

M. 102

1

(P)

A SITUATION STATEMENT ON RESEARCH INTO ANIMAL WELFARE ISSUES
IN AUSTRALIA

D.B. ADAMS AND R.K. MUNRO

Animal Resources Branch
Bureau of Rural Resources

December 1991

CONTENTS

Preface		3
Acknowledgments		4
1. Summary		5
2. Introduction		7
3. An overview of the role of animal welfare research		9
Animal welfare and productivity		9
Gathering knowledge		9
Extension and technology transfer		9
Public bodies and animal welfare		10
Special features of animal welfare research		11
The concept of 'suffering'		12
Behavioural aspects		14
Issues specific to intensive and extensive systems of livestock husbandry		14
The importance of research into the general biological aspects of animal welfare		15
4. Survey of Australian research into the welfare of livestock		17
Methods		17
Results		18
Table 1		20
Perceptions about what constitutes animal welfare research		21
Reluctance to disclose information		21
Conclusions		21
5. Specific welfare issues		24
Intensive systems		24
White veal production		24
Bobby calves		24
Feedlots		25
Extensive systems		27
Feed and water		28
Climate and shelter		29
Disease		31
Husbandry operations		32
Castration and taildocking		33
Spaying		34
Dehorning		35
Identification (branding and ear tagging)		35
Blowfly strike and mulesing		36
Dentistry and tooth grinding		37
Shearing and electro-immobilisation		37
General handling		38
Transportation		39
Slaughter and abattoirs		40
Experiments		42
6. References		44
7. Appendix		45
Current research projects in animal welfare in Australia		

PREFACE

In dealing with future priorities for research on animal welfare within the red-meat industry in Australia, we have drawn heavily on a critical review of animal welfare being prepared within the Bureau of Rural Resources.

Possible threats to the red-meat industry arising from animal welfare issues are a constant consideration. These threats may operate within the marketing system to reduce the acceptability of red meat to consumers, or they may act on the market-place through the enactment of laws designed to regulate the treatment of animals.

It is commonly assumed that attention to animal welfare issues will impose costs and never benefits. Attention to certain issues will without doubt impose costs. However, given the close connection between good welfare and production performance, it is more likely that attention to most issues will confer economic benefits. To assess the costs and benefits of welfare measures, a means for defining welfare status is required.

'Suffering' is a problematical word, but nevertheless the defining issue of animal welfare. It is difficult to imagine how progress in animal welfare can occur and how priorities for research in the area may be set without the development of a working model or 'mock-up' for suffering. We are currently developing such a model, the details of which will be presented elsewhere, and in the preparation of this document have been influenced by our thoughts on the subject.

We have given some areas of animal welfare greater emphasis than others, according to our judgement of priorities at the moment. The issue of live sheep exports, for instance, has not been dealt with because it has been treated extensively in other reports sponsored by the Australian Meat and Livestock Research and Development Corporation. The determinations made in those reports are largely in accord with the approach and viewpoint contained here.

The priorities for future research suggested in this paper relate strongly to Australian conditions. However, consideration is also given to how generic research may be ranked. This is research applying to animal welfare issues in general and not restricted to particular problems in Australia. Scientific research in animal welfare requires interdisciplinary work, and should include animal behaviour, comparative psychology, psychophysiology and systems physiology.

There are problems and shortcomings associated with the

uncritical transfer of overseas research results to the Australian scene. Australia needs to develop lines of argument related to its own situation. Judgements based on inappropriate criteria developed elsewhere may spoil the comparative advantages for animal welfare within the production systems used in Australia, and cause repercussions within the marketplace.

D.B. Adams and R.K. Munro
Bureau of Rural Resources
December 1991

ACKNOWLEDGEMENTS

The authors wish to acknowledge the assistance provided by Mr Paul Meek in data collection, and thank the respondents to the animal welfare research questionnaire for their assistance with that part of the project.

Our draft document was edited by Science Communication Services, Canberra.

1. SUMMARY

1. Animal welfare is recognised in the current 5-year Research and Development Plan of the Meat Research Corporation (MRC) as an important factor in production efficiency and as one of the 'selected threats with likely implications for the red-meat industry'. This report was prepared at the Corporation's request.
2. Animal welfare is a complex subject. It touches on many other disciplines, and is greatly influenced by its social setting. The report attempts to define animal welfare and put it in perspective.
3. Welfare and production issues are usually complementary, and production performance is a key indicator of welfare status.
4. A high-quality animal welfare research base in Australia would add to our international standing in animal welfare matters and enhance meat exports.
5. Animal welfare should be addressed scientifically rather than intuitively. Until basic research provides sufficient knowledge of the subject, there will not be a 'level playing field' for decision-making on animal use in Australia.
6. If projects are to qualify specifically as animal welfare research, they should have the investigation and alleviation of 'suffering' as their primary consideration.
7. Australia needs an improved database on animal welfare research and a system to define what is primarily animal welfare research and what is primarily production research. (Most of 62 projects examined in the survey of current animal welfare research had a strong orientation towards production goals.)
8. Transportation, feedlotting, mulesing/blowfly control in sheep and spaying and slaughtering of cattle all require further research. The preparation of critical reviews would help guide such research.
9. The potential value of field observations in animal welfare research will not be realised until such observations are recorded, collated and analysed in a systematic fashion. Institutions that already provide technical support to animal production could have a special role in this area.

10. There is a need for continuing education of extension personnel in animal welfare, and for the development of educational packages and programs.
11. MRC should take steps now to ensure that there is adequate planning on animal welfare and the subject receives more comprehensive treatment in the next (1996) Research and Development Plan.

2. INTRODUCTION

The issue of animal welfare was considered in a recent research and development investment strategy study undertaken by the Meat Research Corporation of Australia (MRC) to underpin the development of its second 5-year Research and Development Plan. The second 5-year plan recognises that 'society's attitudes to animal welfare are already having an impact on the industry', and that the industry has a 'direct commercial interest in animal welfare' because 'improved welfare practices ... often can mean improved productivity'.

Subsequently, the Corporation commissioned the Bureau of Rural Resources to examine animal welfare research in Australia. The terms of reference for the project were to:

- . identify current and potential issues of significance over the next 5 years in animal welfare in the red-meat and associated livestock industries (both the intensive and extensive industries for cattle, sheep, goats and buffalo);
- . identify organisations involved in research in animal welfare issues in the red-meat industries;
- . summarise scientific projects and major findings of relevance in addressing animal welfare issues.

Our approach depends on an understanding of what defines and describes animal welfare, and how animal welfare is related to, and may be distinguished from, other areas of animal production. In treating each problem area, we have:

- . recorded those aspects that raise welfare concerns by reference to a set of predetermined diagnostic criteria;
- . identified gaps in knowledge.

Traditionally, the subject-matter of animal welfare has been tackled with judgments and opinions based on 'commonsense' or intuition. While many conclusions drawn in this way may prove to be sound, the intuitive approach has now been superseded by developments across a range of scientific disciplines. We have avoided the intuitive approach because it leads to unresolvable dispute rather than constructive argument. Our viewpoint is that issues of animal welfare should be treated in clearly explainable biological terms and analysed through soundly based biological concepts.

The first part of this document is an overview of the nature of animal welfare. It sets out the approach and criteria used in determining what constitutes an animal welfare issue. The overview also examines the issues of welfare relating to animal behaviour and the physiology of pain and stress.

The second part of the document is a survey of Australian research into the welfare of livestock. It incorporates discussion and evaluation of the research content and methodology used.

Finally, the ideas and methods developed in the overview are applied to specific issues and problem areas of animal welfare in Australia.

3. AN OVERVIEW OF THE ROLE OF ANIMAL WELFARE RESEARCH

Animal welfare and productivity

The welfare of animals is an ethical issue for individuals and the community at large. The qualms of meat producers, meat consumers and potential consumers about the slaughter of animals for food are outweighed by the value of animal-derived food for people. However, the community has a moral obligation to treat animals with considerate care.

Promoting animal welfare does not necessarily mean a loss of productive capacity. Welfare and production issues are complementary to a very large extent - in fact, biological production performance is a key indicator of welfare status. This should not be confused with the economic performance, or profitability, of an enterprise, which is influenced by many factors external to the biological world.

Positive links between welfare and biological production performance occur as a repeated theme throughout this report. An extension of this theme is that reflections and research on welfare may identify opportunities for improvements in production performance and production systems.

Gathering knowledge

New knowledge about animal welfare comes from two sources - specific research projects, and experience with animal production as it occurs in practice. The latter source of information is underutilised at present. Its potential will only be realised if appropriate field observations are recorded, collated and analysed in a systematic fashion.

The established technical and diagnostic services for animal production - for example, meat inspection services and regional veterinary laboratories - could extend their role to take in this function. The data obtained by these services already have some application to welfare. With additional effort, observations could be augmented and focussed to allow for the comprehensive monitoring of animal welfare. One obvious benefit would be an objective basis for identifying subjects for experimental research. For example, the systematic appraisal of bruising and other injuries could be used to identify the sources and extent of damage and to suggest possible solutions to this costly problem. This idea has particular relevance to the rapidly expanding beef feedlot industry.

Extension and technology transfer

Successful research and extension must be based on a thorough understanding of the subject matter of animal welfare. The importance of continuing research and scholarship in achieving

that understanding should be recognised.

Effective extension and technology transfer rely on the provision of high-quality knowledge from research, and an infrastructure to deliver that information in an appropriate form to the user. There is a need for the preparation of packages and programs for education and extension in animal welfare, and the need for continuing education of extension personnel.

A crucial factor in successful transfer of new knowledge about animal welfare is the recognition that the material may be unfamiliar to many agricultural technologists and may even provoke hostility. It should also be recognised that the subject matter of animal welfare is demanding and may be misunderstood, glossed over, or re-interpreted to fit preconceptions.

Access by the rural community to tertiary education of all sorts is increasing. Accordingly, it may no longer be appropriate to restrict new knowledge on animal welfare to the traditional extension infrastructure. Formal courses in animal welfare, separate from those on animal husbandry and its connected subjects, are a possibility - for example, animal welfare courses given by university departments of philosophy or sociology. However, given the current state of the biological subject matter of animal welfare, and the rate of transfer of this knowledge into the general academic community, it is unlikely that such courses could meet the needs of people involved in the red-meat industry. Incorporation of animal welfare perspectives into existing courses on animal husbandry may be a more effective option. These courses could range from field days to weekend workshops to full-time technical college or university courses, or to part-time, distance-education courses. Presentation of the close links between biological production performance and animal welfare should be a feature of all such courses.

Public bodies and animal welfare

Most public bodies that deal with matters of animal welfare are concerned with the setting, encouragement and enforcement of community standards of care. In the main, these community standards have been distilled from opinion rather than from consideration of the scientific subject matter of animal care. This statement does not imply that such opinion is necessarily wrong. However, opinion can be wrong and is not open to correction in the absence of a framework for analysis.

Opinion that cannot be substantiated is a continuing impediment for the Royal Society for the Prevention of Cruelty to Animals (RSPCA) in its pursuit of prosecutions for the maltreatment of animals. The RSPCA is concerned about the problem of unsubstantiated opinion in animal care and welfare and the possibility of improper prosecution, as well as about the failure to press home prosecutions that may be wholly

deserved.

Until there is sufficient knowledge of the scientific subject matter of animal welfare and widespread acceptance of the idea that problems of animal welfare ought to be addressed by consideration of this rather than through intuitive opinions, there will not be a 'level playing field' for decision-making about animal use in Australia.

The implications of these deficiencies for animal-based agriculture are almost entirely detrimental. At the moment, there is no single paper, document, book or device that has the scientific elements of animal welfare in a pre-digested form for use by policy makers. This situation should be rectified.

The Australian Council for the Care of Animals in Research and Teaching (ACCART) is an innovative and appropriate solution to the problem of knowledge and information broking on the welfare of laboratory animals. A similar knowledge and information-broking service would be useful for the care and welfare of agricultural livestock.

Special features of animal welfare research

Most research into animal husbandry is directed towards improvements in productivity by enhancing the production performance of individual animals or groups of animals, or by ameliorating the production environment to allow particular genotypes to express their production potential without impediment. Improved health and welfare are usually indirect benefits of improved productivity stemming from such research.

However, to qualify specifically as animal welfare research, a given project must have the investigation and alleviation of animal suffering as its primary consideration. The concept of 'suffering' is developed and clarified below.

A high-quality research base in Australia could add considerably to the country's standing in animal welfare matters and enhance our ability to sell meat internationally.

There is widespread interest in animal welfare within those economically developed countries that buy red meat from Australia. Consequently, poor publicity about the standard of animal welfare within Australia - deserved or otherwise - could damage markets. Accordingly, Australia must be able to make a rational assessment of welfare issues, and mount a scientifically supportable defence where necessary.

The ability to match overseas scientific opinion with opinion from an equally authoritative Australian scientific source is essential. Australia may well need experts to act as advocates on the international stage. Our red-meat industry should not be placed in a weakened position through undue deference to overseas experts and the failure to foster,

through involvement with research, Australian scientists with an international reputation in animal welfare issues.

Australia has inherent advantages for research into animal welfare that have arisen from the openness and tolerance that has characterised debate on the local scene. This state of affairs must, in part, be attributed to the activity and success of the Senate Select Committee on Animal Welfare. It is possible to pursue ideas about animal use in Australia without the same constraints that occur overseas. The present advantage could be used to establish or consolidate Australia's position as a leader in research into animal welfare.

Research into many areas of animal production can be evaluated economically by determining the improved performance that comes from a given process and then extrapolating this improvement industry-wide and giving it a dollar value. It could be expected that intense competition for research funding will encourage this method of assessing the economic value of scientific research.

Under these circumstances, research into animal welfare may be at a disadvantage, because it is not aimed at producing economic gains amenable to this process of evaluation. The benefits of welfare research will relate to the red-meat industry meeting social and political requirements that allow it to operate in a socially acceptable and commercially viable way. For example, research demonstrating that a valuable husbandry operation can be performed in a way that avoids suffering may forestall antipathy from sections of the wider community and prevent damaging consequences to sales, or restrictions on the procedure through legislation.

The concept of 'suffering'

As stated above, animal welfare research must be based on the investigation and alleviation of suffering. While health (in part, the absence of disease) and well-being (in part, the absence of discomfort and distress) are major elements of welfare, the overriding element is private mental experience. When feelings and emotions are unpleasant or aversive they qualify as 'suffering'.

The deficiencies in human stewardship that can cause such suffering in animals have been defined by Ewbank (1985) as abuse, neglect and deprivation:

- . **Abuse** is 'the deliberate maltreatment of animals with resulting fear, pain and distress' and is 'universally condemned'.
- . **Neglect** may be 'either occasional or recurrent' and 'may arise through such causes as idleness, overwork, ignorance and bad design'.

Deprivation is 'a more subtle concept generally encountered in the context of intensive husbandry systems' and is 'linked to the concept of needs - which might be either physiological or behavioural'.

The presence and importance of stress in animal welfare also need to be assessed. The word 'distress' is often used in discussions of animal welfare. The American Veterinary Medical Association (AVMA) defines distress as 'a state in which the animal is unable to adapt to an altered environment or to altered internal stimuli' (AVMA 1987). Ewbank (1985) uses the term distress in a similar way to describe the adverse consequences when an animal's coping response is exceeded by a stressor.

The general fitness of an animal, as well as production performance, must be considered in the diagnosis of adequate welfare. There are some production systems in which performance is related to a physical abnormality that is not compatible with normal health. Examples are production of white veal, where the abnormality is a deficiency of haemoglobin, and *pate de foie*, where it is fatty infiltration of the liver.

A conceptual model for suffering is essential to establish diagnostic criteria for animal welfare. Such models are common in the behavioural sciences, but are not familiar to animal producers. In the animal welfare setting, a conceptual model would deal with the set of preconditions that allow for inferences about the existence of suffering and bring together hypotheses about several aspects of the complex phenomenon. Such a model would then be used to generate sets of criteria for diagnosis.

Physical pain requires special mention in the light of a conceptual model for suffering. Its essential components can be dealt with and made comprehensible by the language of physiology and pathology. These disciplines have much to contribute to the better understanding of animal welfare matters and, more importantly, to their diagnosis and management. Imaginative clinical pathology tests are needed to support diagnosis of both disease and inadequate welfare. At the moment, the role and potential of such tests are not clearly recognised.

An understanding of the effects of chemical mediators on motivational states, emotion and affect could produce innovations for deducing the presence of these mental phenomena in certain circumstances. The presence of certain mediators in certain concentrations could tally with the presence of defined motivational states. The whole area is presently amenable to research, especially by using the analytical methods of molecular biology and, in particular, message analysis of mRNA. There is a great need to explore clinical chemical 'correlates of welfare' in addition to the endorphins/enkephalins, or the hormones of the hypothalamus-

pituitary-adrenal axis.

However, while mental states are triggered by the action of chemical mediators, they depend on many other factors and derive from an intricate and impressive degree of biological organisation. It would be a pity if research on the physiology and pathology of suffering were to have clinical chemical assays as its only outcome. Suffering related to hunger, thirst, cold and heat is accompanied by premonitory physiological signals before the event. These may relate to measurable electrical changes in the whole animal, which are now accessible to continuous and non-invasive monitoring by telemetry.

Imaginative leaps ahead in this sort of technology for quality control of both production performance and welfare are now possible and should be entertained as part of a research effort.

Behavioural aspects

The study of animal behaviour is crucial to issues of animal welfare. Behaviour can both reflect and influence physiology, and physiology can determine behaviour.

Thwarted behaviour may be a source of suffering, but the connection is not absolute. On the other hand, the evocation of behaviours through environmental enrichment may unlock and facilitate physiological activity that benefits production performance. Improved productivity has been recorded in domestic pigs allowed to express the same range of behaviours as their wild counterparts (Stolba and Wood-Gush 1984). Preliminary studies have been made to test for the same possibilities in sheep (Stolba and others 1990).

The time is ripe to develop ethograms - or complete behavioural descriptions - of livestock species as a diagnostic tool for animal welfare considerations.

Issues specific to intensive and extensive systems of livestock husbandry

In general, welfare problems in intensive husbandry arise from confinement, that is, from penning and caging, whereas those arising from extensive grazing systems arise from the lack of shelter, fluctuations in the food supply, and the husbandry operations necessary for management.

Apart from these intermittent troubles, extensive grazing should be seen as having considerable welfare advantages. Animals at pasture are generally given the latitude for expressing normal behaviour. This situation should give the red-meat industry an in-built advantage compared to the poultry and pig-meat industries, where confinement of animals is usual.

Specific problems associated with extensive livestock production include spaying of cattle without anaesthesia and 'shotgun' mustering. Both occur in the beef industry of northern Australia, where conditions for animal husbandry are very different from those in temperate areas. Mulesing of sheep currently causes great and constant concern, and this is highly likely to increase. Birth difficulties in sheep and cattle, and deaths of sheep from cold stress, especially after birth or shearing, can be treated as welfare issues. Endemic diseases and diseases with a clear genetic predisposition, for example ocular carcinoma in Hereford cattle, are particular problems. All entail a strong possibility of suffering.

It is important that regional problems of welfare do not affect other more developed and consistently profitable parts of the red-meat industry. This points to the necessity for formulating regionally focussed programs for research and development on welfare issues. The brief here would be for tactical problem solving. Benefits would apply mainly to the regions involved. However, the removal of regional problems that reflect adversely on the red-meat industry as a whole would confer a general advantage to the whole industry.

The basic problem for intensive animal production is confinement of animals, which may:

- . restrict the expression of behaviour;
- . impose physical conditions that may be stressful;
- . impose nutritional regimes that may be deficient;
- . prevent animals from using their own devices to correct any minor environmental deficiencies;
- . impose untoward psychosocial stressors such as those associated with bullying and dominance;
- . increase exposure to pathogens.

Australia's traditional extensive grazing industries have now been linked to systems of intensive management in the form of feedlots. It is important, therefore:

- . that welfare concerns inherent to feedlotting are identified and solved systematically as part of the commissioning procedure for this practice within Australia; and
- . that the welfare concerns attached to feedlotting have no repercussions for pasture-feeding enterprises.

Importance of research into the general biological aspects of animal welfare

Many questions about animal welfare cannot be answered without improved knowledge about general issues such as pain and

stress in animals. For example, methods to ameliorate husbandry operations depend on species-specific knowledge about pain. This knowledge is not available, but it is clear that some key mechanisms differ widely between cattle and sheep. The research involved can be designated as 'pure' or 'basic' depending on the viewpoint taken. This research is crucial for advances in animal welfare and will give Australia a presence on the world scene.

The establishment of behavioural profiles (ethograms) and motivational choice tests for their value as diagnostic criteria for welfare status and to give insight into suffering and integrative physiology is an important priority. Such studies into environmental enrichment, using the connection between physiology and behaviour as the guiding principle, will improve both welfare and productivity.

4. SURVEY OF AUSTRALIAN RESEARCH INTO THE WELFARE OF LIVESTOCK

Methods

Research related to the welfare of livestock is not recorded in any central register in Australia. Accordingly, the following approaches were used to gather the information:

- . a search of the computerised database ARRIP (Australian Rural Research in Progress) using 'animal welfare' as the keywords;
- . a search of the current Meat Research Corporation (MRC) research program;
- . written enquiries to departments of agriculture in the States and Territories through the Sub-Committee of Animal Welfare of the Standing Committee of Agriculture; and
- . direct contact with the universities and CSIRO.

The projects identified by these enquiries have been listed in the Appendix. The absence of any particular project from this list implies no judgment on the quality or direction of the research, but simply indicates that it was not identified by the survey techniques described above as a research project concerned with animal welfare.

Projects were classified according to the considerations raised in chapter 4. The applied aspects of animal welfare were divided into areas related to activities that are mainly carried out 'on-farm' or 'off-farm'. Projects were further classified according to their species orientation. The headings used in Table 1 (page 18), which summarises this survey, are described below.

On-farm

- . *Nutrition, management and reproduction*
This group of subjects was chosen as representing the major considerations for disposition of livestock within a farm; for example, for allocating available feed to certain classes of stock during certain periods of the farm management cycle, for separating stock after mating and weaning, and for determining overall stocking rates.
- . *Animal health*
Projects in this area relate to maintaining health and vigour of animals for efficient production. They are generally carried out in parallel to the activities under the previous heading.
- . *Husbandry procedures*
This heading covers procedures performed on livestock and

contributing to the nature or efficiency of production. Included are mustering and handling, castration, dehorning, taildocking, shearing, and mulesing.

Off-farm

. *Transport and handling*

Most animals are transported at some time in their lives. Methods for transport can greatly influence the welfare and marketability of animals. One instance of particular concern relates to the export of live sheep.

. *Biology and physiology of animal welfare*

Projects in this group examine the interaction of animals and their environments and use this information to define animal welfare. They include studies in a wide range of disciplines that examine the adaptive responses of animals to their environment.

Very few projects were identified by more than one of the survey techniques described above. This shows the inherent difficulties in assessing the extent of research in any particular area without a recognised and supported central database. ARRIP was expected to yield a substantial number of entries, but was supported to any useful extent only by the Victorian Department of Agriculture (VDA) and the Australian Wool Research and Development Corporation (AWRDC).

Besides the absence of a well-supported register, several other problems were encountered in carrying out this survey and are discussed below.

Results

Sixty-two projects were identified by using the methodology described. They are classified in Table 1.

Only projects concerned with the major commercial species, sheep and cattle, were found. Fifty involved sheep. These projects were predominantly concerned with 'on-farm' issues (38), while six of the seven 'off-farm' issues related to the live sheep export trade. The 12 cattle projects were predominantly concerned with animal health (4) or transport (6). The remaining two were also production oriented, relating to slaughter processes and the effect of shade in feedlots on animal welfare and meat quality.

Five projects using sheep were classed as exploring the biological and physiological determinants of animal welfare. There were no cattle projects concerned with the basic issues of animal welfare, but it is likely that some of the findings from the sheep work could be applied to cattle if the appropriate caveats regarding generalisations across species were observed. Two projects were concerned with stress physiology in production situations, and a third (unfunded) project had a similar focus. Only two projects were concerned

with examining the physiological basis of animal welfare independent of immediate gains in productivity.

External funding of projects came from the two major industry research and development corporations, the Australian Meat and Livestock Research and Development Corporation (AMLRDC), now the Meat Research Corporation (MRC), and the Australian Wool Research and Development Corporation (AWRDC). Eight cattle projects (67%) and 17 sheep projects (34%) were funded from these sources (Table 1).

Table 1. Summary of projects in animal welfare research survey conducted October 1990

Species	Category	No. of Projects and Research Institution*	Funding	
Cattle	<i>On-farm</i>			
	Nutrition, management and reproduction	QDPI (1)	-	
	Animal health	CSIRO (3), QDPI (1)	MRC (3)	
	Husbandry procedures	-	-	
	<i>Off-farm</i>			
	Transport and handling facilities	CSIRO (2), QDPI (2) VDA (3)	MRC (4)	
	Slaughter	CSIRO (1)	MRC (1)	
	<i>Physiology</i>	-	-	
	Sheep	<i>On-farm</i>		
		Nutrition, management and reproduction	CSIRO (1), VDA (15)	MRC (2)
Animal health		AWRDC (1), QDPI (2), UM (2), VDA (12), WADA (1)	MRC (6) AWRDC (1)	
Husbandry procedures		IMVS (1), UM (1), VDA (2)	AWRDC (1)	
<i>Off-farm</i>				
Live sheep exports		Murdoch University (1) VDA (4), WADA (1)	MRC (5)	
Slaughter		QDPI (1)	-	
<i>Physiology</i>				
Behaviour, stress and immunity		CSIRO (2), IMVS (1), NSWA (1), UNE (1)	MRC (2)	
Total			62	27

*** Abbreviations**

AWRDC	Australian Wool Research and Development Corporation
IMVS	Institute of Medical and Veterinary Science
MRC	Meat Research Corporation of Australia
NSWA	New South Wales Agriculture
QDPI	Queensland Department of Primary Industries
UM	University of Melbourne
UNE	University of New England
VDA	Victorian Department of Agriculture
WADA	Western Australian Department of Agriculture

Perceptions about what constitutes animal welfare research

Most research connected with animal production has the capacity to shed light, at least indirectly, on issues of animal welfare. However, there appears to be great confusion about research that can be regarded as having animal welfare as its prime consideration.

Classification seems related largely to the degree of understanding by individuals about the subject matter of animal welfare. It may also be influenced by perceptions of whether animal welfare research is a 'good' or 'bad' activity with which to be associated. VDA freely acknowledges the implications of its research projects for animal welfare, including some in financial and pasture management. Other States and institutions have not classified similar projects in this way. Even within institutions there was evidence of contradictory views on the question of classification of projects. It was the obvious confusion about what constitutes research in animal welfare that prompted the overview of the role of animal welfare research presented in chapter 3.

Future databases or registries of animal welfare research would benefit by the development of systems for classifying different kinds of research - for example, research that mainly addresses animal welfare, or research with a major emphasis on production, but with some orientation towards welfare. The use of such systems by researchers could be facilitated by issuing notes on their use and checklists of key words.

Reluctance to disclose information

Reluctance to disclose information on animal welfare matters was encountered in several institutions. This was presumably prompted by concern about confidentiality, security, and the prospect of attracting unwanted attention. The extent to which these concerns reflected personal rather than institutional attitudes could not be discerned. It does, however, point to the need for institutions to rationalise their positions, especially in regard to disclosure of projects and keywords in databases such as ARRIP.

While these difficulties prevented a definitive survey of research projects related to animal welfare, a broad appreciation of the extent of research into the area was achieved. A comprehensive survey is possible only if problems of classification, registration and disclosure of information are remedied.

Conclusions

The tabulated survey results (Table 1) and the project outlines in the Appendix show that much of the research identified by the survey has a strong orientation towards

animal production goals. Several conclusions can be drawn.

- . The subject matter of animal welfare for domestic livestock, and that of efficient animal production, have many elements in common. Overviews of specific industries would be helpful in identifying welfare-related opportunities to enhance production and allow emerging welfare problems to be pre-empted.
- . Much of the research identified could have been justified on the basis of either gains to animal production or to animal welfare. Concern about animal suffering should be the major factor related to definition of projects in animal welfare though production gains would normally be expected to be involved as well.
- . There are probably many research projects not identified in this survey that could claim relevance to animal welfare on criteria similar to those described in the present report. It may be useful if future projects from fund-granting bodies were recorded in a central data-base such as ARRIP to simplify assessment and management of research in animal welfare.
- . If a true indication of the research effort related to animal welfare in animal production is required, then vastly improved systems for definition and recording are also required. At the present time and with present recording systems, it is possible to underestimate substantially the extent of interest and activity of the red-meat industry in addressing matters of animal welfare. This could be detrimental to the industry.
- . Without greater emphasis on basic biological and physiological research leading to improved definition of animal welfare, and without heightened awareness among researchers and their associates of the implications of animal production research for animal welfare, a true indication of the extent of welfare and welfare-related research is unlikely to be obtained.
- . Currently there is little emphasis on animal welfare research that is not directly concerned with gains in production processes. While this research is desirable and commended, there is a risk that without research to define the scientific basis of animal welfare, the major issues may be ignored or not given the priority they deserve. Similarly, some issues may be wrongly identified as having animal welfare concerns and divert effort away from more important problems.
- . Projects or systems that report and collate events in the field which compromise animal welfare or production may be useful in setting priorities for future research and development activities.

There was little evidence in the survey of systematic pro-active research into the suitability of industry practices in either new or established industries. Several projects, notably the work on live sheep exports, have been reactive rather than pro-active. Indeed, a rational research and development program at the outset of this trade could have forestalled many damaging problems.

In this context, good research policy can be seen as inherent to good business policy. Thorough pilot studies must be regarded as a desirable strategy before large scale enterprises are embarked on, or before new forms of husbandry or modifications to procedures are introduced. The current expansion in beef feedlots is an obvious area where research at an early stage may save costly adjustments later. There was only one project on feedlots revealed in this survey and it was funded from Queensland Department of Primary Industries sources.

There appeared to be little research on established practices and the contribution or otherwise they make to current systems of management. Some cases in point are flystrike control and mulesing in sheep and surgical spaying in cattle. Absence of such research suggests an approach to animal welfare problems that is reactive and which does not view animal welfare as an integral part of an animal production system.

As stated elsewhere, good animal welfare and efficient animal production are strongly linked. Production efficiency of animals is an important indicator of welfare status, and perturbations in welfare are likely to be reflected by reduced productivity. In this light, failure to review industry practices for their welfare implications can be viewed as a failure to seize opportunities for further enhancing the efficiency of animal production.

5. SPECIFIC WELFARE ISSUES

Intensive systems

This paper is not a comprehensive description of the welfare problems of intensive livestock production or a code of practice for the conduct of enterprises. Rather, it attempts to provide some insights into the major welfare problems in these systems and suggests areas of research that may result in improvements in the welfare and productivity of livestock.

The themes for research in intensive systems of animal production are:

- . the need to accredit all production systems and procedures from the viewpoint of welfare;
- . the emerging need for quality-assurance procedures for animal welfare; and
- . the use of suffering as the defining feature of welfare.

White veal production

There is no specialist production of white veal in Australia along the lines of the European system of close confinement in 'veal crates'. This is fortunate, as the veal crate system has a number of deficiencies from the animal welfare viewpoint, including inadequate space, sensory deprivation, poorly designed crates and inadequate diets.

Diets used in white veal production are low in iron, (which causes anaemia) and fibre content (which depresses rumen development and activity). Although growth rates may be comparable to those of paddock-raised calves, these vealers may have major differences in functional ability, such as strength and exercise tolerance. In this instance, normal growth rates are not sufficient indicators of good welfare practice.

Australia has no need for specially produced white veal and there is considerable opposition to such operations here. Sources of opposition have included government departments and community-based organisations.

The survey did not identify any projects on this subject.

Bobby calves

Unweaned or 'bobby' calves are sold at an early age, usually within the first few weeks of life. Because of their lack of development, they are particularly susceptible to injury, disease, fatigue, dehydration and other stressors. They need specialised care and nutrition for their health and welfare. Codes of practice exist and others are being revised to

address the needs of bobby calves.

Particular attention is being given to the need for regular feeding, and protection from environmental insults such as climatic extremes, infectious agents and physical injury. Most problems with bobby calves are associated with extended times from departure from the farm of origin to arrival at abattoirs and eventual slaughter. It is recommended that suffering associated with the feeding, sale, transport and slaughter of young calves be investigated. Measurement of clinical, physiological, psychosocial and production parameters may provide a means of reducing suffering and production losses. On-farm sale by description may also alleviate these problems.

The survey did not identify any projects on this subject.

Feedlots

Beef cattle

The rapid expansion of beef-feedlotting in Australia has provoked debate on a range of issues including animal welfare. In the main, concern about animal welfare relates (1) to nutrition and (2) to confinement of a species with adaptations for a pastoral environment.

The full implications of feedlot diets on the health of ruminants have not been explored in Australian conditions. So-called subclinical disease (i.e. disease detected only through poor production performance) is of particular interest in this regard. The choice of dietary ingredients and their impact on animal health and welfare, and product quality, are also largely unexplored.

It is unfortunate that the selling point of feedlot produce often relates to the time spent consuming a diet with a certain content of grain rather than to direct descriptions of the product's desirable characteristics. Emphasis on desirable characteristics themselves may lead to husbandry systems in which the market demand for quality is satisfied either through shorter periods in feedlots with diets of lower grain content, or through systems of paddock grazing where supplementary feeding can be used to boost performance at critical times. These other possibilities for attaining consistent quality of produce may have economic as well as welfare advantages.

Confinement of cattle at high stock densities in feedlots could increase disease risks and psychosocial problems. In addition, confinement in a feedlot limits an animal's own attempts to escape from environmental stressors such as heat, cold, high humidity, dust and ammonia. Given the possible increased exposure of feedlot cattle to a range of stressors, there has been relatively little investigation into the

effects of this system of husbandry on overall disease resistance.

Determining those aspects of feedlots that affect animal welfare will be an on-going process. Cooperation between industry and researchers is needed to develop a system to collect quantitative data that provide a description of problems. This information will be a basis for determining research directions.

Specific projects could examine the effects of a range of feedlot diets on ruminant pathology and physiology. This should include description of the diet and the pathophysiology of any disease entities associated with it, such as rumenitis and rumen acidosis, laminitis, liver abscesses or clostridial diseases. In addition, the effects of diet on the biochemical profile of animals and the wider implications of that profile for both the biological function of the animals and product composition and quality should be examined. Aspects of biological function would include neural and muscle biochemistry, nutrient partitioning, efficiency of nutrient utilisation, immunocompetence and maintenance of homeostasis.

Behaviour can be an important aspect of achieving homeostasis, providing there is sufficient environmental variation to allow expression of behavioural drives, such as shade-seeking. Examination of the behaviour of feedlot cattle and comparison with the normal ethogram may indicate dysfunction or adaptation induced by the environment. Where behaviour, physiology or pathology is different to that of pastoral cattle, the possibility of environmental inadequacy and consequent suffering must be considered.

Environmental modification or enrichment may be of use in investigating some aspects of these questions. 'Environmental enrichment' refers to alterations in the conditions under which animals are housed that are directed at meeting behavioural, rather than strictly physical, needs. Environmental enrichment is an important part of the husbandry of primates kept in zoos.

One project, which related to the effects of shade in beef cattle feedlots on animal welfare and meat quality, was identified in the survey. (See project 1 in Appendix.)

Dairy cattle

The issues that apply to beef cattle feedlots also apply to dairy cattle feedlots. However, dairy cattle feedlots have additional issues relating to pregnancy, parturition and lactation. (The latter may also apply to beef feedlots where pregnant females are involved.) Little dairy feedlotting occurs in Australia and, as with beef feedlots, there is little knowledge of health and welfare problems under local conditions.

As for beef feedlots, development of a system to compile and analyse data relating to the effects of feedlot nutrition and confinement, gained under local conditions, is the first and logical step in defining problems that may arise. This would allow subsequent efforts to improve health, welfare and productivity to be directed according to a scientific basis.

The survey did not identify any projects on this subject.

Sheep

This section will not deal with live sheep exports, as this has been the subject of specialist publications sponsored by the Meat Research Corporation. The approach in these publications is consistent with the general philosophy of systematic investigation of problems and the scientific setting of research priorities advocated here.

Several intensive systems have been used for production of meat and fibre in recent years, and pre-export feedlots are enormous. Many intensive systems have ceased production owing to economic factors, but different conditions in the future may see their return. It is unlikely that they would ever reach the size of cattle feedlots. However any intensive system has the potential to cause animal welfare problems, regardless of scale.

Housing of sheep for 'Sharlea' wool production has attracted criticism related to physical and psychosocial problems in sheep. Examples are arthritis, foot and dental problems, and behavioural problems such as wool-biting.

Research priorities for intensive sheep production are similar to those for cattle feedlots. Research is needed to develop systems that can be used to identify the problems that exist in intensive farming systems. Clinical diagnostic systems for disease and physical injury are already well developed, and their application to production systems accepted. Diagnostic schemes for behavioural or psychosocial abnormalities are not as well developed, nor is their application to production problems common. Research is needed to establish suitable ways of measuring these disturbances and the extent of their involvement in situations of reduced productivity.

The survey did not identify any projects on intensive sheep production.

Extensive systems

Discussion of animal welfare matters in the extensive pastoral industries of Australia is complicated by the great range of biological, cultural and economic environments in which the activities take place. It is difficult to judge the acceptability of certain practices independently of the environment in which they occur. It is equally difficult to

accept that certain acts can be legitimised by deficiencies in skills, facilities, availability of labour, or economic constraints. It is within this context that animal welfare practices must be judged. Environments for extensive husbandry are as diverse as the Kimberley region of Western Australia and the relatively well-developed pastoral areas of south-eastern Australia.

There is a continuing need to monitor the situation in the field as farm practices change in response to changing economic, social and biological circumstances. The types of data required for this monitoring, and the methods for collection and analysis of data, should be under constant review.

Feed and water

Provision of supplies of feed and water commensurate with the numbers of stock carried throughout the year is a primary responsibility of pastoralists. Predictable seasonal variations should be accounted for, and provision should be made for contingencies such as flood, fire, drought and other calamities. Important here is general research into improved management through decision-support systems that set sustainable stocking rates and provide a basis for either avoiding feed shortages or reducing such crises to manageable dimensions.

Management options during such crises must account for the welfare of animals. Progress in nutrition and digestive physiology have increased survival rates during drought feeding and improved the efficacy of supplementary feeding. However, attention to behavioural aspects of feed acceptance and its continued intake through the feeding period may improve results still further.

Information about ideal liveweights and growth rates for various classes and genotypes of livestock has an important and unrealised potential for assessing the production performance and welfare of grazing animals and for the diagnosis of production-limiting disease. Accreditation for the 'ideal' nature of this information would come from those weights that allow for full expression of key physiological responses, such as disease resistance mediated by acquired immunity.

Poor immunocompetence carries an increased risk of suffering brought about by parasitism or infectious disease. Accordingly, liveweights provide a rapid, preliminary estimation of the adequacy of the nutrition, general husbandry and welfare of animals. Their mean value plus their skewness and spread may be of great help in unravelling the multivariate nature of many disease and welfare problems.

Further research in the following areas may improve the welfare of animals under extensive system of husbandry:

- . decision-support systems for stocking rates and pasture management;
- . nutritional and physiological aspects of drought and supplementary feeding;
- . behavioural aspects of drought and supplementary feeding; and
- . development of tables of acceptable liveweights for stock.

Five projects were identified in the area of extensive management. Two were concerned with the role of nutrition in peri-natal lamb mortality, and three were concerned with the effective allocation of farm resources (pasture, feedstuffs and finances) to adult sheep nutrition. (See projects 15, 16, 17, 18 and 21 in Appendix).

Climate and shelter

Cattle and sheep can normally tolerate the climatic fluctuations encountered in Australia. Losses generally occur only in situations of extreme variation or where husbandry systems prevent the operation of homeostatic mechanisms.

Little can be done to avoid extreme fluctuations of weather or other natural phenomena. However, their effects can be reduced by accurate prediction of their intensity and duration, by preparation of appropriate counter measures such as evacuation of stock to safe areas and provision for supplementary feeding, and by manipulation of the farm environment to ameliorate the effects of natural phenomena.

Improved accuracy of predictive meteorological and bioclimatic models would further assist the ability of graziers to lessen the effects of events such as drought, bushfires and cold snaps. Investigation of the physiological status and metabolic requirements of livestock during natural disasters would also assist in formulating improved measures for stock care before, during and after these sorts of events.

Aspects of the farm environment also interact with climatic parameters and can affect both the severity of climatic episodes at farm level and the ability of animals to cope with climatic stressors. Aspects of the farm environment can be conveniently divided into those associated with the physical form of the farm, such as farm structures, and those associated with farm practices. The degree of interaction between the two is obviously great.

Farm practices, such as selection of time of mating or shearing, can have profound implications for productivity and animal welfare. Timing is often determined by availability of

labour or competing activities, but the biological consequences are often imperfectly understood and not adequately considered in the decision-making process. Sheep losses after shearing or lambing can reach high levels of mortality and extend further to produce lowered productivity in survivors.

Attempts should be made to evaluate the times of lowest risk for these events and investigate the factors that contribute to losses. What, for example, are the factors that induce anorexia in shorn sheep? Is it related to the restraint used, the tissue damage that results from shearing, or the inability to maintain body temperature after the loss of the fleece? Answers to these basic questions would assist in finding strategies to reduce losses and suffering off-shears.

Systems that monitor stock losses, make diagnoses and report, record and analyse the resulting information would provide a reliable basis for determining the best times for farm activities and other corrective measures. Integration of existing regional veterinary structures and agricultural extension services may provide the infrastructures that would make this possible. Accurate diagnosis and investigation of causes of deaths and reduced biological production or fitness of animals is vital to reducing the effects of a range of factors that compromise animal welfare.

Assessment of the impact of the physical and social environments of livestock on their integrated physiological reactions has not been pursued to any great extent in Australian environments. This is unfortunate as it may provide solutions to many welfare and production problems, such as post-shearing anorexia and associated losses off-shears, failure-to-eat syndromes in drought-feeding or feedlot situations, the need for shade in pastoral and feedlot environments, and occurrence of diseases of adaptation.

The role of trees in the farm environment is particularly important. Trees can have profound effects on parameters such as wind speed and chill factors, solar radiation loads, evapotranspiration, pasture productivity and sustainability, water quality and soil erosion. The current government encouragement of tree planting through community land care groups offers an opportunity for involvement of the agricultural sector in activities that may prove of long-term benefit to productivity and animal welfare. Information on planting techniques and placement strategies for windbreak and shelterbelt establishment exists, but not on the scale proposed in the 'billion trees' program. There are thus opportunities to integrate an on-going research and development program with the tree planting programs.

The survey identified two research projects on the effects of agroforestry (trees) on productivity at farm level, and flow-ons to animal welfare. (See projects 20 and 26 in Appendix.)

Major improvements can be expected in welfare through integrated studies of farm structures, microclimates, farm practices and the integrated physiological responses of animals. Development of improved systems for investigation and reporting of field losses would provide valuable information to assist in this process.

The value of existing climatic and meteorological forecasting services has been established. Further progress can be expected in this area.

The provision of shade and shelter through shelter belts of shrubs and trees is highly desirable. Research and development related to demonstrations of the value of shelter and to extension and technology transfer on this topic would have palpable benefit.

Disease

Disease compromises animal welfare through the pain and suffering produced by tissue damage, inflammation, toxaeemias and other pathological processes, and by suffering arising from emotive and aversive experiences associated with previous episodes of disease. As well as compromising welfare, most disease episodes compromise productivity and product quality.

Product examination can reveal much about the experiences of an animal: wool breaks or tenderness, carcass faults such as caseous lymphadenitis (CLA or cheesy gland), grass seeds, liver abscesses, fluke lesions, bruising and hide damage all indicate processes that have put animal welfare at risk. Integration of this sort of information with data from properly diagnosed field outbreaks and accompanying epidemiological data could be of great use in determining priorities for research and in providing some insights into research directions. In addition, developing such information systems would make for greater use of facilities and personnel already available.

Manipulation of an animal production system can either cause disease or predispose animals to outbreaks of disease. For example, wrinkliness in sheep was seen as a desirable characteristic and was the object of genetic selection. Increased susceptibility to flystrike and a welfare problem of large proportions has been the legacy. Welfare concerns are also raised when strains or classes of animals are kept in environments that are either physically or nutritionally unsuitable. Examples here are animals adapted to and originating from temperate climates, but kept in tropical areas; and twin-bearing ewes kept in areas with inadequate feed.

Selection can lead to the propagation of genetic diseases and these, by definition, raise welfare concern through the possibility of suffering. Examples are citrullinaemia, mannosidosis, dystocias and some forms of arthritis. There is

thus a connection between animal welfare and the preservation of quality genestocks - a core issue for sustainable agriculture.

Preservation of genetic diversity has implications for the ability of animals to adapt to future environments and the demands of future production systems. Genotypic adaptability and the absence of genetic disease will thus affect the welfare of animals into the future. These concerns must be accounted for in the genetic selection programs of the present.

There has been surprisingly little research to determine what events are stressful to farm animals and how stress is manifested. Indeed, the techniques for measuring the manifestations of stress are themselves relatively poorly developed. There has been a fixation on hormones associated with the adrenal cortex. Without development of thematic or generic physiology in this area, little progress can be expected in the more specific area of assessing stress in farm animals. Improved systems for reporting and collation of disease and production investigations in extensive animal production systems, taking into account predisposing genetic and environmental factors, may be valuable in determining priorities for activities in this area.

Nineteen projects were identified in the area of welfare related to disease. Four concerned cattle diseases and fifteen concerned sheep diseases. A variety of diseases of parasitic, toxic and microbiological origins, and opportunities for reduction or removal of their occurrence or effects, were under investigation. (For details of individual projects see projects 2-5, 28, 34-36, 39, 40 and 42-50 in Appendix.)

Husbandry operations

Husbandry operations such as castration and taildocking involve surgery and tissue damage. As a result, the shared welfare concern is suffering related to physical pain. Other sources of suffering in these situations are the motivational/emotional states related to fear and anxiety.

Pain itself has been described as a 'needs state' (Wall 1979) which entails observable physiological consequences as well as private and aversive feeling tones. The physiological consequences of the pain-state militate against production performance. Matters of welfare and efficient production performance converge yet again.

The major objectives of research into the welfare aspects of surgical operations can be summed up by the three R's that have been described for animal experimentation (Russell and Burch 1959). These are:

. **replacement** - which means the search for a more acceptable

means to the same end;

- . **refinement** - which refers to ways in which a procedure may be ameliorated; and
- . **reduction** - which means limiting the number of times an animal need be confronted with unpleasantness.

The use of adequately accredited forms of chemical castration and spaying would thus *replace* surgical castration or spaying and avoid the tissue-damage pain involved. A *refinement* may be the use of Burdizzo castrators instead of the knife for castration; that is, of course, if evidence showed that Burdizzo castration caused less suffering. *Reduction* speaks for itself.

Castration and taildocking

Welfare questions relate to the practice of these procedures and the husbandry systems that require them. Development of 'bull-beef' systems and the increasing sale of entire ram lambs have reduced the need for castration, though in relatively small numbers of animals. The need for taildocking could also be re-assessed in environments where nutritional, parasitic and other forms of scours are controlled.

In environments where these practices have been appraised and deemed necessary, the aim of research should be to minimise the pain and suffering that attaches to them. This aim is most likely to be achieved by systematic examination of specific techniques. Transfer of research findings to the farming community and the implementation of improvements is essential.

New knowledge may be required to measure the impact of particular techniques on animals. Assessment would include examination of healing times and the effect of a given procedure and associated handling on the integrated physiological responses of the animals. The incidence of post-operative complications would be an important consideration.

Behavioural and physiological comparisons of castration and taildocking with elastrator rings or the knife have been made in lambs and calves by two different groups of investigators. The conflicting conclusions depended on how various behaviours were interpreted in relation to pain. This sort of approach has promise for identifying ways in which castration and taildocking may be ameliorated. However, the distinction between first pain caused by the threat of tissue damage and second pain caused by tissue damage itself should be accounted for. So should the range of methods for castration.

The last major scientific review of castration methods and their impact on productivity occurred in the mid-1960s. Adjustments to management may lessen the need for these two

operations. It is noteworthy that castration is not normal management practice for pigs in Australia. The need for castration, taildocking and similar husbandry procedures should be the subject of regular reviews, similarly the physiological and behavioural consequences of these procedures should be assessed to allow refinements to be developed and put into practice.

Immunocastration offers the hope of replacement of surgical castration. Expectations, however, should be realistic. For example, improvements in convenience, efficacy and cost are limited by current technology for immunological adjuvants. Advances in this area are most likely to arise from general progress in immunology and reproductive physiology.

Two survey projects were identified in this area. Both were concerned with the development of immunologically based alternatives to castration and spaying. Neither addressed questions related to taildocking. (See projects 19 and 22 in Appendix.)

Spaying

Spaying is practised to prevent pregnancies in cows destined for slaughter. The practice allows for increased liveweight gain and reduces the level of mortalities, especially in older cows.

Spaying causes tissue damage and produces a high probability of infection and subsequent pain and suffering. The acceptance of spaying by lay operators - without the use of anaesthetics, antibiotics, sterile technique or analgesics - can only harm Australia's image and provide the possibility of non-tariff barriers to trade.

Immunological techniques have been suggested (e.g. 'Vaxstrate') as an alternative to surgical spaying. Surgical spaying is a characteristic of production systems with low productivity, low levels of management and variable environmental conditions. It is unlikely that these enterprises could afford the material costs of immunological spaying or the difficulties of booster shots. Nor is it likely that a high proportion of immunised cattle would be mustered again within the period of protection against pregnancy. A further problem exists in that the efficacy of immunisations cannot be guaranteed in environments of high stress due to handling, social, climatic, nutritional and disease factors. The likelihood of immunisation replacing surgical spaying is probably small.

To protect Australia's international trade and the welfare of our animals, surgical spaying must be restricted to veterinary surgeons and involve anaesthesia and analgesia. Spaying should be discouraged as an aid to productivity.

Two survey projects were examining the development of

immunological alternatives to spaying and were located in Victoria. (See projects 19 and 22 in Appendix.)

Dehorning

Horns cause economic losses through carcass bruising, agonistic encounters and reduced growth rates. Horned cattle cause particular welfare concern in feedlots. While surgical removal of horns reduces these problems, it involves extensive tissue damage, pain and suffering, especially in mature animals. At present lay operators can dehorn animals younger than 6 months old. Veterinary surgeons are required to dehorn animals older than this and use appropriate anaesthesia and analgesia. The absence of long acting, efficacious analgesics for ruminants is a problem in this area, as it is for other surgical interventions in ruminants.

A strategy of replacing horned cattle with polled cattle would pay long term dividends and the major stimulus for this may well come from advances in reproductive technologies that allow rapid proliferation of selected genotypes.

Identification (branding and ear tagging)

Identification of individual animals is desirable to assist in management, quality control, disease traceback and prevention of theft. Legislation requires certain measures to be taken for these purposes and tends to rely on tattooing, earmarking and branding. Most concern is attached to the tissue damage caused during the processes, especially branding with hot irons. Freeze branding has been suggested as a way to reduce the tissue damage and associated pain, but has logistical problems in much of Australia and is unsuitable for white-coated cattle.

The search for a suitable alternative continues. Considerable hope is pinned on the development of implantable transponders for individual identification, but these too have problems. As the power and range of transponders increases, the possibility of their use for general identification will increase. However, with present technology, there seems little hope of replacing hot-iron branding. Reduction in the use of hot-iron branding could occur if freeze branding was encouraged in dark coated cattle in parts of Australia where logistics permit.

The major improvements that can be expected in this area may well be brought about by refinements to existing techniques, through extension material and field days to ensure that hot-iron branding takes place using irons of the right design and at the right temperature.

The survey did not identify any projects on this subject.

Blowfly strike and mulesing

The control of blowfly strike in sheep is a major animal welfare issue. The problem arises from the pain and suffering caused by fly strike or the means used to control it. Much attention is given to the surgical operation of mulesing to remove wrinkly skin from around the breech of sheep.

Community support for the continued use of mulesing for the control of myiasis has been based on judgments about the balance of benefits and harm. Put simply, the pain and suffering associated with flystrike has been assessed as greater than the pain and suffering associated with mulesing. The the pain and suffering caused by fly-strike is enormous, considering the degree of tissue damage and the consequent release of neuro- and immuno-modulators. Death from flystrike appears to come from peripheral circulatory failure or shock.

This simple analysis, however, begs the question of whether mulesing is always required. It does not consider some of the detrimental effects of mulesing, which relate to productivity as well as welfare. Mulesing itself is not always carried out in a professional manner. In many cases, the benefits of mulesing in regard to myiasis are lost because of the spread of other diseases transmitted during the mulesing operation. Examples are outbreaks of eperythrozoonosis and spectacular incidences of septicaemia and arthritis. Mulesing may also interfere with other operations. For example, it is not possible to handle sheep for many weeks immediately after mulesing, and this may interfere with programs for controlling other diseases such as footrot and parasite infestations.

After mulesing, sheep endure chronic pain, anorexia, and immobility, which reduce their ability to graze selectively and avoid bio-climatic stressors. Reduced nutrient intake coincides with post-operative stress and infection leading to severe weight loss, often equivalent to a severe outbreak of fly strike itself. Episodes of severe stress and infection interfere with growth, reducing mature liveweight, and depress lifetime productivity. Immune responsiveness is similarly depressed.

The ethical stance that accepts mulesing as a form of fly strike control can only be maintained if vigorous research efforts are being made to provide alternatives. The existence of either fly strike or mulesing is likely to provide the focus for consumer resistance to sheep products or non-tariff barriers to international trade in all animal products from Australia.

Research priorities in this area are a major concern for Australia's animal industries. Emphasis should be placed on the development of integrated control programs with mechanisms for feedback, collection and collation of field data and interactive adjustment of programs for individual farms. Some lessons can be learned from the 'integrated control programs'

for internal parasites, and undue reliance on chemotherapeutics should be avoided. The first step in embarkation on the development of an integrated control program should be a critical review of the scientific literature of the subject and an integration of the existing knowledge as a sound base for further progress.

Responsibility for research into the control of blowfly strike and alternatives to mulesing reside with the sheep and wool industry in the first instance. However, there are repercussions for the red-meat industry, and MRC must keep a watching brief and undertake liaison to ensure that necessary research is continued.

Four survey projects were identified in this area, covering the topics of blowfly ecology, blowfly attractants, vaccines against blowflies and wool follicle biology as an aid in developing an alternative to mulesing by defleecing. (See projects 30, 33, 38 and 41 in Appendix.)

Dentistry and tooth-grinding

The practice of dentistry on sheep that was prevalent some years ago has been abandoned, largely because of opinions that it produced no benefits to animal productivity and was expensive and labour-intensive. Tooth grinding was condemned by the Australian Veterinary Association and animal welfare organisations as causing unwarranted pain and suffering to animals.

More importantly, however, the process of tooth-grinding underwent critical and systematic examination and is a good case study on how issues of animal welfare can be assessed in a scientifically defensible manner. The upshot of the assessment was that tooth-grinding was not as aversive as expected. On the other hand, it gave no demonstrable benefit and thus could not be justified.

Nevertheless, research based on interactions between pasture botany, soil types, stocking densities, supplementary feeding, aspects of nutrition including minerals, and other factors that may play a role in preserving dentition could be useful.

Two survey projects were identified in the area of dentition - one on the animal welfare aspects of tooth grinding, the other on the causes and incidence of incisor tooth loss and effects on productivity in the wool industry. (See project numbers 29 and 37 in Appendix.)

Shearing and electro-immobilisation

Shearing is a central activity on wool producing enterprises, even where the primary aim is meat production. While there has been research aimed at specific aspects of the activity, there has been little integration of this knowledge to provide an overview of where research should be directed or what form

shearing processes should take to satisfy market, production, industrial or welfare considerations in the future. Such an overview would be a major task involving a multi-disciplinary approach.

Major problems associated with shearing include stress, anorexia, lacerations, disease transmission and mortalities, especially where dipping off-shears occurs. There has been little investigation into the causes of the stress and consequent derangements, and little is known of the relative contributions of handling stresses, nutrient intake, metabolic re-adjustment or shearing injuries. Without this specific knowledge, development of counter measures is difficult.

Electro-immobilisation has been pursued to facilitate husbandry procedures on animals, particularly robotic shearing. Widespread support of this technique is not likely until immobilisation techniques show evidence of electro-anaesthesia or analgesia and assurances can be given that no adverse effects are produced. Developments in this area will only proceed after basic research into the effects of specific electrical inputs on integrated physiological responses of animals have been described.

Research in this area falls within the province of the Australian Wool Research and Development Corporation. However, there are repercussions for the red-meat industry related to Australia's reputation for adequate animal welfare. Accordingly, a watching brief is necessary for MRC.

Development of research priorities should centre on reducing the deaths, injuries, diseases and suffering arising from shearing and associated practices. An approach that recognises the integrated physiological and behavioural responses of shorn sheep should be the basis of any project. It is unlikely that substantial progress will be made without improved understanding of the basic processes involved, and it is suggested that this will arise from properly designed experimental studies, rather than from further field observations. Field observations will be necessary, however, as part of the process of implementing modified practices and assessment of efficacy under field conditions.

Electro-immobilisation appears to offer no great advantages to the red-meat industry and, apart from basic investigative research, should not be a high priority when issues that involve suffering of large numbers of animals still require resolution.

Two projects were identified that sought to investigate the effects of electro-immobilisation on sheep and, through examination of these effects, alternative techniques to improve the chances of finding acceptable ways of immobilisation. (See projects 31 and 32 in Appendix.) No survey projects were identified on existing shearing techniques and their effects.

General handling

Handling of animals can be stressful and create escalating problems of behaviour. This situation is not inevitable. Handling can provide the opportunity for dampening behavioural responses through the recognised processes of habituation and learning. The benefits here can flow to physiological function and extend to improved production as well as to improved welfare. A prime example relates to reductions in bruising and carcass damage that can come from improved handling methods. Research leading to improved methods for handling animals could decrease the incidence and severity of accidents at all levels of the red-meat industry.

Design standards for animal handling facilities have improved in recent years as knowledge of animal behaviour has improved and been incorporated. This process should continue and extend to improvements in extension and technology transfer, which should encompass handling skills and attitudes as well as design of facilities.

Emphasis on the costs of poor handling in terms of labour requirements and damage to stock need to be presented. Handling of stock has been regarded as an unskilled task in the past. Much can be learned through experience. However, on-the-job training schemes would be valuable for stock owners and handlers involved with transport, saleyards and abattoirs and should be the subject of research and development. Abattoirs in particular are well placed to monitor the success of training programs through post-mortem assessment of bruising.

The survey did not identify any projects on this subject.

Transportation

Transportation is a process that can cause major compromises to animal welfare. It is increasingly the focus of research and development to improve facilities and practices involved in moving livestock. Many of the factors that affect animal welfare during and after transport are known, and estimates of the losses they cause have been made.

Schemes have also been devised to link economic penalties to carcass damage incurred during transport (e.g. *An objective bruise scoring and penalty system for the Australian beef industry* produced by the Livestock and Meat Authority of Queensland). This sort of scheme is important, not only because of the incentive for sound handling and transport of livestock, but because it provides a base for documentation, on a representative and on-going basis, of the injuries and lesions sustained during transport.

Specific problems, such as dehydration, bruising and trauma, dust inhalation, exhaustion and low muscle glycogen, could all be detected by relevant procedures. Examination of existing

scientific literature could help in formulating a more exhaustive list of parameters. Depression of immunocompetence due to stress, and effects on the incidence of salmonellosis or bacterial contamination of carcasses may be examples of the kinds of linkages that exist.

Research should investigate reporting systems that collect and collate information on the clinical, physiological and psychosocial consequences of transport procedures. Setting up such a system would clarify the nature and extent of problems and provide a scientifically defensible basis for setting and reviewing research priorities and directions. An on-going scheme would also serve to monitor the implementation of research recommendations and the success of education and extension in the field. Strong emphasis is placed on information from abattoir sources in the first instance. Abattoirs have the necessary infrastructures for ante- and post-mortem examination of animals and the ability to take samples for further study and to keep appropriate records. The presence of highly trained staff within the abattoir system would also assist in the execution of such a project.

More immediate research effort is required to improve the design of stock transporting systems. This must not be encumbered by external influences such as competition between road and rail. Current research is low key and there is little evidence of active communication between research groups throughout Australia. Given the large economic and welfare cost of transportation and the high public visibility of welfare problems related to transportation, this situation should be given a high priority for improvement.

Research into transportation must be multidisciplinary, merging the skills and knowledge of biologists, engineers and manufacturers. Research projects into transportation can have large pay-offs and may require large budgets. Currently there is large public expenditure on road networks, and little on new rail infrastructure. The relative efficiency of road and rail transport needs to be examined from the aspects of both animal welfare and product quality.

Twelve projects were identified in the area of transportation. Six were concerned with the movement of cattle to abattoirs and the avoidance of stress, injury or loss of value to the meat product (projects 6 to 11 in Appendix). The remaining six projects were concerned with the live sheep export trade and were centred on maintaining nutrient intake during assembly, adaptation and export of shiploads of sheep. These studies included behavioural and disease aspects. (See projects 51 to 56 in Appendix.)

Slaughter and abattoirs

Slaughter of animals is likely to remain a contentious issue for the red-meat industry, irrespective of improvements in technology and their application within abattoirs. A variety

of factors produces this state of affairs:

- . Arguments about the desirability for humane slaughter can merge and be confused with bio-ethical arguments about the prerogative of people to kill animals for food.
- . The reflex and negative response to the sight of blood and carcasses has a strong impact and can leave a lasting impression on many people. The resulting emotional response can be more powerful than that stimulating concern for animals.
- . Differing cultural and religious outlooks create different requirements for the slaughter of animals and are a source of potential conflict.

These circumstances could pose a threat to the objectivity required for scientific analysis. Nevertheless, scientific analysis can provide common ground for the resolution of conflict. An important proviso is recognition that scientific research will not furnish the total solution to religious and cultural differences about the methods used to slaughter animals for food.

The welfare problems associated with the slaughter of livestock occur at two points - during the period immediately before slaughter and during the slaughter process itself. The problems of suffering during the first period relate to the motivational state of fear, and pain from tissue damage brought about by inadequate handling and consequent injury. The problem of suffering during the process of slaughter relates to tissue damage and pain in the time between the start of the slaughter process and the onset of unconsciousness that precedes death.

This raises an area of uncertainty. Do animals have concepts of death and are the metaphysical uncertainties a source of suffering for them as they are for people? According to their explanation in *The self and its brain*, Popper and Eccles (1977) have a structure for mind that indicates that consciousness of self and death emerged with human language. This explanation means that it is unlikely that fear of death itself is a source of suffering in animals. Unfortunately, humans are likely to project their own concerns at this point. Perhaps the red-meat industry requires more knowledge in this area.

The scientific and technical aspects of slaughter have been encapsulated by Blackmore and Delany (1988) and Rose, Daly and Shaw (1991). Some comments are required.

- . Stunning before slaughter to cause unconsciousness was recommended many years ago, and in the absence of any means for accrediting the effectiveness of the methods used to produce unconsciousness. Under these circumstances, arguments against forms of religious slaughter that do not

involve stunning before death come from a weak base.

- . The criteria used to infer unconsciousness, anaesthesia and death in the slaughter process have often been flawed and are far from perfect even now. For example, visual evoked reactions can occur long after consciousness has been lost and even after many criteria for clinical death have been met.
- . The stages of anaesthesia recognised by clinicians may not be appropriate for understanding the central nervous system changes associated with unconsciousness during the slaughter process. The criteria for judging anaesthesia may have been misapplied to the process of slaughter.
- . Various nervous system functions have a differential sensitivity to blood loss and anoxia. For example, the brain function supporting consciousness is easily damaged by anoxia, whereas reflex muscular reactions associated with breathing, such as nostril flaring, are extremely resistant to anoxia.
- . The epileptiform state that is caused by electrical stunning and that is used to make inferences about consciousness requires additional support for its effectiveness. Unfortunately, this state was invoked as support for the humaneness of electrical stunning well after electrical stunning had been introduced for the contribution it could make to humaneness.
- . Quality control procedures at the workplace for the effectiveness and humaneness of stunning and sticking, or for other methods of slaughter, are required.

Slaughter is likely to remain as a catalyst for welfare concern. Accordingly, the red-meat industry should be able to solve difficulties and contain controversies by mounting scientifically defensible arguments. The sponsorship of research into the physiology of slaughter would produce people able to mount these arguments. In addition, there are questions about the physiology of slaughter that need to be addressed. A satisfactory set of criteria for death in animals, as opposed to people, has not been drawn up.

Two projects were identified in this area, one concerned with the development of advanced slaughter and processing technology (project 12) and one concerned with development of an improved small stock stunning restrainer (project 57 in Appendix).

Experiments

Experiments with animals can and do provide the red-meat industry with valuable information. However, they also present a threat if welfare considerations are treated lightly. The threat has two sides. Poor welfare can bring

ill-repute to both animal-based research and the red-meat industry. Moreover, poor welfare equates with poor research and leads to results that lack quality. There is an enormous amount of documentation to support this latter contention. Basically, however, poor welfare affects physiological status and this, in turn, affects experimental results.

It should not be taken for granted that experimenters without formal education in animal husbandry have sufficient knowledge in this area to make them competent. There is a continuing need for experimenters and animal welfare committee members to renovate their knowledge and understanding of animal welfare. The Australian Council for the Care of Animals in Research and Teaching (ACCART) is commended for the large contribution it can make in this regard.

6. REFERENCES

- AVMA (American Veterinary Medical Association) (1987) Colloquium on recognition and alleviation of animal pain and distress. *Journal of the American Veterinary Medical Association* 161: 1186-296.
- Blackmore, D.W. and Delany, M.W. (1988) *Slaughter of stock: A practical review and guide*. Veterinary Continuing Education Publication, Massey University, Palmerston North, New Zealand.
- Ewbank, R. (1985) The behavioural needs of farm and laboratory animals. In *Animal experimentation: Improvements and alternatives*, eds N. Marsh and S. Haywood, pp. 31-5. Fund for the Replacement of Animals in Medical Experiments, Nottingham.
- Rose, M.A., Daly, D.M. and Shaw, F.D. (1991) Humane slaughter of farm animals. *ACCART News* 4: 2-3.
- Russell, W.M.S. and Burch, R.L. (1959) *The principles of humane experimental technique*. Methuen, London.
- Stolba, A. and Wood-Gush, D.G.M. (1984) The identification of behavioural key features and their incorporation into a housing design for pigs. *Annales Recherche Veterinaire* 15: 287-98.
- Stolba, A., Hinch, G.N., Lynch, J.J., Adams, D.B., Munro, R.K. and Davies, H.I. (1990) Social organisation of Merino sheep of different ages, sex and family structure. *Applied Animal Behaviour Science* 27: 337-49.
- Wall, P.D. (1979) On the relation of injury to pain. *Pain* 6: 253-64.

7. APPENDIX

CURRENT RESEARCH PROJECTS IN ANIMAL WELFARE IN AUSTRALIA

The following list is an expansion of Table 1 in chapter 5 'Survey of Australian research into the welfare of livestock'. The same headings are used, and projects are arranged alphabetically, using the research coordinators' names. The projects are also numbered sequentially to assist cross-referencing.

Abbreviations used

AWRDC	Australian Wool Research and Development Corporation
IMVS	Institute of Medical and Veterinary Science
MRC	Meat Research Corporation of Australia
NSWA	New South Wales Agriculture
QDPI	Queensland Department of Primary Industries
UM	University of Melbourne
UNE	University of New England
VDA	Victorian Department of Agriculture
WADA	Western Australian Department of Agriculture

CATTLE

On-farmNutrition, management and reproduction

Project 1: Shade in feedlots
 Research coordinator: J. Round
 Research organisation: QDPI
 Project objectives: To assess the effect of shade in animal welfare and meat quality

Animal health

Project 2: Development of a vaccine against *Anaplasma marginale*
 Research coordinator: K. Gale
 Research organisation: CSIRO
 Funding organisation: MRC
 Project objectives: Isolate protective antigens and develop recombinant forms for use in vaccination

Project 3: Buffalo fly control
 Research coordinator: D. Hirst
 Research organisation: QDPI
 Project objectives: To improve design and efficiency of fly rubbing posts and rollers

Project 4: Pinkeye vaccine for cattle
 Research coordinator: A. Lepper
 Research organisation: CSIRO
 Funding organisation: MRC
 Project objectives: Develop a vaccine to prevent pinkeye

Project 5: Development of a vaccine against buffalo fly
 Research coordinator: H. Standfast
 Research organisation: CSIRO
 Funding organisation: MRC

Off-farm

Transport and handling

Project 6: Reducing meat wastage and risk to welfare of cattle during marketing, through improved design and operation of livestock transports
 Research coordinator: G.A. Eldridge
 Research organisation: VDA
 Funding organisation: MRC

Project 7: Transport of livestock
 Research coordinator: J. Lapworth
 Research organisation: QDPI
 Funding organisation: QDPI
 Project objectives: To press for volume loading of livestock on a national basis, to research dust reduction, and improve vehicle design

Project 8: Red meat marketing
 Research coordinator: T.G. Pollard
 Research organisation: VDA
 Project objectives: Improved market share for red meat through market-oriented production and efficient selling systems

Project 9: The reduction of pre-slaughter stress by improved handling procedures and facilities
 Research coordinator: R. Shorthose
 Research organisation: CSIRO
 Funding organisation: MRC
 Project objectives: Reduce the incidence of dark-cutting meat

Project 10: Increasing meat quality, yield and animal welfare by improving the transport environment for cattle trucks on unsealed roads
 Research coordinator: W. Town
 Research organisation: QDPI
 Funding organisation: MRC

Project 11: Animal flow and efficiency of cattle yard designs for farms, saleyards and abattoirs
 Research coordinator: W.J. Vowles
 Research organisation: VDA
 Funding organisation: MRC

Slaughter

Project 12: Advanced slaughter technology
 Research coordinator: J Buhot
 Research organisation: CSIRO
 Funding organisation: MRC
 Project objectives: Automation of processes in slaughter and dressing - e.g. hide removal

SHEEPOn-farmNutrition management and reproduction

Project 13: Reproductive biotechnology in sheep, cattle and companion animals
 Research coordinator: R. Fairclough
 Research organisation: VDA
 Project objectives: To improve fecundity of livestock

Project 14: Management of the farm at the Mallee Research Station
 Research coordinator: M.W. Ferguson
 Research organisation: VDA
 Project objectives: Demonstration of advanced farm techniques

Project 15: Laboratory evaluation of feedstuffs for ruminants
 Research coordinator: P.C. Flynn
 Research organisation: VDA
 Funding organisation: MRC

Project 16: Ewe milk production and lamb survival and growth
 Research coordinator: J.Z. Foot
 Research organisation: VDA, UM, La Trobe University
 Project objectives: To reduce lamb mortality

Project 17: Sheep nutrition - improving nutrition and management of grazing sheep
 Research coordinator: J.Z. Foot
 Research organisation: VDA, UM, CSIRO
 Funding organisation: MRC
 Project objectives: Improve utilisation of pasture for sheep nutrition

Project 18: Economic and policy analysis of resources
 Research coordinator: J.E. Gibson
 Research organisation: VDA
 Project objectives: To assist in formulation of policies relating to land use, land values drought etc.

- Project 19:** Development of immunocastration for livestock and companion animals
 Research coordinator: D. Hennessy
 Research organisation: VDA
- Project 20:** Increase farm productivity through agroforestry
 Research coordinator: F.S. Hirst
 Research organisation: VDA
 Project objectives: Study agroforestry for shelter, fodder, erosion control, and timber production
- Project 21:** Effects of nutrition on lamb survival
 Research coordinator: J. Lynch
 Research organisation: CSIRO, UNE
 Funding organisation: CSIRO, UNE
 Project objectives: To reduce post partum lamb mortality
- Project 22:** Development of immunocastration
 Research coordinator: J.C. Malecki
 Research organisation: VDA
 Project objectives: Non-surgical spaying of livestock
- Project 23:** Sheep breeding - wool sheep
 Research coordinator: J.M. Obst
 Research organisation: VDA
 Project objectives: Develop higher producing strains of sheep
- Project 24:** Farm financial management
 Research coordinator: A.J. Patterson
 Research organisation: VDA
 Project objectives: To improve farm management techniques
- Project 25:** Farm management economics
 Research coordinator: A.J. Patterson
 Research organisation: VDA
- Project 26:** Increasing productivity and sustainability of agriculture using trees on farms
 Research coordinator: L.P. Thatcher
 Research organisation: VDA
- Project 27:** Development of innovative animal management systems
 Research coordinator: L.P. Thatcher
 Research organisation: VDA
 Project objectives: Minimise disease and associated losses in production to achieve maximum efficiency

Project 28: Testing of commercial products for improved productivity and welfare of sheep
 Research coordinator: M.J. Watson
 Research organisation: VDA, UM

On-farm
Husbandry procedures

Project 29: Animal welfare aspects of tooth grinding in sheep
 Research coordinator: L.J. Denholm
 Research organisation: VDA, NSWA
 Project objectives: Evaluate benefits of dentistry in sheep.

Project 30: Biology of wool growth
 Research coordinator: M. Dolling
 Research organisation: VDA
 Project objectives: To develop a painless technique to stop wool growth and replace the mulesing operation

Project 31: Immobilisation and restraint of animals for fleece removal
 Research coordinator: A.R. Egan
 Research organisation: UM
 Funding organisation: AWRDC
 Project objectives: Evaluation of aversiveness of electro-immobilisation; alternative methods of immobilisation, sensory deprivation and positional immobilisation for shearing

Project 32: An appraisal of the putative analgesia produced by electro-immobilisation
 Research coordinator: T.R. Kuchel
 Research organisation: IMVS
 Project objectives: To investigate effects of electro-immobilisation of analgesia and subsequent aversive behaviour with a view to separating these phenomena

Animal health

Project 33: The relative contributions of sheep susceptibility and blowfly numbers to the initiation of blowfly strike in the arid zone and a new strike control strategy
 Research coordinator: J. Anderson
 Research organisation: UNSW
 Funding organisation: AWRDC

- Project objectives:** Management of fly and sheep to decrease strike
- Project 34:** Diagnosis, treatment and control of external parasites of sheep
- Research coordinator:** N.J. Campbell
Research organisation: VDA
Project objectives: Control of itchmite and lice on sheep
- Project 35:** Sheep nematodes - breeding sheep resistant to parasites
- Research coordinator:** L.J. Cummins
Research organisation: VDA
Project objectives: To increase sheep resistance to worm infection
- Project 36:** Improved control and eradication methods for salmonellosis
- Research coordinator:** W.D. Davies
Research organisation: VDA
Funding organisation: MRC
Project objectives: Develop an oral vaccine to protect export sheep against salmonella
- Project 37:** Survey of periodontal disease and premature incisor tooth loss in the Australian wool industry
- Research coordinator:** L.J. Denholm
Research organisation: VDA, UM
Project objectives: To establish prevalence and severity of tooth loss in sheep
- Project 38:** Sheep blowfly attractants
- Research coordinator:** P. Green
Research organisation: QDPI
Funding organisation: QDPI
Project objectives: To investigate attractants for use in fly baits
- Project 39:** Investigation of the causes and importance of sheep losses in the Mallee
- Research coordinator:** D.J. Harris
Research organisation: VDA
Project objectives: To estimate sheep losses and diagnose causes, especially plant toxins
- Project 40:** Development of vaccines for parasitic infections of livestock
- Research coordinator:** E. Meeusen
Research organisation: UM
Funding organisation: MRC
Project objectives: To control infections with internal nematodes of sheep and cattle

- Project 41:**
 Research coordinator: G. Murphy
 Research organisation: QDPI
 Funding organisation: QDPI
 Project objectives: To develop a vaccine to protect sheep from fly strike
- Project 42:**
 Research coordinator: D. Overend
 Research organisation: VDA
 Project objectives: Investigate interaction of management and worm control
- Project 43:**
 Research coordinator: M. Paton
 Research organisation: WADA
 Funding organisation: MRC
 Project objectives: Investigate causes of CLA and its consequences, and management and vaccination strategies to control it
- Project 44:**
 Research coordinator: M.D. Rickard
 Research organisation: UM
 Funding organisation: MRC
 Project objectives: Application of recombinant DNA methods for the *in vitro* production of cestode antigens for vaccination and diagnosis
 Better control of parasitic diseases - e.g. hydatids, beef and sheep measles
- Project 45:**
 Research coordinator: G.G. Riffkin
 Research organisation: VDA, Monash University
 Funding organisation: MRC
 Project objectives: Sheep nematodes - research
 To develop a suite of control measures for sheep nematodes
- Project 46:**
 Research coordinator: G.G. Riffkin
 Research organisation: VDA, Monash University
 Funding organisation: MRC
 Project objectives: Development of rapid and accurate tests for diagnosis and classification of *Bacteroides nodosus* strains
 Control of footrot
- Project 47:**
 Research coordinator: R.J. Rubina
 Research organisation: VDA
 Project objectives: Animal disease diagnosis
 To diagnose disease for treatment and control

- Project 48:** Commercial development of biotechnology
 Research coordinator: L. Stephens
 Research organisation: VDA
 Project objectives: To develop new products for diagnosis and treatment of disease
- Project 49:** Contract services related to development of commercial technology in the Gippsland region
 Research coordinator: K.W. Thomas
 Research organisation: VDA
 Project objectives: To develop commercial technologies for animal production - e.g. vaccines, teat dips, scour remedies, immunodeficiency detection kits
- Project 50:** Footrot prevention, control and eradication in the north-eastern region
 Research coordinator: W.K. Woonton
 Research organisation: VDA
- Off-farm
Live sheep exports
- Project 51:** Rations for feeding sheep during live sheep export
 Research coordinator: N. Costa
 Research organisation: Murdoch University
 Project objectives: To improve the diets for sheep in feedlots and on board ships
- Project 52:** Live sheep for export
 Research coordinator: J.Z. Foot
 Research organisation: VDA
 Funding organisation: MRC
 Project objectives: Investigate behavioural aspects of adaptation feedlot practices and pelleted feeds
- Project 53:** Live sheep for export
 Research coordinator: R.W. Hodge
 Research organisation: VDA
 Funding organisation: MRC
 Project objectives: To examine the effects of feed availability and trough space on carcase weight and quality
- Project 54:** New feeding systems for improving the efficiency of nutrient utilisation in boat sheep
 Research coordinator: P. Hopkins

Research organisation: VDA
 Funding organisation: MRC
 Project objectives: Investigate delivery of nutrients through drinking water

Project 55: Improving the health and welfare of sheep exported by sea to the Middle East

Research coordinator: A.P. Kelly
 Research organisation: VDA, DPIE, UM
 Funding organisation: MRC
 Project objectives: Take a multidisciplinary approach to investigate and prevent anorexia and deaths during export voyages

Project 56: Reducing the mortality of export sheep by improved management and nutrition

Research coordinator: R. Norris
 Research organisation: WADA
 Funding organisation: MRC
 Project objectives: Investigate shipboard management

Off-farm
Slaughter

Project 57: Slaughtering techniques
 Research coordinator: J. Anderson
 Research organisation: QDPI
 Funding organisation: QDPI
 Project objectives: To develop an improved small stock stunning restrainer

PHYSIOLOGY_

Behaviour, stress and immunity

Project 58: Reduction of stress in sheep by immunisation against cortisol
 Research coordinator: N. Adams
 Research organisation: CSIRO
 Funding organisation: MRC
 Project objectives: Examine effects of glucocorticoids on food intake of sheep in feedlots

Project 59: Behaviour and immunity in sheep
 Research coordinator: L. Fell
 Research organisation: NSWA
 Project objectives: To examine effects of environment on behaviour and immunity to enable management of animals in a way that optimises immune responses

Project 60: Effects of immunisation against ACTH on responses of sheep to stress

Research coordinator: G. Hinch
Research organisation: UNE
Project objectives: Observe role of ACTH in stress responses

Project 61: Immunisation against stress effects in livestock

Research coordinator: M. Jones
Research organisation: CSIRO
Funding organisation: MRC
Project objectives: Develop a vaccine to help combat effects of stress

Project 62: Stress in farm animals

Research coordinator: T.R. Kuchel
Research organisation: IMVS
Project objectives: To study the link between behaviour and endocrine response - e.g. the mechanism of stress induced analgesia