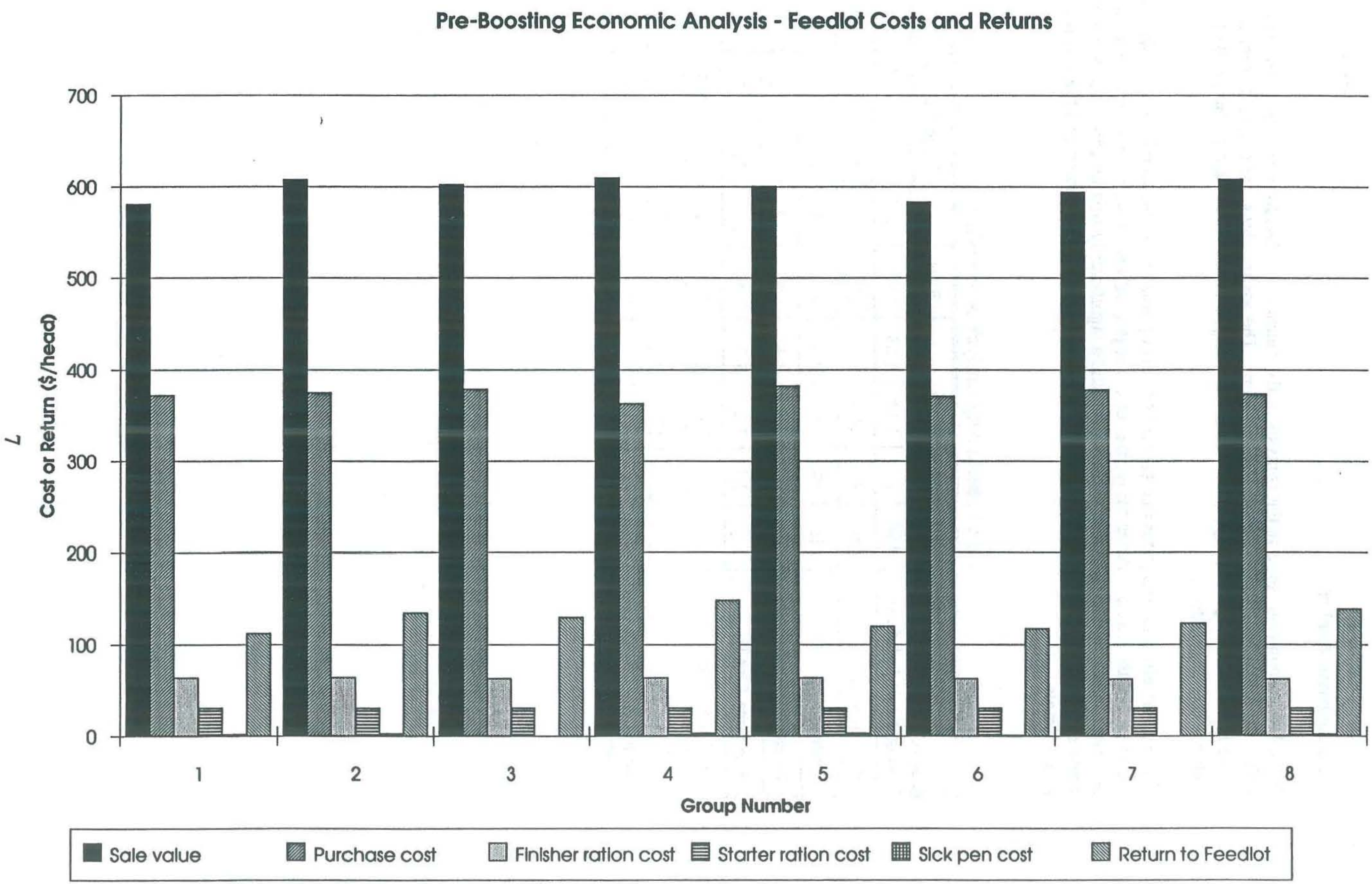

Figure 1. Costs and Returns for the Eight Pre-Boosting Groups.

2.4 Sensitivity Analysis

Eight key assumptions used in the analysis of the return to the feedlot were varied to see their effect on the gross margin for each trial group. The assumptions were varied from a low value for the industry to a high value for the industry, and the results are presented below in Table 9 and in Figure 2.

The biggest effect on the gross margin for each group was due to the purchase and sale price assumed for the cattle. After those, the next biggest influence was the live weight gains achieved. The remaining assumptions, which had a significantly smaller effect on the overall gross margin were the total feed cost, deaths, sick pen cost, interest rates and the number of sick animals.

Table 9. Sensitivity Analysis Assumptions

	Low Values				Base	High Values			
Weight gain kg/hd/day	0.86	1	1.14	1.28	1.43	1.57	1.71	1.85	2
Sick animals %	0%	5%	10%	15%	20%	25%	30%	35%	40%
Deaths %	0%	1%	2%	3%	4%	5%	6%	7%	8%
Purchase price $/kg lw	0.8	0.9	1	1.1	1.2	1.3	1.4	1.5	1.6
Sale price $/kg lw	1	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8
Feed cost $/kg total cost	57	66	76	85	95	104	114	123	133
Sick pen cost $/hd	10	15	20	25	30	35	40	45	50
Interest rate % p.a.	6	7	8	9	10	11	12	13	14

Pre-Boosting Economic Analysis - The Effect of Changing One Variable At A Time While Holding All Others Fixed - All Results Collated Onto This Graph.

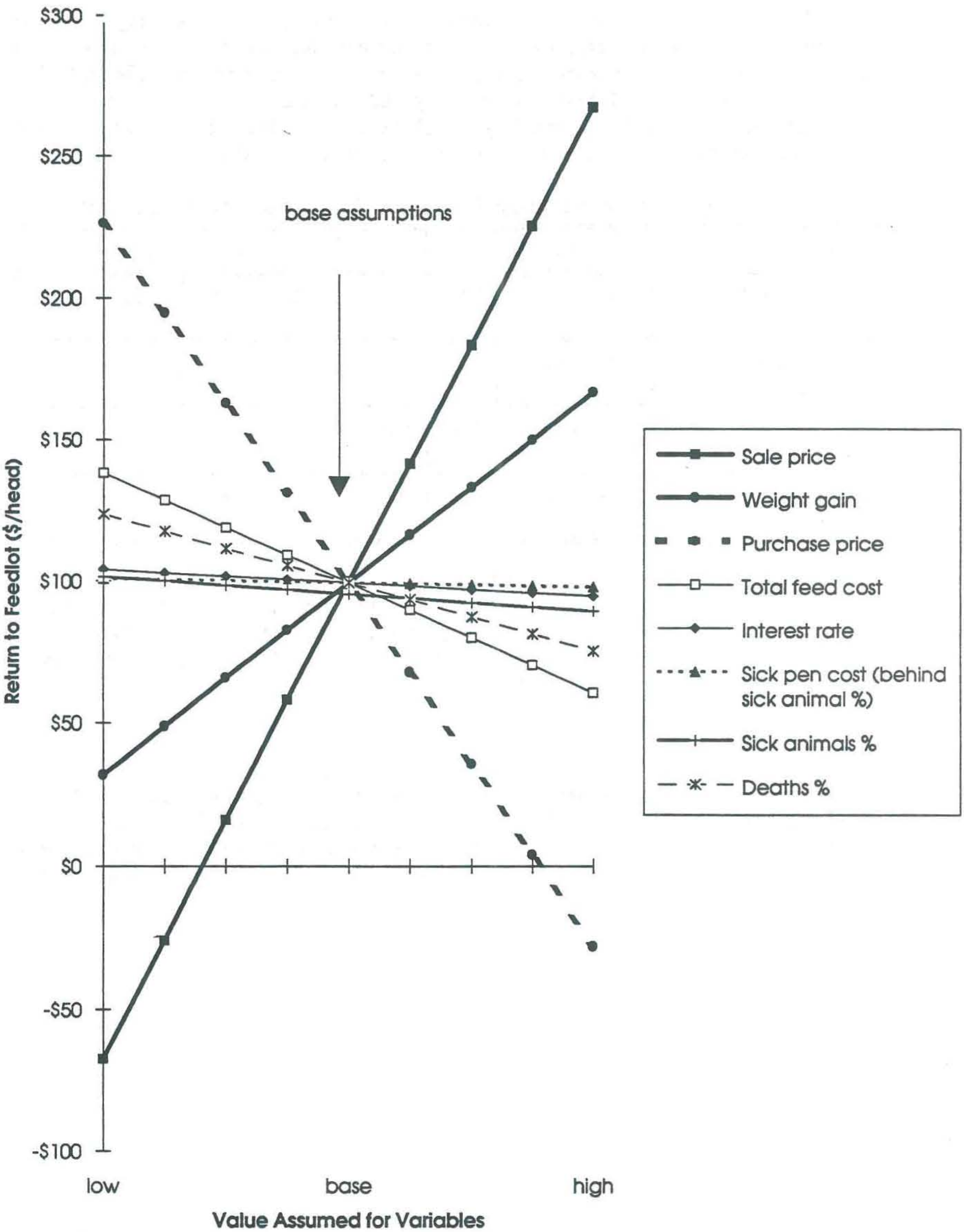

Figure 2. Sensitivity Analysis of Eight Variables Used in the Pre-Boosting Economic Analysis.

3. Comparison of pre-boosting costs to feedlot returns

The ability of the feedlot to pay the premium cattle prices required to cover the cost of the pre-boosting operations depends on the key assumptions discussed above in the sensitivity analysis. Figure 3 presents the difference between the control group and the other groups for the feedlot returns (gross margin) - before the cost of pre-boosting is taken into account.

Table 10 summarises the gross margin return to the feedlot, the pre-boosting costs, the difference between the two and how the trial groups compared to the control group. The comparison between the control group and the other groups is also presented in Figure 4. The extra costs incurred in the different pre-boosting trials can then be compared to the extra returns generated by the different weight gains, sickness % and death %; and also compared to the control group where no pre-boosting treatments were undertaken.

Table 10. Summary of the economic analysis of the pre-boosting trial groups

Group	1	2	3	4	5	6	7	8
Pre-boosting (PB) cost ($/hd)	0.00	9.28	7.50	16.78	12.30	21.58	24.03	33.31
Feedlot gross margin (GM) ($/hd)	101	123	118	136	108	106	111	127
Difference GM-PB ($/hd)	101	113	111	120	96	84	87	94
Difference cf. control ($/hd)		12	10	19	-5	-16	-13	-7

All pre-boosted groups provided a higher gross margin to the feedlot than the commercial average, control group and the commercial poor. The central reason the control group returned less than the commercial average group was the death of one beast from the group of 25. This effectively caused a death rate of 4% to be factored into the control group costs, as compared to the industry average of 1%.

In conclusion then, if the cost of the pre-boosting is taken from the gross margin (the situation if the feedlot had to pay for the pre-boosting), then only groups 2, 3 and 4 had a higher return than the control. Thus, if the full cost of pre-boosting was paid to producers, it would only be profitable for the feedlot to purchase groups which had been vaccinated, fed with hay or both.

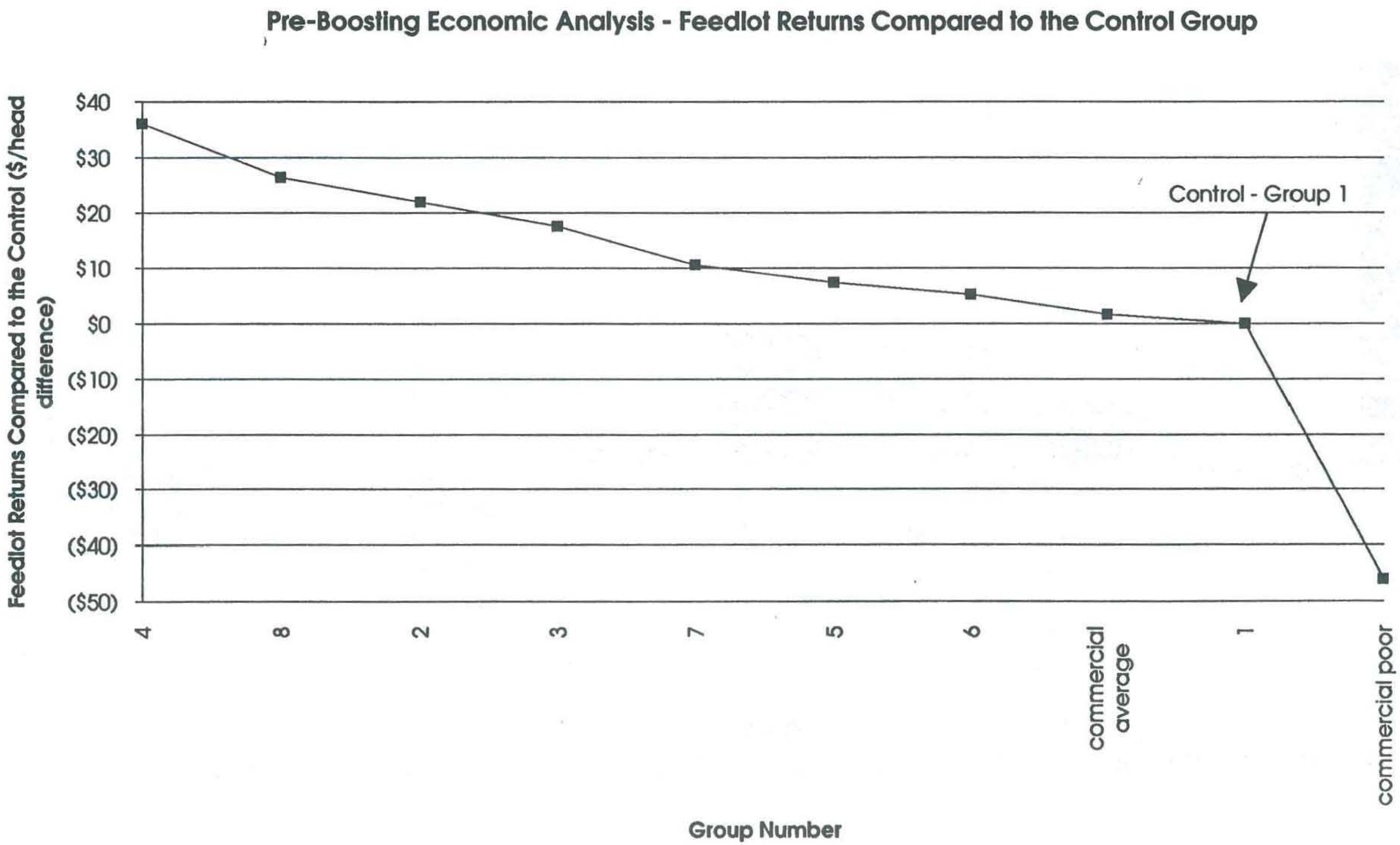

Figure 3. Comparison of Pre-Boosting Trial Feedlot Returns to the Control Group

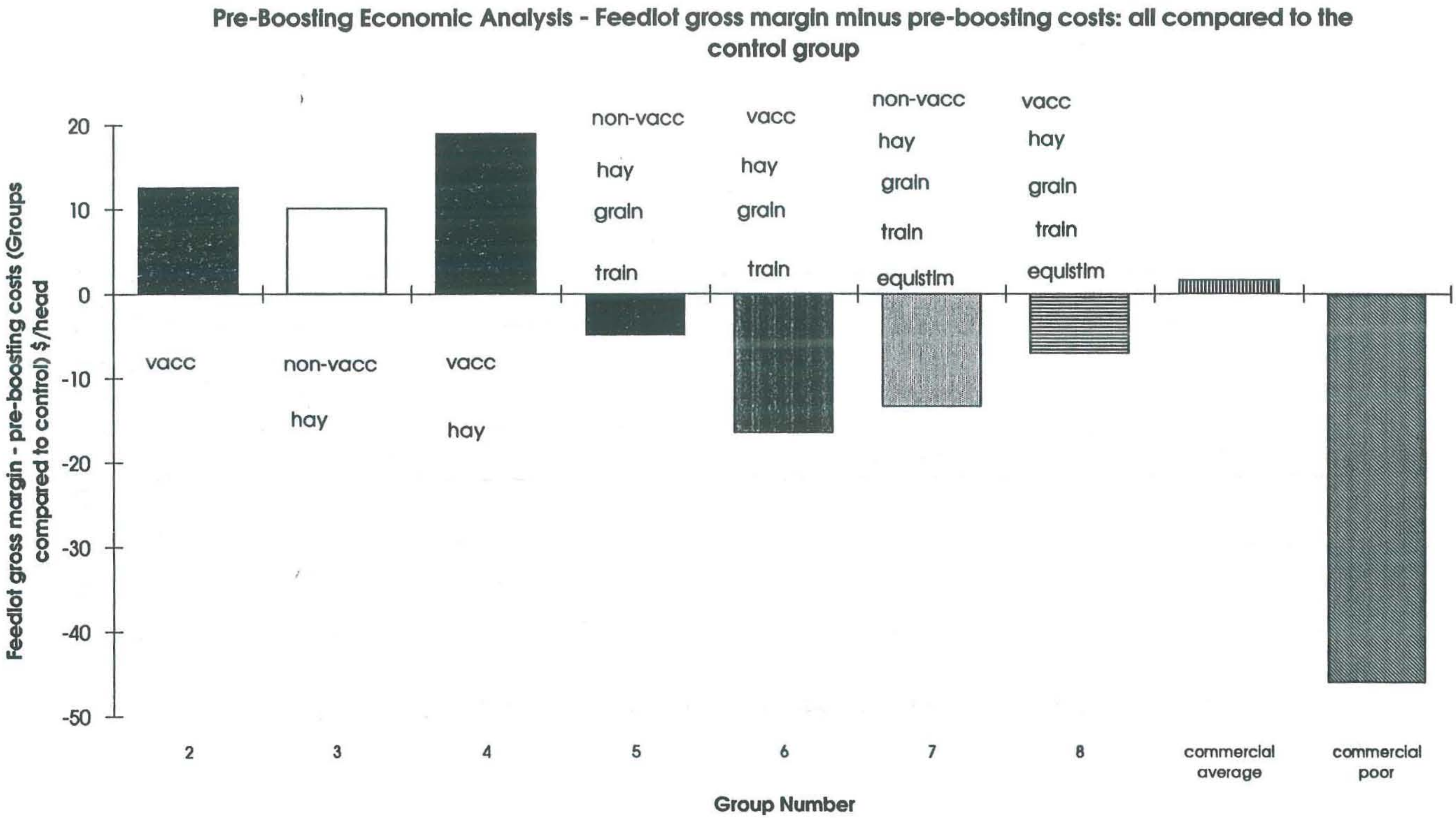

Figure 4. Comparison of Pre-Boosting Trial Feedlot Returns After Pre-Boosting Costs to the Control Group.

Appendix 2

Progress Report on Completion of Phase 2, September 1996

Meat Research Corporation Project DAN.069

Reducing Feedlot Costs by Pre-Boosting: A Tool to Improve the Health and Adaptability of Feedlot Cattle

Progress Report on Completion of Phase 2

prepared by

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September 1996

Table of Contents

The original copies of this report are printed in colour which simplifies the interpretation of the numerous bar charts which it contains.

Summary of Phase 2

This was conducted in a very similar fashion to Phase 1. Angus/Hereford weaners were divided between 8 treatment groups (25 animals/group) which differed in various aspects of pre-feedlot management and their health and performance for 92 days on feed in a large commercial feedlot was determined. The experimental cattle came from two sources before weaning (EMAI and Braidwood) and were run as a single group from the end of the various weaning treatments and then mixed with a similar group of commercial in-contact cattle in one pen at the feedlot. The experimental herd consisted of a control group (supposedly current industry practice) and 7 levels of treatments known as pre-boosting which included vaccination against Pestivirus, IBR, PI_3 and Pasteurella around 1 month prior to feedlot entry, yard weaning with supplementary hay, additional handling and training to eat from a trough, and non-specific immunostimulation given shortly after weaning.

The main difference from Phase 1 was that the commercial-in-contact cattle (187 head) were put into the feedlot pen 3 days earlier than the experimental cattle (196 head). The commercial cattle were also somewhat heavier (369 cf. 312 kg) and a bit older than the experimental animals this year.

As in Phase 1 all experimental groups (including the control) adapted well to the feedlot, got onto feed quickly and had reasonable growth rates throughout the feeding period. The groups which were yard weaned and trained had significantly greater feeding activity than the paddock-weaned control cattle during the first week in the pen while the commercial cattle were very much slower to get onto the feedlot starter ration. Trained cattle had a slightly better average daily gain, but this difference was not significant.

The beneficial effects of vaccination on weight gain which were observed in Phase 1 were not confirmed in Phase 2. Unfortunately the effect of vaccine was confounded with the effect of source of cattle this year which compromised our ability to determine vaccine effects unequivocally. This problem did not occur in Phase 1 or Phase 3.

As in Phase 1 the morbidity was appreciably less for experimental cattle than for commercial cattle in the first month of feeding (8% cf. 16% sick) and it was less for pre-boosted groups than for the control. However, some deaths occurred in all groups due to gastro-intestinal disease in this early period and there were further deaths due to an outbreak of bovine respiratory disease after 11 weeks on feed. In total there were 18 deaths in the pen of 383 animals, but 11 of these were by salvage slaughter which gained further information for the project.

The most important finding in Phase 2 was that the vaccine did not appear to protect cattle from the Braidwood source against respiratory disease whereas it did appear to protect the EMAI cattle, there being no deaths in vaccinated EMAI groups. This important interaction between vaccine efficacy and the type of cattle will require careful attention in future trials.

In contrast to Phase 1, the economic analysis did not show any advantage for the pre-boosting treatments this year although it did allow some further comparison of different components of pre-boosting which will be helpful in the final analysis.

METHODS and EXPERIMENTAL DESIGN

The experimental details were very similar to Phase 1 (see diagram on page 8).

Some 200 calves (predominantly Angus x Hereford) were weaned at 7-8 months of age at EMAI (in April 1994) and allocated to 4 main experimental groups of 50 animals per group. The groups were matched for liveweight and source (property of origin). Later, each group was divided into vaccinated and non-vaccinated sub-groups so that there were 8 treatment groups in all (25 animals per treatment) designated as follows:

Group 1	1C	Control
	1V	Control, Vaccinated
Group 2	2C	Yard Weaned
	2V	Yard Weaned, Vaccinated
Group 3	3C	Yard Weaned/Trained
	3V	Yard Weaned/Trained, Vaccinated
Group 4	4C	Yard Weaned/Trained/Immunostimulated
	4V	Yard Weaned/Trained/Immunostimulated, Vaccinated

This year the cattle came from two different sources - 69 from Braidwood Station and 131 from the EMAI herd. Unlike Phase 1, the majority of the Braidwood steers were found to be Pestivirus positive, but this was discovered after the animals had been allocated to the main treatment groups for weaning. Therefore, in Phase 2, the source effect and vaccination effect were confounded because all but one of the Braidwood steers had to be disqualified from the control (non-vaccinated) groups due to their pre-existing seroconversion to Pestivirus. These animals had to be placed in the vaccinated groups.

The treatments were as follows:

Group 1 (1C and 1V) - paddock weaned, no supplements, less handling than Phase 1 (through the crush 4 times between weaning and shipping to feedlot (5 times for V animals).
Group 2 (2C and 2V) - yard weaned for 10 days with meadow hay, 1 round bale per day, no handling except for sampling on days 1 and 23 after separation from their mothers.
Group 3 (3C and 3V) - yard weaned as above plus daily confidence testing/training as in Phase 1 for 45 min each morning on days 2 - 9 and 15 and 18. The training procedure involved access to a 40:60 lupins/oats ration supplied in feed bunks at a rate of 1kg/head/day.
Group 4 (4C and 4V) - yard weaned plus confidence testing/training as above plus Equistim injection (1 ml/100kg) on day 9 accompanied by sweetened drinking water (1% sucrose). Access to the sweetened drinking water was repeated 1 day prior to shipping to the feedlot.

The vaccination treatment utilised experimental vaccines against Pestivirus, Infectious Rhinotracheitis virus (IBR), Parainfluenza 3 virus (PI_3) and Pasteurellosis (P. haemolytica and P. multocida) given at least 1 month before entry into the feedlot. The experimental vaccination program (groups 1V, 2V, 3V, 4V) was as follows:

Day -70 (from feedlot induction) - 2ml killed adjuvanted IBR vaccine and 1ml inactivated Pasteurella vaccine, subcutaneously (s.c.).

Day -48 - 2ml killed adjuvanted IBR vaccine and 1ml inactivated Pasteurella vaccine, s.c.
Day -27 - 2ml live unmodified Pestivirus, s.c.
Day -22 - 2ml live PI_3, s.c.

The vaccinated and unvaccinated groups were run separately from day -22 until shipping.

All animals also received appropriate 5-in-one vaccination and drenching for internal parasites.

The experimental groups were run as one herd on pasture at EMAI from day 23 after weaning until shipping to Caroona feedlot 8 months later (at 15-16 months of age) in February 1995. There were 196 steers shipped and successfully inducted into the feedlot.

The 196 steers were fed in one pen of 4,350 m^2 together with 187 steers of reasonably similar age and weight purchased by the feedlot for the purpose of providing a realistic behavioural and infectious challenge for the experimental animals. The feedlot-owned cattle were designated as **commercial-in-contact** to distinguish them from the **experimental** (EMAI) group. The commercial-in-contact steers this year were about 60 kg heavier on average and slightly older (40% 2 tooth cf. 1% for experimental cattle) and were introduced to the feedlot pen three days before the experimental cattle arrived instead of 3 days after the experimental cattle as had been the case in Phase 1. In total there were 383 animals in the pen, thus providing an average space allowance of 11 m^2/head with 66 m of feed bunk space.

Weather conditions were very dry and warm which provided a firm pen surface at all times, but also produced a considerable amount of dust throughout the trial.

All animals were weighed at induction (day 0) and after 39 and 92 days on feed . The experimental cattle were slaughtered on day 95 at Aberdeen. Commercial-in-contact cattle were slaughtered at various times over the next 7 months.

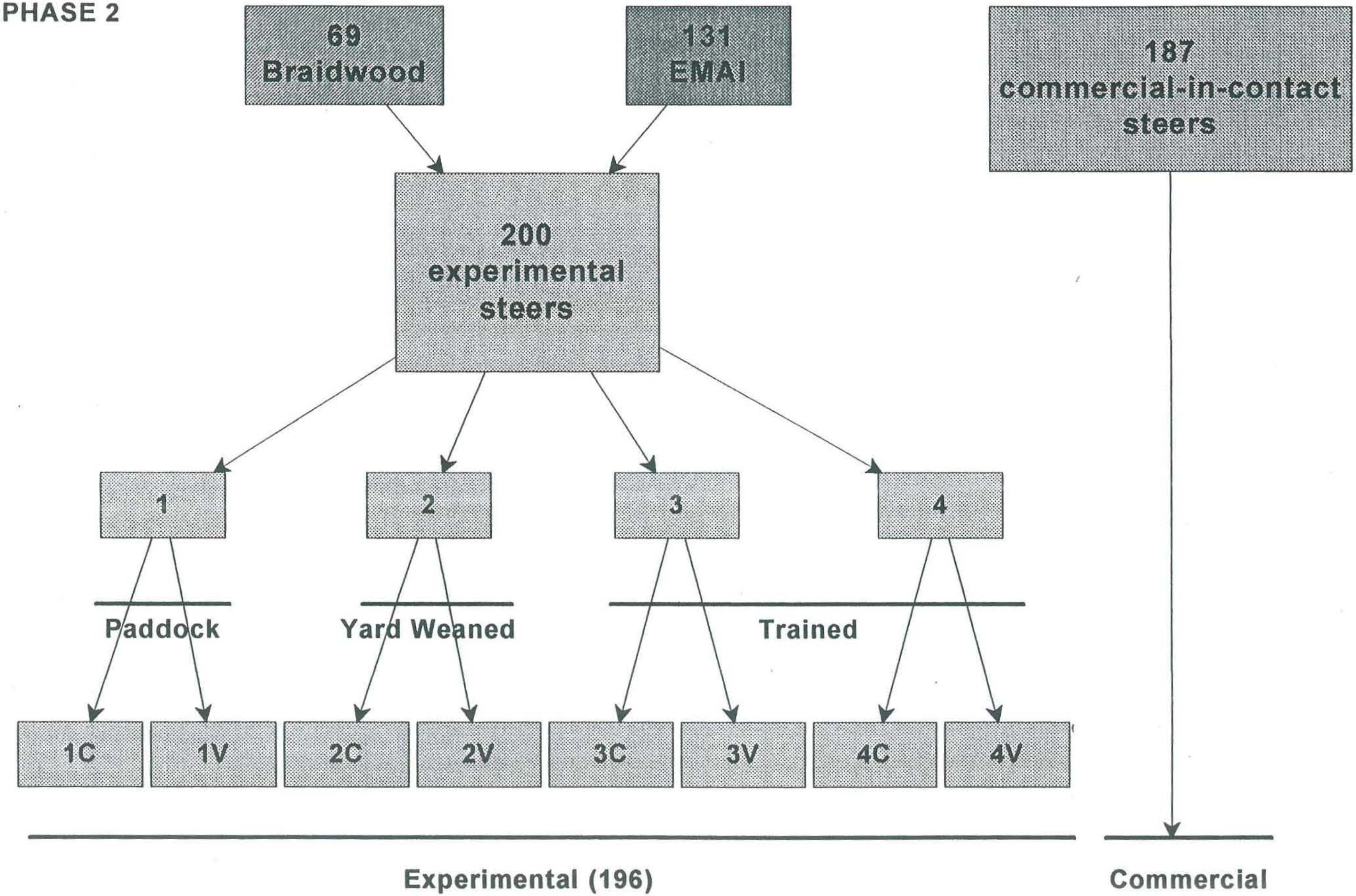
Serology was performed on blood samples collected from all cattle at induction, on day 39 and prior to slaughter (day 92 in the case of commercial-in-contact cattle) and also from all animals which were pulled because of sickness or sent for salvage slaughter. At slaughter all organs were examined for the presence of lesions.

Intensive behavioural observations and other measurements of stress were carried out from the afternoon of day 0 (induction) to the morning of day 11 as in Phase 1. Continual (24 hour/day) surveillance was maintained at the feed bunk (with the aid of video recording). Agonistic and social behaviour and standing, lying etc. was also recorded at frequent intervals.

Other measurements of stress included plasma cortisol assays for each animal on 3 different occasions and differential blood cell counts before and after the weaning. This individual animal data can be compared with the detailed serology and with extensive records of the behavioural attributes of individual animals. The detailed individual animal data which is still being analysed will not be discussed here. This report is confined to group comparisons to determine the treatment effects, including their statistical significance.

Groups 3 and 4 have been combined for some analyses (because the Equistim treatment appeared to have no effect in Phases 1 or 2 and therefore could be ignored). The three groups thus formed for analysis of mangement effects other than vaccination were **Trained** (Groups 3 and 4), **Yard Weaned** (Group 2) and **Paddock** (Group 1). For overall management effects the combination of all yard weaned groups is referred to as the **Treated** group.

PHASE 2



69
Braidwood
131
EMAI
187
commercial-in-contact
steers
200
experimental
steers
1
2
3
4
Paddock
Yard Weaned
Trained
1C
1V
2C
2V
3C
3V
4C
4V
Experimental (196)
Commercial

RESULTS

The effect of the experimental treatments must be measured against the appropriate EMAI control group. The commercial in-contact cattle provided another comparison, but the purpose of that group was to create a realistic behavioural and infectious challenge for the experimental cattle and it is not an appropriate "control" because those cattle were managed differently in some respects, *i.e.* they received hormonal growth promotants which the experimental cattle did not and the worst performers could be culled from that group whereas all experimental animals had to be included in the final result. However, the feedlot-owned cattle serve as an example of one possible commercial situation and data from this group are also discussed in this report.

General

Prior to feedlot entry the growth of experimental cattle in Phase 2 was very similar to Phase 1. The average liveweight of experimental animals at weaning in April 1994, was 182 kg. From weaning to feedlot induction in February 1995 their growth rate was reasonable at 0.4 kg/day despite the drought conditions in late winter, spring and summer which necessitated them being put onto irrigated pasture at times throughout the summer months.

The average liveweight at induction into the feedlot was 312 kg for the experimental cattle and 369 kg for the commercial-in-contact cattle. The commercial animals were sourced from a backgrounding property at Tumbarumba, NSW, but had been acquired from various other properties some months earlier.

The general pattern of health and production was that the experimental cattle got onto feed quickly and produced reasonable weight gains over the feeding period, but, in sharp contrast to Phase 1, there was an unexpectedly high level of mortality and salvage slaughter late in the feeding period due to an outbreak of bovine respiratory disease.

Weight Gain

The initial weight gain (to day 39) for experimental cattle averaged about 20% lower than it had done in Phase 1, for reasons which are not clear, but over the full feeding period it was the same as for Phase 1.

Generally, there were few statistically significant effects on weight gain, although the pre-boosting training treatments did produce the highest gains in the initial period and also over the total feeding period, as they had done in Phase 1.

Confounding of Vaccine Effect and Source Effect

As described in the Methods, there was an experimental design problem which occurred during the course of this trial, which needs to be considered at the outset. Late discovery of the Pestivirus status of the Braidwood cattle, meant that those animals had to be allocated almost entirely to the vaccinated groups. This has affected the results in the following manner.

The average daily weight gain of vaccinated animals was lower than control (unvaccinated) animals (see Figure 1) and this apparent vaccine effect was significant over the full feeding period (day 0-92). However, the significant effect of source on weight gain should also be noted, the Braidwood cattle having lower weight gains at all stages. If the Braidwood cattle were excluded from this analysis (i.e. EMAI cattle only), there were no significant effects of vaccine on weight gain. The only difference was that the liveweight at induction (and at weaning) was significantly lower for the EMAI vaccinated cattle than for the EMAI controls because of the need to balance the liveweight between groups (see Methods).

Because of the confounding of source of cattle with the vaccination treatment it cannot be concluded that vaccination had any effect on weight gain in this trial. This result must be considered in due course alongside the results from Phase 1 and Phase 3 in which there was no such problem with the experimental design.

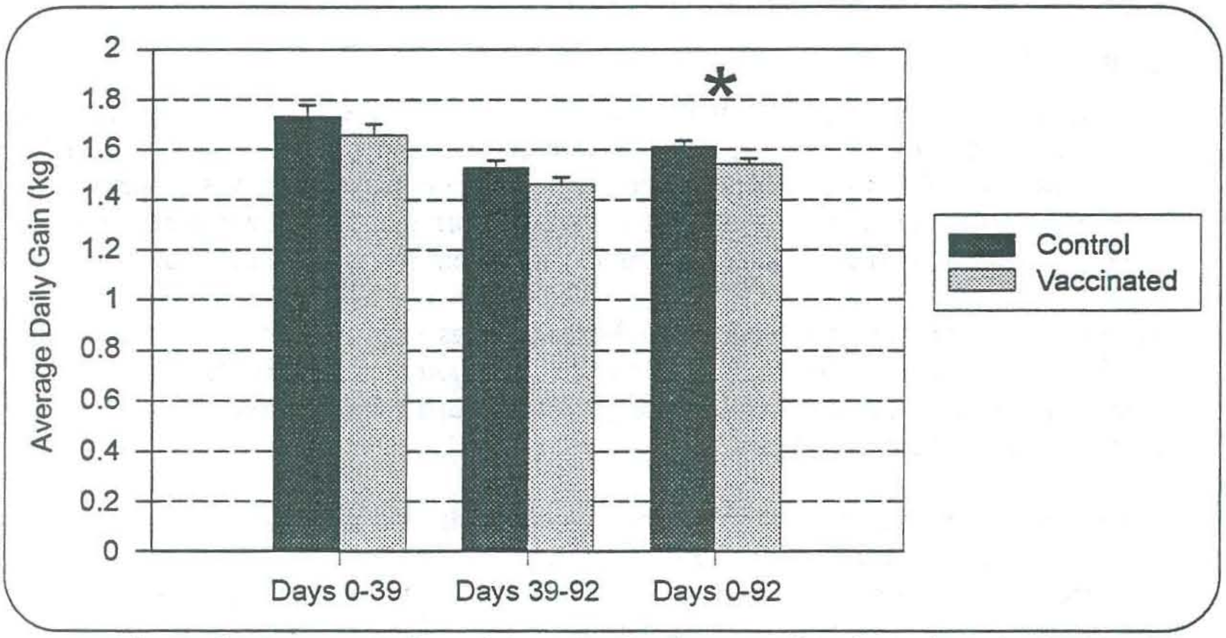


Figure 1: Average daily weight gains for the control and vaccinated animals

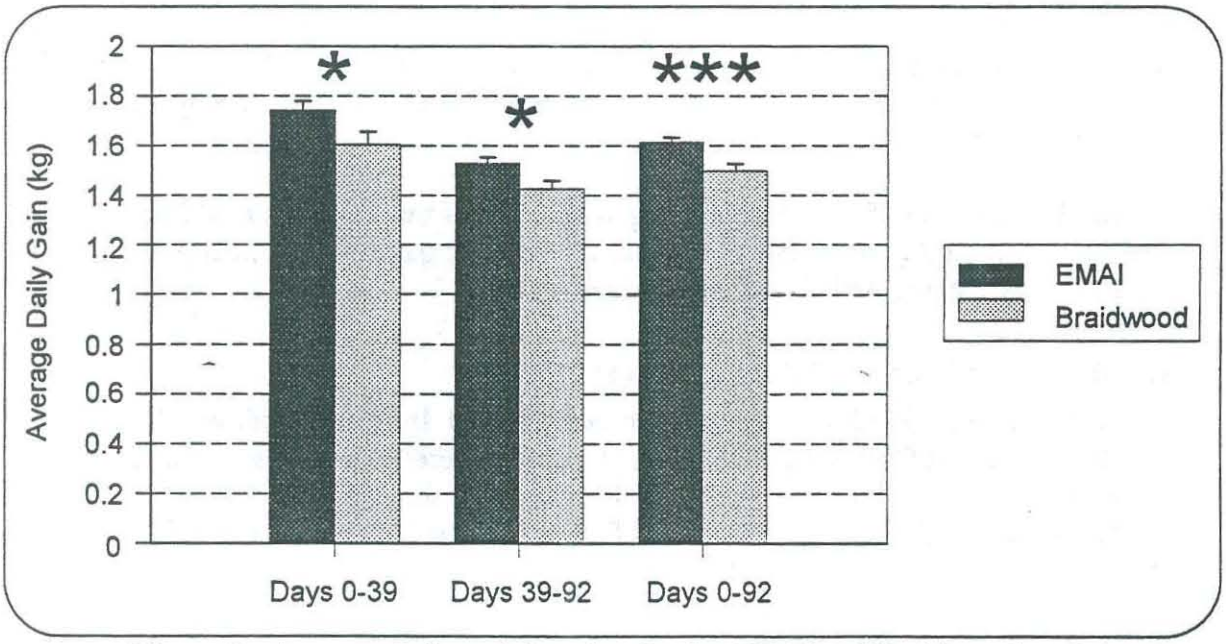


Figure 2: Average daily weight gains for the EMAI and Braidwood cattle

The average daily gains for all 8 treatment groups are shown in Figures 3 and 4. There was some variability between groups, but few significant differences. Group 2V had an unusually low weight gain, particularly to day 39. This was not associated with a higher morbidity (number of pulls) in that group. When the source effect is corrected for in the statistical analysis (Figure 4), the comparative failure of group 2V is somewhate reduced, but not eliminated. Apart from group 2V, the vaccinated groups actually showed the highest weight gains up to day 39 (Figure 4), which was the same trend as seen in Phase 1.

At this stage we cannot explain the poor performance in that particular sub-group. The fact that commercial feedlots also report some inexplicable variation between lots indicates that there are still factors affecting growth rate which have not been accounted for.

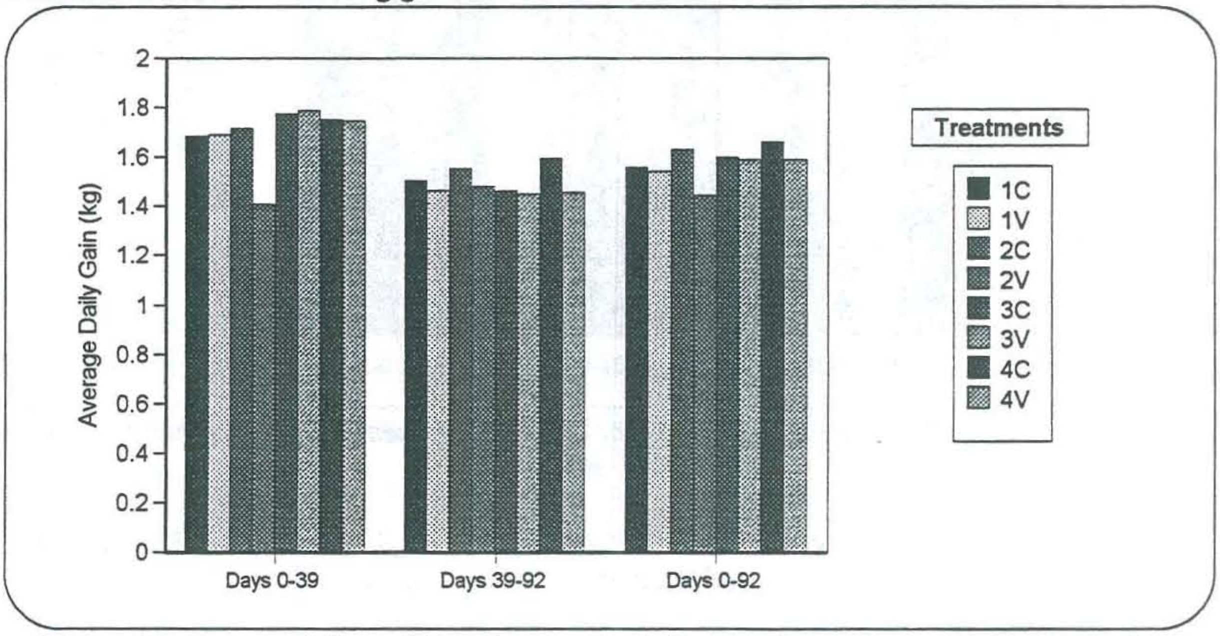


Figure 3: Average daily weight gains for the eight experimental groups (uncorrected for source effect)

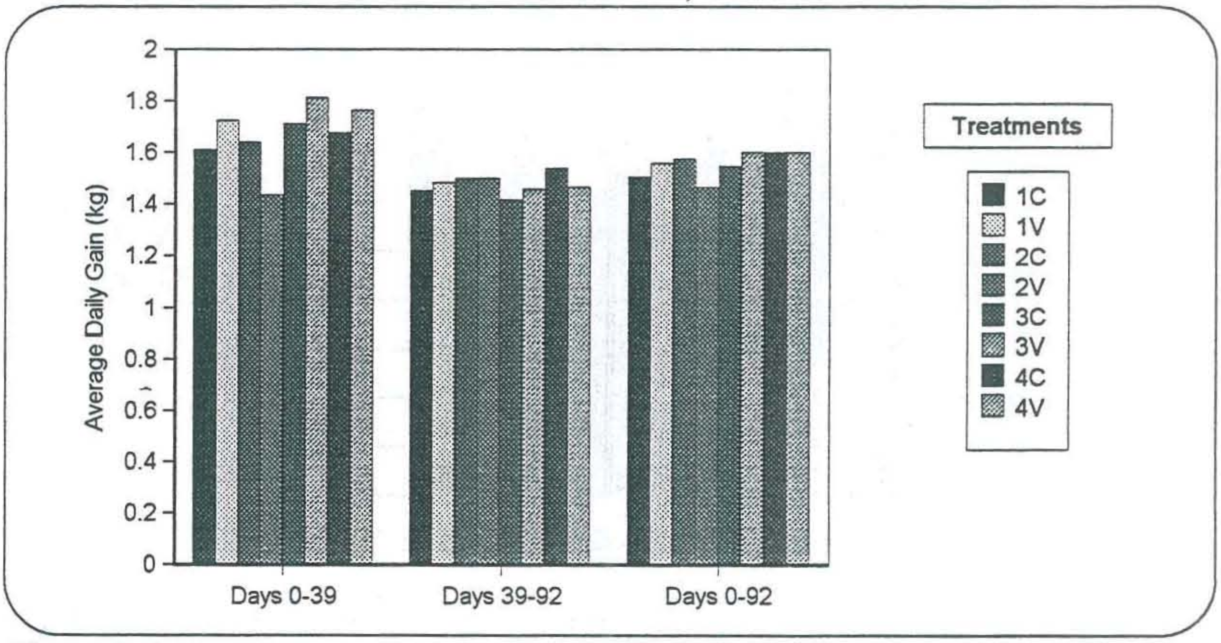


Figure 4: Average daily weight gains for the eight experimental groups (corrected for source effect)

When compared in terms of the four main treatments (Figure 5), groups 3 and 4, i.e. the cattle which had been trained as well as yard weaned, tended to have slightly higher weight gains than groups 1 and 2, particularly in the initial period, but these differences were generally not significant.

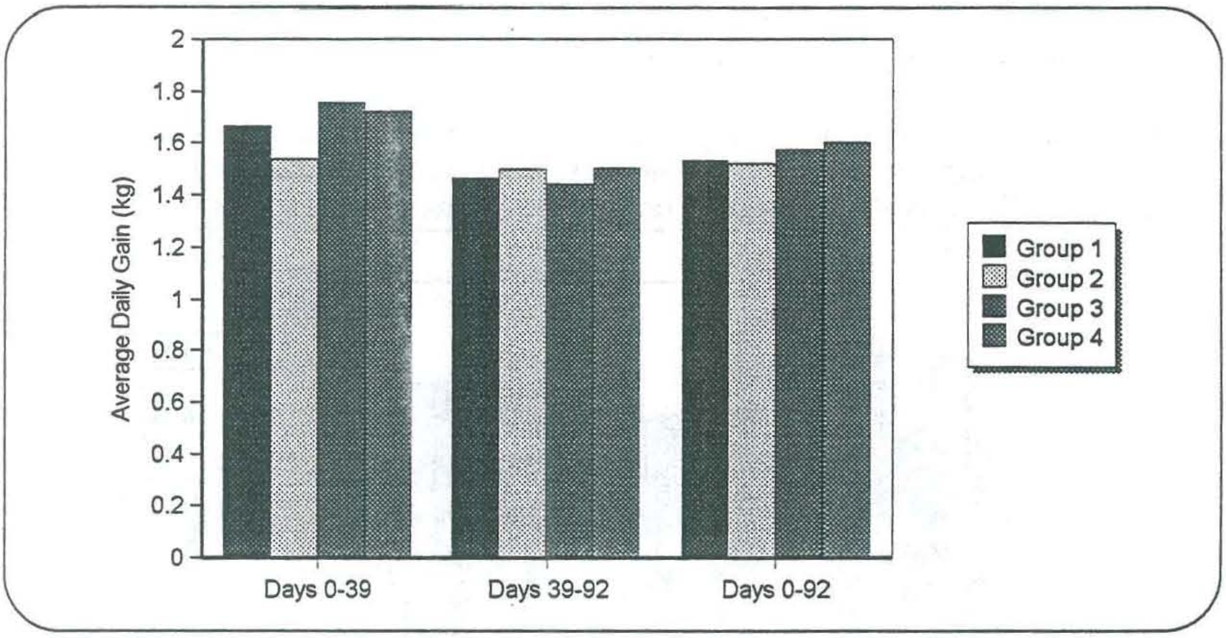


***Figure 5**: Average daily weight gains for the four treatment groups (corrected for source effect)*

As shown in Figure 6, the trained cattle had the highest weight gain to day 39. This was significantly different from the yard weaned group, but not significantly different from the paddock group.

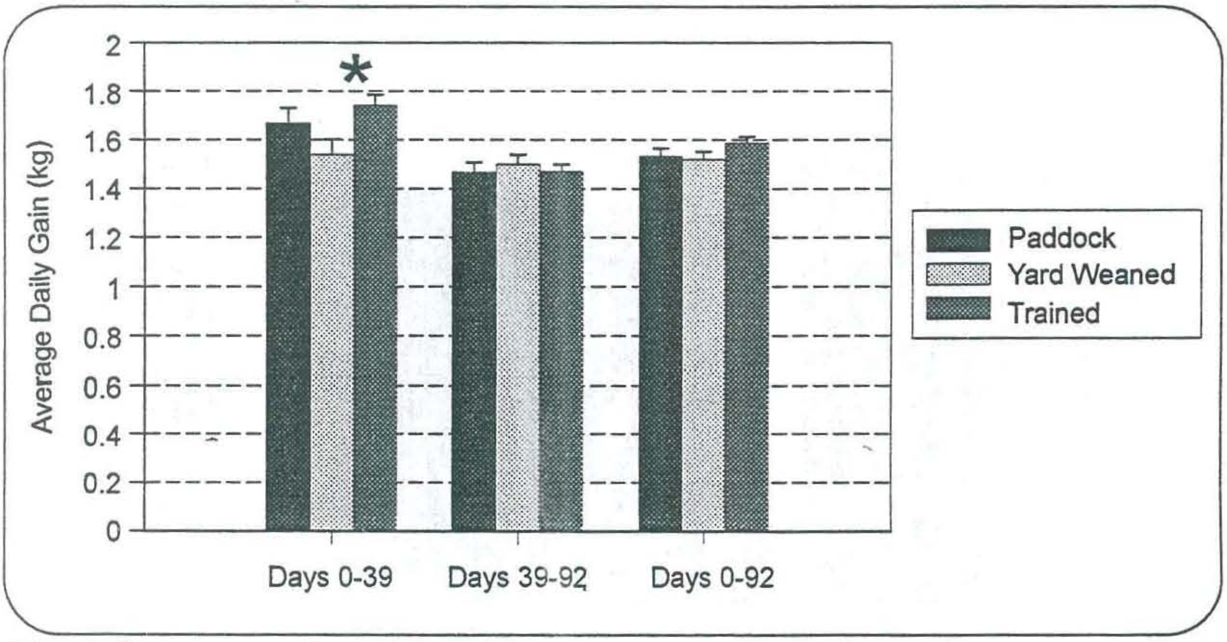


***Figure 6**: Average daily feedlot weight gains for paddock, yard weaned and trained animals (corrected for source effect)*

Figure 7 shows that the average daily gains for commercial-in-contact animals were the same as paddock animals and lower than the trained group up to day 39, but this difference was not significant unless the more advanced age and weight of the commercial animals is taken into account (i.e. gain as a percentage of induction weight was significantly higher for the trained cattle). Overall the commercial cattle, with hormonal growth promotants and reasonably good health (compared to Phase 1), grew significantly faster than the experimental groups which did not have growth promotant.

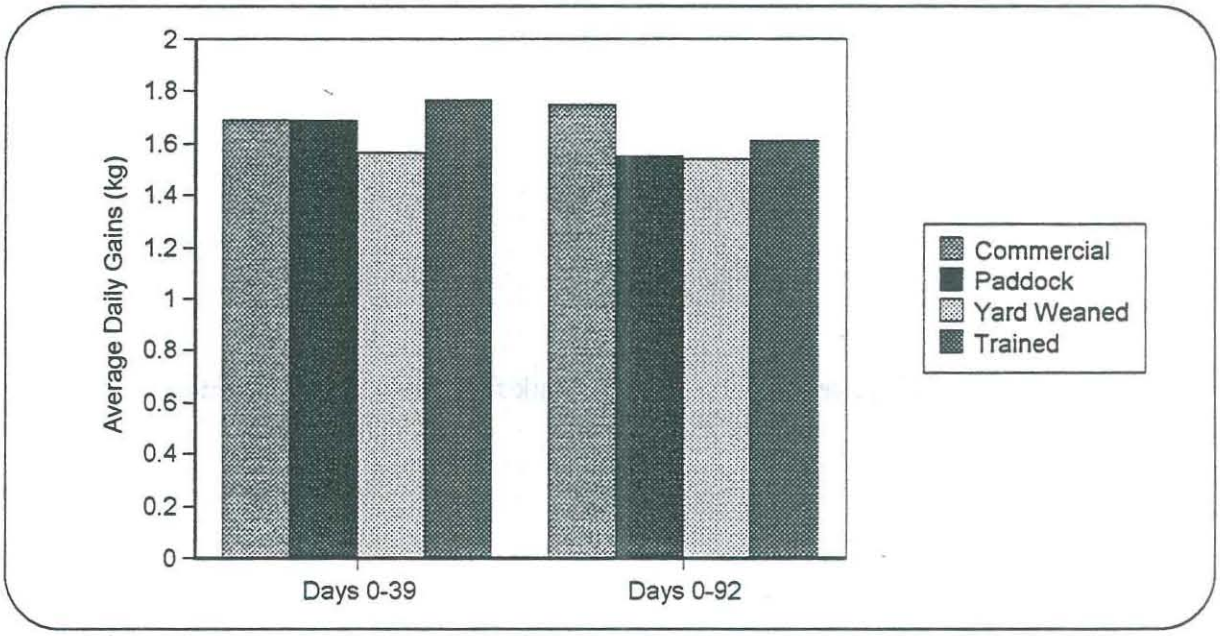


***Figure 7**: Average daily feedlot weight gains for the commercial and experimental (paddock, yard weaned, trained) cattle*

In summary these growth rate results were similar to Phase 1 in that there was some advantage of the treatments in terms of early weight gain, but these effects were not sustained over the entire feeding period. Whereas there had been a significant positive vaccine effect on overall weight gain in Phase 1 (i.e. the vaccinated cattle grew faster), this was not apparent in Phase 2.

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Health

There was a high mortality in experimental cattle in Phase 2, particularly when compared with Phase 1. Most of the mortality was due to the salvage slaughter of sick animals, that being the procedure which yielded the maximum amount of useful information about the cause and nature of the disease. The source of animals again proved to be a highly significant factor affecting the outcome.

The treatments under investigation in this project were designed principally to combat bovine respiratory disease (BRD) in the early feeding period. As it turned out the disease problems which occurred during the early feeding period in Phase 2 were not respiratory in nature. However, there was also an outbreak that was verified as BRD which occurred after 11 weeks on feed. This situation was quite different from Phase 1, but is certainly not unknown in commercial feedlot operation.

Mortality

Figure 1 shows the number of deaths (including salvage slaughter) and the week in which the deaths occurred. In the first 5 weeks on feed 6 animals died (3 experimental, 3 commercial) from gastro-intestinal related conditions, 4 being colonic perforation (3 experimental, 1 commercial). The cause of these problems has not been determined.

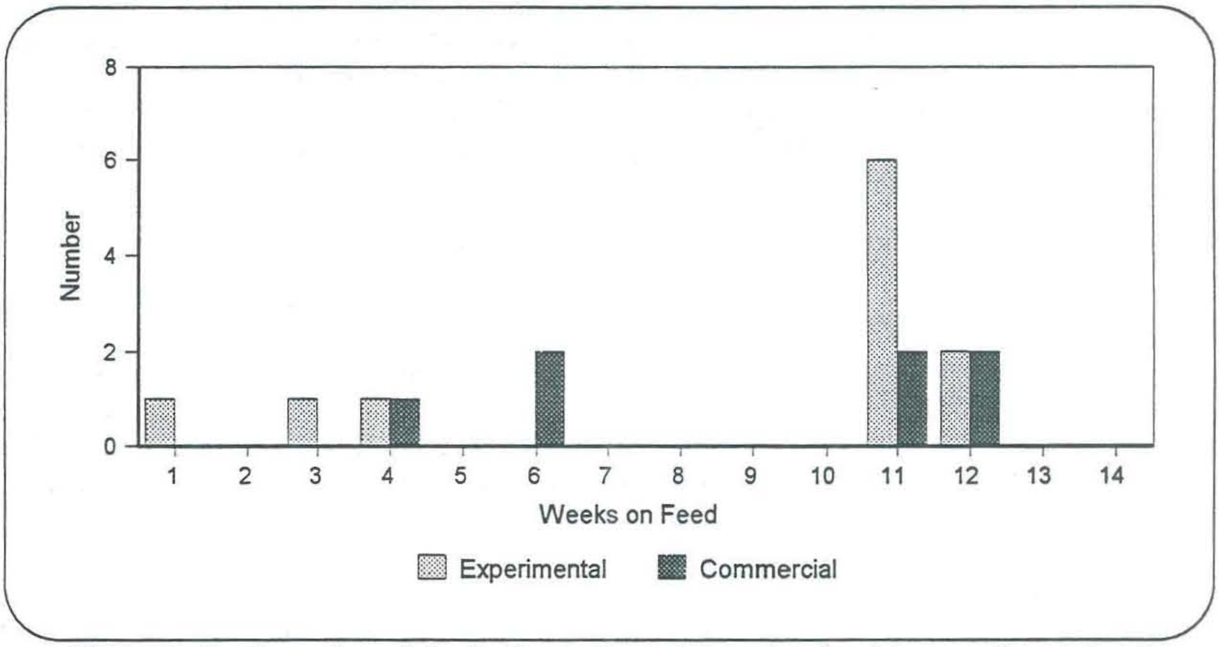


Figure 1: *Total number of deaths (including salvage slaughter) in experimental and commercial cattle each week*

Another 12 animals died (1 shot, 11 salvage slaughter) from respiratory disease during days 77-84 in the feedlot. This included 8 experimental and 4 comercial-in-contact cattle and was confirmed as IBR infection in 10 of the 12 animals.

Figure 2 on the next page shows the particular groups in which the deaths occurred each week. The deaths of experimental animals included 5 from vaccinated groups (all 5 sourced from Braidwood) and 3 from control (unvaccinated) groups (these 3 being sourced from EMAI) (see Figure 2).

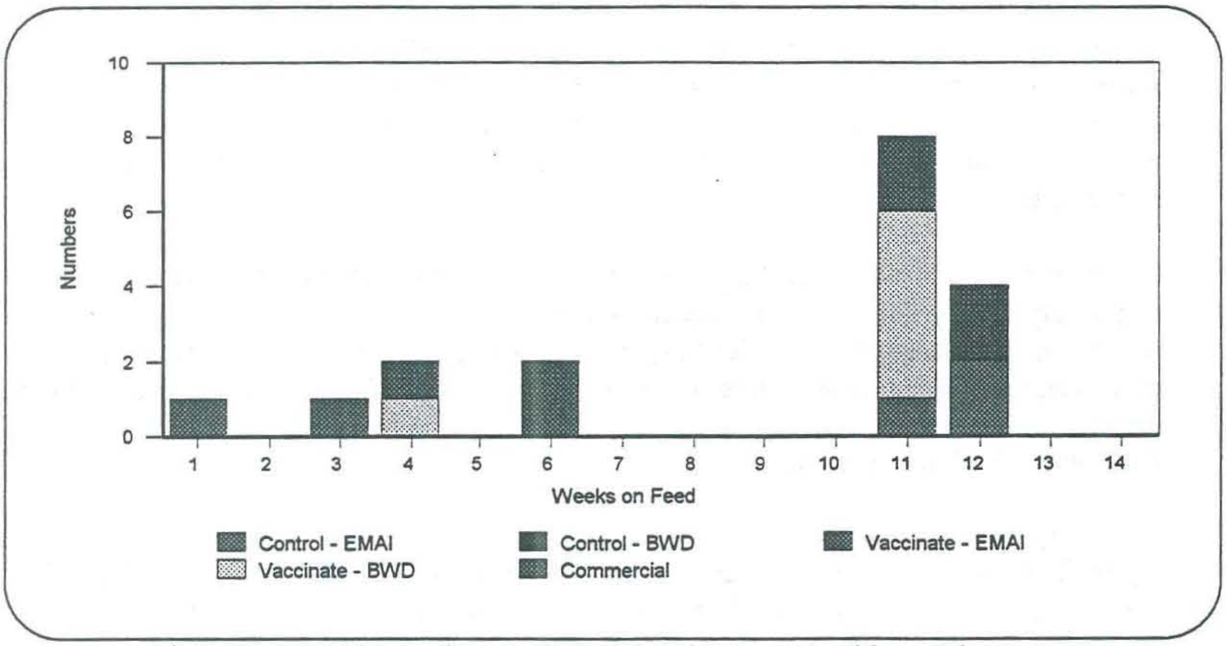


Figure 2: Weekly deaths or salvage slaughter arranged by cattle source

This indicates that, so far as respiratory disease was concerned, there was an absence of vaccine protection in those cattle which were sourced from Braidwood. The source effect (i.e. Braidwood deaths) was significant ($P<0.05$) when compared with deaths in the total cattle population (experimental plus commercial). The fact that vaccinated animals from the EMAI source did not die from respiratory disease suggested that there was either a vaccine or vaccine x source protective effect in that case.

This evidence that the protective effect of the vaccines could be dependent on the source of the cattle is an important result which needs to be considered carefully. One possible reason for such an effect is that the pre-weaning management of the Braidwood animals or their response to the weaning treatments in some way predisposed them to greater stress in the feedlot and this compromised the development of immunity following vaccination. Efficacy of vaccines is known to be affected by stress. This difference may well have a genetic basis. Further trials with vaccines against respiratory disease in feedlot cattle will need to address this issue.

Morbidity

The number of experimental and commercial cattle removed to the hospital pen each week is shown in Figure 3 on the next page. Pulls generally (i.e. total pulls for all reasons) tended to be concentrated in the first 3 weeks, particularly for the commercial cattle (11 experimental, 31 commercial) with another peak in weeks 11 and 12 due to the respiratory disease outbreak (8 experimental, 4 commercial) mostly for salvage slaughter at that stage.

The percentage of experimental and commercial animals which were pulled because of sickness, lameness or buller behaviour is summarised in Figure 4 on the next page. It is clear that morbidity in commercial cattle was at least twice that in experimental cattle in each category. This represents a better health picture for the commercial cattle than was the case in Phase 1, but a clear difference between the two is still apparent.

Amongst the treatment groups, differences in morbidity were not significant, but the paddock-weaned control animals had the highest rate (10.2%), the yard weaned cattle were the lowest (4.1%) and the trained yard-weaned groups were 7.8%.

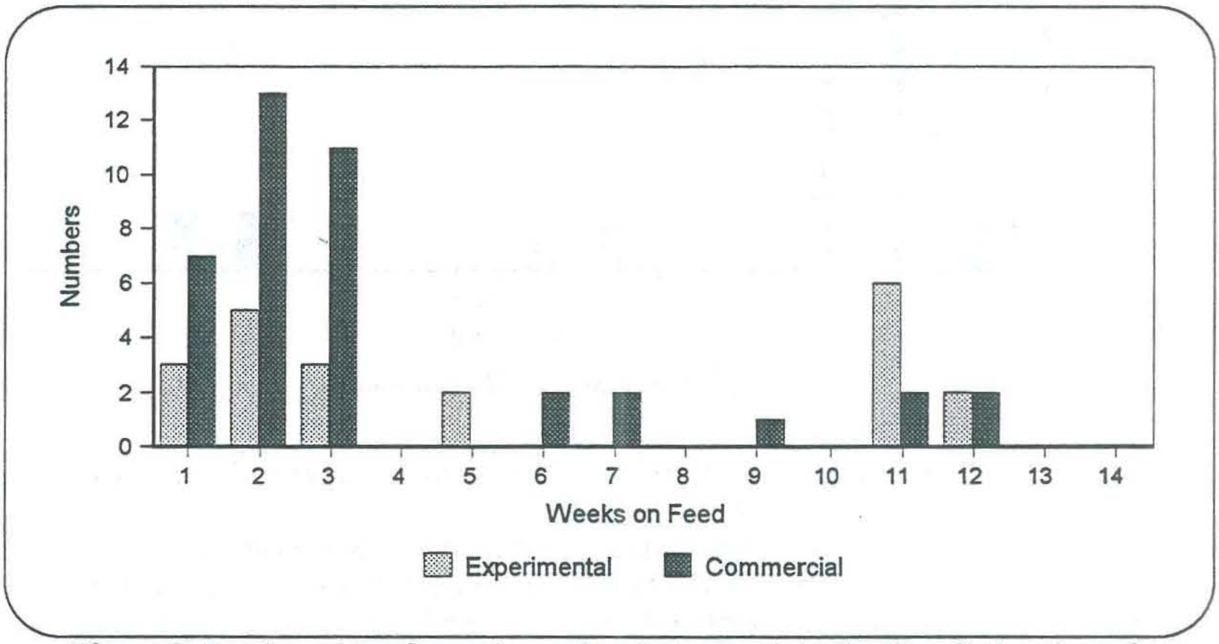


Figure 3: Total number of experimental and commercial animals pulled each week

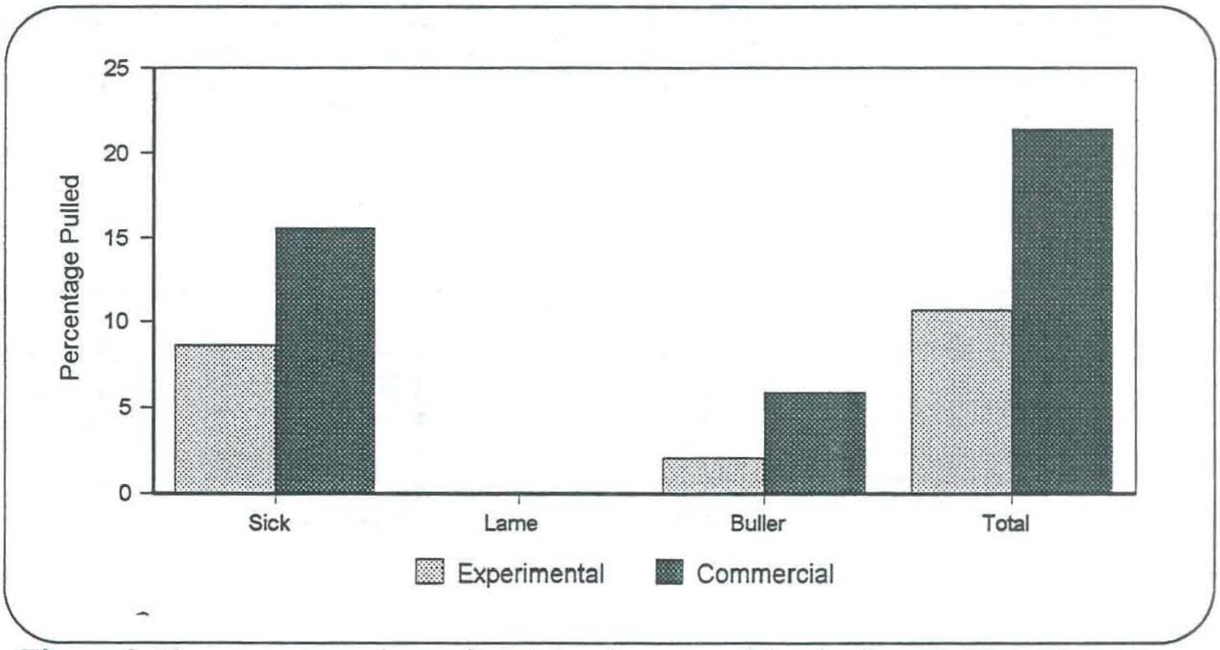


Figure 4: The percentage of experimental and commercial animals pulled in each category

The number of pulls which were classified as sick each week is shown in Figure 5 on the next page. This result further indicates that the morbidity was substantially lower in experimental cattle than in commercial cattle except for week 11 when most of the salvage slaughters occurred.

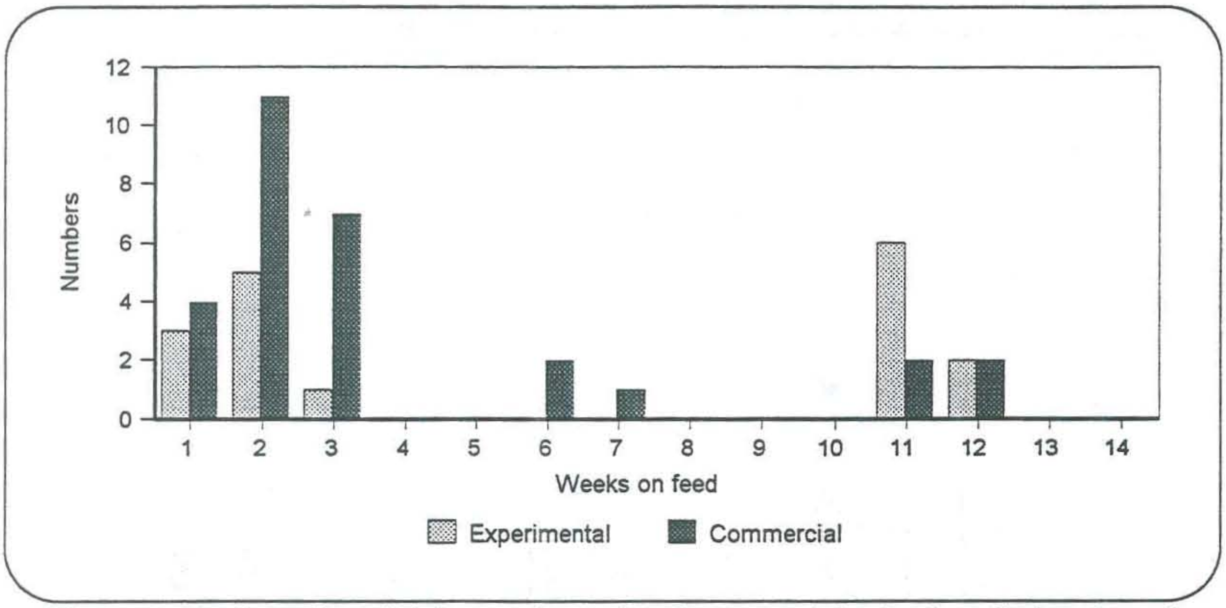


Figure 5: Total number of sick experimental and commercial animals pulled each week

It was clear in Phase 1 that morbidity adversely affected weight gain and this was investigated further in Phase 2. In the commercial cattle there was a significantly higher weight gain for healthy cattle compared to those which had been pulled. The same trend for experimental cattle (excluding gastro-intestinal related deaths) was not significant perhaps because of the superior adaptation and weight gain (to day 39) of these animals generally.

	Average Daily Gain Days 0-39		Average Daily Gain Days 39-92		Average Daily Gain Days 0-92	
EMAI						
Healthy	1.70		1.50		1.58	
Sick	1.58		1.47		1.45	
Buller	-		-		1.39	
Commercial						
Healthy	1.74	a	1.84	a	1.79	a
Sick	1.27	b	1.90	a	1.55	b
Buller	2.13	c	1.19	b	1.41	b

***Table 1:** Weight gains for healthy, sick and buller steers*

Serology

The seroconversion activity for Pestivirus, Parainfluenze (PI_3), and Bovine Respiratory Syncytial Virus (BRSV) at different stages from weaning through to slaughter is illustrated in Figures 6, 7 and 8 on the next page. It is clear that the seroconversion which occurred for Pestivirus, PI_3 and BRSV during Phase 2 was not closely related to disease events or pulls. This is in contrast to Phase 1 for Pestivirus and possibly BRSV where seroconversion during the first 38 days coincided with the major respiratory disease event.

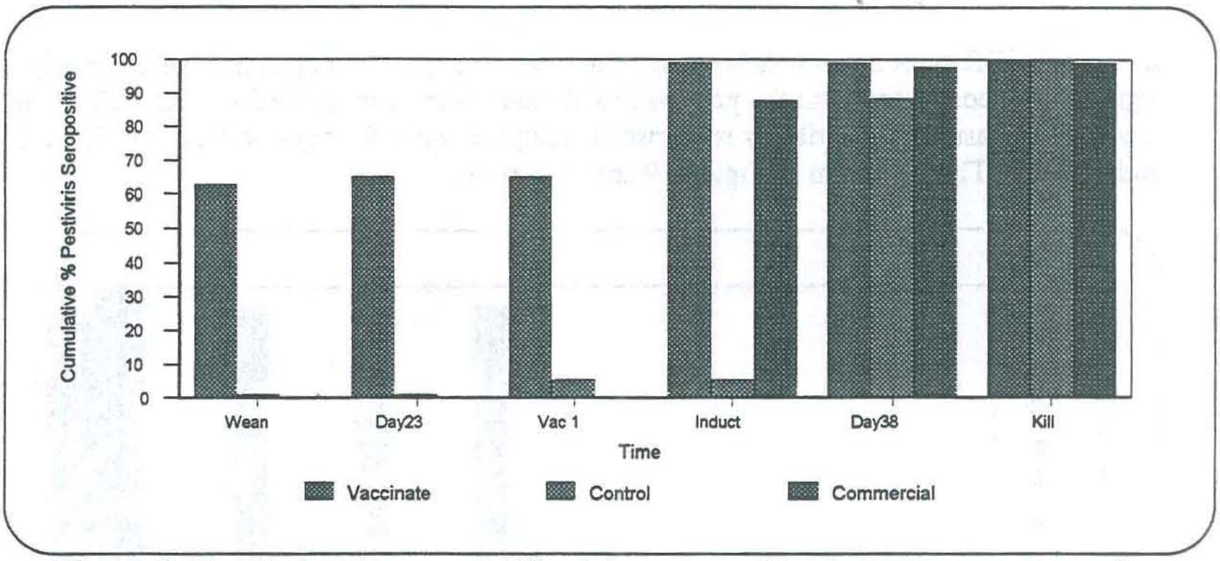


Figure 6: *Cumulative percentage of Pestivirus seropositive between groups over time*

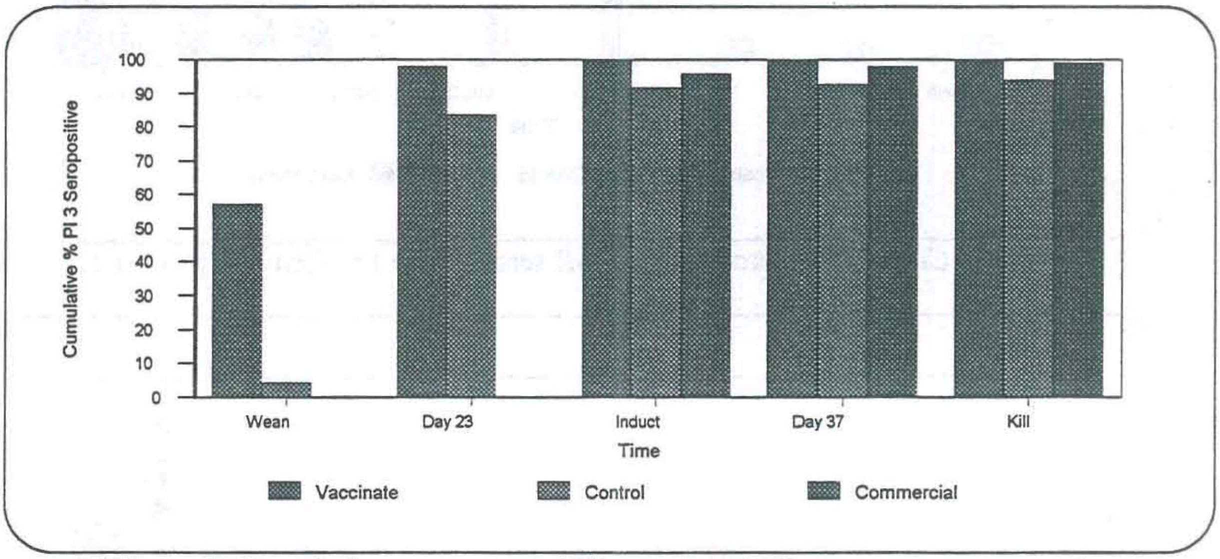


Figure 7: *Cumulative percentage of PI_3 seropositive between groups over time*

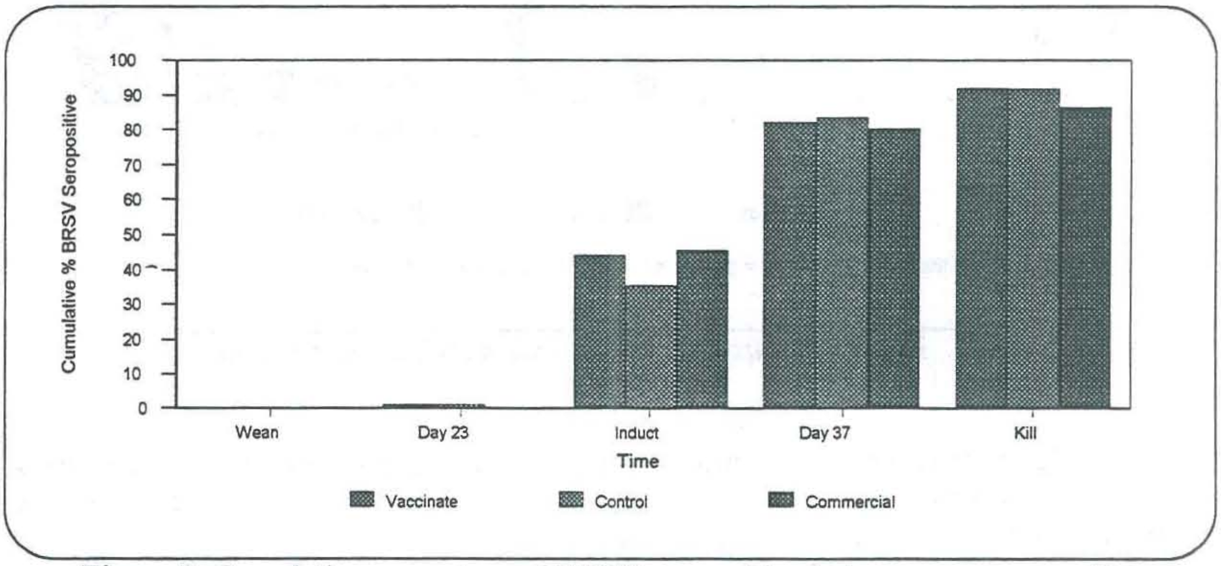


Figure 8: *Cumulative percentage of BRSV seropositive between groups over time*

In contrast IBR seroconversion (exposure) and titres (degree of exposure) were directly and significantly correlated with the proven IBR disease event during weeks 11 and 12 in the feedlot as measured by antibody response at slaughter (after 93 days on feed, i.e. 13 weeks and 2 days). This is shown in Figures 9 and 10 below.

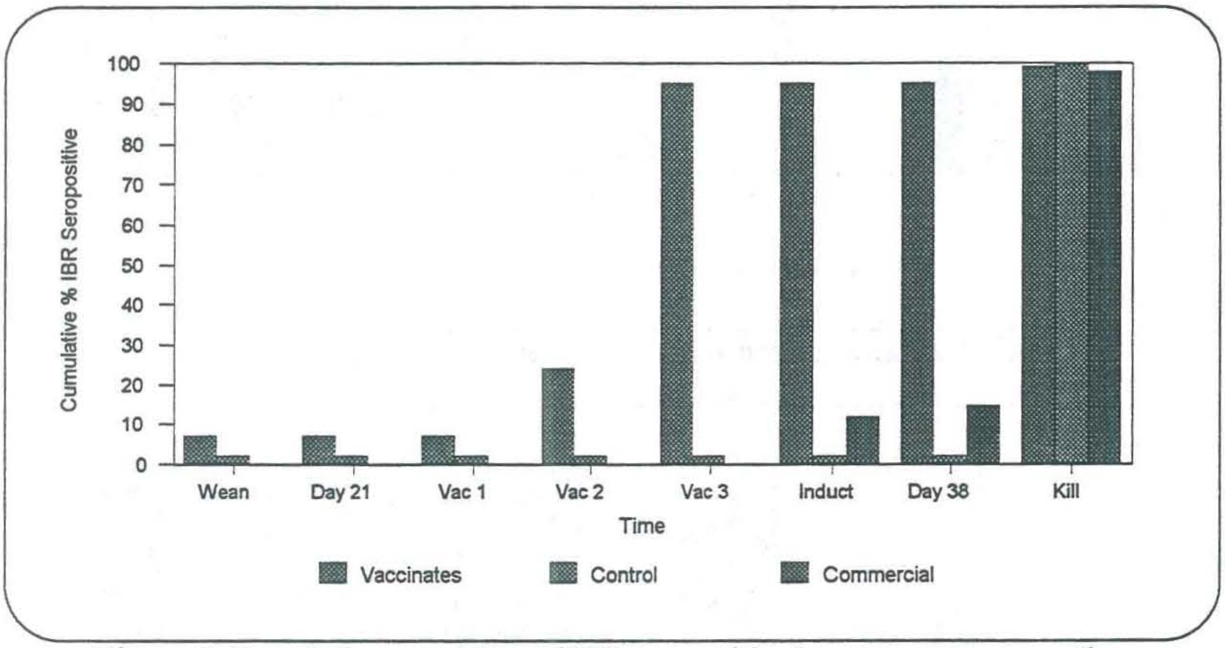


Figure 9: *Cumulative percentage of IBR seropositive between groups over time*

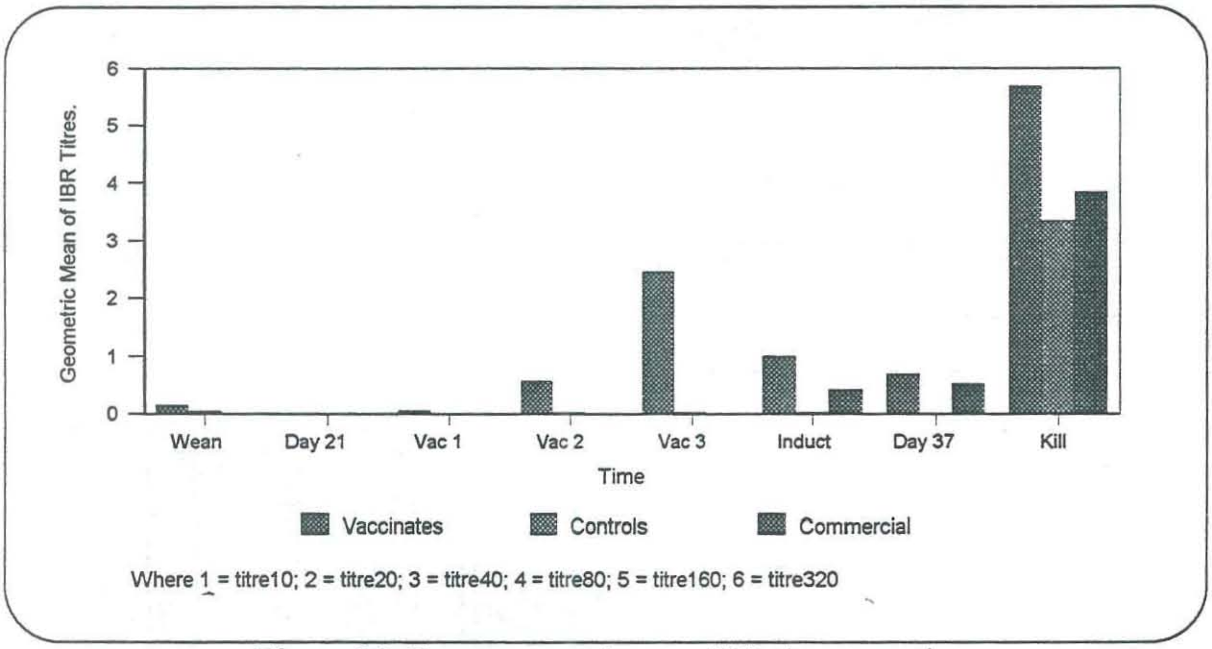


Figure 10: *Group geometric mean IBR titres over time*

Salmonella serology indicated significant S.typhimurium exposure after induction during the first 1-2 months on feed and S.dublin exposure on the EMAI property with further exposure after induction, e.g. from commercial cattle.

These patterns of disease can be compared with Phase 1 results, particularly the timing of BRD events, viz. <38 days in Phase 1 cf. 77-84 days in Phase 2. Earlier IBR seroconversion was evident in Phase 1 concurrent with the earlier BRD disease event. As previously described, the positive vaccine effect on weight gain that was demonstrated in Phase 1 was not seen in Phase 2. This may relate to the different timing (first 38 days) and nature (Pestiviris, IBR, BRSV and Pasteurella) of the Phase 1 disease challenge.

Post-Mortem Lesions

In Figures 11 and 12 the incidence of respiratory lesions detected at the abattoir is compared for Phases 1 and 2.

Abattoir lesion monitoring for Phase 1 in the organs of all animals at slaughter indicated a 51% prevalence of residual respiratory lesions some 60 days after the BRD episode in the commercial-in-contact cattle. Experimental cattle, in line with the vaccine protective effect, had only 18% prevalence of lesions. These findings were consistent with the overall severity of illness in the commercial cattle in Phase 1.

In contrast, Phase 2 slaughter lesion evaluation indicated a uniformly high prevalence of minor respiratory lesions (Grade 1 and/or 2) from all groups of animals (experimental and commercial-in-contact). This is consistent with the respiratory disease episode which occurred late in the feeding period (within 12 days of slaughter).

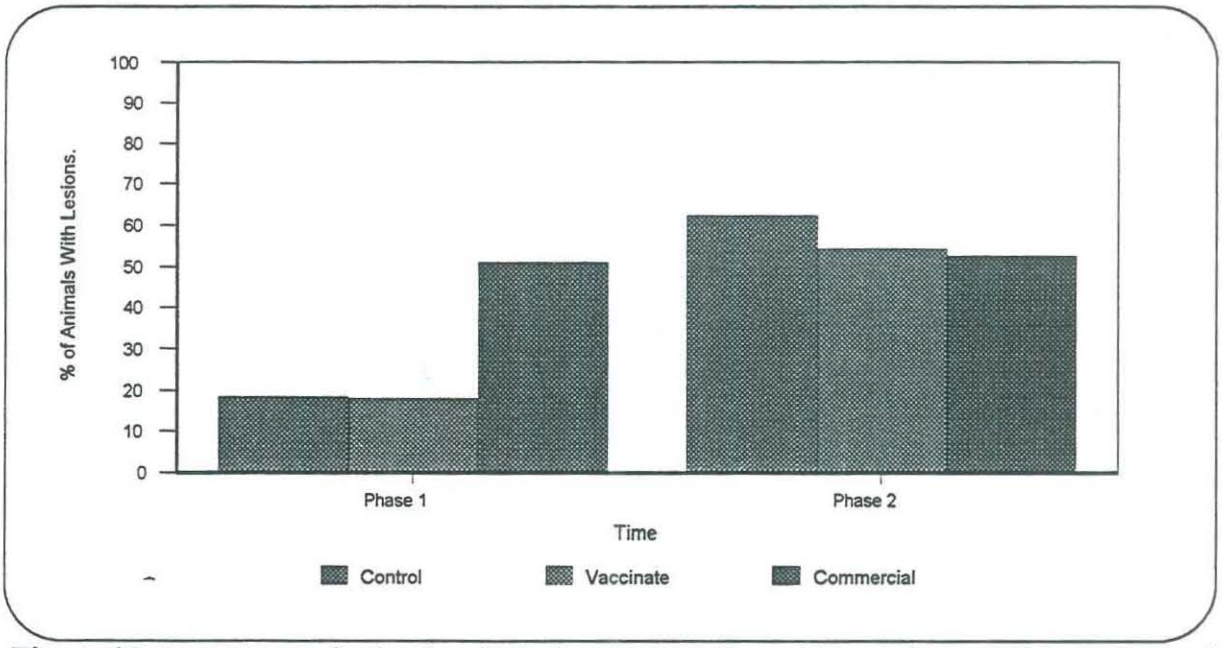


Figure 11: Percentage of animals with lesions at slaughter within each group for phase 1 and phase 2.

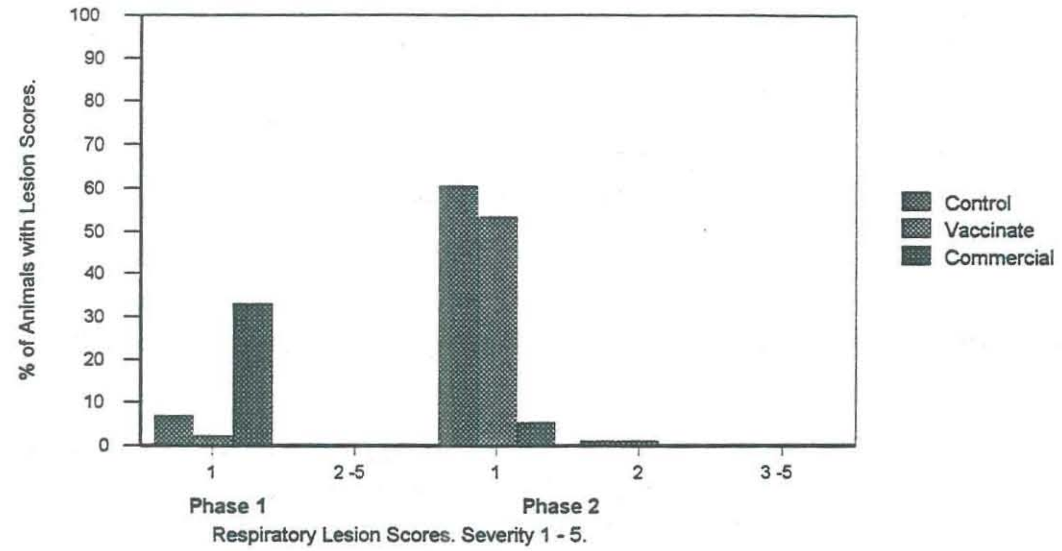


Figure 12: Percentage of animals with respiratory lesions scored at slaughter within each group for phase 1 and phase 2 (incomplete data due to delayed slaughter)

Feeding Behaviour

In Phase 1 the evidence that training had a positive effect on feeding behaviour in the early adaptation period in the feedlot was fragmentary, but Phase 2 has provided clear and unequivocal evidence about this effect. Phase 2 has yielded the most complete set of data on feeding behaviour of feedlot cattle ever recorded. The feedbunk was scanned every 10 minutes for 24 hours per day for the first 10 days of feeding to determine the number of animals from each of the treatment groups. Individual animals were identified for every scan during daylight hours (0630 - 2000 h) for the first 5 days.

The plots of feeding activity for each treatment group which are summarised below in Figure 8 show a distinct diurnal rhythm with a biphasic peak which corresponds with the feed delivery. This pattern appears to be established a little earlier in the trained and yard weaned groups than in the paddock group and was quite different in the commercial group which had to be given hay to get the animals to the feed bunk over the first few days.

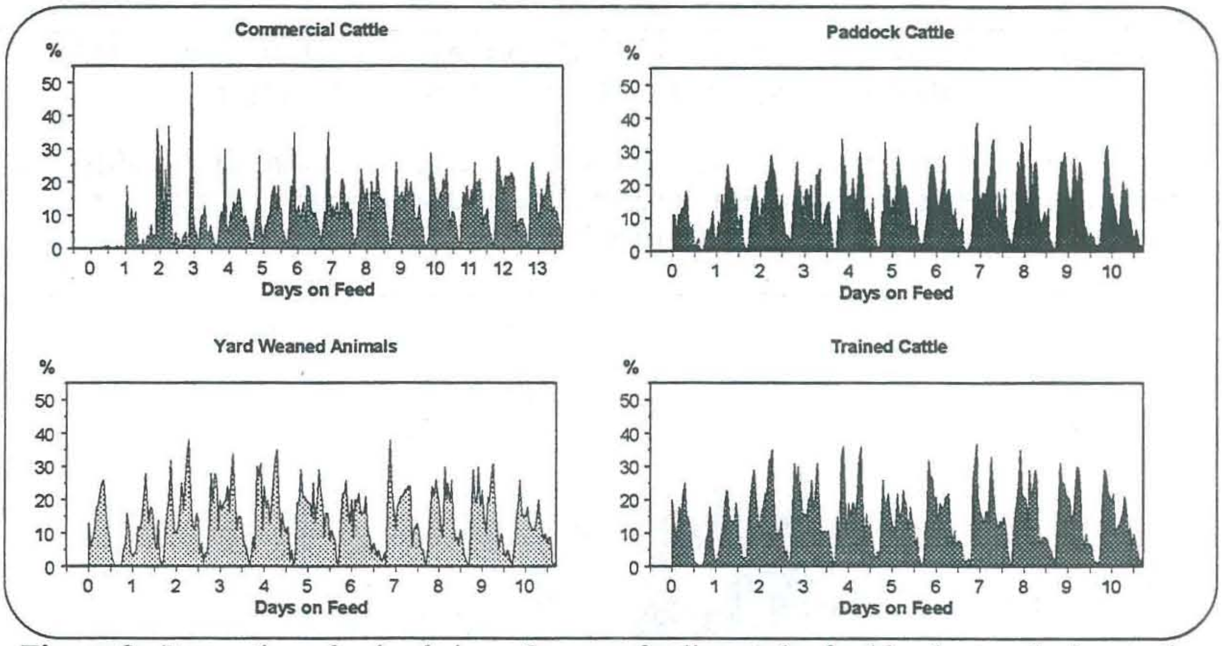


Figure 8: Proportion of animals in each group feeding at the feed bunk at each observation (scan)

The average daily proportion of animals at the feedbunk at one scan (mean of 144 scans, day and night) showed clear differences between the commercial, paddock and treated groups in the first few days (see Figure 9 on the next page). This was most pronounced on the day of induction (day 0) when the number of commercial cattle which approached the feed bunk was virtually zero. Feeding activity of the commercial cattle showed a marked increase on the second day, but had not reached the levels of experimental cattle until day 8. Feeding activity of the paddock animals was considerably below the treated groups on the day of induction, but increased each day to reach the same level as their herd mates on day 4. The statistical significance of those differences cannot be determined because the groups were not replicated.

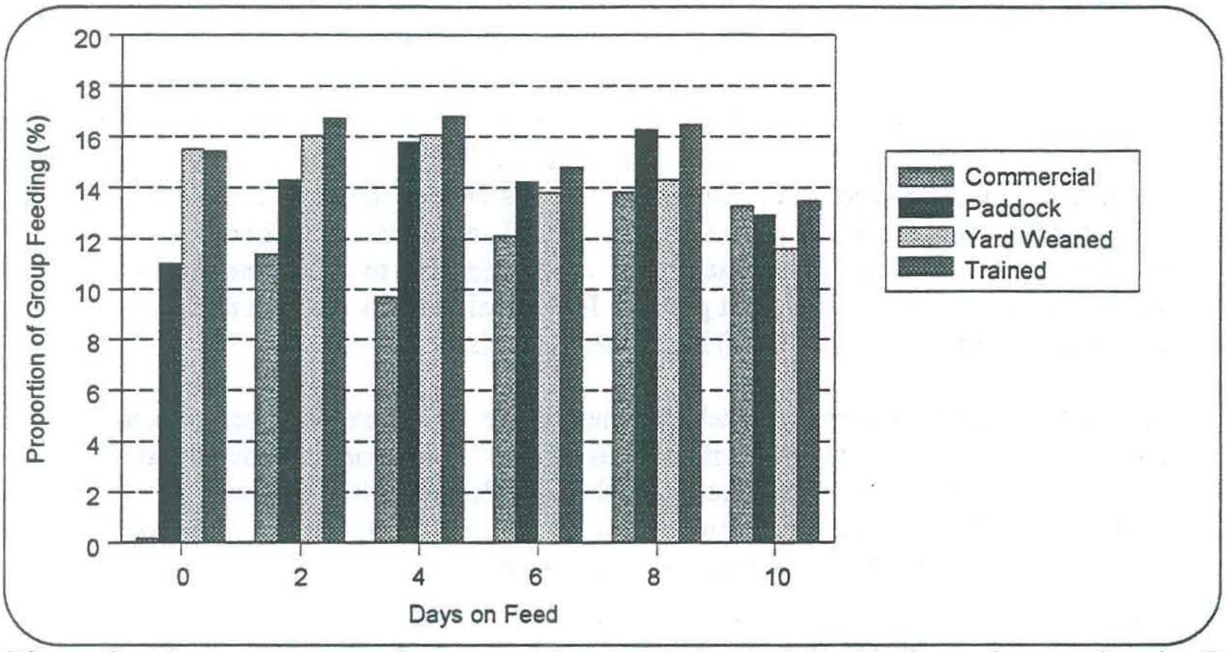


***Figure 9**: Mean proportion of commercial and experimental (paddock, yard weaned, trained) animals feeding at any particular scan, over a 24 hour period*

Individual animal data from the first 5 days showed that there was a significant difference between treated and paddock animals overall (Figure 10 below) and the treated animals had significantly higher feeding activity on days 0, 2 and 3 (Figure 11 over).

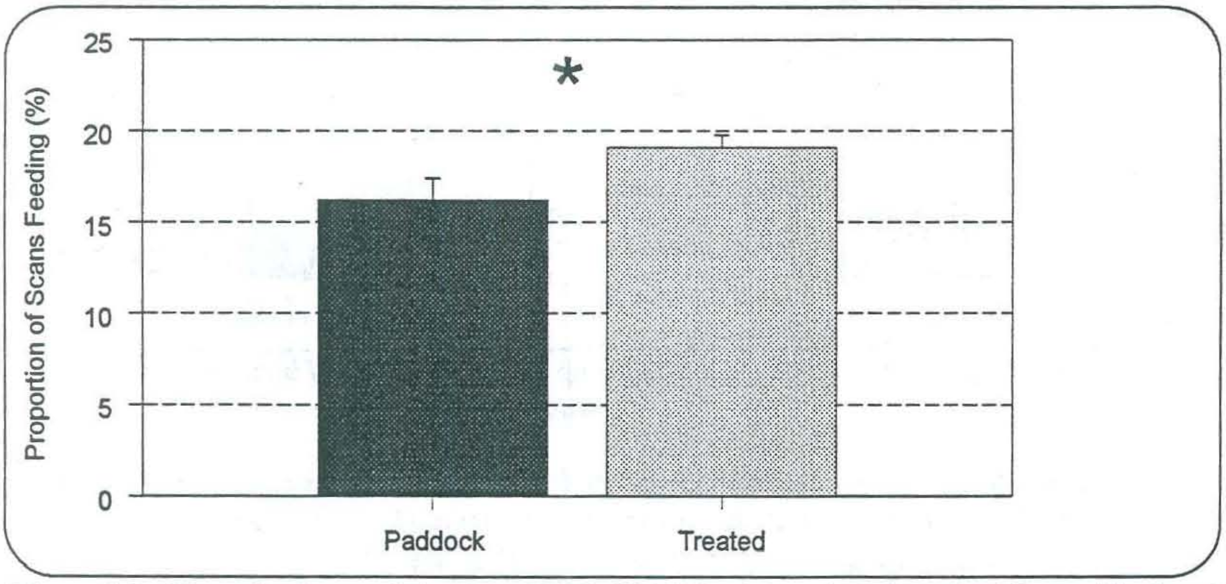


***Figure 10**: Mean feeding activity from 0630 till 2000 of days 0 to 4 on feed for paddock and treated cattle (corrected for source effect)*

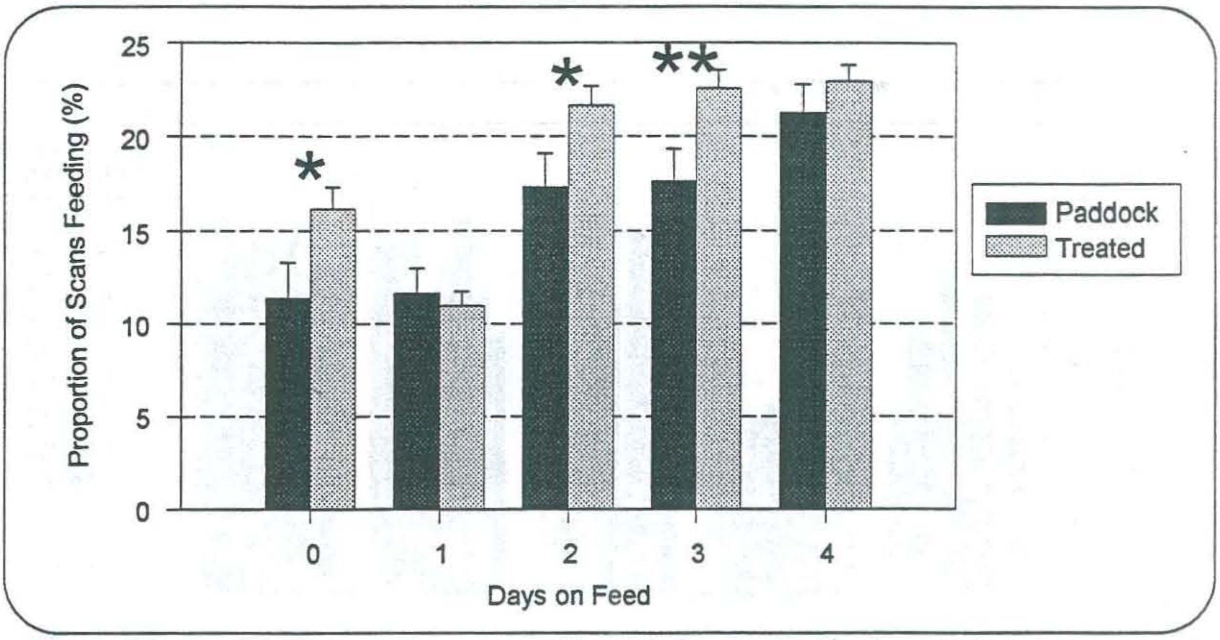


Figure 11: Feeding activity from 0630 till 2000, for paddock and treated cattle (corrected for source effect)

In Figure 12 below the main treatment groups can be compared. The trained animals (groups 3 and 4) had the highest feeding activity (days 0-4), but the yard weaned group (group 2) was only marginally lower and not significantly different.

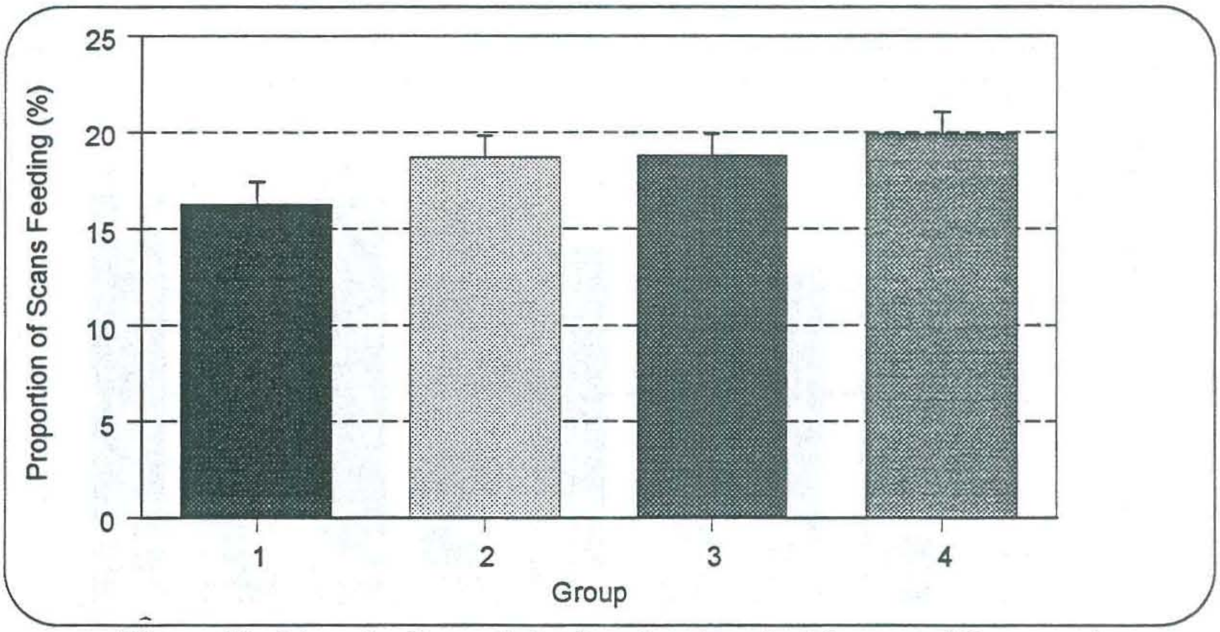


Figure 12: Mean feeding activity days 0 to 4 on feed (corrected for source)

All 8 treatment groups are compared in Figure 13 on the next page. On day 0 there appeared to be a vaccination effect in that all vaccinated groups had significantly lower feeding activity than their unvaccinated control group, but this was not seen on subsequent days. It should be noted that the effect of source of cattle was confounded with vaccination (see earlier) and that could be the reason for this difference. For mean feeding activity (days 0-4) there were no significant differences between the 8 treatment groups (see Figure 14 on the next page).

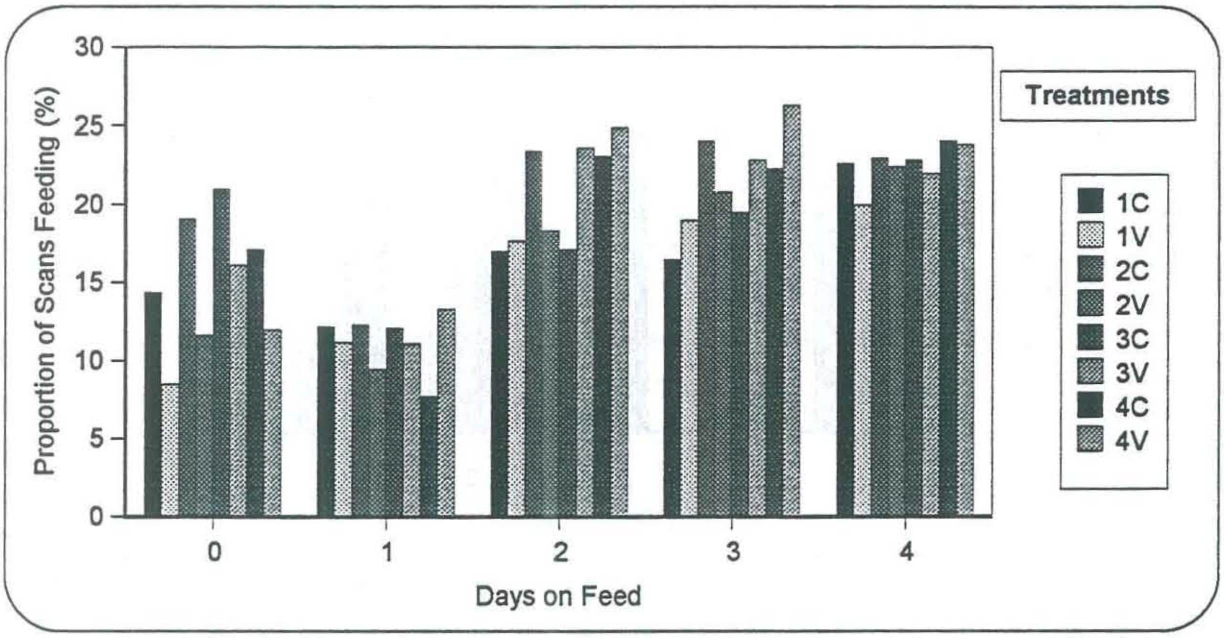


Figure 13: Feeding activity by experimental group (corrected for source effect)

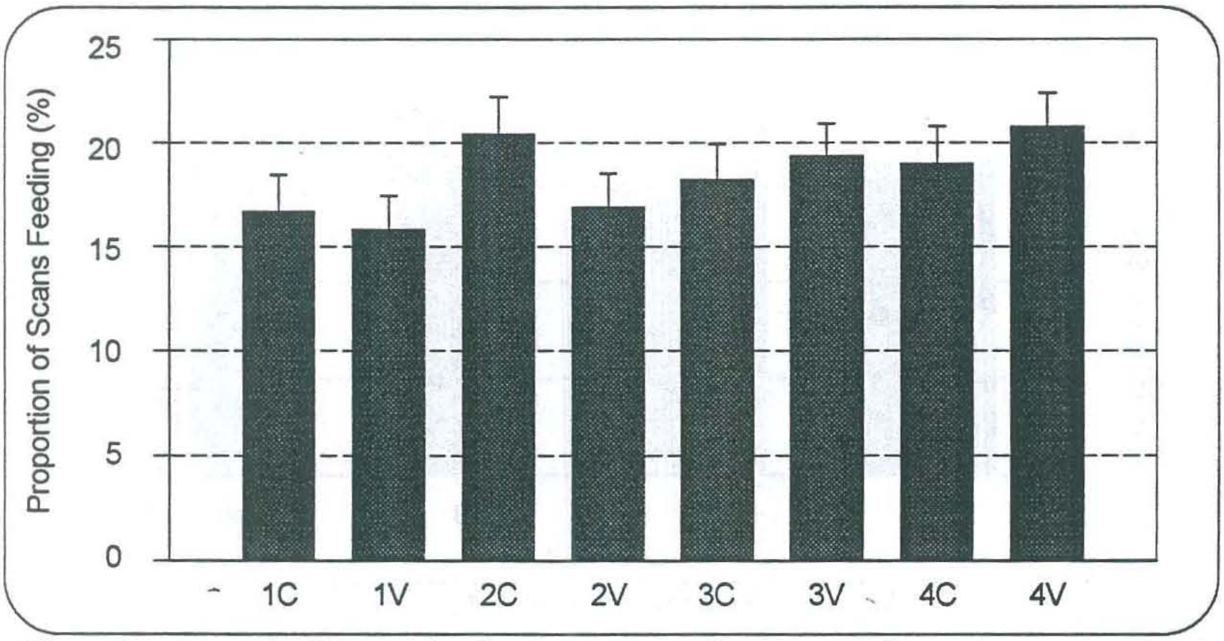


Figure 14: Mean feeding activity for days 0 to 4 on feed by experimental group (corrected for source)

Stress Response (Plasma Cortisol)

The data for Phase 2 are summarised below in Figure 15. There were no significant differences between treatment groups. The Braidwood cattle tended to show a greater drop after weaning than the EMAI cattle as was also the case in Phase 1.

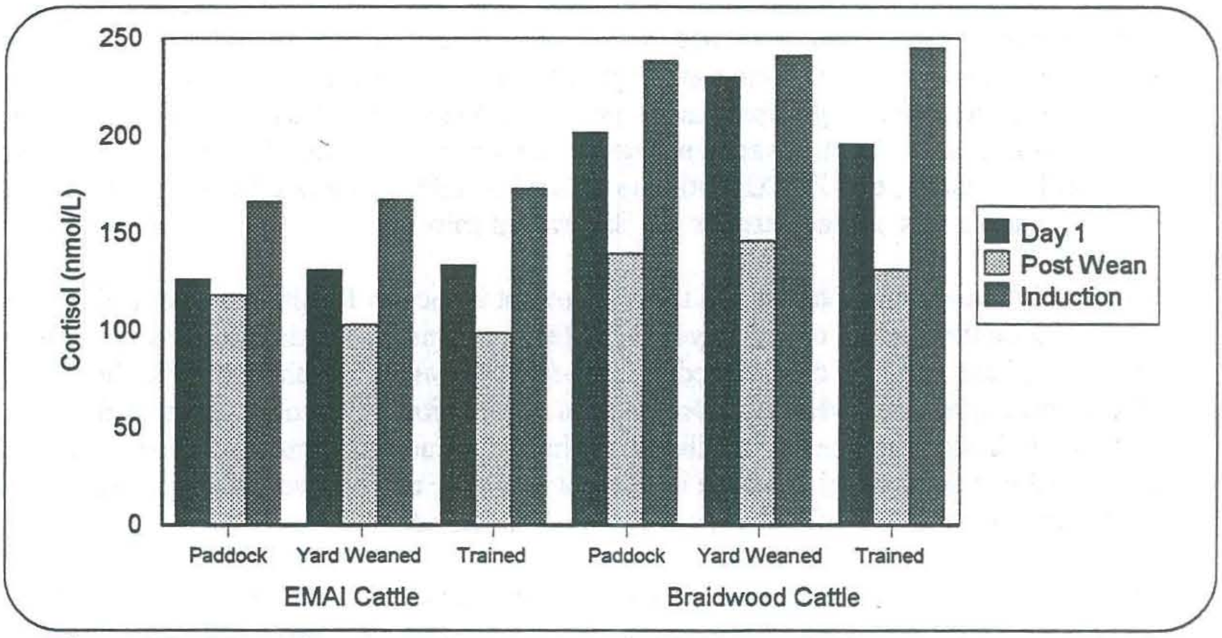


***Figure 15**: Mean plasma cortisol concentration before and after weaning and at feedlot induction for EMAI and Braidwood cattle in the paddock, yard-weaned and trained groups*

The comparison between Phase 1 and 2 is quite interesting in that the cortisol levels around weaning were much lower in phase 1 (see Figure 16 below) whereas the levels at induction were generally higher than in phase 2.

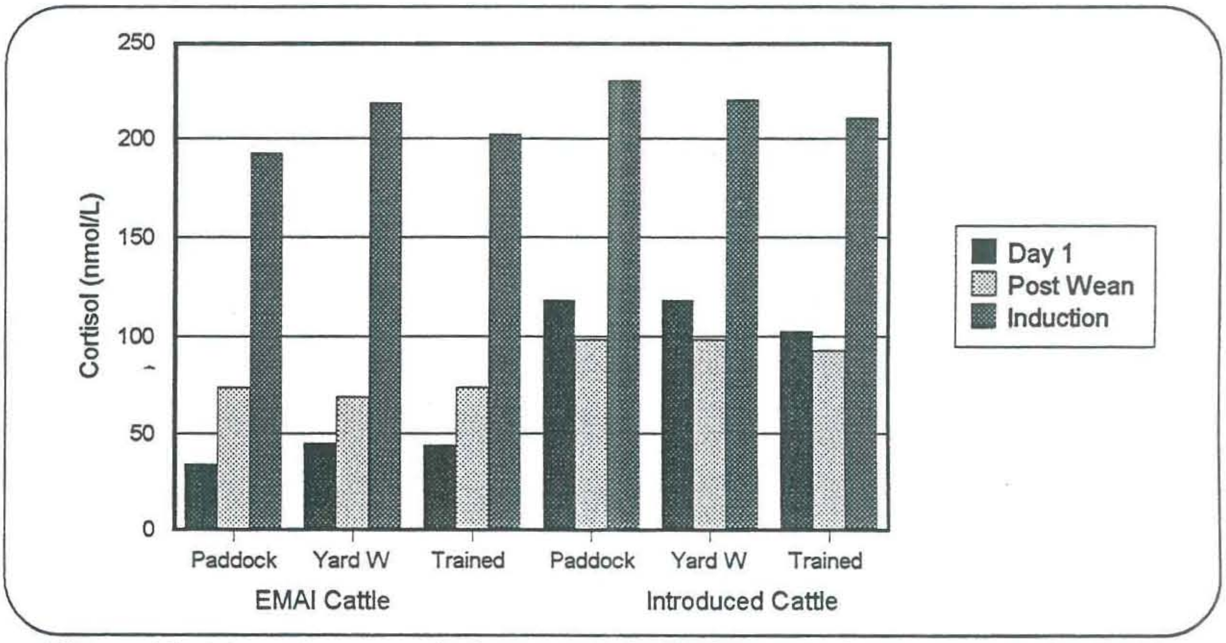


***Figure 16**: Mean plasma cortisol concentration before and after weaning and at feedlot induction for the paddock, yard-weaned and trained groups in phase 1*

The introduced animals in phase 1 were about 50% from the same Braidwood source as phase 2 and about 50% from another property.

In Phase 1 the average plasma cortisol was slightly increased between the start and end of weaning and greatly increased at feedlot induction. This was similar for all treatment groups (there was a significant source effect on the cortisol rise at induction).

In Phase 2 the initial values were much higher, there was a fall by the end of weaning (which tended to be more obvious in the trained groups) and there was still a rise at induction. The level at induction over all groups was not greatly different from Phase 1, but the change in cortisol from farm to feedlot was significantly less - it rose by only 25% compared to 190% in Phase 1. In the case of EMAI cattle the cortisol at induction was substantially less in phase 2, but this was not the case for the Braidwood animals.

This could have been due to the fact that the feedlot induction facilities and procedure were altered before the phase 2 cattle arrived. The feedlot managers made these changes after seeing the phase 1 data in order to reduce the level of stress to which cattle were being exposed during routine induction. Behavioural observation of all animals during the induction indicated that the new facilities had indeed reduced the amount of stress. We anticipated that the cortisol response in phase 2 would be much lower then in phase 1. This was the case for EMAI cattle, but not for those from Braidwood.

Considering this in relation to other behavioural, production and health data for Braidwood cattle, it would appear that those animals were inherently more stress susceptible throughout the trial. They had much higher levels before weaning. Comparing their levels at induction in phase 2 may not be a fair comparison with phase 1. The difference between farm and feedlot levels (see above) may be a clearer indication. This certainly supports the finding that the feedlot induction facilities have been improved and are now less stressful to the cattle. We will await phase 3 data with interest.

Confidence Testing at Weaning

As in Phase 1 the procedure for confidence testing and training was applied to groups 3 and 4 (98 animals) during yard weaning. In Phase 2 there were 8 animals that were classified as "shy" on the basis of these measurements. It is possible that this test could be used to cull animals that are unlikely to adapt to the feedlot so that they could be re-directed to a less intensive handling system which would suit them better. In this way the proportion of poor doers or problem animals in the feedlot might be significantly reduced with considerable economic benefit as these are the animals which contribute most to the costs of production.

The performance of shy animals has been compared with the performance of all other animals (confident animals) in Phase 2.

Figure 16 below shows that the shy animals in Phase 2 had significantly lower weight gains during weaning (day 1-23 after weaning), but were not different during the pasture phase (end of weaning to induction). Shy animals had a significantly lower weight gain in the feedlot over the feeding period (day 0-92).

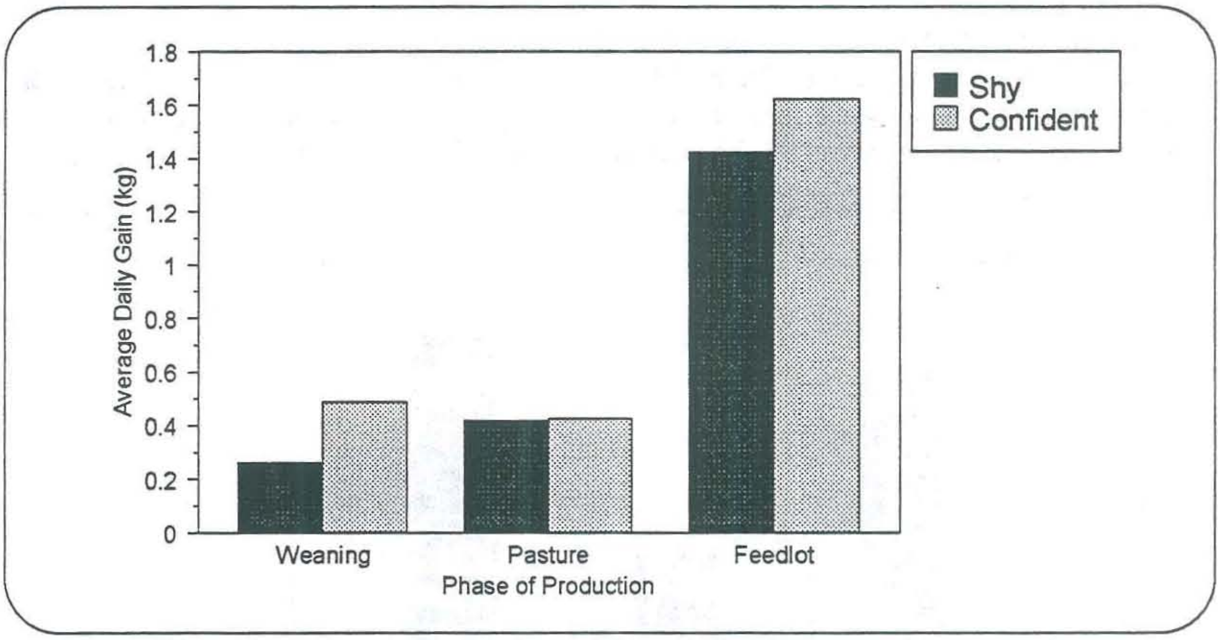


Figure 16: *Average daily liveweight gain for shy and confident cattle*

As would be expected, the shy animals also had significantly lower feeding activity during days 0-4 in the feedlot (see Figure 17 over the page).

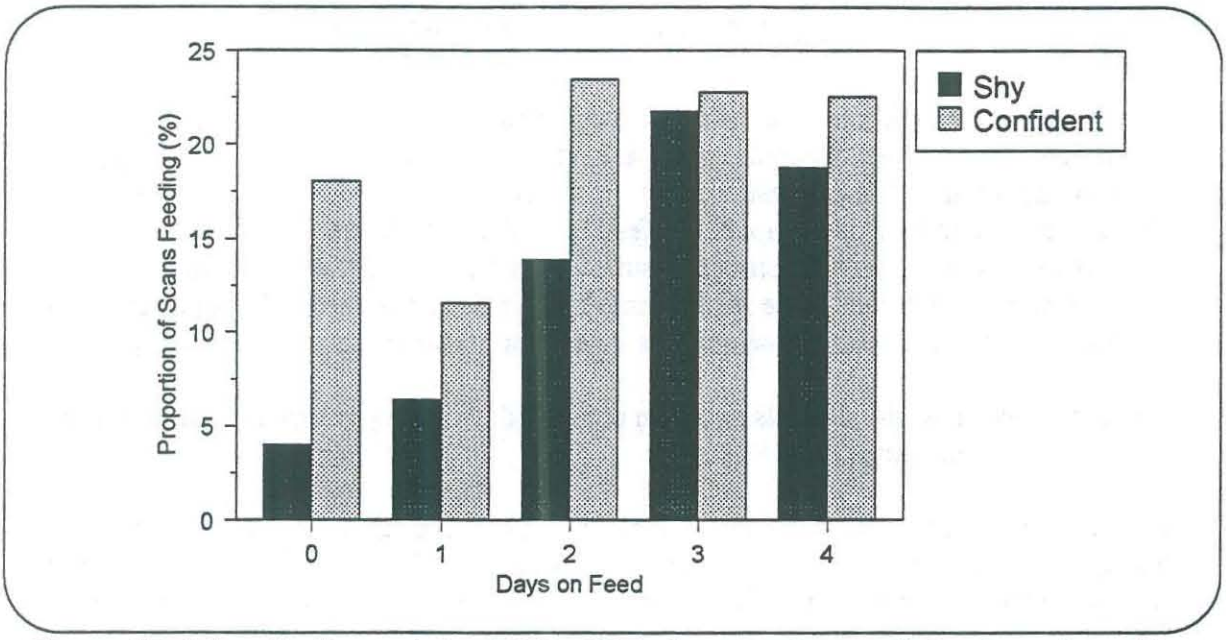


Figure 17: *Mean feeding activity, 0630 - 2000, days 0 to 4 on feed, for shy and confident cattle*

It is interesting that the shy animals had a significantly higher cortisol response at day 1 of weaning and at induction (see Figure 18 below). The difference was not significant at day 23 after weaning. This suggests that these animals may be more susceptible to handling stressors which could be part of the explanation for their worse performance in the feedlot.

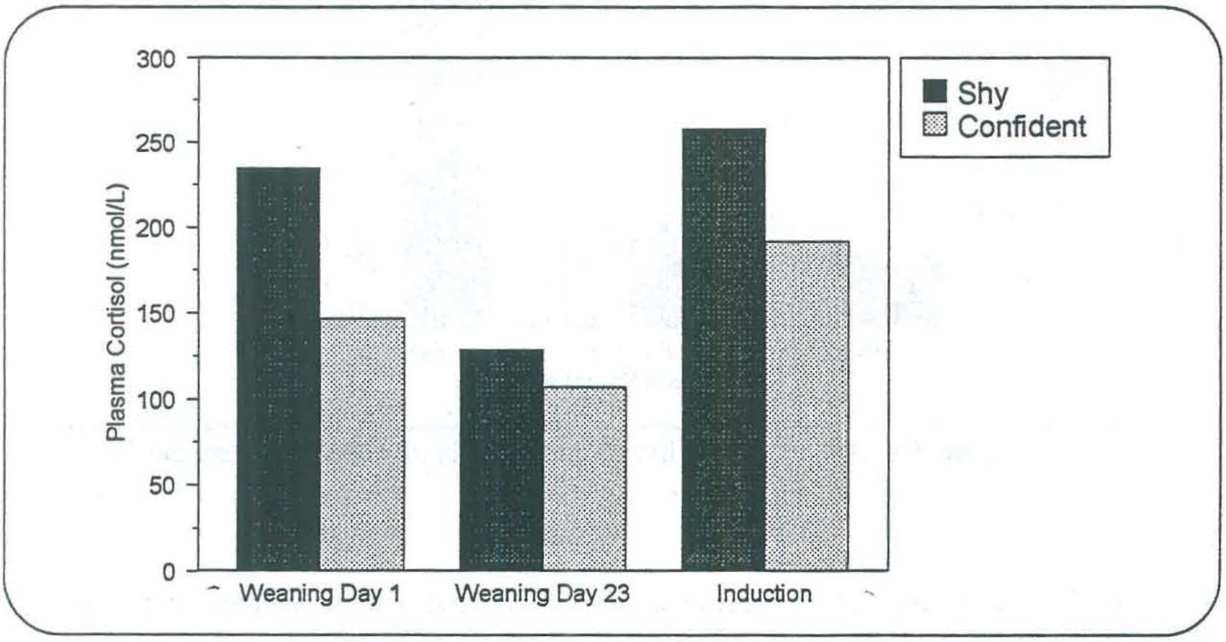


Figure 18: *Plasma cortisol levels for shy and confident animals*

Preliminary consideration of the ability of this test to predict feedlot performance has given promising results, but further work is needed to test this hypothesis thoroughly.

Economic Analysis

This economic analysis is more limited than that carried out for Phase 1, for two reasons. Firstly the feedlot finishing operation for the experimental cattle incurred a substantial loss this year for all groups due to higher grain prices and lower beef returns than in Phase 1. This situation was not unusual during the drought of 1994-95. Secondly the deaths due to the late disease outbreak would seriously distort the analysis if they were taken as being representative of larger groups of cattle.

Sufficient economic analysis is provided here to further compare the cost-effectiveness of different pre-boosting treatments. This must be considered in conjunction with the more detailed analysis in the Phase 1 report and the analyses which will be provided for the Phase 3 operation and for the Final Report which will provide an overview of the entire project. In the meantime conclusions about the individual pre-boosting treatments should not be based on the unsatisfactory economic outcomes which are detailed here.

The treatments were costed and assumptions were made in the same way as for Phase 1 except that hay was fed on 8 days instead of 10 days and the price of grain was $250/tonne compared to $230/tonne last year. Also the time spent on training was reduced from 1 hour per day to 45 minutes per day. Table 2 summarises the costs per head for each of the pre-boosting treatment groups.

Costs/hd for each Group	1C	1V	2C	2V	3C	3V	4C	4V
Vaccine		$9.48		$9.48		$9.48		$9.48
Feed hay			$6.00	$6.00	$6.00	$6.00	$6.00	$6.00
Feed grain					$3.00	$3.00	$3.00	$3.00
Sugar/Equistim							$6.78	$6.78
Training					$1.50	$1.50	$1.50	$1.50
TOTAL	$0.00	$9.48	$6.00	$15.48	$10.50	$19.98	$17.28	$26.76

Table 2: Costs per head for the pre-boosting treatment groups

The production and health data obtained during the feedlot finishing period is summarised in Table 3 using the same format and assumptions as for the Phase 1 report. Further detail about the basis for these assumptions was provided in the Phase 1 report. Note that the weight gain has not been calculated from the raw purchase and sale weights, but is actually the least squares mean from the statistical analysis in which the confounding source effect has been taken into account. This provides a more accurate comparison between the groups.

In this economic analysis the vaccine effect is considered separately from the effect of the four main treatments which constitute the weaning management aspects of pre-boosting, i.e. paddock weaning (group 1), yard weaning (group 2) and yard weaning with training (groups 3 and 4 - the latter group receiving Equistim as well) (see Table 2). The cattle deaths have not been included in the analysis of weaning treatments for the reasons given above. The vaccine

effect has been analysed for all animals and also for EMAI animals only because of the strong effect of source of cattle on the efficacy of the vaccine (see Health section). Thus, three separate analyses have been performed to compare:
(1) the cost effectiveness of the weaning treatments, per se,
(2) the cost effectiveness of the vaccine when the susceptible Braidwood animals are included,
(3) the cost effectiveness of the vaccine for EMAI animals only.

	Main Treatment Groups				All Animals		EMAI Animals only	
	1	2	3	4	Control	Vaccine	Control	Vaccine
Purchase weight (kg/hd)	316.41	312.53	307.67	313.36	314.32	310.62	314.49	290.23
Starter ration intake (kg/hd/day)	10.56	10.56	10.56	10.56	10.56	10.56	10.56	10.56
Time on starter ration (days)	40	40	40	40	40	40	40	40
Change over ration intake (kg/hd/day)	11.15	11.15	11.15	11.15	11.15	11.15	11.15	11.15
Time on change over ration (days)	14	14	14	14	14	14	14	14
Finisher ration intake (kg/hd/day)	10.52	10.52	10.52	10.52	10.52	10.52	10.52	10.52
Time on finisher ration (days)	38	38	38	38	38	38	38	38
Weight gain (kg/hd/day)	1.55	1.54	1.59	1.62	1.56	1.56	1.61	1.62
Proportion taken to sick pen (%)	10.2	4.1	7.8	7.8	5.2	12.0	4.2	3.0
Proportion dead or salvage slaughter (%)	Deaths excluded				3.1	5.0	3.1	0
Sale weight (kg/hd)	460.73	454.36	454.89	462.44	463.55	452.45	463.59	440.61

Table 3: Production and health data used in the economic analysis

The economic assumptions used in these analyses are summarised below in Table 4 in the same manner as for Phase 1. The ration costs are considerably higher in Phase 2 and the sale price is considerably lower than for Phase 1.

	All Groups							
Purchase price	$1.20/kg liveweight							
Starter ration cost	$195/tonne							
Change over ration cost	$244/tonne							
Finisher ration cost	$290/tonne							
Sick pen cost	$30/head							
Interest rate	10% per annum							
Sale cost	$5/head							
	Main Treatment Groups				All Animals		EMAI Animals only	
	1	2	3	4	Control	Vaccine	Control	Vaccine
Sale Price ($/kg lw)	1.18	1.17	1.17	1.17	1.18	1.17	1.18	1.16

***Table 4:** Economic (monetary) data used in the economic analysis*

Given the above animal and economic assumptions, the marginal returns (not allowing for overheads) for each group which is being considered in the analysis are presented in Table 5 on the next page.

	Main Treatment Groups				All Animals		EMAI Animals only	
	1	2	3	4	Control	Vaccine	Control	Vaccine
Purchase Cost	379.69	375.04	369.20	376.03	377.18	372.74	377.39	348.28
Starter ration	82.37	82.37	82.37	82.37	82.37	82.37	82.37	82.37
Change over ration	38.09	38.09	38.09	38.09	38.09	38.09	38.09	38.09
Finisher ration	115.93	115.93	115.93	115.93	115.93	115.93	115.93	115.93
Sick pen cost	3.06	1.23	2.34	2.34	1.56	3.60	1.26	0.90
Interest cost	15.61	15.44	15.32	15.53	15.50	15.44	15.50	14.76
Death Cost	Deaths excluded				19.07	30.76	19.07	0.00
TOTAL COST	635	628	623	630	650	659	650	600
SALE VALUE	539	527	527	536	542	524	542	506
Gross Margin	-96	-101	-96	-94	-108	-135	-108	-94
Gross margin compared to control		-5	0	2		-27		14

***Table 5:** Variable Costs and Returns to the feedlotter ($/head)*

The gross margins per head were very different from those achieved in Phase 1, being losses of approximately $100 compared to profits of more than $100 in Phase 1. This was due not only to greatly increased feed costs, but also to the poor return for the cattle at the end of the feeding period (about $1.17 compared to $1.42 in Phase 1).

It is clear from the main weaning comparison that the pre-boosting treatments had no beneficial effect on gross margin, in fact the simplest yard weaning treatment had a lower gross margin than the paddock weaning control. The pre-boosted cattle had somewhat higher weight gains than the controls, but their sale price per kg was slightly lower. This is in sharp contrast to Phase 1 where all pre-boosting treatments provided a higher gross margin to the feedlot than either the appropriate control group or the commercial cattle.

The apparent adverse effect of vaccination when all animals are included has been discussed in detail earlier in this report. It translates into a substantial reduction in gross margin as would be expected. However, this effect should not be attributed to the vaccines because of the confounding effect of the source of cattle as discussed earlier.

In EMAI cattle the vaccination treatment returned an extra $14 per head in gross margin which is considerably more than the cost of the vaccines themselves ($9.48 per head). This was mainly due to the cost of the deaths of unvaccinated cattle and also to their higher morbidity. The question of vaccine efficacy over a range of cattle types will require much more investigation in the future, but this result shows that an efficacious vaccine has the potential to be cost effective in this situation.

It should be noted that the Phase 2 study is only one part of a larger study which is not yet complete. These results should not be considered in isolation and should be amalgamated with the results of Phase 1 and Phase 3 before final conclusions are drawn. The overall economic analysis will be included in the Final Report which is due at the end of 1996.

Appendix 3

Progress Report on Completion of Phase 3, January 1997

Meat Research Corporation Project DAN.069

Reducing Feedlot Costs by Pre-Boosting: A Tool to Improve the Health and Adaptability of Feedlot Cattle

Progress Report on Completion of Phase 3

prepared by

Lloyd Fell, Keith Walker, Lesley Reddacliff and Heather Vallance

NSW Agriculture
Elizabeth Macarthur Agricultural Institute, Camden, NSW

Economic Analysis by Lloyd Davies

NSW Agriculture, Maitland, NSW

January, 1997

Table of Contents

The original copies of this report are printed in colour which simplifies the interpretation of the numerous bar charts it contains.

Summary of Phase 3

This was conducted in similar fashion to phases 1 and 2. A mixture of Angus/Hereford and Hereford weaners were divided between eight treatment groups (25 animals per group) which differed in various aspects of pre-feedlot management. Their subsequent health and performance during about 90 days on feed in a large commercial feedlot was determined. The experimental cattle came from two sources (EMAI and Braidwood) before weaning, but were divided equally amongst the treatment groups and then all experimental cattle were mixed with a similar group of commercial-in-contact cattle in one pen at the feedlot. The experimental herd consisted of a control group that was paddock-weaned (based on current industry practice) and five different levels of treatments known as pre-boosting which included vaccination against Pestivirus, IBR, PI_3 and Pasteurella around one month prior to feedlot entry, yard weaning with supplementary silage (yard-weaned); also additional handling and training to eat from a trough (yard-trained).

As was the case in phase 2, the commercial-in-contact cattle (155 head) were put into the feedlot pen three days earlier than the experimental cattle (209 head). The commercial cattle were slightly lighter than the experimental animals this year (265 cf. 290 kg).

All experimental groups adapted well to the feedlot, got onto feed quickly and showed reasonable growth rates throughout the feeding period. The yard-weaned and yard-trained cattle had significantly greater feeding activity than the paddock-weaned controls, at least during the first week in the pen, and they also had substantially higher average daily gains (28% higher up to day 78 in the feedlot). This effect was more clear-cut than in previous phases, probably because the paddock-weaned animals were not run together with the pre-boosted animals after weaning in phase 3 as they had been in phases 1 and 2. The weight gain of vaccinated animals was significantly higher than unvaccinated animals as it had been in phase 1 indicating a beneficial effect of the vaccination on subclinical disease. The commercial cattle got onto feed quicker than in previous years and had an excellent growth rate.

There was a low level of sickness in all groups and one experimental animal and one commercial animal died, but this was not shown to be due to respiratory disease. Morbidity was again lowest for yard-weaned animals as it had been in previous years. In phase 3, for the first time, the commercial cattle had lower morbidity that the experimental paddock-weaned group. This is consistent with the much better feeding behaviour and growth rate of commercial cattle this year.

The economic analysis showed that the yard weaning treatment or yard weaning plus vaccination gave the best improvement in gross margin and these treatments were clearly cost-effective. The additional expense of the yard training treatment was not cost-effective in this study, but this procedure has other potential benefits in that it permits the identification of problem animals that will be cost-burdens in the feedlot. This will be further analysed in the Final Report which combines the results from all three phases of the study.

METHODS and EXPERIMENTAL DESIGN

The experimental details were very similar to Phase 1 and Phase 2.

There were 209 calves (predominantly Hereford and Angus x Hereford) weaned at 7-8 months of age at EMAI (on 2/5/95) and allocated to 4 main experimental groups of 52 animals per group (see Figure 1 on page 8). The groups were matched for liveweight and source (property of origin). Later, each group was divided into vaccinated and non-vaccinated sub-groups so that there were 8 treatment groups in all (26 animals per treatment) as follows:

Group 1	1C	Control
	1V	Control, Vaccinated
Group 2	2C	Yard Weaned
	2V	Yard Weaned, Vaccinated
Group 3	3C	Yard Weaned/Trained
	3V	Yard Weaned/Trained, Vaccinated
Group 4	4C	Yard Weaned/Trained *
	4V	Yard Weaned/Trained, Vaccinated *

* The immunostimulation (Equistim) treatment was omitted this year because it had not given promising results and was too difficult to manage. Therefore Groups 3 and 4 were identical this year.

The cattle came from the same two sources as in Phase 2 - 99 from Braidwood Station and 110 from the EMAI herd. Unlike Phase 2, the majority of the Braidwood steers were found to be Pestivirus negative, but there were two undetected pre-weaning Pestivirus carriers in the herd. As in Phase 1 the two sources of cattle were divided equally amongst all groups so there was no confounding of the source effect as there had been in Phase 2. By the time of vaccination, however, the undetected Braidwood carrier animals had exposed most of the other animals (EMAI and Braidwood) to Pestivirus.

Weaning commenced on 2 May 1995. The treatments were as follows:
Group 1 (1C and 1V) - paddock weaned, no supplements, less handling than Phase 1 (through the crush 3 times between weaning and shipping to feedlot (4 times for V animals). A major difference this year was that Group 1 was kept entirely separate from all other groups from weaning through until they were trucked to the feedlot whereas all groups had been run together in previous years.
Group 2 (2C and 2V) - yard weaned for 10 days with silage, 1 round bale per day, no handling except for sampling on days 1 and 23 after separation from their mothers.
Groups 3 and 4 (3C, 3V, 4C and 4V) - yard weaned as above plus daily confidence testing/training as in Phase 1 for 45 min each morning on days 2 - 8 and day 18. The training

procedure involved access to a 40:60 lupins/oats ration supplied in feed bunks at a rate of 1kg/head/day.

The vaccination treatment utilised experimental vaccines against Pestivirus, Infectious Rhinotracheitis virus (IBR), Parainfluenza 3 virus (PI_3) and Pasteurellosis (P. haemolytica and P. multocida) given approximately 1 month before entry into the feedlot (nearer to induction this year. The vaccination program (groups 1V, 2V, 3V, 4V) was as follows:
Day -32 (from feedlot induction) - 2ml killed adjuvanted IBR vaccine and 1ml inactivated Pasteurella vaccine, subcutaneously (s.c.).
Day -13 - 2ml killed adjuvanted IBR vaccine and 1ml inactivated Pasteurella vaccine, s.c. and 2ml live unmodified Pestivirus and 2ml live PI_3, s.c.

The vaccinated and unvaccinated groups and the control groups (1V and 1C) were all run separately from day -13 until shipping. All animals also received appropriate 5-in-1 vaccination and drenching for internal parasites.

The experimental groups were run as two herds (Group 1 of 54 animals and Groups 2, 3 and 4 combined, 155 animals) on pasture at EMAI from day 23 after weaning until shipping to Caroona feedlot 6 months later at 14-17 months of age. There were 209 steers shipped and successfully inducted into the feedlot on 6 November 1995.

The 209 steers were fed in one pen of 4,350 m^2 together with 155 steers of similar age and weight purchased by the feedlot for the purpose of providing a realistic behavioural and infectious challenge for the experimental animals. The feedlot-owned cattle were designated as **commercial-in-contact** to distinguish them from the **experimental** (EMAI) group and, as in Phase 2, were introduced to the feedlot pen three days before the experimental cattle arrived instead of 3 days after the experimental cattle as had been the case in Phase 1. In total there were 363 animals in the pen, thus providing an average space allowance of 12 m^2/head with 66 m of feed bunk space.

Weather conditions were cool and wet for much of the early weeks in the feedlot. Daily rainfall recording ranged from 2mm to 37 mm. The pen surface was muddy during most of the intensive behaviour observation, but not unduly boggy.

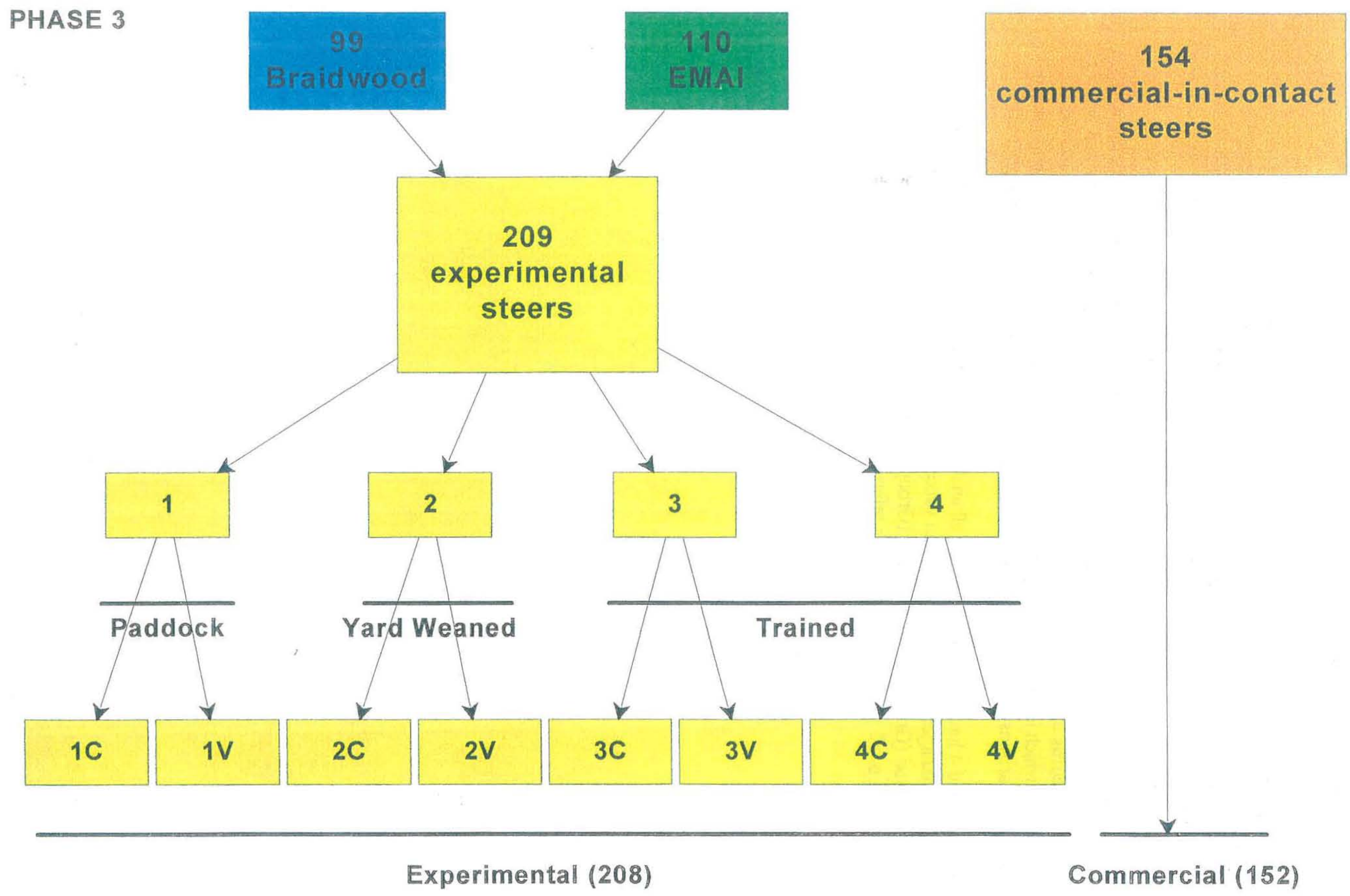
All animals were weighed at induction (day 0) and after 37 and 78 days on feed . The experimental cattle were slaughtered as follows: 70 head on day 85 at Tamworth, 80 head on day 95 at Aberdeen and 58 head on day 100 at Scone. Commercial-in-contact cattle were slaughtered at various times between 13/1/96 and 24/7/96, a total of 152 head. The results described here are mostly confined to the 78 days on feed between induction and the final weighing of all animals, but all health records were continued until the slaughter of the last experimental cattle after 100 days on feed

Serology was performed on blood samples collected from all cattle at induction, on day 37 and prior to slaughter (day 78 in the case of commercial-in-contact cattle) and also from any animals which were pulled because of apparent sickness. At slaughter all organs were examined for the presence of lesions.

Intensive behavioural observations and other measurements of stress were carried out from the afternoon of day 0 (induction) to the morning of day 18 (day -2 to day 15 for commercial animals. Continual (24 hour/day) surveillance was maintained at the feed bunk (with the aid of video recording). Agonistic and social behaviour and standing, lying etc. was also recorded at frequent intervals.

Other measurements of stress included plasma cortisol assays for each animal on 3 different occasions. This individual animal data can be compared with the detailed serology and with extensive records of the behavioural attributes of individual animals. The detailed individual animal data which is still being analysed will not be discussed here. This report is confined to group comparisons to determine the treatment effects, including their statistical significance.

Groups 3 and 4 have been combined for all analyses. The three groups thus formed for analysis of management effects other than vaccination were **Yard Trained** (Groups 3 and 4), **Yard Weaned** (Group 2) and **Paddock** (Group 1). For overall management effects the combination of all yard weaned groups is referred to as the **Treated** group.


PHASE 3
99
Braidwood
110
EMAI
154
commercial-in-contact
steers
209
experimental
steers
1
2
3
4
Paddock
Yard Weaned
Trained
1C
1V
2C
2V
3C
3V
4C
4V
Experimental (208)
Commercial (152)

RESULTS

The effect of the experimental treatments must be measured against the appropriate EMAI control group. The commercial in-contact cattle provided another comparison, but the purpose of that group was to create a realistic behavioural and infectious challenge for the experimental cattle and it is not an appropriate "control" because those cattle were managed differently in some respects, *i.e.* they received hormonal growth promotants which the experimental cattle did not and the worst performers could be culled from that group whereas all experimental animals had to be included in the final result. However, the feedlot-owned cattle serve as an example of one possible commercial situation and data from this group are also discussed in this report.

General

Prior to feedlot entry the growth of experimental cattle in phase 3 was similar to phases 1 and 2 (despite better pre-weaning growth of these calves), due to dry winter conditions at EMAI. It was decided to begin the feedlot stage some three months earlier than in previous years to try to avoid such heavy financial losses as were incurred in phase 2 due to spring/summer drought conditions. The average liveweight of experimental animals at weaning in May 1995 was 217 kg. From weaning to feedlot induction in November 1995 their growth rate at pasture was 0.4 kg/day which was the same as in phase 2.

The average liveweight at induction into the feedlot was 290 kg for the experimental cattle and 265 kg for the commercial-in-contact cattle. The commercial animals were sourced from six different local properties (within 100 km of the feedlot) and five of the six groups (87% of the animals) had been drought fed at some stage prior to feedlot entry. They included Hereford, Angus, Murray Grey and Shorthorn cattle and ranged in age from 5 - 12 months. Five of the groups had been weaned into small paddocks with some exposure to yards and only one group (Mob 5, 20/155 animals) was shipped straight to the feedlot after separation from their mothers. Full details of the pre-feedlot management of these six mobs are given in Table 2 on pages 13 and 14.

The general pattern of health and production in phase 3 was that both the experimental and commercial-in-contact cattle got onto feed quickly, in contrast to phases 1 and 2 when the commercial cattle had been much slower in this regard. All groups produced good weight gains, but the superiority of pre-boosted groups over the paddock-weaned controls was greater in phase 3 than in previous years making this the best result achieved since the trial began. Likely reasons for this are discussed later. There was very little respiratory disease in phase 3 for experimental or commercial-in-contact cattle. This was the best overall health result of the three phases also.

Weight Gain

The overall weight gain of experimental animals was similar to phase 2. The commercial-in-contact animals had appreciably higher gains than in previous phases presumably because these cattle were not unduly stressed by long transport and they had previous experience of drought feeding so that they got onto feed quickly (see later for details). It should also be noted that the commercial cattle received HGP treatment whereas the experimental animals did not.

The average weight gains for the main treatment groups during the early adaptation phase (see Figure 2) and over the full feeding period (see Figure 3) are shown below. Both the yard-weaned and yard-trained groups had significantly higher gains than the paddock-weaned control group, the yard-weaned cattle growing 26% faster initially and 28% faster over the 77 days on feed.

Figure 2. *Average daily weight gain (kg) of the main treatment groups and the commercial-in-contact cattle from induction to day 37 in the feedlot.*

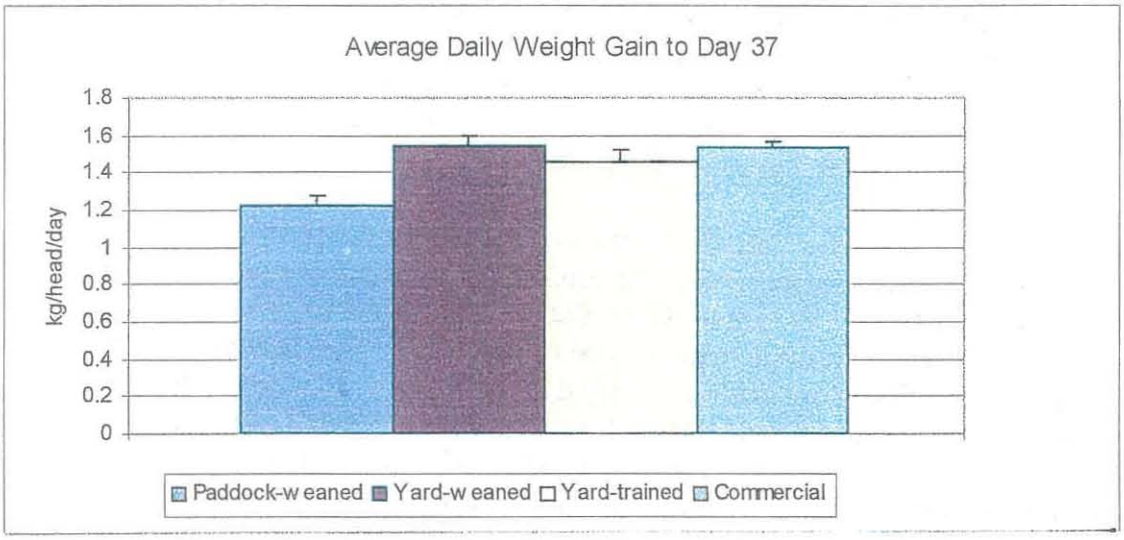
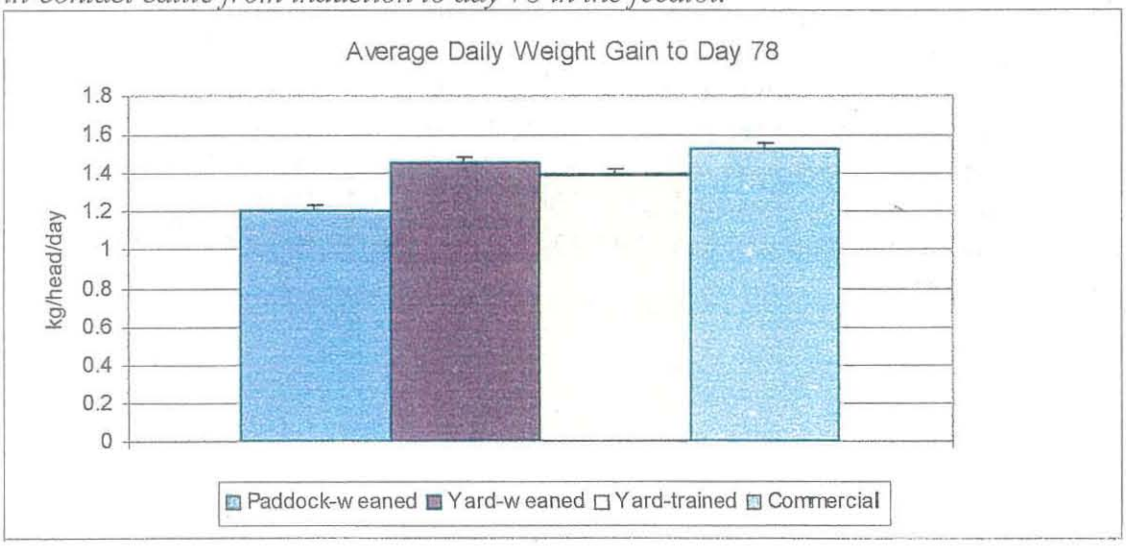


Figure 3. *Average daily weight gain (kg) of the main treatment groups and the commercial-in-contact cattle from induction to day 78 in the feedlot.*



This is the biggest weight gain difference found since we began this work and it suggests that we have refined or fine-tuned the pre-boosting treatments during the course of the research which was our original aim. Perhaps the major reason, however, for this more convincing result in phase 3 is the fact that the paddock-weaned cattle were not run together with the pre-boosted animals between weaning and feedlot entry some 6 months later. Therefore the effect of social facilitation of untreated animals by treated animals when the cattle arrived in the feedlot was probably somewhat less than in previous years.

As in phase 1 the vaccination treatment had a significant positive effect on weight gain in its own right. This is shown below in Figures 4 and 5. The overall comparison between vaccinated and unvaccinated animals was 1.43 ∓ 0.022 cf. 1.35 ∓ 0.022 kg/head/day to day 78 ($p<0.05$). Presumably this is due to a reduction in subclinical disease even though the difference is not necessarily reflected in terms of numbers of animals pulled from the pen (see later for details).

Figure 4. *Average daily weight gain (kg) of the vaccinated and un-vaccinated subgroups from induction to day 37 in the feedlot.*

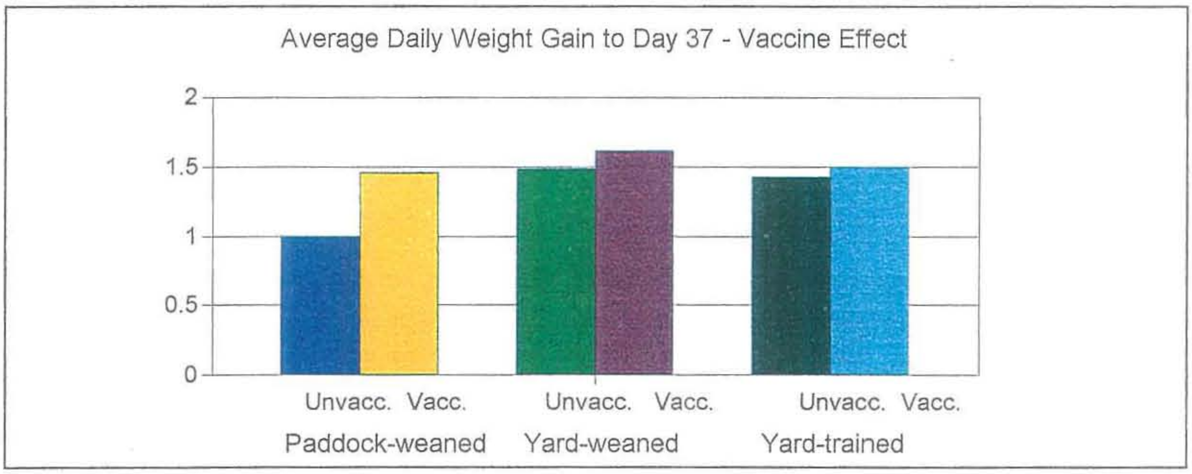
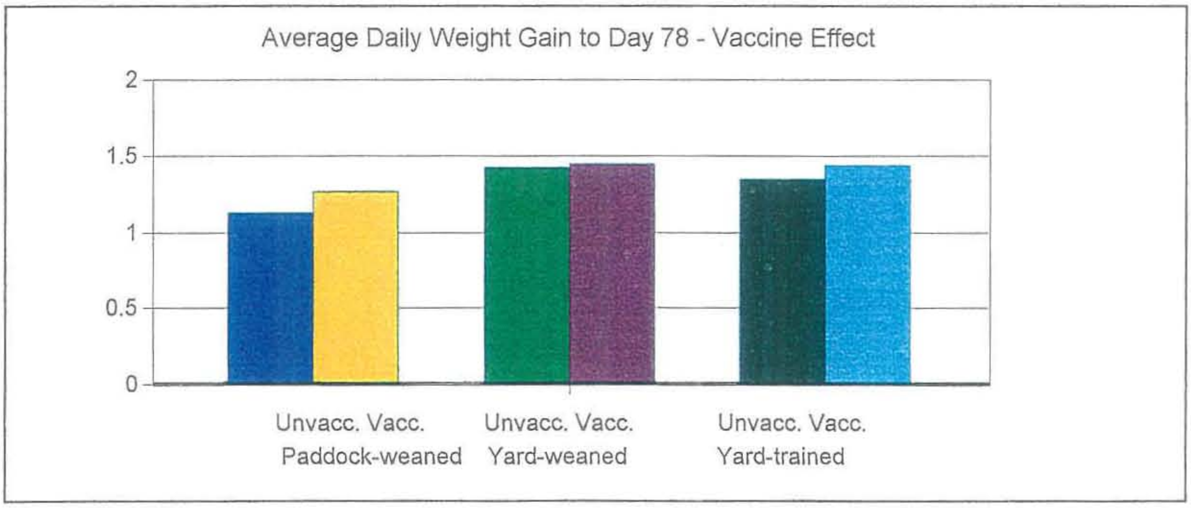
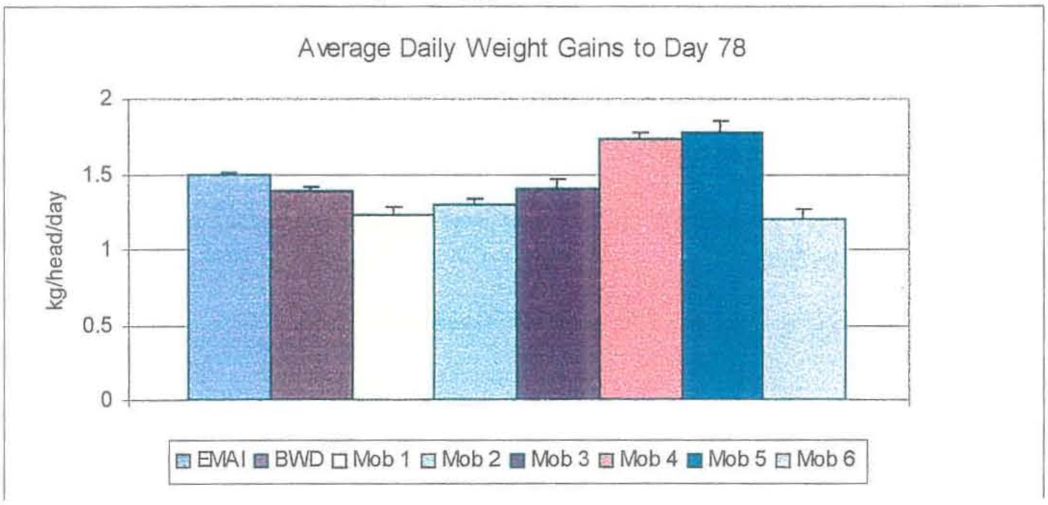


Figure 5. *Average daily weight gain (kg) of the vaccinated and un-vaccinated subgroups from induction to day 78 in the feedlot.*



There were significant source differences in weight gain between the EMAI and Braidwood cattle and also significant differences amongst the six commercial sources. The superior weight gain of EMAI animals, compared to Braidwood, has been consistently related to the greater morbidity and mortality in Braidwood animals throughout this study. Details of the pre-feedlot management of the various commercial sources are summarised in Table 2 on the next two pages. It is difficult to attribute the differences in weight gain to any particular factor without a further study.

Figure 6. *Average daily weight gain (kg) of cattle from the two experimental sources and six commercial sources over the feeding period.*



In summary, this final experiment in the three-phase series has also shown a beneficial effect of the treatments on early weight gain, thus confirming previous results, but in this case it is a bigger effect and it is clearly more sustained, at least throughout a 78 day feeding period. Further work will be needed to explore longer term effects, but by this stage of the feedlot operation it is expected that the principal benefits in terms of reducing respiratory disease should already have been achieved and will be retained thereafter.

***Table 2a.** Details of the pre-feedlot management of cattle from the various commercial sources (Mobs 1-3)*

		Mob 1	Mob 2	Mob 3
Background	Vendor's Location	Coonabarabran, NSW	Barraba, NSW	Carroll, NSW
	Number	27	40	20
	Breed	Shorthorn	32 Hereford, 6 Angus, 1 M.Grey, 1 HFDx	Shorthorn (milk teeth)
	Av wt at feedlot entry	260.4 kg	263.5 kg	308 kg
Feeding History	Handfed?	yes	yes	yes
	Type & quantity fed	1 Bale prime lucerne hay/ 8 steers (survival ration)	Good quality lucerne hay	Calf weaner meal (Farmstock Gunnedah
	When fed	Mid May 95- Mid Sept 95 (post weaning)	Weaning	Sept - Dec 94 (pre-weaning)
	How fed		Hay feeders	Creep feeder
Weaning	Method	Into small paddocks	Yard	Paddock (15ha)
	Age at weaning	5 - 7 months	11-12 months	5-7 months
	Fed?	Prime Lucerne hay for 10 days	Good quality lucerne hay	no
Post-weaning	Management	Turned into large grass paddocks after weaning	Lucerne paddock for 1 month, then on oats for 2-3 months until went to feedlot	Treated with Ivomex pour-on at weaning; then run in paddock
	Pasture conditions	Very poor May - Sept. 95; Quite good late Sept to sale on 2/11/95	Lucerne then oats	Fodder sorghum, then grazing oats
Handling	Size of group run in	94 Head	Large group post weaning until Oct, separated into smaller groups by quality; these animals would be one such group of 40 animals	Run in weaner mob of around 80 head
	Frequency of handling		Once in 2 months (drafting & 5-in-1 vaccination)	2-3 times in 7 months
Comments	Comments	Born into extreme drought Sept -Oct 94: only good feed in Jan - Feb 95 and Oct 95; survived because had good mothers and then fed lucerne hay.		Born in Spring 94 in an extremely bad drought

Table 2b. *Details of the pre-feedlot management of cattle from the various commercial sources (Mobs 4-6)*

		Mob 4	Mob 5	Mob 6
Background	Vendor's Location	Breeza, NSW	Spring Ridge, NSW	Quirindi, NSW
	Number	35	20	12
	Breed	Shorthorn	Angus	11 Murray Grey, 1 Angus
	Av wt at feedlot entry	247.7 kg	321 kg	273 kg
Feeding History	Handfed?	Yes	No	Yes
	Type & quantity fed	Lucerne and wheat hay, minimal amount		Fair quality lucerne hay
	When fed	Pre-weaning, drought		Occasional, depending on seasonal conditions
	How fed			
Weaning	Method	Yard overnight, then small paddock 10 days	No actual weaning - separated from mothers night before shipping	Small paddock 20 Days
	Age at weaning	6-9 months		8 months
	Fed?	Hay thrown in yards, grass and lucerne paddocks		Lucerne hay
Post-weaning	Management	Very little handling post-weaning		Run in large paddock
	Pasture conditions	Paddock lucerne, sorghum stubble and sunflower stubble	Good natural pasture; fair variety	Mainly lucerne combined with native pasture
Handling	Size of group run in	300 breeders pre-weaning; 90-100 weaners, both heifers and steers; drafted into mob of 110 steers and run in this mob for 2 months prior to feedlot	80-100 cows and calves	Approx. 20 head
	Frequency of handling	Once every 3 months (marking and random vaccination)	Yarded about 3 times for castration, drenching and lice treatment	Yarded approx. every 2 months
Comments	Comments	Mainly cropping enterprise; cattle handled as little as possible - "let them look after themselves"	Don't use dogs, horses or whips - only 4 wheel bike or ute; fairly flat country; cattle very quiet and handled quietly; not enough land to physically separate cows and calves at weaning	

Health

There were fewer health problems in Phase 3 than in either Phase 1 or 2. Significant source effects were again obvious when considering the number of animals pulled for sickness (mainly bovine respiratory disease in the first few weeks on feed).

Mortality

There were three animals which died during the feeding period (1 experimental, 2 commercial), but examination of these did not implicate any specific aetiologies so there were no mortalities specifically associated with respiratory disease.

One commercial-in-contact animal was killed after 8 days on feed. It was thin and inappetant and there were no significant virologic or bacteriologic findings. Another commercial-in-contact animal was sent to salvage slaughter on day 110 after it had been pulled four times for poor performance and respiratory conditions, without any specific findings. No post mortem samples were available. It had seroconverted to Pestivirus and BRSV during the period when first pulled, was positive to PI_3 on arrival and had no other significant serology.

The other animal to die was an experimental animal from the paddock-weaned vaccinated group. It had failed to gain weight from day 37 onwards until it was sent for salvage slaughter on day 74. Post mortem revealed chronic tracheobronchitis but virologic and bacteriologic examinations were negative. There were no significant seroconversions detected on serologic examination (Pestivirus positive from vaccination, PI_3 positive by day 37 and negative for all other tests). For the purposes of the economic analysis of the phase 3 treatment effects, this was not regarded as a mortality due to respiratory disease.

Serology

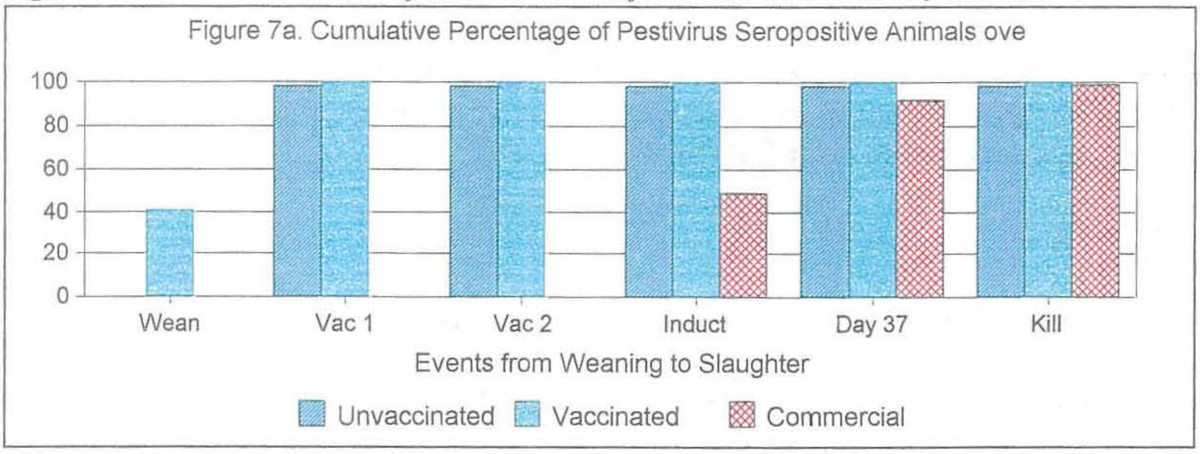
Seroconversions for Pestivirus, IBR, PI_3 and BRSV are shown in Figure 7a-e below.

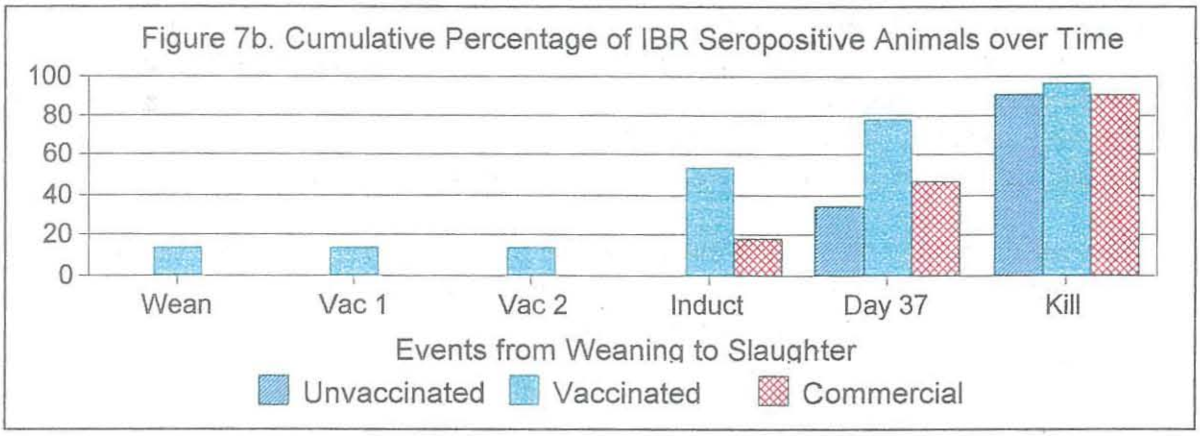
In commercial-in-contact animals, Pestivirus seroconversions were temporally related to the early disease events and, in all cattle, IBR and BRSV, seroconversions were temporally related to the early disease events (see morbidity, Fig. 8). Pestivirus in experimental animals and PI_3 in all animals were mainly positive at induction, so there was no significant seroconversion during the feedlot phase.

The results for Pestivirus (Figure 7a) indicate exposure of all experimental cattle to Pestivirus at EMAI, due to inclusion of two undetected carriers in the mobs. Almost half of the commercial-in-contact animals had been exposed to Pestivirus before the feedlot, and most of the remainder seroconverted in the first 37 days.

For IBR, about 50% of vaccinated cattle had titres at induction (Figure 7b). Some 13% had been positive at weaning (and presumably were carriers). Some 18% of the commercial-in-contact cattle were presumed carriers at induction. There was continued

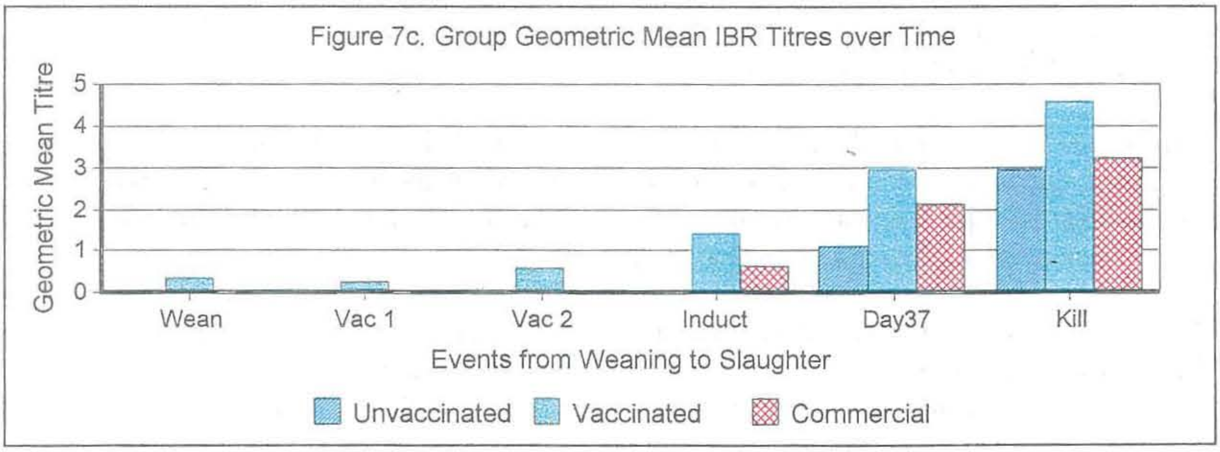
Figure 7a-e. *The time course of seroconversion for Pestivirus, IBR, PI_3 and BRSV.*





seroconversion over the feeding period, with about 36% of animals seronegative at induction becoming positive by day 37 and about 93% seroconversion by the end of the feeding period.

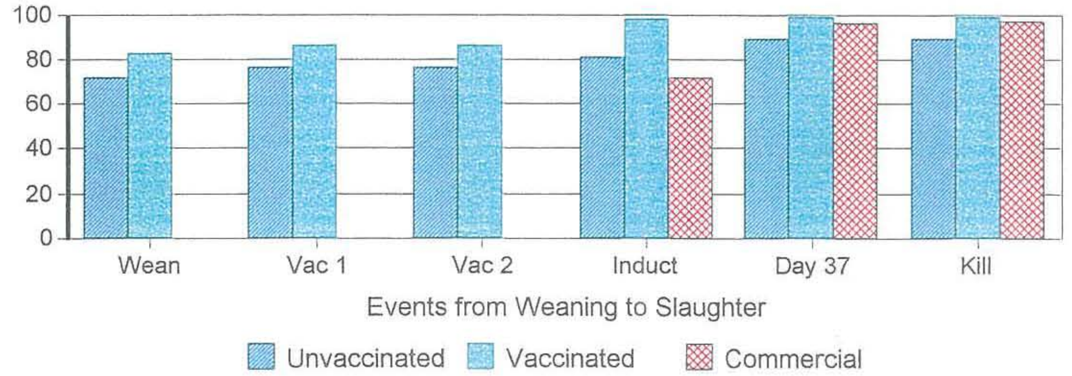
Further evidence for IBR spread during the feedlot period was provided by viral isolation from pyrexic animals at the day 37 bleed, with three of 36 animals sampled yielding IBR virus. IBR was also isolated from five animals pulled in the first five weeks.



Vaccinated animals reached higher titres than non-vaccinated animals in the feedlot period (Figure 7c). It is also of interest that, despite 13% of EMAI animals being positive at weaning, there was *no* spread of IBR in the weaning yards or in the paddock prior to feedlot entry.

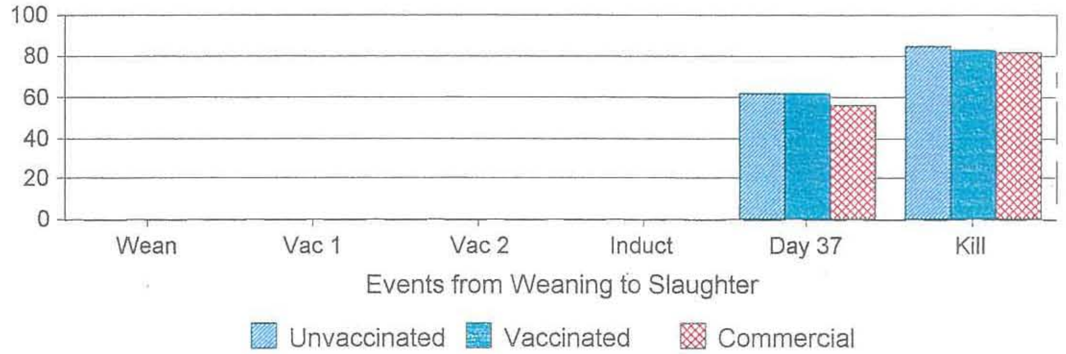
Most animals were already seropositive to PI_3 on arrival at the feedlot (Figure 7d), so it is unlikely that PI_3 played a significant role in disease.

Figure 7d. Cumulative Percentage of PI3 Seropositive Animals over Time



All animals were naive to BRSV on induction (Figure 7e) and about 70% had seroconverted in the first 37 days.

Figure 7e. Cumulative Percentage of BRSV Seropositive Animals over Time

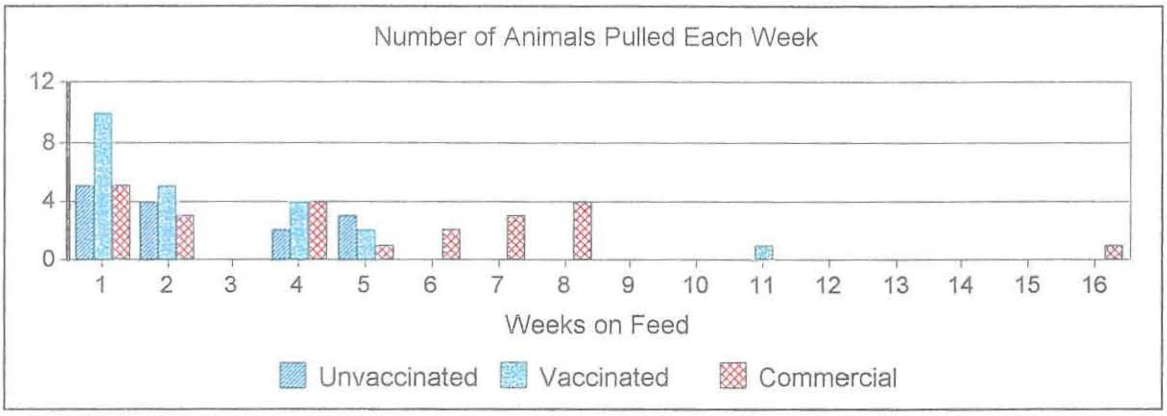


Salmonella serology indicated that all herds of origin had some exposure to both *Salmonella typhimurium* and *S. dublin.* There was some indication of slight spread beyond day 37 but no correlation with the incidence of disease prior to Day 37.

Morbidity

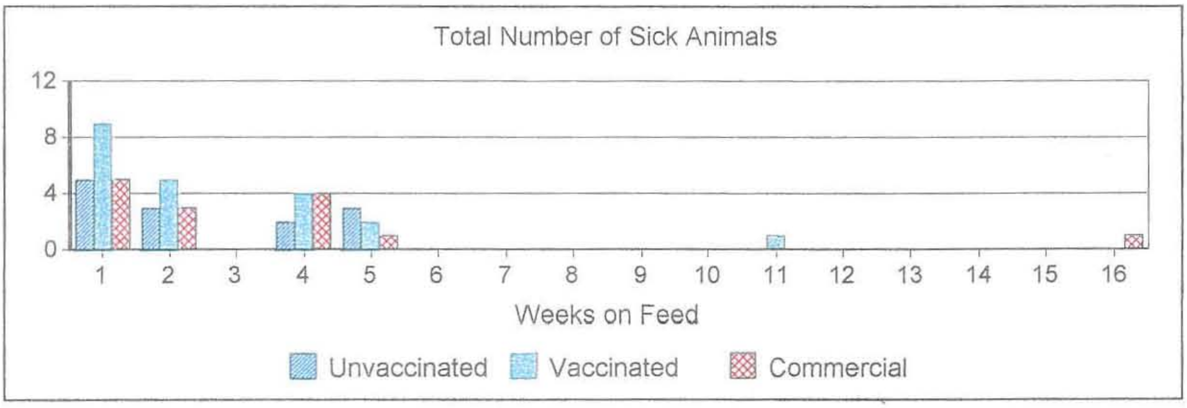
The total number of experimental animals (unvaccinated and vaccinated) and commercial cattle removed to the hospital pen each week is shown in Figure 8.

Figure 8. *The total number of animals pulled for any reason over the feeding period.*



All pulls beyond week 5 were for lameness (8 animals), bulling (1 animal) and chronic wasting (1 animal, week 11). Thus the 'sick' pulls were again concentrated in the early post-induction period, being in the first five weeks on feed for Phase 3 (see Figure 9 below). Not all animals which were pulled as sick showed clinical symptoms, a point that will be discussed further in the Final Report. There was no later respiratory disease (weeks 11 and 12) in Phase 3 as seen in Phase 2.

Figure 9. *The total number of animals pulled as 'sick' over the feeding period.*



In week 1 there were clearly more pulls from the vaccinated groups. However, Figures 10 and 11 clearly show that these vaccinated animals were almost all from the Braidwood (BWD) source, not from EMAI. There was much greater susceptibility to sickness and subsequent pulling in the Braidwood animals in the first five weeks post-induction, irrespective of vaccination history. No fatal respiratory disease occurred during this period.

Figure 10. The number of animals pulled as 'sick', the number of multiple pulls and the total number of pulls for any reason in vaccinated and unvaccinated groups from either the EMAI or the Braidwood source.

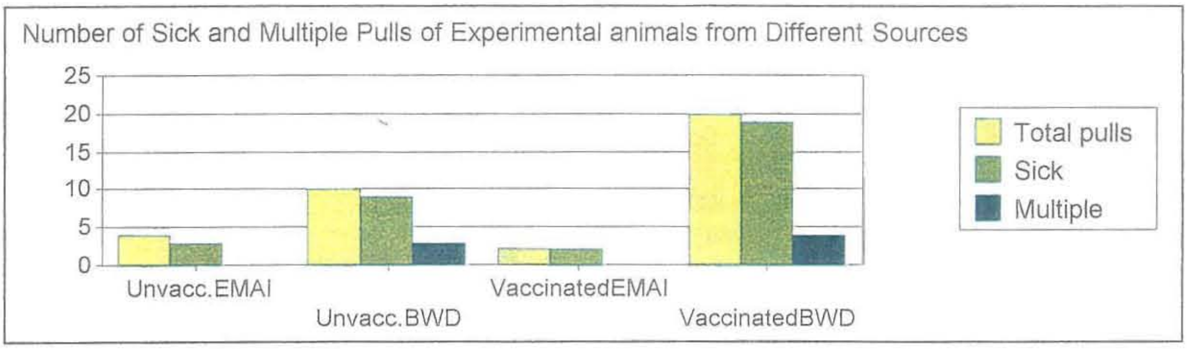
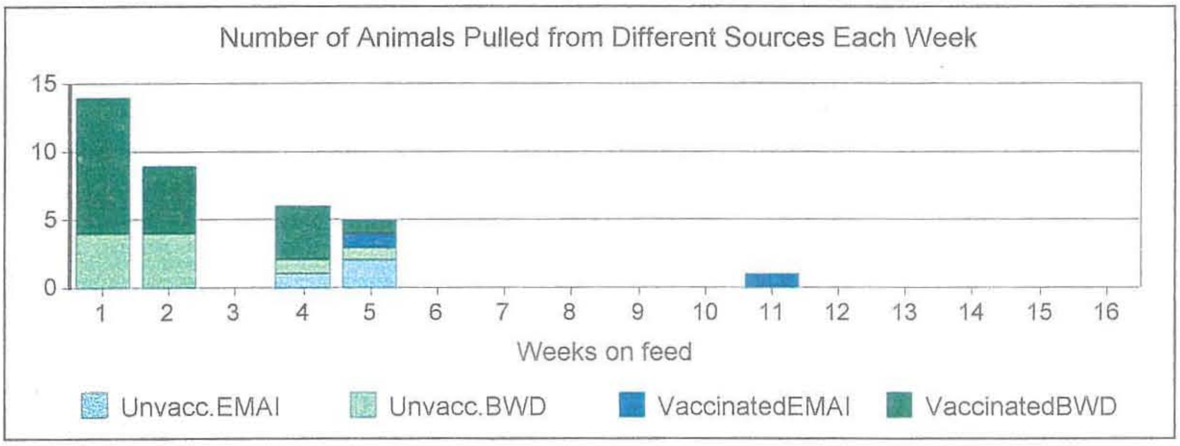


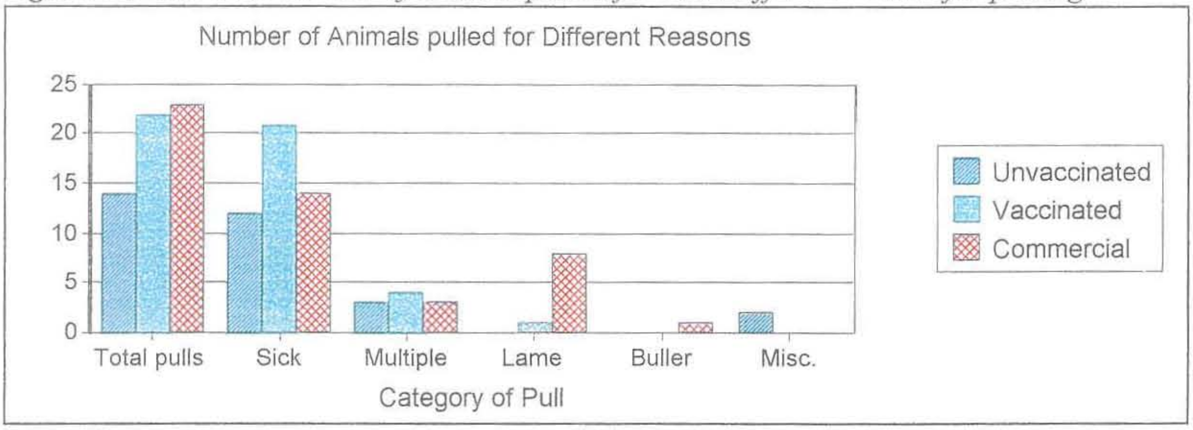
Figure 11. The total number of animals pulled for any reason over the feeding period in the vaccinated and unvaccinated groups from either the EMAI or the Braidwood source.



The commercial-in-contact cattle were derived from six local herds. Source 2 was clearly over-represented in the total pulls with 10 sick pulls and four lameness pulls compared to one or two pulls in each of the other herds. It was significant (p=0.038, Fisher's exact test) that all the animals pulled from source 2 were Herefords.

The different reasons for pulling animals are summarised in Figure 12 on the next page. The fact that the commercial-in-contact cattle were not the most frequent sick pull group this year (Figures 8 and 12) was different from phases 1 and 2. This was associated with the observed better feeding behaviour of commercial cattle this year and their background history of drought feeding during rearing (see previous discussion).

Figure 12. *The total number of animals pulled for each different reason for pulling*



Amongst the treatment groups, differences in morbidity were not statistically significant due mainly to the small numbers pulled. The paddock-weaned animals (Groups 1C and 1V) had the highest rate (22.2%), the yard-weaned cattle were the lowest (5.9%) and the yard-trained groups (3C,3V,4C,4V), were intermediate (17.3%). The yard weaned unvaccinated subgroup actually had zero pulls this year which gave it an advantage in the economic analysis of phase 3 (see later).

It was clear in phases 1 and 2 that morbidity adversely affected weight gain and this was again evident in phase 3 as indicated in Table 3 below. The effect was greatest for sick animals in early weight gain, there being some catching up later, but the effect was also sustained over the whole feeding period, particularly for multiple pulls.

There appeared to be a relationship between animal temperament and morbidity in phase 3 which will be need to be analysed over all three phases in the Final Report. In phase 3 there were six animals from the yard trained groups which completely failed the confidence test at weaning and five of these were pulled in the first few weeks. Of the remaining 98 trained animals there were 13 pulls during this period. This difference was significant (p=0.011, Fisher's exact test). Further analysis is required including the other groups from previous years to investigate this thoroughly.

Table 3. *Weight gains for healthy and sick steers and those pulled for other reasons*

		Average Daily Gain Days 0 - 38 on Feed (kg/hd/day)	Average Daily Gain Days 0 - 77 on Feed (kg/hd/day)
Experimental	Healthy	1.46	1.38
	Sick Pulls	1.07	1.30
	Multiple Pulls	1.12	0.99
	Lame Pull (1)	1.78	1.12
Commercial	Healthy	1.59	1.61
	Sick Pulls	1.22	1.52
	Multiple Pulls	0.80	1.17
	Lame Pulls	1.42	1.54
	Bullers (1)	1.38	1.03

Post - mortem Lesions

With regard to the total number of lesions in any organ at slaughter, 52% of experimental animals had lesions and there were no significant differences between treatment groups or sources. Commercial-in-contact cattle had fewer overall lesions this year (18%), in contrast to previous years. This may be due to the longer time course to the date of slaughter with possible lesion resolution given that the majority of lesions found in experimental animals were grade 1 or 2. The commercial cattle were slaughtered at irregular intervals up to 153 days after the last experimental cattle went to slaughter.

The frequency of respiratory and hepatic lesions in experimental animals is detailed in Table 4 below. There were no significant differences between experimental groups, source or vaccinated versus unvaccinated groups for all comparisons with the exception of the total vaccinated versus total unvaccinated comparison for liver lesions, i.e. 18 cf. 32 animals with lesions, which was marginally significant (p=0.049). No explanation can be offered at this stage.

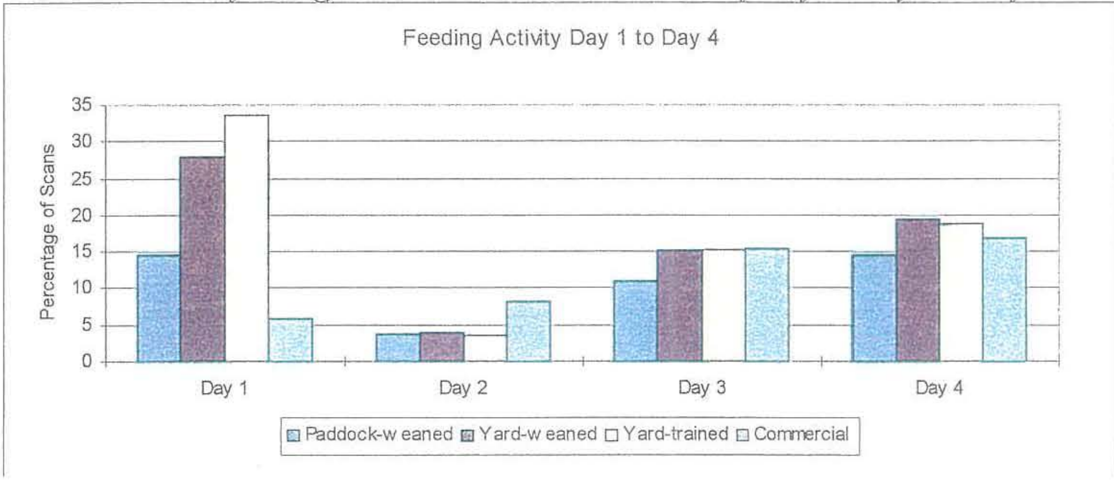
Table 4. *Number and type of respiratory and liver lesions found at slaughter in experimental cattle.*

	Weaning Treatment			Unvaccinated		Vaccinated	
LESION SCORES	Paddock Weaned	Yard Weaned	Yard Trained	EMAI	BWD	EMAI	BWD
RESPIRATORY							
1	3	6	20	12	3	11	3
2	2	2	2	0	2	1	3
3	4	4	11	6	7	1	5
4	1	2	5	4	1	1	2
5	2	0	0	0	1	0	1
6	0	0	0	0	0	0	0
Total No.	12	14	38	22	14	14	14
LIVER							
1	6	4	7	4	4	4	5
2	7	4	8	3	2	5	9
3	0	1	7	1	3	2	2
4	2	1	1	0	0	1	3
5	0	0	2	0	1	1	0
Total No.	15	10	25	8	10	13	19
No. of Animals in the Group	53	51	104	55	50	54	49

Feeding Behaviour

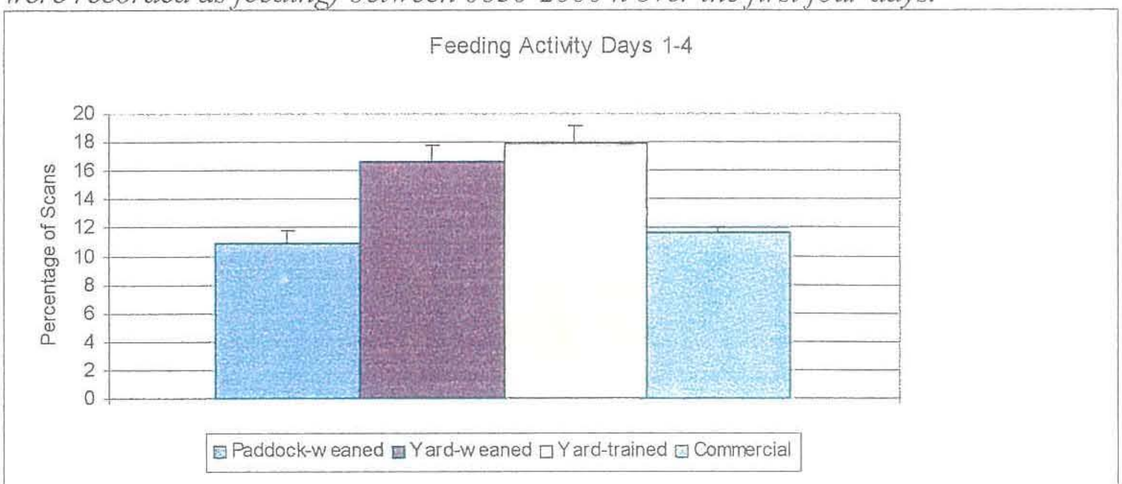
The data from phase 3 clearly confirm the previous findings in this project that both yard weaning and yard training result in significantly greater feeding activity when the cattle first arrive in the feedlot pen. The pre-boosted groups were significantly different from the paddock-weaned group on days 1, 3 and 4, but not significantly different from one another, even though the animals which were trained to eat from the trough appeared to be more active on day 1 (see Figure 13 below).

Figure 13. *Feeding activity (percentage of scans at which animals from each group were recorded as feeding) between 0630-2000 h on their first four days in the feedlot.*



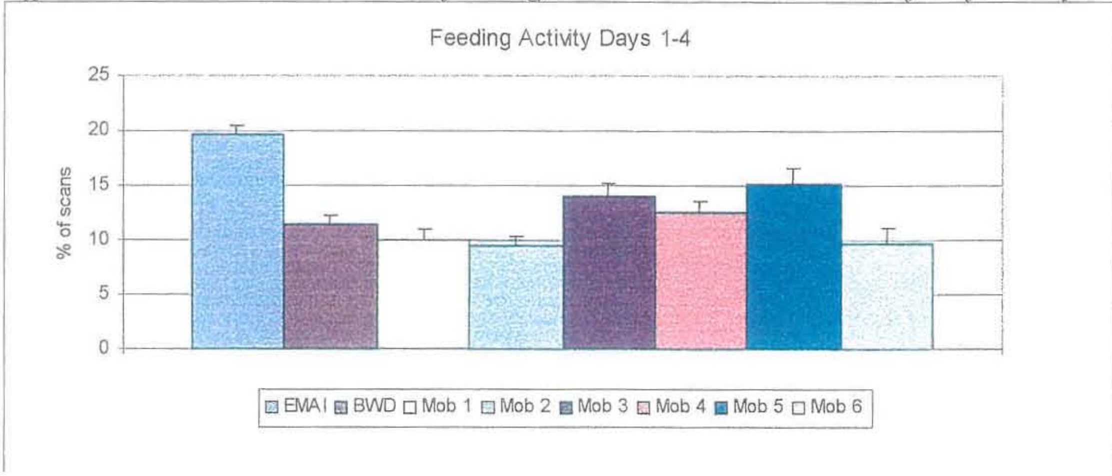
As in previous years there was a distinct lull in feeding activity on the second day in the feedlot which probably reflects the animals' need for rest after the handling at induction. This year the commercial-in-contact animals got onto feed much quicker than in previous years, presumably because most of them had previous experience of drought feeding which the experimental animals, especially the paddock-weaned controls, did not. Nevertheless the commercial cattle still ate much less than experimental cattle on their first day in the pen and, as a result, were also significantly lower on average over the first four days (see Figure 14 below).

Figure 14. *Feeding activity (percentage of scans at which animals from each group were recorded as feeding) between 0630-2000 h over the first four days.*



There was absolutely no difference in feeding activity between vaccinated and unvaccinated animals in phase 3. However, there were significant differences between the various sources (see Figure 15), as there were for weight gain. It is difficult to relate these to specific management strategies without further study. The details of pre-feedlot management for each of the commercial sources was summarised earlier in Table 2.

Figure 15. *Feeding activity (percentage of scans at which animals from each different source were recorded as feeding) between 0630-2000 on the first four days.*



Stress Response (Plasma Cortisol)

The cortisol data for phase 3 are summarised below in Figures 16 and 17. The pattern was very similar to previous years with a small drop from the start to the end of weaning and the highest levels during feedlot induction. There were no significant differences between treatment groups, nor was there any difference between the EMAI and Braidwood source groups this year. The suggestion in phase 2 that the acute stress at induction had been reduced by changes implemented at the feedlot after phase 1 has not been confirmed.

Figure 16. *Mean plasma cortisol concentration before and after weaning and at feedlot induction for the main treatment and source groups.*

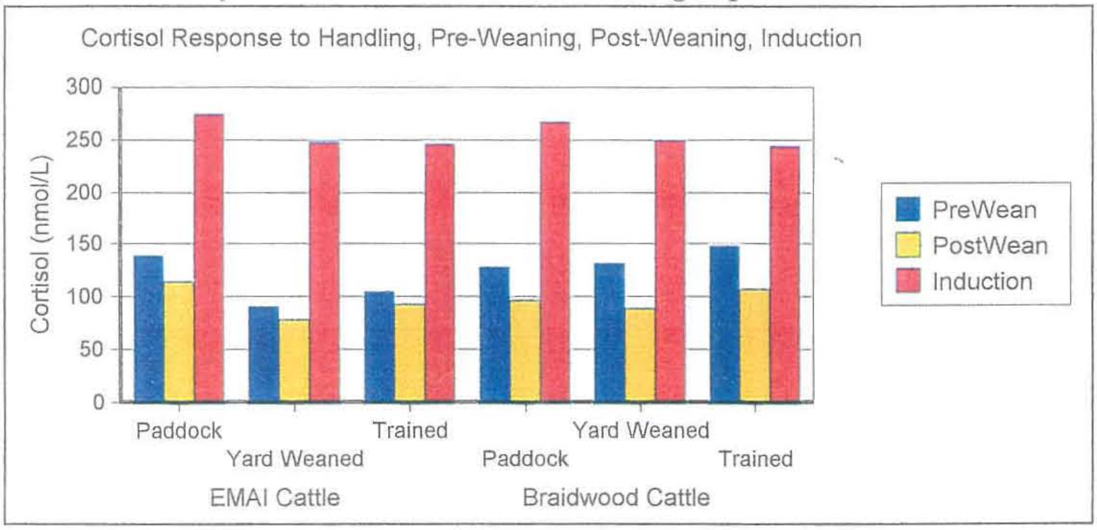
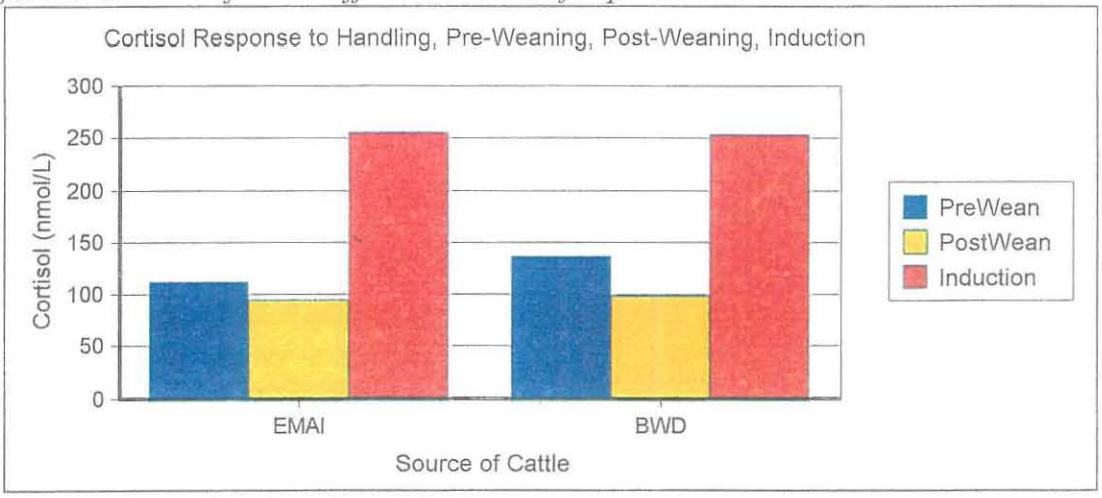


Figure 17. *Mean plasma cortisol concentration before and after weaning and at feedlot induction for the different sources of experimental animals.*



Confidence Testing at Weaning

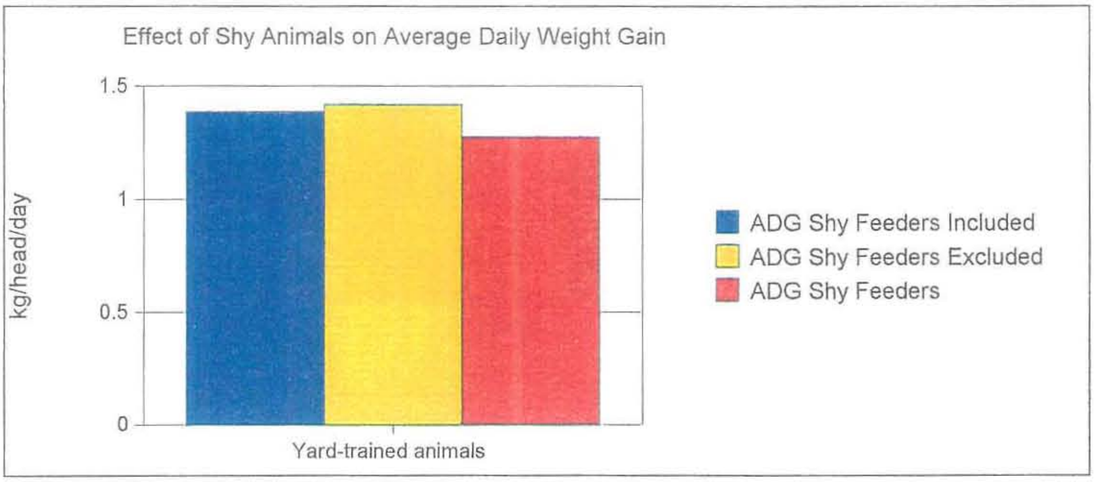
As in previous phases the procedure for confidence testing and training was applied to groups 3 and 4 (yard-trained) during the yard weaning. This year, unlike previous years, there were six animals which never succeeded in getting though the gate to the feed even after 10 days of training, i.e. they failed the confidence test altogether. There was also a larger group classified as shy this year (18 out of 104 or 17% cf. to around 10% in previous years).

As discussed previously, it is possible that this test could be used to cull animals that are unlikely to adapt to the feedlot so that they could be re-directed to a less intensive handling and finishing system which would suit them better. In this way the proportion of poor doers or problem animals in the feedlot might be significantly reduced with considerable economic benefit as these are the animals which contribute most to the costs of production through morbidity (pulls), subsequent treatment costs and sub-optimal production (see earlier).

The most telling result this year is that five of the six animals which failed the training were pulled as sick. If these six bad-temperament animals are removed from the analysis, the overall morbidity for yard-trained cattle is reduced from 17.3% to 10.5% which is more in line with average morbidity levels of around 10% or the result for yard-weaned animals (5.9%).

As in previous years, we looked at the weight gain of the 18 animals which were classified as shy on the basis of the confidence test. Their weight gain was somewhat lower than the rest of the group (see Figure 18 on the next page), but a further detailed analysis utilising data from all three phases will be necessary before we can reliably determine the magnitude and the signficance of this effect. The effect on average gain of removing those 18 animals is quite small in phase 3. The effect on average weight gain of removing only the six animals which failed the confidence test is also very small in this particular trial.

***Figure 18**. Average daily weight gain to day 78 for shy animals compared to the remainder of the trained groups.*



A more detailed analysis of this interesting offshoot from the pre-boosting project will be included in the forthcoming Final Report. It is likely that some more research will be needed on this aspect.

ECONOMIC ANALYSIS

The economic analysis for phase 3 is more detailed than the phase 2 report and similar to that provided for phase 1 except that, as well as using actual costs, it includes some analyses using projected costs that may be more representative of long term average beef and feed prices.

1. Assumptions and Costs involved in Pre-boosting Treatments

The treatments were costed and assumptions were made in the same way as for Phase 2, excepting that silage was fed instead of hay and feeding was for 10 days instead of 8 days during the yard weaning process. In addition there was no Equistim treatment for group 4 cattle. This meant that the costs for group 3 and 4 are identical.

Table 5. *Labour cost for the different activities*

Operation	Time per day	Frequency	Labour cost	No. of animals	Cost per animal
Vaccinating	2 hr	twice	$10/hr	100	$0.40/hd
Feeding silage	0.25 hr	10 days	$10/hr	50	$0.50/hd
Feeding grain	0.25 hr	8 days	$10/hr	50	$0.40/hd
Training	0.75 hr	8 days	$10/hr	50	$1.20/hd

Vaccines

Four vaccines were given to four of the groups; a bacterial vaccine and three viral vaccines, two of which were given twice to the cattle. It was estimated that it took two hours to vaccinate the group of 100 cattle. Vaccines were priced at $1.34/hd (bacterial vaccine) and $7.74/hd (viral vaccines). These prices were based on similar vaccines for other agents which are currently available in Australia.

Feeding silage

One round bale of silage has been fed per group per day. Silage was not of high quality and was costed at $25 per bale.

Feeding grain during training

Lupins (0.4 kg/hd/day) and oats (0.6 kg/hd/day) were fed to groups 3 and 4 on days 2 to 8 after weaning and again on day 18 after weaning; a total of 8 kg of grain per calf.

Training
A daily training procedure/confidence test involved labour of 45 minutes per day per group.

A summary of the assumptions and costs involved in the pre-boosting treatments is given below in Table 6.

Table 6. Assumptions and Costs involved in Pre-Boosting Trials

Inputs		Rate	Cost	Head	Cost/hd	Totals
1. Vaccines	bacterial viral labour	overall	$1.34/hd $7.74/hd $10/hr	100	$1.34 $7.74 $0.40	$9.48/hd
2. Feed silage	1 bale/day 0.25hr/day	10 days	$25/bale $10/hr	50	$5.00 $0.50	$5.50
3. Feed lupins Feed oats	0.4 kg/hd/day 0.6 kg/hd/day 0.25 hr/day	8 days	$350/t $220/t $10/hr	50	$1.12 $1.06 $0.40	$2.58/hd
4. Training	0.75 hr/day	8 days	$10/hr	50	$1.20	$1.20/hd

1.1 Costs for each pre-boosting group

In phase 3 there were three main weaning treatments, not four as in previous phases. These were ***paddock weaning*** (groups 1C and 1V), ***yard weaning*** (groups 2C and 2V) ***and yard training*** (groups 3&4C and 3&4V). Therefore there were six sub-treatment groups, not eight as in previous phases. These were paddock-weaned unvaccinated (1C), paddock-weaned vaccinated (1V), yard-weaned unvaccinated (2C), yard-weaned vaccinated (2V), yard trained unvaccinated (3&4C) and yard trained vaccinated (3&4V)

The six pre-boosting trial groups had the costs as indicated in Table 7.

Table 7. Costs per head involved in the pre-boosting trial groups

Costs/hd for each group	1C	1V	2C	2V	3&4C	3&4V
Vaccine		$9.48		$9.48		$9.48
Feed silage			$5.50	$5.50	$5.50	$5.50
Feed grain					$2.58	$2.58
Training					$1.20	$1.20
TOTAL	0	$9.48	$5.5	$14.98	$9.28	$18.76

2. Feedlot operations

The assumptions used for the economic analysis of the feedlot operation for the main pre-boosting treatment groups are presented below in Table 8.

Table 8. Animal assumptions used in the economic analysis- Actual results

Assumptions - animal	Paddock Weaned	Yard Weaned	Yard Trained	Vaccinated	Un-vaccinated
Purchase weight - kg	293.3	288.4	290.5	289.2	292.3
Started ration 1 - intake kg/hd/day	11.88	11.88	11.88	11.88	11.88
Started ration 1 - days on	20	20	20	20	20
Starter ration 2 - intake kg/hd/day	15.71	15.71	15.71	15.71	15.71
Starter ration 2 - days on	21	21	21	21	21
Changeover ration* - intake kg/hd/day	3.88	3.88	3.88	3.88	3.88
Change over ration* - days on	12	12	12	12	12
Finisher ration - intake kg/hd/day	10.52	10.52	10.52	10.52	10.52
Finisher ration - days on	36	36	36	36	36
Total days on feed	77	77	77	77	77
Weight gain - kg/hd/day	1.2	1.45	1.39	1.43	1.35
Proportion of sick animals %	24.0%	5.9%	19.2%	21.0%	13.3%
Proportion of deaths %	0%	0%	0%	0%	0%
Liveweight at weighing	385.7	400.05	397.53	399.31	396.25

* Change over ration overlapped with the second starter ration and the finisher ration. The total days on feed to the final liveweight weighing was 77 days.

2.1 Animal Assumptions

Purchase weight
The cattle were weighed upon entry to the feedlot and an average weight for each group was used in the economic analysis.

Starter ration - intake and days on
The cattle were fed for 20 days on the starter ration. Their intake was not able to be measured and therefore an average value for all groups was used at 11.88 kg per head per day

Starter ration 2 - intake and days on
The cattle spent a further 21 days on this ration consuming an average of 15.71 kg per head per day.

Changeover ration - intake and days on
A changeover ration overlapped starter ration 2 and the finisher ration for 12 days at an average consumption of 3.88 kg per head per day.

Finisher ration - intake and days on
Cattle were fed a finished ration for the final 36 days with an average of 10.52 kg per head per day being fed.

Weight gain and sale weight
The cattle were weighed at different times from 7-22 days before slaughter. This was due to industrial problems at the abattoirs. Final liveweights were subtracted from entry weights to estimate the weight gains for each group (kg/head/day).

Proportion of sick animals
The number of animals which were removed from the pen with a suspected problem was recorded for each group. These values were used as the proportion of "sick" animals, although they also included those which were bulling or lame.

Proportion of deaths
No deaths occurred that were relevant to the hypotheses being tested.

The animal assumptions used for the economic analysis of the feedlot operation for the pre-boosting sub-groups which combine the various treatments are presented below in Table 9. The various ration costs and days on feed are the same as those given in the previous table.

Table 9. Animal assumptions for the pre-boosting trial sub-groups - Actual results

Group	Paddock Weaned Un-vacc.	Paddock Weaned Vaccinated	Yard Weaned Un-vacc.	Yard Weaned Vaccinated	Yard Trained Un-vacc.	Yard Trained Vaccinated
Purchase liveweight - kg	298	289	288	289	291	290
Weight gain - kg/hd/day	1.13	1.27	1.43	1.46	1.35	1.44
Proportion of sick animals %	18.5	29.6	0	12	17.3	21.2
Proportion of deaths %	0	0	0	0	0	0
Liveweight at weighing - kg	385	387	398	401	395	401

2.2 Economic assumptions

Two sets of economic assumptions used in this analysis are summarised below in Table 10. The first uses figures that are as close as possible to the actual costs incurred. The second uses costs that may be more representative of longer term average beef prices and feed prices.

Table 10. Economic assumptions

Assumptions	Actual	Anticipated long term
Purchase price	$1.20/kg liveweight	$1.20/kg liveweight
Starter ration 1 cost	$137.93/tonne	$183.94/tonne for all*
Starter ration 2 cost	$140.91/tonne	$183.94/tonne for all*
Change over ration cost	$199.09/tonne	$183.94/tonne for all*
Finisher ration cost	$221.0/tonne	$183.94/tonne for all*
Sick pen cost	$20.00/head	$20.00/head
Interest rate	10% per annum	10% per annum
Sale cost	$5/head	$5/head

*custom feed price used.

Purchase price
A purchase price of $1.20/kg liveweight was assumed for each group.

Sale price
The sale value used in this analysis is based on the final liveweight (after 77 days in the feedlot) and the actual sale prices for each of the groups which are recorded below in Tables 11 and 12. The cattle were actually slaughtered 7-22 days after the final weighing, but for the purpose of comparing the treatments which have been costed only for the 77 day feeding period, the estimated sale value has been based on the weight after 77 days on feed.

***Table 11.** Sale prices used in economic assumptions for main treatment groups $/kg lw*

Group	Paddock weaned	Yard weaned	Yard trained	Vaccinated	Un-vaccinated
Actual	1.19	1.16	1.16	1.17	1.17
Anticipated longer term	1.30	1.30	1.30	1.30	1.30

***Table 12.** Sale prices used in economic assumptions for treatment combinations $/kg lw*

Group	Paddock weaned Un-vacc.	Paddock weaned Vaccinated	Yard weaned Un-vacc.	Yard weaned Vaccinated	Yard trained Un-vacc.	Yard trained Vaccinated
Actual	1.19	1.18	1.16	1.16	1.16	1.16
Anticipated longer term	1.30	1.30	1.30	1.30	1.30	1.30

Sale cost
A sale cost of $5.00/head was used to cover transport costs to move cattle from the feedlot to the abattoir.

Sick pen cost
The sick pen cost was estimated to cost around $15/head for medicine and $5/head for veterinary services and labour to move cattle around, a total of $20/head. This cost has been reduced from that of $30 per head used in phase 1 on advice from the feedlot operators.

Starter and finisher ration costs
Two sets of feed prices are used. Actual feed prices used are custom feed prices during phase 3. To provide a set of feed prices considered more representative of the long term market, a custom feed price quotation for cattle entering a feedlot in February 1997 was chosen.

Interest rates
Interest rates were assumed to be 10% per annum, or 2.5% per quarter, (close to the overdraft rate.) The purchase cost, feed costs and sick pen costs were all multiplied by the quarterly interest rate to allow for an opportunity cost on the money invested in the cattle.

2.3 Returns to the feedlot operators - actual and projected longer term

Given the above animal and economic assumptions, marginal returns (not allowing for overheads) for each group of cattle, are presented in Table 13 (actual results) and Table 14 (projected longer term results).

Table 13. Costs and Returns for pre-boosting trial groups phase 3 ($/head) Actual Results

Group	Paddock Weaned	Yard Weaned	Yard Trained	Vaccinated	Un-vaccinated
Purchase cost	351.96	346.08	348.60	347.04	350.76
Starter ration 1	32.77	32.77	32.77	32.77	32.77
Starter ration 2	46.49	46.49	46.49	46.49	46.49
Change over ration	9.27	9.27	9.27	9.27	9.27
Finisher ration	83.70	83.70	83.70	83.70	83.70
Sick pen cost	4.80	1.18	3.84	4.20	2.66
Interest cost	11.16	10.96	11.07	11.04	11.09
TOTAL COST	540.15	530.45	535.74	534.51	536.74
SALE VALUE	458.98	464.06	461.13	467.19	463.61
Gross margin	-81.17	-66.39	-74.61	-67.32	-73.13
Gross margin compared to paddock weaned	control	14.78	6.56	13.85	8.04

Table 14. Costs and Returns for pre-boosting trial groups phase 3 ($/head) - Projected at custom feeding costs and average beef prices

Group	Paddock Weaned	Yard Weaned	Yard Trained	Vaccinated	Un-vaccinated
Purchase cost	351.96	346.08	348.60	347.04	350.76
Feed costs	182.67	182.67	182.67	182.67	182.67
Sick pen cost	4.80	1.18	3.84	4.20	2.66
Interest cost	11.38	11.18	11.29	11.26	11.31
TOTAL COST	550.81	541.11	546.40	545.17	547.40
SALE VALUE	501.41	520.07	516.79	519.10	515.13
Gross margin	-49.40	-21.04	-29.60	-26.07	-32.27
Gross margin compared to paddock weaned	control	28.36	19.80	23.33	17.13

Comparison of Individual Sub-Treatment Groups

The various combinations of vaccine treatment with each weaning treatment have also been compared. The marginal returns (not allowing for overheads) for each of the six sub-treatment groups of cattle, are presented on the next page in Table 15 (actual results) and Table 16 (projected longer term results).

Table 15. Costs and Returns for pre-boosting trial groups phase 3 ($/head) Actual Results

Group	Paddock Weaned Un-vacc.	Paddock Weaned Vaccinated	Yard Weaned Un-vacc.	Yard Weaned Vaccinated	Yard Trained Un-vacc.	Yard Trained Vaccinated
Purchase cost	357.60	346.80	345.60	346.80	349.20	348.00
Starter ration 1	32.77	32.77	32.77	32.77	32.77	32.77
Starter ration 2	46.49	46.49	46.49	46.49	46.49	46.49
Changeover ration	9.27	9.27	9.27	9.27	9.27	9.27
Finisher ration	83.70	83.70	83.70	83.70	83.70	83.70
Sick pen cost	3.70	5.92	0	2.40	3.46	4.24
Interest cost	11.26	11.07	10.92	11.00	11.07	11.06
TOTAL COST	544.79	536.02	528.75	532.43	536.74	535.53
SALE VALUE	458.15	456.66	461.68	465.16	458.20	465.16
Gross margin	-86.64	-79.36	-67.07	-67.27	-78.54	-70.37
Gross margin compared to paddock weaned	control	7.28	19.57	19.37	8.10	16.27

Discussion of Results

The resultant gross margin figures in Tables 13, 14, 15 and 16 are negative, due in part to the feed prices used. However, the main purpose of this analysis is to compare the performance of each of the groups against the control, which is either the paddock weaned group (vaccinated plus unvaccinated), in Tables 13 and 14, or the paddock-weaned unvaccinated group, in Tables 15 and 16.

Despite the fact that the market favoured smaller animals at this time and the sale price was higher for the control groups (see Tables 11 and 12), all treatment groups showed improved financial results as compared to the control. However, when compared to the on-farm cost of the various pre-boosting treatments, it would appear from Tables 13 and 14 that the yard weaning treatment is the most economical. The difference in gross margin figures indicates that, in most circumstances, under the assumption that all groups have consumed equal amounts of feed, yard weaning is worthwhile. It would appear that the additional cost of yard training is not warranted unless shy feeders could be identified and removed with subsequent cost savings in the feedlot phase (see earlier discussion).

Vaccination improved the gross margin, but in this study by an amount which was slightly less than the estimated cost of the vaccines. Until the actual cost of these vaccines is known no final conclusion can be drawn. It can be seen in Tables 15 and 16 that yard weaning combined with vaccination produced the highest gross margin, but the improvement over the control was the same as for yard weaning without vaccination in this study. This was largely due to the zero sick pen costs in the latter group. The overall economic analysis in the forthcoming Final Report will be needed to resolve this issue.

Table 16. Costs and Returns for pre-boosting trial groups phase 3 ($/head) - Projected at custom feeding prices and average beef returns

Group	Paddock Weaned Un-vacc.	Paddock Weaned Vaccinated	Yard Weaned Un-vacc.	Yard Weaned Vaccinated	Yard Trained Un-vacc.	Yard Trained Vaccinated
Purchase cost	357.60	346.80	345.60	346.80	349.20	348.00
Starter ration 1	43.70	43.70	43.70	43.70	43.70	43.70
Starter ration 2	60.68	60.68	60.68	60.68	60.68	60.68
Changeover ration	8.56	8.56	8.56	8.56	8.56	8.56
Finisher ration	69.66	69.66	69.66	69.66	69.66	69.66
Sick pen cost	3.70	5.92	0	2.40	3.46	4.24
Interest cost	11.47	11.29	11.14	11.22	11.29	11.28
TOTAL COST	555.39	546.63	539.36	543.03	546.57	546.14
SALE VALUE	500.50	503.10	517.40	521.30	513.50	521.30
Gross margin	-54.89	-43.53	-21.46	-21.73	-33.07	-24.84
Gross margin compared to paddock weaned	control	11.36	33.43	33.16	21.82	30.05

Sensitivity analysis

Eight key assumptions used in the analysis of the return to the feedlot were varied to see their effect on the gross margin for a trial group. The assumptions were varied from a low value for the industry to a high value for the industry. Assumptions are shown in Table 17 and the results are presented in Table 18. The vaccinated group from Table 14 was used as the base group in which to test the sensitivity of results.

Table 17. Sensitivity Analysis Assumptions

	Low Values				Base	High Values			
Weight gain kg/hd/day	0.86	1.00	1.14	1.29	1.43	1.57	1.72	1.86	2.00
Sick animals %	4.2	8.4	12.6	16.8	21	25.2	29.4	33.6	37.8
Deaths %	.01	.25	.5	.75	1	1.25	1.5	1.75	2.0
Purchase price $/kg lw	.72	.84	.96	1.08	1.20	1.32	1.44	1.56	1.68
Sale price $/kg/lw	.78	.91	1.04	1.17	1.30	1.43	1.56	1.69	1.82
feed cost $/kg total	110	128	146	164	183	201	109	237	256
Sick pen cost $/hd	0	5	10	15	20	25	30	35	40
Interest rate%	4	5.5	7	8.5	10	11.5	13	14.5	16

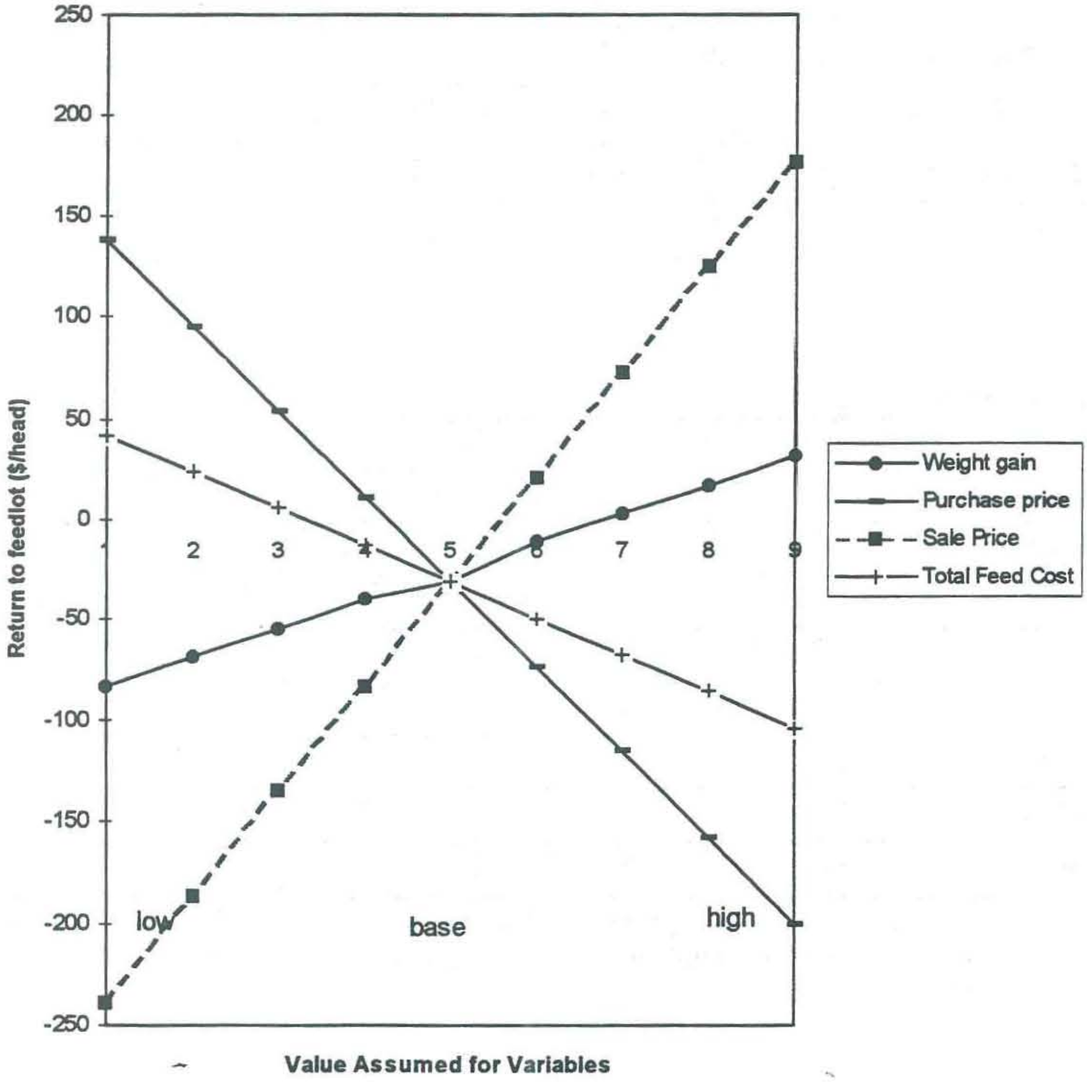
Table 18. Sensitivity Analysis

	Low Values				Base	High Values			
Weight gain	-83	-69	-54	-40	-31	-11	3	17	32
Sick animals %	-28	-28	-29	-30	-31	-32	-33	-34	-34
Deaths %*	-31	-32	-34	-35	-36	-38	-39	-40	-42
Purchase price	138	96	53	11	-31	-73	-115	-158	-200
Sale price	-239	-187	-135	-83	-31	21	73	125	177
Total feed cost	42	24	6	-13	-31	-49	-68	-86	-104
Sick pen cost	-27	-28	-29	-30	-31	-32	-33	-34	-35
Interest Rate	-24	-26	-28	-29	-31	-33	-34	-36	-38

* Base figure lower than other base gross margins because a figure of 1% deaths was used so that the sensitivity of the results could be tested between 0 and 2%. The actual base figure for deaths was 0%.

The biggest effect on the gross margin for each group was due to the purchase and sale price assumed for the cattle. After those, the next biggest influences was the liveweight gains achieved. The remaining assumptions which had a significantly smaller effect on the overall gross margin were total feed cost, deaths, sick pen cost and interest rates. Results from the four most significant factors are presented graphically in Figure 20 on the next page.

Figure 2: Pre-Boosting Economic Analysis - The effect of changing one variable at a time while holding all others fixed - Results for four significant variable only are collated onto this Graph



Appendix 4

A Note on the Effects of the Additional Immunostimulation Treatment and the Reasons for Abandoning this Procedure

Treatment 4 listed on page 18 of this report was abandoned after the end of phase 2 because it had not yielded promising results and had proved too difficult to manage.

This treatment consisted of an intravenous injection (1ml/100kg liveweight) of Equistim® (Virbac Aust. Pty. Ltd., Peakhurst, NSW) about 48 hours prior to the end of the yard weaning (i.e. on day 8 after separation from their mothers). At the same time, sucrose was added to the water troughs in the yards at a concentration of approximately 1% during the remaining two days of yard weaning.

The flavour in the water was intended to establish a conditioned immune response which could then be re-enlisted at a later date by the administration of the flavoured water alone.

Group 4 (yard trained) was treated as above, while 10 animals from Group 3 (the other yard trained group) were given the Equistim, but not the flavoured water to act as one kind of control. On the day before shipping to the feedlot half the animals in each of these groups were re-exposed to the flavoured water in the yards for about four hours while they were being weighed and sampled. Unfortunately it was not possible to determine if all animals which had flavoured water available actually drank from the trough.

In any case there was absolutely no difference in daily weight gain, morbidity, nor in feeding behaviour at the feedlot, between the immunostimulated conditioned animals, those which were only immunostimulated and those which received neither treatment.

In the context of the group management and commercial operations that we were working it was considered too difficult to continue with these treatments in the absence of any promising results.

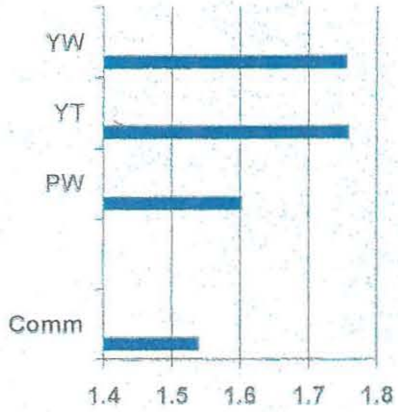
However, the idea of a conditioned immunostimulation procedure to combat stress effects during critical periods has not been disproved by this work and would still be worthy of further investigation.

It was apparent from this experience that a proper test of the hypotheses involved would require another experiment devoted solely to this purpose with a better design and more practical management situation and also the ability to closely monitor changes in the immune system following the treatment.

Appendix 5

A Diagrammatic Overview of the Research and
Summary of Combined Data from all Three Phases
(A Set of Overheads)

Weight Gain - First Month



Yard weaned

=

Yard Trained

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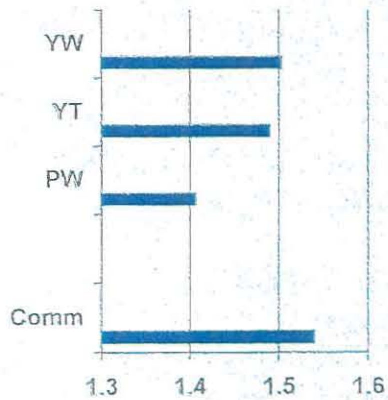
Paddock weaned

- Commercial

Weight Gain - 90 days on feed



Yard weaned

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Yard Trained

>

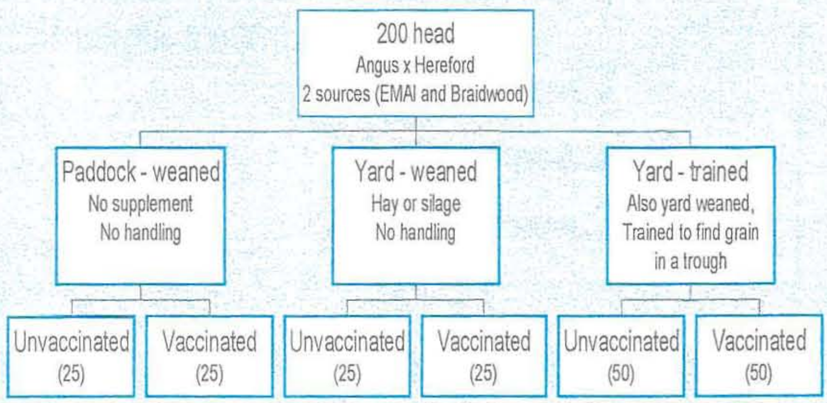
Paddock weaned

- Commercial

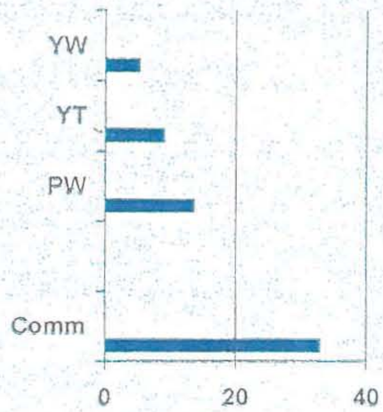
3 phases - 200 head in each

	Born	Weaned	Feedlot
	Spring	Autumn	Summer
Phase 1	1992	1993	1994
Phase 2	1993	1994	1995
Phase 3	1994	1995	1995-96

Experimental Design



Morbidity - Number of Pulls



Yard weaned

>

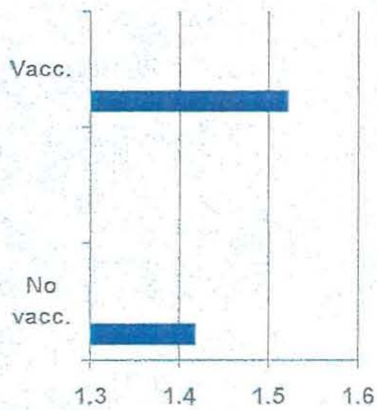
Yard Trained

>

Paddock weaned

- Commercial

Weight Gain - 90 days on feed

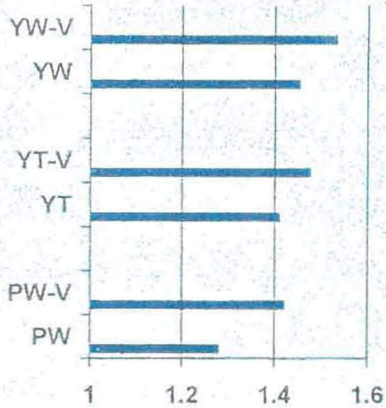


Vaccinated

>

Unvaccinated

Weight Gain - 90 days on feed



Yard weaned / vacc.
Yard trained / vacc.

>

Yard weaned
Yard trained
Paddock weaned / vacc.

>

Paddock weaned