Sow Housing and Management Systems

A Literature Review Update for the New Zealand Pork Industry Board

Final Report

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Report prepared by Miss M.K. Edge, Mr A.A. Davidson and Dr A.B. Pearson
Prime Consulting International (Australia) Pty Ltd
ABN: 67 120 994 685
Unit 3 / 502 North East Road
Windsor Gardens SA 5087
AUSTRALIA

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Preamble

This review was commissioned to provide the New Zealand Pork Industry Board with recent information relating to the management and housing of sows and the welfare implications. The review was designed to build on several previous reviews on the housing of sows. Whilst referring to some earlier publications, this review focuses primarily on the research published since the previous reviews commissioned by the New Zealand Pork Industry in 2001 and the more recent work commissioned by Australian Pork Limited in 2003.

It is anticipated that this review, together with the previous reviews on the topic, will be utilised by the New Zealand Pork Industry Board to help determine next steps for research, policy development, education and extension.

Executive Summary

This review of sow welfare, focusing primarily on housing and husbandry systems, was commissioned to provide the New Zealand pork industry with information in relation to the current state of knowledge and practice together with gaps in that knowledge. The aim of this review is to provide the New Zealand Pork Industry Board (NZPIB) with an update on the key issues relating to sow welfare in various housing systems since the previous reviews by NZPIB and Australian Pork Limited in 2003.

Pig farming is a complex, multi-faceted livestock production system. There are many variations in practice utilised in managing pork production systems and in particular, systems and management practices may vary greatly for breeding animals, with all systems providing a number of advantages and disadvantages. In addition, internationally within scientific circles and across the general community, there is a lack of agreement over a suitable definition and the methodology to assess animal welfare. These circumstances lead to some difficulty in providing agreed scientifically based standards for production systems that can account for all the variables in management, climatic, genetic and other breeding and housing conditions.

On the specific issue of sow housing systems, the scientific evidence is still equivocal. No sow housing system is perfect: be that for gestating sows or farrowing/ lactating sows. Accordingly, at present there does not appear to be any 'silver bullet' in terms of an ideal system.

In the meantime, international trends reported in the literature are emphasising the importance for industry of demonstrating compliance with existing 'good practices' and contributing towards continual improvement in areas of housing systems, management and stockpersonship. Training and competency levels for stockpersons as well as targeted research on alternative systems and community relations/ education programmes are recommended as the key areas of focus to move forward.

There has been an increase in the use of systems of pig housing other than those based on conventional indoor sheds in New Zealand over recent years, particularly outdoor production.

These systems are also considered in this review. It is important that the animal welfare requirements of these systems are also fully understood and communicated to producers as well as other stakeholders.

This review covers the various sow housing and management systems currently available, welfare assessment and implications of housing systems, mating management, reproduction, stockpersonship and industry extension programs. It highlights gaps in knowledge that apply internationally and suggests that New Zealand continues to monitor international developments and to contribute where feasible.

1.0 Introduction

It is only relatively recently that the welfare of farm animals has generated considerable interest around the world. The intensification of production systems, changes in technology and a shift in expression of community concern and ethical values towards animal welfare have placed pressure on the livestock industries and society to address responsibilities associated with animal use. Over the last decade, there has been a continuing evolution in the attitudes towards the use of animals. More developed countries in particular appear to be adopting the values once expressed famously by Mahatma Gandhi in 1931 that *"the greatness of a nation and its moral progress can be judged by the way its animals are treated."* Therefore, many developed countries are increasingly placing emphasis and resource into the development of science, policy and education for animal welfare.

The housing and other conditions under which pigs are managed in intensive production systems have received continuing scrutiny from consumers, the general public and animal welfare organisations. The housing of gestating sows is one of the most controversial issues in farm animal welfare and pig production. Over the last 10 years in particular, there has been substantial local and international pressure to ban or restrict individual housing of pigs. For example, from 2013, the European Union will impose a maximum time in stalls of four weeks after mating. Consequently, there is now increasing interest in alternative housing and group systems for pigs. The main welfare concerns raised in relation to the confinement of pigs include inappropriate/ insufficient social contact, inability to exercise, restricted opportunity for stimuli and social activity, restricted access to feed and a number of features of the physical environment. Research (Barnett *et. al.* 1997, Barnett *et. al.* 2001) indicated, following a series of experiments, that the design features of housing systems (e.g. space provided, shape/ dimensions of stalls/ pens, group size etc) may be more important than the housing system *per se.* Therefore, emphasis should be placed on assessing the impact of these features on the welfare of pigs, including social contact, space requirements and utilisation, animal interaction, environmental stimulation and human contact. The wider issue of provision of adequate housing for pigs for all stages of production and not just the single issue of the appropriate use of gestation stalls, needs to be part of an overall program for the care of pigs (Deen, Anil and Anil 2005).

The role of science to assess animal welfare has increasing potential to resolve some of these issues and further assist the development of policies, standards and targets for pork production. Recently, the need for greater underpinning of standards and guidelines by scientific evidence has increased, alongside the need for industry and government to demonstrate clearly defined animal welfare standards and management systems.

Increasingly, many countries are developing methods to integrate the views of scientists, veterinarians and policy makers in a more co-operative manner towards achieving consensus on animal welfare standards and a more informed debate on animal welfare issues. Thus the role of education in relation to many of these issues is considered as important as the science that underpins the standards being developed. The Commission of the European Communities is regularly reviewing and amending European Community Directives covering the minimum standards for animals. During 2001, two amendments to one such Directive (91/630/EEC) resulted in specific provisions for pigs. These included an increase in the floor space available for sows and gilts, a requirement for permanent access for sows and gilts to materials for rooting, higher levels of training and competency requirements for stockpeople, light and maximum noise requirements and a minimum weaning age of four weeks. However, it is important to note that not all of these amendments have been based on scientific evidence alone; community attitudes and the ethics/ values of society are also clearly playing a part in shaping these policies and will continue to do so in the future. In addition to the European Commission, the International organisation responsible for animal health and welfare, the OIE (Office International des épizooties: World Organisation for Animal Health) is also continuing to develop guidelines for specific activities and practices and reviewing the impacts on animal welfare.

Therefore, it is important to consider the resultant policies in relation to the social and political climate to which they apply. The EU is clearly following a particular policy line in the direction of reducing intensification of pig production and incorporating features that might be seen as aspects of a living environment for pigs more akin in some areas to what the animals might experience in an undomesticated environment. On the other hand, North America has followed a different direction. Much of the science carried out in North America relates to productivity, hygiene and improving welfare outcomes in intensive systems rather than moving away from them. In New Zealand and Australia, policies and Codes of Practice are being developed with the input of science and also with consideration of the ethical, moral and community attitudes, whereby input into policy is now being provided from scientists, policy professionals, veterinarians, animal welfare groups, public consultations and industry.

These codes of practice, in conjunction with overarching legislation, are changing to reflect key standards and requirements, one of the most recent changes in many countries being the setting of minimum time for sows to be housed in stalls. Specifically in New Zealand, the current Code of Welfare became mandatory in January 2005 replacing the previous ‘deemed’ code that was based on an earlier advisory code. Other developments include the adoption of industry-based standards and associated quality assurance programs.

For example within Australia in 2003, the development of a pork welfare audit led to the introduction of animal welfare standards into the Australian Pork Industry Quality Program and in 1996, one supermarket chain in the UK adopted the Five Freedom Food label of the Royal Society for the Prevention of Cruelty to Animals (RSPCA) for layer hens.

Following the development of the industry Standards in Australia, the Code was consequently reviewed and a draft revised Code now also contains minimum Standards for specific activities and practices.

Processors and retailers in the United States, under pressure from consumers and the public in relation to animal welfare issues, are adopting animal welfare standards. The Food Marketing Institute (FMI) and the National Council of Chain Restaurants (NCCR), with advice from scientists, welfare representatives, government and industry, have been developing farm animal welfare guidelines. For example, recently Smithfield foods announced on the 25 January 2007 the aim to phase out of gestation stalls in 10 years. Similarly, McDonalds and Burger King have continued to set standards for animal welfare, principally focussing on processing and now more recently, transport and on farm practices with key critical control points being specified in accordance with quality assurance principles.

These developments have all played a major role in changing animal welfare standards and essentially highlighting animal welfare as a key characteristic of the production chain. It is likely that within New Zealand, similarly to Australia, the production, processing and retail sectors of the livestock industries will be more influential in setting animal welfare standards and promoting preferred practices than legislation *per se*. This kind of market and industry driven approach has other benefits in terms of setting improved or best practice management standards and requirements surrounding the production system as a whole, rather than a strict regulatory approach which tend to focus on individual issues or concerns. In contrary, the changes in the European Union, whilst resulting from similar pressures, have expressed themselves directly in terms of legislation. In New Zealand, we see a common sense approach evolving whereby future developments will be based around the 'middle ground' between an EU regulatory and a North American 'market driven' approach.

The industry, government and other key stakeholders have an opportunity to work together towards targeted research and development, extension and education in animal welfare.

Failure to manage animal welfare well from a perspective of the public's perception may result in changes or restrictions to production practices that may be inappropriate, or based on misconceptions of current activities, and that will also have influence over practices within other industries in New Zealand.

Furthermore, these changes may consequently inhibit the profitability and sustainability of the industry and in fact may not always be beneficial to animal welfare outcomes if driven from a reaction to the public concern, without the concerted and balanced input of policy, industry, science and informed animal welfare organisations.

1.1 The Effect of Consumers and the Community

Consumers and the general community are now demanding to know more about the manner in which animals are raised, managed, produced and transported across the production chain. Over the last 10 years there has been a noticeable shift in the ways in which people are responding and expressing their views on animal welfare. Increasingly, consumers and the general public are writing letters to newspapers, commenting on specific welfare concerns, talking with people about their concerns and in general taking more interest in their purchases of food products. Animal rights groups are providing increased pressure for changes to current practices and elimination of specific systems such as conventional stalls for pigs. For example, ARLAN (Animal Rights Legal Advocacy Network), SAFE (Save Animals From Exploitation) and WARN (Wellington Animal Rights Network) are all active in this area in New Zealand. Furthermore, animal welfare organisations, such as the RNZSPCA (Royal New Zealand Society for the Prevention of Cruelty to Animals), are becoming increasingly recognised in an advocacy role by regulators and the public, through contributions to setting policy and their own public education programmes. The latter are also contributing towards changing public and consumer attitudes.

The effects of this increasing concern and communication of community views towards animal welfare is also being expressed in terms of consumer preferences, with differentiation of product now being presented in various markets on the basis of specific animal welfare standards and management systems. In addition to preference for products that are considered, safe, wholesome, appropriately labelled and nutritious, consumers are now considering the importance of animal welfare as a product attribute.

The effects of this increased interest, however has not necessarily translated into buying behaviour, although there is little work available that has definitively considered the relationship between consumer attitudes and consequent buying behaviour. For example, many market research reports indicate that animal welfare is often high or middle of the list of required product attributes, however further investigation is needed into whether these consumers interviewed, actually buy on the basis of their feeling towards animal welfare. In a recent study (Ngapo, Dransfield, Martin, 2002) it was reported that whilst the consumers interview were highly concerned when questioned about intensive rearing conditions of pigs, these individuals willingly admitted that their purchasing habits were not influenced by these concerns.

A research group in Australia at Monash University have attempted to further investigate the issue of modelling consumer attitudes and consequent buying behaviour. Coleman, (2004), examined the effects of consumer attitudes and behaviour on the pork industry and determined that concerns relating to animal welfare accounted for as much as 11-17% variation in consumer buying behaviour. Further research on public attitudes to animal welfare issues (Coleman *et. al.*, 2003) indicates a high frequency of community behaviours (14-36%) such as signing petitions, engaging in discussions with colleagues and friends, donating money or writing to a newspaper in relation to animal welfare concerns.

In comparison, a review of international consumer research undertaken by Prime Consulting International Ltd for Australian Pork Ltd in 2003 found that shopping behaviour for many consumers is a 'peripherally directed' activity which is heavily influenced by many other factors ranging from product positioning in the store, product brand familiarity, price and store environment (Pearson, 2003a). This makes 'ethical' issues (such as animal welfare) less likely to be important in directing buying behaviour at the point of purchase than attitudinal research might suggest.

This review also found that, in European research on consumer concerns about animal production, the level of concern was highest about the following issues in decreasing order: feed, space, outside access, possibility to express natural behaviour, methods of transportation, methods of slaughtering (Harper, 2002).

The same European study indicated that concern for animal welfare amongst European consumers was highly correlated with food safety concerns – which is likely to be a consequence of a number of widely publicised food safety breakdowns in Europe over recent years (hence the high level of importance placed by the consumers in this study on the feed given to animals and its possible adverse effects). These data therefore need to be interpreted with caution in relation to their direct applicability to the New Zealand environment.

There is evidence of reduction and intention to reduce meat consumption in developed countries, coupled with an increase in vegetarianism (Worsley and Skrzypiec, 1998) due to public concern for farm animals. In an effort to gain further understanding of the attitude of young people in the community, and in particular children, that can influence parent's buying behaviour, one study by Hay and Coleman (2004) reported that 85% of primary school children sometimes or 'often' thought about the treatment of farm animals. 42% considered that farm animals being treated well was an important factor in the choice of food. Whilst some industries are now starting to place a premium on products where there is a demonstrated or perceived welfare benefit (such as free range eggs and pork), evidence to date indicates that there is yet to be any dramatic influence of these products on consumer buying behaviour.

At a United States animal welfare forum on sow housing (Kuehn and Kahler, 2005) public needs were described as: accountability, effective management to meet animals' needs, a quality assurance program that can be trusted; product quality and cost effectiveness. Conversely, animal rights groups seek stronger regulatory enforcement; increased consideration for the legal status of animals; and promotion of ethical values in relation to food production, purchase and other product consumption. Producers seek sustainable farming systems, quality of life, profitability, flexibility, and effective and efficient management systems for rearing, growing and producing animals. In balancing those multiple factors, improving any one dimension may lead to decline in another, so the problem is not one in finding an ideal but of finding a way to balance the trade-offs.

In general it is observed over the last few years that changing community and consumer attitudes, coupled with the response in terms of increasing policies and differentiation of product, both represent an increase in the value placed on animal welfare and demonstrate a variety of views across all the relevant stakeholders.

Industry is aware of these issues and possible influences that animal welfare may have on product acceptability and sustainability. Thus, animal welfare is consequently gaining recognition as a major quality attribute, alongside other existing criteria, such as traceability and food safety. In general, any failure to address welfare issues may lead governments, livestock industries, food processors and retailers or consumers to react, perhaps without sound biological knowledge, by introducing or changing codes of practice, banning/ modifying procedure(s) or boycotting products. Misconceptions of welfare issues, or failures within industry and government to address these issues, may markedly affect the sustainability of the livestock industries. In addition, pressures for change without adequately addressing the welfare issue may lead to the introduction of inappropriate systems, policies or procedures, which might actually have a negative future impact on animal welfare, rather than improving it. Furthermore, animal welfare issues faced in one industry may also impact the perception of stakeholders or the public on another industry, for example concerns about livestock transport, where more than one species and practice may be involved.

The above summary clearly indicates the need for accurate science. In some sectors of the livestock industries, where pressure on retailers or businesses has been immense, animal welfare standards and targets have been put in place, sometimes with little scientific rigour. This is evident in the varying animal welfare requirements across retailers and businesses in several countries. In addition, upon the introduction of these varying standards by retailers or other bodies, there is confusion in terms of what the expected standard need be and consumers may not necessarily discern between these different targets when selecting a product. It would be more accurate to conclude that consumers simply want assurance that particular requirements for animal welfare are being set in place and demonstrated. This indicates a clear role for animal welfare science in terms of providing further understanding and determining the appropriate management targets and measures upon which standards, policies and product differentiation can then be based.

It is becoming increasingly evident that governments and industries must continue to obtain clear and concise information relating to welfare issues affecting production sectors. This will enable strategies to improve animal welfare outcomes in relation to these issues to be continually thought out and put in place.

2.0 The New Zealand Pork Industry – Setting the Scene

2.1 Demographics

New Zealand is currently a very small pork-producing nation. The total number of pigs processed in New Zealand for the year ending 30 September 2006 was 755,846, which equated to 50,650 tonnes of pigmeat (New Zealand Pork Industry Board 2006a). This compares with a total world pigmeat of 108 million tonnes for the calendar year 2006 and global trade in pigmeat 4.8 million tonnes (FAO 2006). Whilst these figures may appear somewhat overwhelming at first, the local pork production and processing industry does play a vital role in New Zealand economy. The wider industry makes a significant contribution to the New Zealand economy with total economic activity related to pork exceeding one billion dollars per annum (NZIER, 2007).

By virtue of its relatively small size the industry, by necessity as much as anything, is efficient and the domestic supply chain is well aligned with arguably only six major pork wholesalers and processors dealing directly with approximately 300 registered producers[1]. A previous study, which reviewed New Zealand's pork production efficiency, concluded that "*New Zealand compares very well with Australia and the United States of America and quite well with Canada on some specific benchmarks"* (Davidson 2004, p. 35).

There are approximately 40,000 sows in New Zealand with 40 percent of production located in the North Island and the remaining 60 percent in the South Island (refer Figure 1). The average number of breeding sows and gilts per farm in New Zealand is 389 with the median being 245 (Davidson 2004). It is reasonable to expect that because of urban encroachment, there will be a slow but steady move south in the production base over time. However, it is important to point out that to date, grain availability has been the principal reason for the industry's expansion in the South Island and other grain growing areas, such as the Manawatu. The industry's continuing aggregation is resulting in a reduction in the number of individual producers, yet maintaining the total size of the sow herd. This is consistent with a global trend that is widely recognised and has been reported by Barone & DeCarlo (2003), Lawrence, *et. al.* 1997 and Paarlberg & Haley (2001).

Due to differing soil types and topography, the overwhelming majority of sows are housed indoors in the North Island, with only three producers of commercial size farming their sows outdoors. In contrast, on the South Island approximately 60% of the sows spend some of their time outdoors This is a reflection of local producers taking advantage of the free-draining alluvial plains and low rainfall found in the Canterbury region. Within these overall management systems, there is a wide variety of individual housing and husbandry options found on individual farms (I. Barugh, pers. comm. 2007).

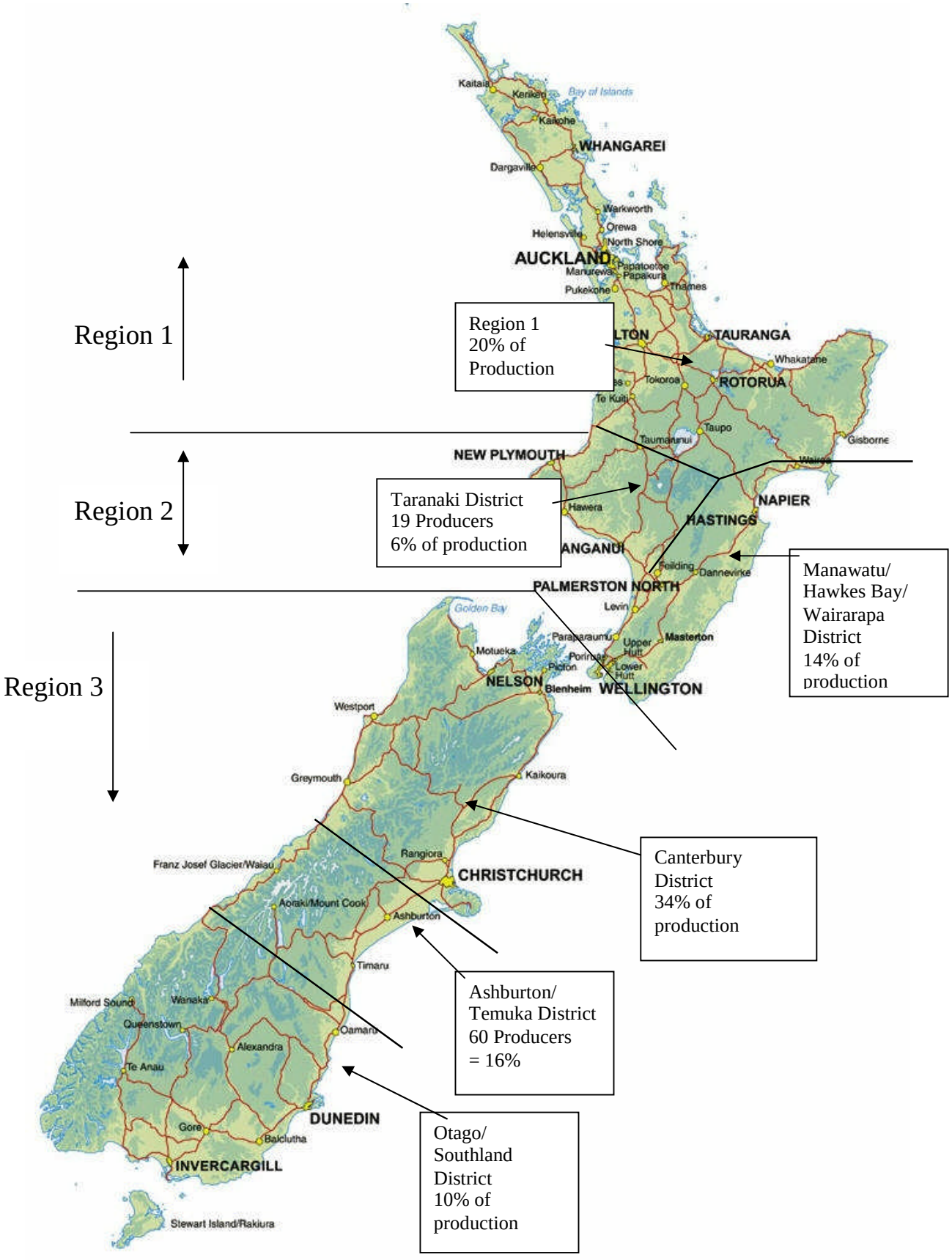


Figure 1: Map of the Geographical Locations of NZPIB Districts and Regions

[1] Its worth noting that only around one third of the these would be considered to be of commercial scale

2.2 Strategic Focus

The New Zealand Pork Industry Board (2006b) states that a key objective, in order to ensure that it fulfils its requirements under the Pork Industry Board Act (1997), is to enhance New Zealand's unique production system. NZPIB justifies this statement by adding that by virtue of its geographical location, New Zealand has a unique production system.

NZPIB goes on to state that, "New Zealand producers pay great attention to the welfare of their livestock and the environment in which they farm. It is vital that opportunities provided by this uniqueness, including New Zealand's internationally comparable low disease status, are fostered." (New Zealand Pork Industry Board 2006b).

It is noted that there are three key strategies in place in order to achieve this objective, these being:

1. Widely advocating for a reduction in compliance costs, ensuring farming is economically viable for New Zealand producers;
2. Ensuring that the regulatory animal welfare requirements are appropriate in the international environment; and
3. Encouraging and promoting environmentally sustainable and economically viable farm management practices (New Zealand Pork Industry Board 2006b).

Specifically in the area of animal welfare, there is good evidence that to date the Board has demonstrated a proactive commitment to assisting producers with meeting their obligations under the Animal Welfare Act (1999). Examples include the provision of a laminated poster containing all 20 minimum standards from the Animal Welfare (Pigs) Code of Welfare 2005 (the Code) to all producers (refer Figure 2) and the development of a self-assessment checklist (Animal Welfare 'Warrant of Fitness') for producers to help ensure they remain compliant with the Code. Furthermore, NZPIB has now commissioned this review in order to update itself on the current state of knowledge in the area of sow housing and management and to fulfil the requirements as stated the Code.

Animal Welfare (Pigs) Code of Welfare 2005, Minimum Standards

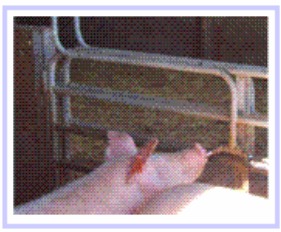
Note: Under the Act the "owner" and "person in charge" are responsible for meeting the legal obligations for animal welfare. Generally a stc handler is the "person in charge" of the animals at a particular point in time. In practice this will depend on the minimum standard in questio

Minimum Standard No.1 – Feed

(a) Feed must be available to weaners at least twice daily and to all other pigs at least daily.
(b) Feed must be provided in such a way as to prevent undue competition and injury.
(c) Pigs must receive adequate quantities of food and nutrients to enable each pig to:
  (i) maintain good health;
  (ii) meet its physiological requirements; and
  (iii) avoid metabolic and nutritional disorders.
  (iv) Automatic feeding systems must be checked at least once every 24 hours to ensure they are in working order and any problems rectified promptly.
  (v) When the body condition score of grower and finisher pigs, gilts, sows and boars falls below 2.5 (on a scale of 1-5), remedial action either through veterinary attention improved nutrition or husbandry practice must be taken to improve body condition.
  (vi) All pigs (excluding piglets) must be maintained at a body condition score of 2 or above (on a scale of 1-5).

Minimum Standard No.2 – New-Born Piglets

(a) All piglets must receive colostrum or an appropriate substitute within 24 hours of birth.
(b) If a lactating sow dies, or her milk supply fails, or if her piglets are receiving inadequate nutrition, the piglets must be fostered, hand-reared or humanely destroyed.



Minimum Standard No.3 – Watering Systems

(a) An adequate daily supply of water that is palatable and not harmful to health must be accessible to all pigs.
(b) Pigs on pasture must have access to a water supply to meet their daily requirements.
(c) Automatic watering systems must be checked at least once every 24 hours to ensure they are in working order and any problems rectified promptly.
(d) The water supply for a piggery must be sufficient and the reserves adequate to cope with the 24 hour demand.
(e) Alternative arrangements must be available in case of equipment failure to ensure that pigs get their daily water requirements.
(f) The water delivery system must be at a height that is appropriate for the size of the animal it is supplying.
(g) Water supplied to pigs must be at a temperature which does not inhibit drinking.

Minimum Standard No.4 – Indoors – Buildings and Maintenance

(a) Natural or artificial light of at least 20 lux must be available at pig level in all buildings for a minimum of nine hours daily.
(b) All pig sheds must have sufficient light of at least 20 lux available to enable inspection of animals.
(c) All sharp projections and edges including damaged flooring likely to cause injury to pigs must be removed or covered.
(d) Pen fittings must be kept in good working order.
(e) Any electrical fittings and attachments to mains voltage must be out of the reach of pigs, or protected from interference or damage by pigs.
(f) All mechanical equipment used in pig production must be maintained in good working order – this includes feeding and effluent removal equipment, drinkers, ventilation systems, lighting units, heaters, fire extinguishers, water pumps and hoses and emergency power generators.
(g) In case of power failure or mechanical breakdown in a fully enclosed system, provision must be made for other means of heating, lighting and ventilation, and for the feeding and watering of stock.
(h) In case of power failure or mechanical breakdown in a fully enclosed system, an alarm with a back-up battery system must be installed to warn of any ventilation system breakdown.
(i) For deep litter systems, provision must be made to minimise the impact of flooding through water pipes bursting.
(j) All pig sheds must contain suitable fire fighting equipment and have a documented emergency plan to be followed in the case of fire. This also applies to feed milling areas where they are adjacent to pig housing.

Minimum Standard No.5 – Indoors – Space

(a) Each pig housed indoors must provided with the following minir space allowances:
  (i) Growing pigs must be provided with an ar calculated in accordance with the followin formula: Area (m2) per pig = 0.030 x live-weight$^{0.67}$(kg)
  Note: Minimum space allowances for particular weights of pig are shown in the Code.
  (ii) Breeding stock must be provided with an area determined in accordance with Table 6 below
(b) Where a dunging area, as part of total slab, and/or an open drain, provided, this area must be excluded from calculation of the total space requirement pig.
(c) In hot conditions (over 25° C) s must be taken to reduce overheating pigs such as opening flaps and dc misting, increasing ventilation providing more space.
(d) Table 6: Minimum space requirem (m2) for breeding stock

Pig Class	Area (m2)
Unmated Gilts in groups	1.00
Mated Gilts in groups	1.50
Boars in individual stall or Crates	1.68 (0.7 m x 2.4n
Boar pens	6.0
Adult sows in groups	2.0
Pregnant Sows in individual stalls	1.20 (0.6m x 2.0n
Lactating Sows and litters	3.2 (total area)
Farrowing crates and creep areas	

Minimum Standard No.6 – Indoors: Temperature

(a) Provision must be made to ensure appropriate ambient temperature range maintain normal body temperatures of r born piglets.
(b) Heating devices (e.g. infrared lamps, pads) must be securely fixed and prote from interference by the sow and piglets.
(c) An airflow, or other measures, that will en pigs do not become overheated or stressed must be maintained during extreme weather.

Minimum Standard No.7 – Indoors: Air Quality

(a) Ventilation must be sufficient to prevent build-up of harmful concentrations of ga such as ammonia and CO_2.
(b) If ammonia levels of 25ppm or more detected within the pig house during re daily inspections (see Minimum Standard immediate and appropriate action must taken to ensure a return to levels which do cause eye and nasal irritation in people an reduce ammonia levels below 25ppm.

Animal Welfare (Pigs) Code of Welfare 2005, Minimum Standards

Minimum Standard No.8 – Outdoors: Environment

(a) A warm, dry, adequately ventilated area for sleeping and resting must be provided for all classes of pig.
(b) Piglets must be provided with a warm dry area which is adequately ventilated and protected from harmful draughts.
(c) If there is no artificial heating, bedding materials must be available for piglets.
(d) To prevent heat stroke or sunburn, shelter must be provided from the sun, or a wallow must be provided, or both.
(e) Effective fencing must be provided to prevent stock from fouling drinking water and gaining access to areas containing toxic plants or other hazards.
(f) Handling facilities must be available to deal with pigs and piglets undergoing routine procedures or for animals that are sick and requiring treatment.
(g) Accommodation for lactating sows must be of suitable design and sufficient size to allow the sow to lie down at full length and without leg restriction. The sow must also be able to lie down, rise and stand comfortably without undue risk of injury to her litter.

Minimum Standard No.9 – Farrowing

(a) Whatever type of farrowing system is used, it must be of suitable design and size to allow the sow to lie down at full length and without leg restriction. Sows must also be able to rise and stand comfortably.
(b) If sows are to be confined in farrowing crates, they must be confined for no more than 6 weeks in any one reproductive cycle.
(c) There must be a space of 300mm width on the narrowest side of the farrowing crate to provide an escape area for the piglets.

Minimum Standard No.10 – Dry Sow Stalls

(a) Dry sow stalls must allow sufficient clearance to enable sows and gilts to stand comfortably in their natural stance and be able to lie comfortably on their sides.
(b) Sows that show severe lameness or severe behavioural problems e.g. prolonged 'dog sitting' must be removed from dry sow stalls and placed in alternative accommodation to facilitate rehabilitation or be culled.
(c) From 10 years after this code comes into force (1 January 2015), individual confinement in dry sow stalls must be for no more than the first 4 weeks after mating.
(d) Dry sow stalls in any new facility built after the issue of this code must not be used to house sows and gilts from 4 weeks after mating until the completion of that pregnancy.

Minimum Standard No.11 – Tethering

Confinement of pigs must be by methods other than tethering.

Minimum Standard No.12 – Boars

(a) From 5 years after this code comes into force, boars, including young boars selected for breeding purposes must be housed in accommodation other than stalls, except where individual housing to treat injury or disease is temporarily necessary.
(b) If stalls are used, prior to minimum standard (a) taking effect, they must allow sufficient clearance to enable the boar to stand comfortably in his natural stance and to lie down comfortably on his side.
(c) If stalls are used, prior to minimum standard (a) taking effect, daily inspections must be carried out to ensure that any skin conditions especially those arising from urine scald, are treated.
(d) If stalls are used, prior to minimum standard (a) taking effect, boars must be removed from stalls at least twice per week either for mating purposes or to be given sufficient exercise to maintain adequate locomotory function and to prevent skeletal and muscular weakness.

Minimum Standard No.13 – Elective Husbandry Procedures

(a) Elective invasive procedures must be carried out by competent operators.
(b) Surgical castration or tail docking of pigs over 7 days of age must only be carried out by a veterinarian.
(c) If tail docking is performed, it must be done before 8 days of age and must be carried out using clippers, a searing iron, knife or other instrument that severs the tail immediately.
(d) If performed, teeth clipping of pigs must be carried out before 3 days of age.
(e) Non-invasive equipment must be used to measure back-fat on live animals.

Minimum Standard No.14 – Restraint and Handling

Pigs, including piglets, must not be picked up or suspended by one or both of their front legs.

Minimum Standard No.15 – Movement

(a) Pigs must not be prodded in sensitive areas, including the eyes, nose, anus, vulva and testicles.
(b) Only the minimal force required must be used when moving pigs.

Minimum Standard No.16 – Weaning

Weaning must be managed in a way that avoids undue stress on the piglets and therefore minimises negative impacts on their health and welfare.

Minimum Standard No.17 – Health

(a) Those responsible for the care of pigs must be competent at recognising the signs of good health, ill-health, or injury and must consult a veterinarian as appropriate.
(b) Medication must only be used in accordance with registration conditions, manufacturer's instructions or professional advice.
(c) Piglets must receive sufficient iron to avoid anaemia.
(d) Contaminated bedding, faeces and urine must not be permitted to accumulate to the extent that they pose a threat to the health and welfare of pigs.

Minimum Standard No.18 – Inspections

The owner or person in charge must check pigs at least once each day for signs of ill-health or injury and take action as appropriate.

Minimum Standard No.19 – Pre-Transport Selection

Pigs must be inspected prior to transport to ensure all are fit to be transported.

Minimum Standard No. 20 – Stockmanship

Pigs must be cared for by a sufficient number of personnel who possess the appropriate ability, knowledge and professional competence to maintain the health and welfare of the animals in accordance with the minimum standards listed in this code.

Figure 2: Poster containing the Animal Welfare (Pigs) Code of Welfare 2005 Minimum Standards

3.0 Welfare Issues in the Pork Industry

There has been a large body of literature published in relation to the key requirements of animals and these are listed in the guiding principles of most animal care documents, industry publications and Codes of Practice. The requirements generally agreed for the welfare of livestock include provision of feed and water, shelter, protection from weather extremes that predispose animals to heat or cold stress, protection from predation, absence of injury or disease and the ability to exhibit normal behaviour. All of these requirements are consistent with principles contained in the 'five freedoms' originally developed by the UK Farm Animal Welfare Council and since generally adopted as a guideline for scoping of animal welfare provisions by many animal welfare organisations and regulators.

There is no doubt that failure to meet these key requirements for animal welfare in general, will result in serious risks to the welfare of animals. In addition to these more basic requirements, are several other considerations for the welfare of pigs, some of which have been a point of controversy for a number of years. These include the ability to exhibit social behaviour, the need for sufficient stimuli, the need for various resources and the interactions with stockpeople. This review will focus more on the more specific welfare issues relating to sows in both conventional and alternative housing systems under current commercial conditions. In some cases, the identified welfare issues may be somewhat controversial, meaning that they may be more a result of perceptions and expectations than necessarily a proven requirement. For example, the ability to express natural or normal behaviour can present some difficulties, as defining natural behaviour in an array of systems, including both indoor and outdoor environments, can be difficult. In addition, systems that enable some of the required or preferred natural behaviours may also be limiting in terms of other welfare requirements, such as freedom from weather extremes or predation. Some of the literature available remains inconclusive in some areas, and in other cases may indicate that practices thought to be beneficial in some ways may in fact result in reduced animal welfare outcomes in others.

The issues most commonly identified in scientific circles, and by industry and welfare organisations include confinement, space requirements, social requirements, aggression, mixing, stereotypies, resource provision, surgical procedures, routine husbandry, livestock handling and stockpersonship, transport, stunning, euthanasia and slaughter.

Over the last 10 years, there has been a series of reviews conducted to examine the welfare of pigs in relation to a number of these issues.

As mentioned previously, the objective of this review is to build on the extensive literature already provided and to overview some additional literature on specific issues. Thus, the following reviews previously provided are of direct relevance to this work:

1. A Review of the Welfare Issues for Sows and Piglets in Relation to Housing, J.L Barnett, P.H Hemsworth, G.M Cronin, E.C Jongman and G.D Hutson, Australian Journal Agricultural Research, 2003;
2. The Welfare of Intensively Kept Pigs, Report of the Scientific Veterinary Committee, 1997, E. Von Borell, D.M. Broom, D. Csermely, A. A. Dukhuizen, S. A. Edwards, P. Jensen, F. Madec, C. Stamataris, (eds) (Council Directive 91/630/EEC) European Commission
3. Effects of Dry Sow Stall Use for a Limited Period after Mating, Johnson, M. and King, M.R., Massey University, 2001.
4. Use of Farrowing Crates During Farrowing and Lactation, Skorupski, M., Massey University, 2001.
5. Farm Animal Welfare Council, Report on the Welfare of Pigs Kept Outdoors, 1996. Report no. 2608.

These reviews all highlight the key issues in relation to sow housing and associated management practices, and provide a series of recommendations for research, extension, policy and education. This review, for NZPIB, intends to build on the findings of these previous reviews.

In addition to the above reviews, there have been several investigations into specific issues, such as space requirements (Baxter and Schwaller, 1983), stereotypies (Broom, 1993, and Lawrence and Terlow, 1993) and other key housing and husbandry issues and these provide much more detailed information for key areas of pork production.

In one particular review conducted by the Animal Welfare Science Centre (2002), a planning process was developed, involving a large number of stakeholders, to determine the main welfare issues affecting the pork industry in Australia for the next 5 years. These issues were determined by representatives from industry, government, welfare, science and other disciplines. They were then categorised in terms of their priority, by assessing the numbers of pigs involved in the particular issue or concern (e.g. routine husbandry, transport), the perceived public perception towards the issue and welfare effect on the individual animal. Prioritisation ranged from ‘extremely important’ to ‘important’. Whilst it is important to note that the issues and priorities identified for Australia may differ from those in New Zealand, the output of this work is helpful in setting the scene. The issues identified for Australia, ranging from ‘extremely important’ to ‘important’, are listed below:

1. ***Stockpersonship – handling, knowledge, motivation and skills***

   Research currently indicates that stockpersonship has vast impact on the welfare and productivity of pigs. Furthermore, as standards and issues relating to compliance with regulations and Codes increase over time, the issue of competency will continue to evolve, possibly requiring at some stage training or demonstration of training ability and associated systems within industries. This is being seen increasingly for specific responsibilities and practices in the livestock industries.

2. ***Dry Sow Stalls***

   Potential public pressure for alternative housing systems to be developed. (n.b. The recent Consultation Draft of the revised Australian Pig Welfare Code introduced a requirement for the minimum time that sows were to be confined in gestation stalls (6 weeks from 10 years after the endorsement of the Code) however this is currently being finalised. Concern related to the issue of confinement and the length of time the animal is confined in stalls. Current science suggests minor risk to sow welfare, however there is evidence of abnormal behaviour & differences in behaviour between pigs in stalls vs. group housing. Also evidence of a chronic stress response with respect to stall design. Some evidence in the literature of higher urinary tract infections, but practical experience suggests this may be related to hygiene. Increased reproductive performance (litter size) in stalls.

3. ***Farrowing/ Lactating Sows – Crates (indoors)***

   Literature suggests no serious effects on sow welfare e.g. stress response associated with parturition per se. Concern over limiting pre-farrowing (nesting) behaviour, especially young sows. Evidence of chronic stress in sows at day 28 of lactation when housed in farrowing crates and straw-bedded pens. Other issues include stall space for posture changing, floor type (facilities) and the potential for lameness.

4. ***Handling at Abattoir including Slaughter***

   Main issues are the time off feed, time in lairage, stocking density in lairage, handling and inspections during lairage. Problems with the efficiency of the stunning procedures resulting in stunning inefficient not bled out properly and not rendered insensible rapidly enough.

5. ***Transport of Finisher Pigs to Abattoirs***

   Transport observed by community. Temperature control and stocking density are the main issues. Concern for welfare during the shift in responsibility between farmer and transport operators and the lairage personnel. Handling of pigs by stockpeople during transport (loading and unloading) an issue – use of electric prodders.

Inadequate loading and unloading facilities can impact welfare and meat quality. Time off water (i.e. in truck) if delivery delayed, e.g. labour dispute at abattoir.

6. ***Piglet Mortality and Morbidity***

   Piglet mortality ranges between 10 and 15% of total born. Most deaths occur in 1st 3 days. Piglet morbidity levels may be similar. Welfare issues relate to interactions between factors such as level of pain & time taken to die/recover. Various causes of death/morbidity (e.g. overlay/stood on by sow, starvation, savaging, illness, abnormality including splay leg, chilling, undersize/non-viable). Management of the sow's health, the physical environment, the microclimate, frequency of inspections and stockperson skill level to detect and remedy problems or euthanase piglet are critical to piglet welfare.

7. ***Routine Husbandry, Castration, Teeth Clipping, Tail Docking of Piglets***

   Castration at various ages, methods used and some pain if not carried out appropriately. Surgical intervention can have more serious implications for welfare. Risks of infection if done badly. Long-term risks of not carrying out procedure e.g. facial lesions to litter mates, damage to sow's udder. Tail-docking usually done within first few days of life, rather than later. Some pain but minimal impact on welfare if done competently. Long term benefit of reduced occurrence of tail biting.

8. ***Dry Sow Groups - indoors, concrete***

   Community concern minimal as pigs are in groups, indoors vs. outdoors may be a perception issue. Management of groups is an issue with respect to aggression, adequate inspection, space and escape areas at the time of mixing, feeding space (aggression as a result of limited access to feed – bullying).

9. ***Euthanasia on Farm***

   Issue of identifying unthrifty pigs. Handling of animals to be euthanased may require examination – staff requires training to identify and carry out procedure effectively and as soon as possible within the facility. Remains some difficulty in obtaining effective firearms (licensing issues). (See also piglet mortality)

10. ***Mixing Unfamiliar Pigs***

    Mixing pigs – aggression and injury /disease issues.

11. ***Transport of Pigs between Sites***

    Lower risk associated with transport of pigs between company facilities (i.e. weaners/ growers) due to better QA/ control over individual company practices and contracted transport personnel.

12. ***Dry Sow Groups – outdoors***

    Although community concern minimal or nil, welfare risks include impact of season/ climate (sunburn, heat, cold, chilling), availability of shade & wallows, soil type and paddock aspect affects drainage and mud/dust, access to feed (aggression), cool water, over-grown hooves etc.

13. ***Farrowing/ Lactating Sows (outdoors)***

    Outdoor systems require additional husbandry skills and better-motivated stockpeople compared to indoors. Inspection frequency and access to sow for treatment can be more difficult. Outdoor housing presents a number of welfare risks that may be difficult to manage - climatic conditions, access to food, access to water in hot weather, bullying, mud/dust, etc.

14. ***Sucking Piglets in Farrowing Crates (indoors)***

    Community concern is more for sow and litter as a whole, with respect to housing in crates. Crates promote neonate survival due to small space and provision of heater. Higher risk of sow problems affecting piglet survival – savaging, poor milking. Slippery floor may initiate splay leg (genetic component).

15. ***Sucking Piglets in Farrowing Huts paddocks (outdoors)***

    Outdoor farrowing systems have increased risk of mortality from sows abandoning litters (sow bullied out of hut), incidence of (gilts) farrowing outside hut in cold, predation by foxes and cats.

16. ***Foot and Leg Injuries, Lameness***

    Lameness in sows is a main cause of culling of breeding animals. Primary issue is pain. Other issues include discomfort and potential for this to interfere with maintenance activities (feeding, drinking, exercise) with carry over issues risks to piglet safety in crates, secondary illness e.g. bladder infection, difficulty in moving lame animals – require more force by stockperson, etc.

17. ***Large Group Size (alternative housing systems)***

    Access to feed/ competition for feed by timid pigs, inspection of individual pigs more difficult, quality of bedding at the end of the cycle may be health issue.

18. Inadequate Disease Control

Disease control – concern that there is a lack of guidance and insufficient animal health policies on small farms or those with poorly managed or over stocked continuous flow systems.

19. Farrowing/ Lactating Sows – pens (indoors)

Pens require additional husbandry skills and better-motivated stockpeople compared to crates. Inspections and access to sow for treatment can be more difficult. Solid floors require more cleaning, reduce hygiene.

20. Diet, Restricted Feeding

There are obviously welfare implications with inadequate nutrition, unlikely to occur. The development of stereotypies due to hunger – main remedy is to increase bulk in diet.

These findings are also broadly consistent with the outcome of a review of the international literature and gap analysis carried out by Prime Consulting International Ltd for Australian Pork Ltd in 2003 (Pearson, 2003b). That review listed the following as priorities for further research and innovation:

1. *Systematic evaluation of proposed new approaches in commercial field trials wherever possible before promoting their adoption. These trials should include animal welfare measures, productivity measures and cost-benefit analysis.*
2. *Further work on mixing strategies, group sizes, pen and feeding systems design for group housing of sows.*
3. *Evaluation of the true value of bedding materials in intensive indoor systems for pig welfare as well as practical methods to provide this if required. The scope of this work should also include investigation of alternative ways to provide adequate edible roughage in the diet if it should be determined that this is required.*
4. *Further work on practical and cost-effective alternatives to the farrowing crate that will deliver acceptable pig welfare.*
5. *Investigation of the genetic basis of aggression in pigs as well as its potential linkage to productive traits and if appropriate development of phenotypic or genetic markers that may be used for selective breeding of pigs with desired social adaptation characteristics.*
6. *Development of "animal-centric" research approaches to experimental design that incorporate assessment of animal preferences in terms of available behavioural choices.*
7. *Further investigation of the human-animal interrelationship and its implications for improving stockpersonship.*

8. *Education of the public and stakeholder groups about the science of pig welfare and its practical application, both to assist in management of expectations and to ensure that there is a more informed public climate for debate and political decision-making.*

The issues identified in these reviews are also broadly consistent with many identified by NZPIB through a number of strategic planning forums and currently being addressed in its existing animal welfare activities as well as being reflected in the New Zealand Code of Practice for the Welfare of pigs.

This review utilises the key priorities identified by these and other processes, as well as additional published literature, to provide a full update of the scientific literature for the New Zealand pork industry.

4.0 Definition of Animal Welfare

The definition and methodology for assessing animal welfare still remains a controversial area of science. As reported in several international reviews of animal welfare, science has an important role in establishing the facts in terms of the animal response to practices, procedures or environments in question. However, in many cases, individuals making decisions on whether an animal's welfare is compromised will additionally incorporate moral views into their decision. Within scientific circles, there are various definitions and methodologies applied in the assessment of animal welfare. The variety of views and methods, in terms of defining and assessing animal welfare further contributes to some disagreement in terms of what defines animal welfare and presents some difficulty in achieving consensus on the methods that are used in the assessment of animal welfare. For policy makers and regulators responsible for setting standards and defining compliance with legislation or codes of practice, the difficulties encountered in terms of defining and assessing animal welfare can create some inconvenience, particularly when the demand for science to underpin standards and legislation is increasing.

4.1 The Assessment of Animal Welfare

Some have argued that science and ethics cannot be separated in any discussion of animal welfare. In most cases, people will, when deciding on whether an animal's welfare is appropriate, incorporate both factual and moral points of view. Many determine the meaning of animal welfare as relating to well being and quality of life and consider that assessment of animal welfare involves judgements based on both factual information and values-based assessments. Consequently, when determining the appropriate measures for animal welfare, the role of science, from a physiological, behavioural and in some cases psychological and social perspective, in providing the appropriate facts is key to the argument. Certainly, there have been many examples of interpreting and assessing animal welfare using different scientific measures and methodologies, across disciplines including behavioural, veterinary, epidemiological, physiological/ immunological, psychological (animal learning, animal choice or preferences) measures. In addition, several reviews have incorporated more philosophical measures and other combinations of criteria including social science and moral judgements or values. Consequently, pathways to utilise science in defining animal welfare have been somewhat inhibited by the variation in methodology, lack of a clear definition of animal welfare and variation in the interpretation of outcomes. Without an agreed and clear definition, the study of animal welfare and further, the extension of the research towards an agreed position is often difficult, particularly where measures and hard fact are required for setting policy and determining appropriate targets or conditions for the management of animals.

A common definition that is becoming more widely used is the definition provided by Broom (1986a); *"The welfare of an individual is its state as regards its attempts to cope with its environment."* In this instance, welfare can be assessed in terms of how much has to be done by the animal in order to cope with a particular environmental imposition and secondly, the extent to which the animal's coping attempts are succeeding. Attempts to cope are described as the functioning of body repair systems, physiological and immunological responses, and behavioural responses. The risks to animal welfare from an imposition or environment are then determined from the magnitude of the exhibited response for the above variables and the consequent cost to the animal of these responses. For example, cost from a physiological stress response may include reduced reproductive function, reduced growth or cost from a behavioural stress response may include abnormal or stereotypical behaviours, considered as evidence of poor conditions.

Certainly this approach is favoured by many as the ability to be healthy, grow and reproduce are all considered measures of fitness and well being and have obvious acute and chronic effects on the welfare of an animal. The practical application of these measures within the animal industries is also useful, as many industry sectors maintain records of such data to assess the fitness of the animals under their care and make production decisions. Credibility for this approach is further supported by the use of accepted veterinary and other criteria including measures of health, immunology, injuries, mortality, growth and reproduction rates.

However, the definition provided by Broom is not necessarily universally accepted, posing ongoing difficulties with the conduct and assessment of pig welfare to the satisfaction of all stakeholders. Notwithstanding that, science can provide facts on how well animals cope with their environment. Such a consideration will include the issues of emotions, natural behaviours in natural settings and preferences (Duncan and Fraser, 1997). The issue of whether or not animals require environments that provide more than those that address their 'basic' biological requirements (for example, pleasure) is another level of discussion that perhaps needs to occur. Nevertheless, if we can develop a consensus that those conditions that create biological dysfunction are the most serious for animals, then we can probably reach some agreement that it is these issues that are the most important to be promptly addressed.

There are five main approaches to the assessment of animal welfare that are generally accepted internationally (Appleby 2005; Fraser, Weary and Pajor 1997, Broom, 1991 and Pajor 2005); the functioning based approach, the five freedoms approach, the animal choice or animal preference approach, the nature of the species approach and the feelings based approach. These have been reported in previous reviews and therefore are only described briefly below.

4.1.1 The functioning based approach or homeostasis approach

This approach aims to provide the facts on how well animals adapt to a housing or husbandry practice and give an indication of the welfare risks. The definition of animal welfare that underpins this approach is *"the welfare of an individual is its state as regards its attempts to cope with its environment"* (Broom, 1986a). In this definition, the "state as regards attempts to cope" refers to both how much has to be done by the animal in order to cope with the environment and the extent to which the animal's coping attempts are succeeding.

Attempts to cope include the functioning of body repair systems, immunological defences, physiological stress responses and a variety of behavioural responses. The extent to which coping attempts are succeeding refers to the lack of biological costs to the animal such as deterioration in growth efficiency, reproduction, health and freedom from injury. Therefore, using such a definition, the risks to the welfare of an animal by an environmental challenge can be assessed at two levels: firstly the magnitude of the behavioural and physiological responses and secondly the biological or fitness costs of these responses. For example, conception rates and mortality, morbidity and growth of offspring can be used as a measure of 'fitness'. Similarly, reproductive performance of domestic species has been linked with welfare. The difficulty with this type of assessment in some instances is that in rare cases, production and fitness variables are not always indicative of welfare, particularly for more subtle challenges to animals. As with the other approaches, there is some disagreement within science in terms of this definition. In particular, some argue that animal welfare only concerns animal feelings and others that the approach is conservative and, because of methodological limitations, a lack of difference using this approach may not mean that welfare is unaffected.

An attribute of the 'homeostasis' approach that affords this approach credibility within scientific circles is that it contains some widely accepted criteria of poor welfare. Handling studies on both young and adult pigs have shown that fearful pigs have a sustained elevation of plasma free corticosteroid concentrations; the consequences of this chronic stress response in these fearful animals include depressions in growth and reproductive performance.

4.1.2 The five freedoms approach

One of the most commonly quoted approaches to welfare involves the 'Five freedoms' from a review by Brambell (1965). The five freedoms are:

- freedom from thirst, hunger and malnutrition
- freedom from discomfort
- freedom from pain, injury and disease
- freedom to express normal behaviour
- freedom from fear and distress

It has been suggested that these five freedoms would be better presented as the '5 needs' as the absolute attainment of all five freedoms on a daily basis is unrealistic (Deen, Anil and Anil 2005). With developments over subsequent years, the above behavioural requirements have become widely known, with the UK Farm Animal Welfare Council proposing in 1992 that the welfare of animals can be protected by recognising the Five Freedoms. While most would agree with the ethical basis of this general approach, it requires a number of definitions – similar to the approach described below, the nature of the species approach. As an example, freedom from discomfort requires definition, as does natural behaviour. Comfort levels and behaviours that may be desirable and undesirable are difficult to define given the evolution of livestock species, the variety of systems and management types and the differences between the various pressures on the animals in either a wild or domesticated environment. Similarly, the levels of hunger, fear and stress that may impinge on animal welfare require clarification. Until these definitions are made with consensus, the five freedoms approach to welfare assessment may be used to reflect an ethical position, but is not necessarily open to scientific scrutiny. In many cases, application of the five freedoms as guiding principals, coupled with the application of specific fitness or physiological measures, is utilised to present key standards for the husbandry and management of livestock in policy and industry programs.

4.1.3 The nature of the species approach

The principle underlying this approach is that animals should be raised in 'natural' environments and allowed to behave in 'natural' ways. This approach is reflected in the much quoted proposal that has been incorporated into the 'five freedoms' requirement for animals: animals should have the 'freedom to perform normal behaviour', where in this case advocates of this approach consider 'natural' as the benchmark for assessing what is 'normal'. However, of all the approaches to assess welfare, the nature of the species approach has least scientific credibility because it does not define 'natural' nor does it specify the welfare risks if such 'natural' conditions are not provided. Thus this approach, lacking some key definitions, may reflect an ethical position more often than a basis for comparison with other scientific approaches. Furthermore, despite it seeming feasible for good animal welfare outcomes that animals perform their full natural behaviour, there are some other considerations. For example, wild behaviour may in some cases be developed upon a basis for survival, a life and death situation, thus these behavioural responses may simply be adaptations to cope with certain situations. These situations obviously reduce animal welfare and therefore are not situations which animals should be subjected to where avoidable. In addition, 'natural' environments for animals can present other implications for animal welfare, such as increased predation and mortality from extreme conditions. In conclusion, this approach requires further definition and is perhaps more related to people's perceived intuitive beliefs of an animal's needs rather than any scientific criterion.

Difficulties in particular, relate to defining natural behaviour, especially as modern domestic animals are the product of thousands of generations of selective breeding and consequently the behaviour and physiology of domestic animals have been modified during domestication. While the behaviour of domestic animals in wild or semi-wild conditions is often similar to their wild relatives, there are differences in the behavioural responses and thresholds to a number of stimuli such as sexual stimuli, novel stimuli, humans and environmental conditions.

4.1.4 The feelings based approach

This approach defines animal welfare in terms of emotions by emphasising any reduction in negative emotions such as pain and fear, and any increase in positive emotions such as comfort and pleasure. In human psychology, it is understood that humans have a great variety of emotions; animal behaviourists generally consider that animals are restricted to a few basic emotions such as anger, fear, joy and happiness. The difficulty in studying emotions as though they were objective states of bodily arousal is well recognised in the literature. Whereas each emotion may reflect a different pattern of arousal, the visceral response to many emotions is reasonably uniform in animals. Most animals react physiologically in essentially the same way whether the arousal is sexual, fear provoking or if there is the anticipation of play or food. It is obviously a major challenge to study and understand emotions in animals, however there are some examples in the literature that indicate that it is possible to assess the strength of emotions in animals in intuitively negative and positive emotionally arousing situations. Behavioural and physiological correlates of fear of humans by pigs demonstrate our ability to quantify the level of fear towards a specific stimulus in pigs. Thus, further definition of feelings and emotive states in animals is likely to increase and provide more detailed insight into animal welfare assessment in the future.

4.1.5 The animal choice or animal preferences approach

Animals have functional systems controlling, for example, body temperature, nutritional state and social interactions. By investigating these functional systems and the associated motivational mechanisms, there is opportunity to identify the resources or stimuli in the environment that are required by or are important to animals, and thereby learn something about an animal's needs.

The simplest preference study involves allowing the animal to make a choice between two situations in which the resource is varied. Observing animals in complex environments that provide a range of activities will also provide details of the animal's preference for habitats and resources. Scientists, when attempting to measure the strength of an animal's choice, have incorporated tasks in which the animal has to expend energy or take risks in gaining access to an alternative resource.

The strength of motivation ('need') for a resource can be measured through the animal's willingness to consume ('work' for) the resource as the 'price' of the resource increases. Preference or choice testing has been criticised on several grounds and further research, not only on methodological issues, but also on understanding the principles underpinning the animal's decision is required. For example, an animal's short term choice may reflect its proximate (immediate) needs, which are likely to vary markedly over time, rather than the animal's ultimate needs or those necessary for survival, growth and reproduction.

4.2 Other Considerations in Welfare Assessment

Numerous modifications, interpretations and additions to the debate surrounding animal welfare assessment have arisen since the Brambell (1965) freedoms were reported. Some of these are discussed below.

4.2.1 Freedom of movement

The lack of freedom of movement for animals on large scale intensive farms is one of the key welfare concerns that have garnered the public's attention (Kuehn and Kahler 2005). The scientific rationale for allowing animals' freedom of movement is that it gives animals control over their environment reduces frustration and allows them to maintain physical condition. Brambell (1965) stated 'an animal should at least have sufficient freedom of movement to be able, without difficulty, to turn round, groom itself, get up, lie down and stretch its limbs'. This statement refers to dynamic space or that space necessary to change postures and perform certain behaviours. The Farm Animal Welfare Council (Gonyou 2005) expanded on this concept by stating 'freedom to express normal behaviour by providing sufficient space, proper facilities and company of the animal's own kind'. This is a clear shift from postural changes to a more comprehensive expression of behaviour. The importance of freedom of movement arises from three needs of the animal: a sense of control over the environment; the opportunity to select the most comfortable microenvironment; and the benefits arising from increased exercise and social interaction. For example, studies on the benefits of exercise have shown decreased muscle mass and decreased bone strength of sows kept in stalls compared with sows housed in groups (Marchant and Broom 1996).

4.2.2 Natural behaviours

Pigs have certain natural behaviours that they are highly motivated to perform (e.g. nest building, foraging) and if they are unable to execute these behaviours then they may resort to stereotypic behaviours (Kuehn and Kahler 2005).

Similarly, the establishment of the social hierarchy and the changes introduced as grouping and mixing of pigs occurs when moving from group to individual housing is another consideration that may require further investigation. However, as previously mentioned, the definition of 'natural' behaviour still remains somewhat controversial.

4.2.3 Freedom from aggression

Freedom from aggression is addressed in the Brambell (1965) report, which also states 'confinement may well confer advantages, notably shelter from the weather, predators and bullying'. Aggression in group housing of sows arises for three major reasons (Gonyou 2005). The first form is associated with regrouping. Sows will fight with unfamiliar animals in an attempt to either exclude them from the social group or establish dominance over them. The second form is aggression related to competition over limited resources, specifically feed. The third form is the continuing low level of aggression within groups as animals maintain social order within the pen. To a large degree industry adopted the gestation stalls specifically to eliminate aggressive interactions, especially the first two forms. Studies typically demonstrate that a higher number of injuries occur in sows for several days or weeks after regrouping if undertaken in early gestation, but that these injuries heal by mid gestation. Aggression associated with competition for feed will result in mild injuries throughout the gestation period but more importantly will affect access to feed. Mixing and aggression in larger groups, however, still requires some investigation, as does the establishment of the social hierarchy and how this changes as pigs move through the various housing systems.

4.2.4 Environmental enrichment

The lack of environmental complexity/ stimulation for sows in gestation stalls is another welfare consideration. According to a European Commission Directive, (2001/93/EC), pigs must have 'permanent access to sufficient quantity of material to enable proper investigation and manipulation activities, such as straw, hay, wood, sawdust, mushroom compost or mixture of such materials, which does not compromise the health of the animals'. The objective of this requirement is that by providing manipulative materials the needs of pigs for exploration will be better met, thus reducing the risk of pigs performing abnormal behaviours that may be harmful to themselves or their pen mates.

There are other benefits of providing straw or bedding material for pigs. Bedding will assist with thermoregulation in cold climates, serve as a dietary supplement, provide protection and comfort from flooring as well as providing a substrate of interest for exploration or rooting behaviour. In some countries or situations however, there is resistance to adoption due to the cost or availability of suitable materials, additional cleaning and care required and the lack of compatibility with some feeding or hygiene/waste systems, such as liquid feeding for pigs.

In the case of sows, there is a strong argument for the provision of bedding material in that it fulfils the strong motivation of preparturient sows to conduct nesting behaviours. There is some evidence that confining primiparous sows at farrowing and/or denying access to bedding or nesting materials may induce an acute stress response (Cronin *et. al.*, 1991, Lawrence *et. al.*, 1994), however this is somewhat inconclusive. Whilst is proven that sows will be highly motivated to perform nesting behaviours during the 24 hours pre-partum (Jensen, 1989) and will utilise straw if available (Hutson, 1988), the implied welfare risk of sows as a consequence of reduced nest building in a farrowing crate has not been demonstrated (Barnett, *et. al.* 2003). Certainly, there has been some work investigating the possible effect of reducing the level of maternal behaviour by housing sows in farrowing crates and the impact on piglet survival. Nesting and other maternal behaviours are conducted with the aim of reducing piglet mortality (Barnett *et. al.* 2001, Baxter, 1989), although it is thought that this may not be relevant to piglet survival in conventional housing systems if the requirements for piglets (i.e. heating lamps) are provided. One alternative view is that nest building behaviour may influence the course of parturition and consequently the survival of the piglet (Svendsen, Svendsen and Bengtsson 1986) and additionally may lead the sow towards inappropriate behaviours such as savaging of her litter. It has been reported that there may be other benefits (apart from those directly related to nesting behaviour) from provision of straw or other material, including increased immune response in piglets (Metz and Oosterlee, 1980), increased suckling (Cronin and Smith, 1992a and Barnett et. al., 2001) and reduced stillbirths (McGlone et. al. 1996). Generally, it has been reported that the effect of the farrowing environment of the sow on the incidence of piglet survival and stillbirths is greater than the effect of the gestation stall environment (Fraser, Weary and Pajor 1997). This is one example where combinations of animal preference and homeostasis approaches are further required to define appropriate guidelines for bedding and environmental enrichment requirements for pigs.

4.2.5 Social and spatial requirements

The response to the expressed needs for improving the design of housing and other issues relating to confinement of pigs has tended to be in terms of developing alternative systems, altering design parameters and varying management techniques. For adult pigs, this has resulted in a range of options being developed, including conventional housing in the form of pens and stalls, modified conventional pens, deep litter systems, large group and free range systems. However more information is required to investigate the negative aspects of these systems, given that previous research has indicated that the design features of the housing environment are perhaps more important than the housing system *per se*. For example, improved understanding is required in relation to space, social requirements, features of the environment, enrichment, animal interactions including aggression and human-animal interactions. Furthermore, this research needs to be conducted with the view of better understanding and definition of animal welfare.

The failure to achieve a consensus view on an adequate definition of animal welfare has limited the role of science in developing and defining appropriate welfare standards. Thus research is needed to investigate further those features of housing and husbandry systems that will directly underpin the definition and assessment of sow welfare. This will then provide a sound basis for establishing animal welfare standards relating to features of the housing environment, for example space requirements.

4.2.6 Practical and applied approaches to assessing animal welfare

The practical difficulties of how to assess the overall welfare status of animals during farming conditions have contributed to the ongoing debate on defining animal welfare (Bracke *et. al.* 2002a). In an attempt to utilise the existing definitions and methodologies to describe welfare standards, there have been a number of applied approaches developed, many of which are being used internationally to provide a basis to assess and measure animal welfare in accordance with key standards or provisions. These approaches generally utilise a combination of the homeostasis approach and the five freedoms approach, to determine or describe temporary and practical measures within production system requirements. For example, the U.S. based Food Marketing institute (FMI) and National Council of Chain Restaurants (NCCR) (Anon. 2002a) have introduced static space as a welfare requirement in terms of space for sows to lie comfortably and safely. As a short-term measure, the FMI and NCCR support enhanced pork industry guidelines regarding individual housing systems, including:

1. The pregnant sow should be able to lie down on her side without her teats extending into the adjacent stall;
2. Her head should not have to rest on a raised feeder;
3. Her rear quarters should not be in contact with the back of the stall; and
4. The pregnant sow should be able to stand up unimpeded.

This is an example of a market driven, combined approach to defining standards for space requirements. It also avoids the need to make over-prescriptive dimensional requirements for facilities that may not apply to all installations or housing situations, whilst at the same time seeking to put in place some basic safeguards against commonly recognised sow welfare risks.

Another approach to providing a basis for determining and measuring animal welfare has been adopted by Temple Grandin (Grandin, 1997) and has since been applied internationally as part of many retail requirements. In this approach, measures based upon a series of applied research investigations have been developed into a HACCP (Hazard Analysis Critical Control Point) based system, similar to that applied in food safety, for assessing animal welfare at slaughter. The critical control points employed measure vocalisations as an indicator of stress and other behavioural observations including, calculating the numbers of animals slipping, falling and numbers of animals that are rendered effectively insensible. Von Borell et. al. (2001) describes the use of a similar HACCP based system for on farm assessment of pig housing.

This system is effectively based upon the European Council Directive (91/630/EEC, 1991) and on recommendations from the report 'The Welfare of Intensively Kept Pigs' by the expert group of the Scientific Veterinary Committee of the European Commission.

Other examples include an on-farm index system in Austria (Bartussek, 1999) where relevant parameters are graded, giving the highest scores to those systems considered to improve animal welfare. The European Association for Animal Production also proposed a series of criteria, relating to functional areas of pig housing systems, with emphasis on animal welfare, health, environmental care and management (Von Borell and Van den Weghe, 1998). Nordhuizen and Welpelo (1996) addressed the principles of HACCP in relation to animal health and management strategies and the National Pork Producers Council in the United States have also introduced critical control points for production processes.

There is some controversy in relation to applying this practical methodology to welfare. Some commentators say that HACCP, being comprised of critical control points, whilst a preferable approach for food safety, does not establish sufficient measure for animal welfare. There are varying stages at which welfare may decline and reductions in welfare may sometimes only be slight, rather than extreme or obvious (e.g. in the case of a critical control point for food safety, temperature). It is clear that with the science available (taking into account the difficulties in determining definition, methodology and measure) that only a few criteria for animal welfare can actually fulfil the HACCP principles and methods for application. However, there is nonetheless a clear opportunity for the introduction of animal welfare into on farm and other sector quality assurance, complete with effective standard operating procedures and processes. This concept reflects the increasing view that animal welfare is a quality characteristic of food production and the increasing need to deliver customers, consumers and the general community assurance on the level of animal welfare standards and provisions.

Another approach is the use of a model for welfare assessment in pregnant sows on the basis of available scientific knowledge. The SOWEL (from SOw WELfare) model (Bracke, Spruijt and Metz, 1999; Bracke, *et. al.*, 2002a; Bracke, *et. al.*, 2002b; Bracke, *et. al.*, in press) contains 37 attributes that describe the welfare-relevant properties of housing and management systems. This type of model is utilised for the design of farm animal welfare indexing systems, which in the future may become an important part of the producer's 'license to produce' in accordance with key animal welfare standards.

Munsterhjelm *et. al.* (2006) report on The Tiergerechtheitsindex (TGI) Animal Needs Index (ANI) modified for use in Finnish pig production.

The index for dry sows and lactating sows comprised of 6 categories: locomotion, social interaction, floor quality, stable climate, feeding, and health and stockpersonship. Total ANI points varied between 36–80 for lactating sows and 40–86 for dry sows out of a maximum score of 100. High quality floors and stockpersonship appeared to correlate positively with reproductive performance in the sow. Effects of a welfare promoting feeding strategy on reproduction were contradictory.

The USA's Swine Welfare Assessment Program (SWAP) consists of 9 Care and Well-being Principles (CWPs) (Anon. 2003). There are explanations of each principle and suggestions for its implementation. The programme includes an example of how to track daily observations on farm and an Assessment Table that can be used for an internal self assessment. Relevant sow parameters include:

- sows lame <0.1% no action, 0.1–2% warrants attention; >2% needs immediate attention
- sows with abscesses <1% no action, 1–2% warrants attention; >2% needs immediate attention
- sows with wounds <5% no action, 5–15% warrants attention; >15% needs immediate attention
- sows with scratches <15% no action, 15–40% warrants attention; >40% needs immediate attention
- sows return back to hand or show a relaxed posture within 15 s >50% no action, 20–50% warrants attention; <20% needs immediate attention.

These issues relating to animal welfare definitions and its assessment, together with the available literature and the relative impacts of various housing systems and environments on the welfare of pigs will be discussed throughout the report.

4.3 Conclusions on Animal Welfare Assessment

In the future, there are obvious opportunities to integrate the various approaches to the assessment of animal welfare. For example it has been proposed by some (Hemsworth and Barnett 1997) that a combined approach to the methodology, such as coupling the 'feelings' or 'preferences' approach within the 'homeostasis' approach may bring a more accurate assessment of animal welfare in the future. It has been documented in many future research strategies for both industry and scientific organisations that further investigation into the definition and fundamental assessment of animal welfare will be required in order to refine further the methodology to study animal welfare. This will be necessary also in order to develop the appropriate tools to assess animal welfare in the various systems and environments surrounding production animals.

As research into the fundamental assessment of animal welfare continues towards developing an agreed definition and methodology for assessing animal welfare, the application of animal welfare science to the development of standards, policies and providing a basis for education and extension will strengthen.

5.0 Welfare Regulation

Different countries have taken a number of approaches towards regulating animal welfare. In some cases, the approach has been directly legislative and in others is more reliant on industry codes of practice and other duty of care or cruelty provisions.

As a result, numerous regulations, codes of practice and guidelines have been developed around the world for the management and welfare of sows during gestation, farrowing and lactation. The following is a summary of some of the various approaches.

5.1 United States

Significant strides have been made in the United States regarding animal welfare standards over recent years (Anon. 2002b). These changes in the US have been precipitated by pressure from animal rights groups, changing public attitudes regarding animal production, and changing animal welfare standards and legislative changes in Europe. One of the most well known developments was during 2000, when McDonald's announced that their suppliers would have to meet specific animal welfare standards, and be audited to prove that they are meeting the standards. In 2001, Burger King announced that it would also require their suppliers to meet specific animal welfare standards, and the Food Marketing Institute (FMI)/ National Council of Chain Restaurants (NCCR) process to develop standards for beef, pork and poultry processing began.

Until specific recommendations are made regarding gestating sow housing, FMI and NCCR have indicated they support pork industry guidelines regarding individual housing systems that specify how much movement and space a gestating sow should have in a stall (Anon. 2002b).

The U.S. National Pork Board Animal Welfare Committee has been working with an international panel of advisory experts to develop a method by which a pork producer could objectively assess the welfare of their animals at the farm level. The Swine Welfare Indexing System was the first phase of this collaboration and concentrated on the gestating sow housed in stalls, pens and on pasture. Farms of all sizes geographically dispersed across the U.S. participated in the pilot assessments, which were completed early in 2002 by animal and veterinary experts.

These experts covered physiology, behaviour, production, veterinary medicine, housing, handling and stockpersonship/ training. In addition, three areas of the farm were identified for welfare assessment:

- Farm records;
- The animals directly; and

- The facilities.

The experts and the Animal Welfare Committee identified a total of 43 measures of welfare for inclusion into the Index.

The Animal Welfare Committee agreed to expand this Swine Welfare Indexing System to address the well being of the farrowing sow, neonatal piglets, nursery and finisher pigs. It was renamed the Swine Welfare Assurance Program (SWAP).

The Swine Welfare Assurance Program (SWAP) divides pig production into two stages: 1. Gilts, Sows, Boars and Neonatal Piglets, and 2. Nursery and Finisher Pigs, assessing and evaluating pig well being on farm. This program will be applicable to all sizes and types of production systems throughout the U.S. Thus SWAP, whilst voluntary, is a science-based program for America's pork producers to assess objectively and benchmark the care and welfare of their pigs.

The major focus of SWAP is animal welfare. SWAP is an assessment program that benchmarks animal welfare practices. Individual production sites are assessed by a Certified SWAP Educator for adherence to nine principles of pig care and well being. The facilities, individual animals, and record keeping practices are all evaluated. SWAP gauges sow welfare according to behaviour, production and physiology by evaluating farm records, the sows themselves and facility conditions.

5.2 Canada

In Canada, the pig Code of Practice specifies the dimensions of individual sow holding units according to the sow's weight. In contrast, in the United States, the U.S. National Pork Board does not specify dimensions but does have guidelines that address the sow's ability to move in 'individual housing systems' (Anon. 2002b). The Canadian Code of Practice suggests sows in wider stalls with each parity (Gonyou 2005).

5.3 European Union

In 1999, the United Kingdom banned sow gestation stalls. This has been followed subsequently by development of an EU-wide framework of welfare standards for pigs. This framework is generally based on prescription of certain husbandry practices and design of pig housing facilities. To allow the industry time to adjust, provision was made for the phased introduction of the measures (Anon 1999).

Sow gestation housing has been considered in legislation by the EU and individual member countries for many years. Scientific evidence and impressions of experiences of animals are considered in such decisions. From 2013, the EU will impose a maximum time in stalls of four weeks after mating and up to one week before farrowing. Some EU member countries have voluntary enacted legislation to restrict the use of stalls within a shorter timeframe. For example the Netherlands will require compliance with this directive by 2008 (Anon. (1999).

The proposal for the Council Directive to amend Directive 91/630/EEC (Anon. 2001a, Anon, 2001b), aims to:

- Restrict the use of individual stalls for pregnant sows and gilts for the period from four weeks after mating to one week before farrowing and ban the use of tethers completely;
- Increase the living space available for sows and gilts;
- Allow the sows and the gilts to have permanent access to materials for rooting;
- Introduce a higher level of training and competence on welfare issues for the stockmen and the personnel in charge of the animals; and
- Request new scientific advice in relation to certain issues of pig farming.

Breeding sows may currently be housed individually, in stable groups (formed at weaning or service and remaining unchanged until farrowing) or in large dynamic groups (where existing sows are removed to farrow and replaced by newly served sows on a regular basis). Individual housing may be in fully enclosed stalls or in partial stalls where the sow is tethered by a collar or girth belt (tethering will be banned in the EU after 2005 as provided by Council Directive 91/630/EEC).

5.4 United Kingdom

The main law relating to the welfare of animals is contained in the *Protection of Animals Act 1911.* The welfare of all farmed livestock is further protected in Great Britain by the *Agriculture (Miscellaneous Provisions) Act 1968*, which makes it an offence to cause or allow unnecessary pain or unnecessary distress. *Welfare of Farmed Animals (England) Regulations* came into force in August 2000 and were subsequently amended to implement new EU Directives on the welfare of pigs and laying hens.

5.5 Sweden

In Sweden gestation stalls are not allowed and straw bedding must be used (McGlone 2006).

5.6 Australia

The current Model Code of Practice for the Welfare of Animals has been in use since 1988 (Anon. 1998). The Code provides recommendations for individual stalls, farrowing crates and group pens. Pigs accommodated individually in stalls should be able to stand normally, lie with legs extended, to stretch and move freely. They should have sufficient space in which to feed and sleep and a clean dry place on which to lie. To minimise leg problems in pigs, the Code suggests that housing in conventional stalls followed by housing in farrowing crates should be avoided, although in the revised draft version (2007), there are specific targets for the time spent in stalls when followed by farrowing crates. Practical alternatives to current conventional stalls (e.g. turnaround stalls or use of group housing) are recommended to be continually investigated.

In partial stalls systems in which groups of dry sows and gilts are kept, action should be taken to prevent bullying or deprivation of food. Stalls in which dry sow and gilts can feed are strongly recommended.

The present Australian Code has emphasis on the physical side of welfare only. The Code is presently being reviewed and a new version is being finalised. Further developments in Australia include the consideration of key animal welfare standards being introduced into legislation. This is similar to the direction being following in the United States and Europe and already in Australia there is duty of care legislation in addition to legislation for cruelty adopted in most States. Furthermore, some States have developed their own specific Code that specifies key guidelines for the different climatic or other environmental conditions for the particular State.

The Commonwealth of Australian Governments published an overarching Australian Animal Welfare Strategy document in 2004. This is designed to bring all the key stakeholder interests together into an overarching strategy. It will address the key priorities for all the animal industries in areas of science (research and development), policy, extension, education and training. The strategy will define the future direction for the development of animal welfare policy across Australia. Whilst implementation of this strategy will require a complex programme of activities across States and sectors, it will ultimately result in a standards-based system for animal welfare underpinned by science and community involvement. The current review of the pig Code of Practice is being undertaken in that context.

5.7 New Zealand

The Animal Welfare (Pigs) Code of Welfare 2005 was gazetted in late 2004 and became law on 1st January 2005, on the recommendation of the National Animal Welfare Advisory Committee (NAWAC). The Code requires a restriction of use of dry sow stalls during a sow's pregnancy to first four weeks after mating for all new facilities as from 1 January 2005 and for all facilities by 1 January 2015. The Code also indicates that the disadvantages of the farrowing crate system for the sow 'include the restriction of movement and a reduced ability to carry out nest building' and indicates that NAWAC would like to see farrowing crates 'eventually phased out altogether'.

6.0 Welfare Implications for Pigs in the Various Housing Systems

6.1 Background

There is a range of housing systems in use in New Zealand, with many variations in management across the stages of production. Systems may vary from indoors to outdoors and more recently, combinations of both (Hemansen, 2003) and from farrow to finish to solely farrowing to weaning or grower and finisher systems. In addition, there are combinations of both independent producers and contract producers, with contract or sharefarming generally part of the larger company farm systems.

Farrow to finish farms, predominately the most common, house sows in stalls or groups, farrow in crates, wean into group accommodation and then move growing pigs in batches through various group housing setups for growing and finishing. Typically, the accommodation provided is in varying sizes of purpose-built sheds with concrete or slatted floors, the latter with under-floor effluent removal systems. An alternative for the conventional system described above is the deep litter system, where weaners, growers and finishers and more recently dry sows, are kept usually in large groups in shelter-type structures with loose bedding. The further potential of this system is being investigated for adult pigs, predominately sows in large groups of 20-200 pigs. Other alternatives are free-range and barn systems, used for the breeding herd, lactating sows and piglets to 10 weeks, with grower and finisher pigs commonly being reared in conventional systems indoors or in deep litter systems. Most sows farrow in farrowing crates, with the exception of outdoor systems where sows farrow in huts or similar types of housing design. A small number of farms may also utilise farrowing pens, historically in Europe and in the early days of New Zealand's pig industry the main form of farrowing housing.

Such a range of systems and the various management combinations provides a number of different variables to consider when assessing animal welfare outcomes of these systems for different stages of production. Welfare issues with group housed pigs can include aggression, space allowance, injury and inappropriate behaviours (i.e. tail biting). Welfare issues for confined pigs in stalls or crates can include lack of environmental complexity, inability to exercise, space allowance, injury and stereotypical behaviour. The housing of sows in particular is one of the most controversial issues for conventional pig production.

A survey in New Zealand (Gregory and Devine, 1999) reported that 32% of sows were housed in stalls for most of their pregnancy, 40% in indoor group pens, and 28% housed outdoors, although these figures have changed somewhat, with the emphasis leaning towards increased outdoor production systems (I. Barugh, pers. comm., 2007).

A common view following the increase in focus on housing systems and the development of new requirements is that the welfare of pigs is more related to the management and the environmental features of the housing system, rather than the design of the system per se (Barnett *et. al.* 1997, Barnett *et. al.* 2001).

Thus, the role of science and the development of standards for the pork industry both need to focus more on providing methods to minimise the disadvantages of the various systems and provide advice on the application of management and stockpersonship principles to maximise the advantages of the various systems, as well as allowing for the continual improvement in the welfare of pigs. For example, it is difficult when comparing the various systems for housing pigs, to weigh up the advantages of increased space, environmental enrichment, exercise and socialisation in group systems versus the disadvantages of increased aggression, injury, culling rates and poorer reproductive performance. The following sections address some of the recent research and information available on the various types of housing for pigs, to build on the research presented in the previous reviews mentioned on housing in relation to the welfare of pigs.

6.2 Gestating Sows

6.2.1 Outdoor group housing

Commonly expressed animal welfare concerns require the development of housing systems that allow the animals to express their normal (often interpreted as 'natural') behaviour. The group housing of pregnant or lactating sows has been presented as such a system.

Over recent times, the numbers of producers adopting outdoor housing systems has increased and in addition, promotion of these systems through labelling and other quality assurance means, including RSPCA accreditation, has become apparent. In New Zealand, a report by Gregory and Devine (1999) indicated that around 28% of sows were housed outdoors. This system has increased greatly over the last 20 years in the United Kingdom and some parts of Europe because of animal welfare regulations regarding intensive indoor systems, coupled with economic building costs.

Sows living in outdoor pens account for 20–25% in the United Kingdom, 24% in Denmark and 1% in Italy and the Netherlands (Hendriks *et. al.* 1998; von Borrell *et. al.* 1997). In Australia, current estimates of sows living in outdoor pens are approximately 6-7% (pers comm., I. Stephens). Previous reports expected growth in Australia of outdoor systems to have reached 7-10% although there is no current data collected on this to date (Barnett et al, 2001, from a report by Agribiz Engineering, 1999). In New Zealand an estimated 35% of sows are housed outdoors (Barugh pers. comm. 2007), up from 28% reported by Gregory and Devine (1999).

In some cases, national production figures indicate that outdoor systems achieve the same averages as indoor systems, however this is somewhat controversial, with other studies reporting poorer averages of 1-2 pigs weaned per sow (Berger *et. al.* 1995; Edwards, 1995).

Typically, local pig breeds and outdoor-adapted breeds for certain environments are generally more suitable for free-range systems. Welfare considerations previously reported for outdoor systems include health and disease, access to feed and water, stocking density, pasture management and site selection, paddock rotation, predation, climatic conditions, lameness, management of the sow and piglets and behavioural needs including wallowing and rooting (Berger, et al, 1998, Berger, et al, 1997, . Outdoor sow housing has been previously reported on by the Farm Animal Welfare Council (1996), where a series of recommendations were made in terms of current and best practice and the need for further research, policy and extension.

Outdoor systems are comprised of fenced paddocks, with communal shelters and wallows and individual huts for farrowing and lactating sows. The sows are provided with feed either on the ground, in troughs or by self feeders. Huts or shelters are crucial for protecting pigs from direct sun burn and heat stress, especially when shade from trees and other facilities is not available. Communal huts tend to be large iron arcs, sometimes constructed of other materials. More recently, polypropylene roofing and straw bales have gained in popularity. Farrowing huts are smaller iron or wooden arcs with a smaller door and may be insulated. There are various different designs with variations in bedding and other materials provided also. Outdoor pig systems should be located in a low rainfall area, as waterlogging can be one of the main problems for this type of system.

Recommendations for the UK (Thornton, 1990, Farm Animal Welfare Council, 1996) suggest that paddocks should be relatively flat, with light topsoil overlying free-draining subsoil with the absence of sharp stones that can cause foot damage. Pigs commonly graze on strip pastures and are rotated between paddocks. Modern outdoor rearing systems require simple portable and flexible housing with low cost fencing.

Site selection is considered one of the most important considerations for outdoor farming, as unsuitable sites have the capacity to increase the potential for poor welfare. In future, it is anticipated that more information will be developed for use when selecting sites for outdoor pig production, for example information that enables decisions to be made on aspects of stocking density, rainfall and soil type to assist in the determination of site suitability. A good, well-established grass sward provides additional drainage on some soil types and protects the soil should it become waterlogged which is of particular importance in farrowing paddocks. Lower stocking density and the rotation of paddocks help reduce the effects of wet weather, as can provision of shade and shelter. The review by Barnett *et.*

al. (2003) suggested that multiparous sows required 1.3m^2 of shelter space per sow and for dry sows, 1.2-1.5m^2 per sow is recommended, but that space allowance for sows in outdoor systems needed further research. Research on space allowance would need to examine space in terms of fundamental welfare needs, as well as applied considerations including design, dimensions and type of hut provided.

Activity patterns and thermoregulation studies for pigs housed outdoors have often referred to the evolution of wild pigs, where daily activity has been found to be highly variable and depend to a large degree on hunting and foraging activity. Weather is a large determinant in the activity of pigs kept outdoors, with animals behaving more passively during hot weather (Hanson 1959) and domestic pigs have been found to concentrate their activity during the morning and late afternoon hours (Woodgush and Vesterguaard, 1990). Pigs have been observed to move between foraging areas during these periods of the day and utilise resting sites (Graves, 1984). Even when fed full rations of feed, domestic pigs have been reported to spend at least 6-8 hours each day searching or foraging for food (Woodgush and Vesterguaard, 1990). The observed behaviours are primarily foraging, grazing and browsing on pasture areas for one to two hours in sequence (Anon, 1996).

As reported in the previous review by Barnett *et. al.* (2001), it is common practice to reduce the amount of foraging behaviour shown by outdoor pigs by placing metal rings in their noses, which supposedly cause discomfort when they root. When a nose ring is inserted in the pig, normal exploratory behaviour by rooting cannot be expressed as the ring causes discomfort when the sow attempts to dig and root. It is reported that some producers consider this essential to prevent rooting and maintain the grass sward, for farrowing paddocks where grass provides insulating and cooling properties, to maintain ground conditions reducing lameness and to avoid pigs digging deep nests and overlaying piglets.

Provision of bedding can reduce the possibility of the latter and rotation and pasture management can also reduce the need for nose ringing. Ringing in itself can result in considerable distress to the sow when the procedure is carried out, especially when wire rings are lost and have to be regularly replaced and this type of ring is particularly inappropriate. If a nose ring was pulled it would be very painful and is generally painful for the sow when pushed during rooting. As rooting is a behaviour which pigs have a strong preference to perform, (Hutson, 1988), there will be an adverse effect on their welfare, which is increased when surrounded by stimuli that would normally elicit rooting behaviour.

The review by Barnett *et. al.* (2001) reported that in addition to the adverse effects of nose ringing, the procedure has other implications in addition to inhibiting rooting behaviours, such as affects on grazing and stone chewing.

Some impacts may be reduced if there is provision of other opportunities to carry out rooting behaviours, however some studies have reported that providing alternative forage for sows can be unsuccessful in reducing rooting need (Braund, *et. al.* 1998; Hutson, 1988). The review by Barnett *et. al.* (2001) indicated that further research is required to examine the implications of nose ringing. This recommendation was also supported by the Farm Animal Welfare Council review of outdoor housed pigs (1996), reporting a need to assess the efficacy of nose-ringing and to establish the extent of acute and chronic pain which occurs during and after the operation.

Furthermore, it appears that there is also a need to examine further the motivational state underlying rooting needs and the frustration caused by prevention of rooting. Despite many outdoor sow enterprises effectively managing pasture without the need for nose ringing, it may also be useful for those that continue to perceive a need for the procedure to examine provision of alternative sources or materials for rooting, in order to develop alternative practice (Edwards and Zanella, 1996).

It is also important to note that producers in New Zealand may face regulatory constraints in some cases in relation to any attempt to cease the practice of nose ringing, because of the perceived negative impact on the environment and resultant local body regulations. For example, an excerpt from the Ashburton District Plan states "All pigs, other than progeny up to weaner stage, shall be ringed at all times."[2]

Amongst the environmental variables that can affect the welfare of pigs, temperature is certainly one of the most important. Given that pigs have limited sweating and panting abilities to lower their temperature during hot weather, wallowing is important for cooling (Baldwin and Ingram, 1967). During summer, high temperatures can cause problems for sow and piglet welfare, and an early sign of heat stress is decreased feed intake, resulting in loss of condition, reduced reproductive performance and for sows in lactation, reduced milk production for piglets. The Australian review (Barnett *et. al.* 2001) reported that outdoor production should be confined to areas that experience few days over 30^{o}C and fewer above 35^{o}C, in a low rainfall area, with gently sloping land and a variety of soil types. The review also reported that soils with a high clay content and poor drainage or very light soils do not tend to result in a coating of mud required from exiting the wallow for cooling the pig.

[2] Ashburton District Council (2007); Ashburton District Plan 2007; Rural Zones; 7.6.5.19 Extensive (Outdoor) Pig Farming

However, the extent to which this latter point is important in New Zealand needs to be evaluated in relation to the generally lower ambient temperatures compared with Australia.

Bruce and Clarke (1979) developed a model to calculate lower and upper critical temperatures for sows. They reported that the lower critical temperature for pigs reduces as liveweight increases and that other factors such as body condition, stage of production, climatic factors such as wind speed or rain, the feed level and the provision of bedding can affect the lower and upper critical temperature of pigs. For example, for sows fed at maintenance level on dry concrete the lower critical temperature was 19°C and on straw was 14°C. Conversely, the upper critical temperature for sows fed at maintenance level on dry concrete was 32°C and for straw 30°C.

Thus, for indoor housed sows, high heat can also be a concern, although there are more options available to manage heat in sows housed on concrete or slatted floors (Baxter, 1984). Most commonly, this is through the application of sprays or drippers for cooling and other practices such as hosing and washing out effluent channels, enabling pigs to conduct some wallowing behaviours in order to cool down. Outdoor housed sows may be affected by sunburn if appropriate shade and shelter is unavailable (Berger, 1998). The review of the welfare issues for sows and piglets in relation to housing conducted by Australian researchers reported that there also may also be some thermal problems for sows housed outdoors in cooler months. A recent study by Barnett and colleagues (see Agribiz A study in Australia (Barnett *et. al.* 1999) comparing biological variables in pigs across all seasons for both indoor and outdoor housed sows indicated higher rectal temperatures and greater variation in these rectal temperatures in outdoor pigs compared to indoor pigs. The variation in rectal temperature, with temperatures being higher for outdoor pigs suggested that some pigs may have more difficulty in controlling their body temperature in the outdoor environment during winter. Additionally, the outdoor sows in this study exhibited greater variation in back-fat measures, claw lengths and farrowing rates.

This finding may be particularly relevant to New Zealand, where winter temperatures may be generally lower than in most parts of Australia, particularly in the South Island.

The zones of thermal comfort for the sow and piglet differ markedly; between 12-22°C for the sow and 30-37°C for piglets. Offering wallows for free-range pigs meets their behavioural requirements, and also overcomes the effects of high ambient temperatures on feed intake. Pigs can increase their evaporative heat loss via an increase in the proportion of wet skin by using a wallow, or through water drips and spray. Mud from wallows can also coat the skin of pigs, preventing sunburn. Under grazing conditions, it is difficult to control the fibre intake of pigs although a high energy, low fibre diet can be used. Nose rings used to prevent sows from uprooting the grass reduce nutrient leaching of the land

due to less rooting. In general, free-range pigs have a higher piglet mortality compared to intensively housed pigs (Berger, et al 1998). Many factors can contribute to the death of the piglet including crushing, disease, heat stress and poor nutrition. With successful management, free-range pigs can have similar production to indoor pigs, although the growth rate of the litters is affected by season (Edwards and Zanella, 1996). Piglets grow quicker indoors during the cold season compared to outdoor systems. Pigs reared outdoors show calmer behaviour. Aggressive interactions during feeding are lower compared to indoor pigs whilst outdoor sows are more active than indoor sows. Outdoor pigs have a higher parasite burden, which increases the nutrient requirement for maintenance and reduces their feed utilisation efficiency. Parasite infections in free-range pigs also pose risk to the image of free-range pork as a clean and safe product. Diseases can be controlled to a certain degree by grazing management. Frequent paddock rotation is required although most farmers are keeping their pigs for a longer period before rotating. The concept of using selected pasture species to minimise nematode infections in grazing pigs looks promising. Plants that can be grown locally and used as part of the normal feeding regime are most likely to be acceptable to farmers, particularly organic farmers. However, one of the key concerns from the public for free-range pig production systems is the impact on the environment. In the past, the pigs were held in the same paddock at a high stocking rate, which resulted in damage to the vegetation, nutrient loading in the soil, nitrate leaching and gas emission. To avoid this, outdoor pigs should be integrated in the cropping pasture system, the stock should be mobile and stocking rate related to the amount of feed given to the animals.

The United Kingdom Farm Animal Welfare Council (FAWC) issued a report on the welfare of pigs kept outdoors (Anon. 1996). The report has 48 recommendations. Relevant sow welfare issues include the following:

- The stockman is the most significant influence on the welfare of the pigs in his or her care and must plan and execute an effective daily routine whatever the weather conditions;
- Newcomers to outdoor pig-keeping should obtain appropriate training from experienced outdoor pig stockmen and/or from approved agricultural trainers;
- Selection of a suitable site is one of the most important decisions for the outdoor pig farmer because an unsuitable site will greatly increase the potential for poor welfare;
- The ideal site for keeping pigs outdoors is on a light and free-draining soil in an area of low rainfall. Heavy rainfall, strong winds, high temperature and extreme cold can all affect welfare standards on a pig unit. On an ideal site a maximum stocking density will be about 25 sows per hectare;
- Inspection of farrowing sows and piglets should occur at least twice per day;
- No piglet should be weaned at less than 3 weeks of age;
- Practical research should be undertaken into the most effective, least painful and minimally invasive methods of nose ringing;

- Selection of breeding stock to be kept on outdoor enterprises must ensure that only those strains of pig with the genetic potential to thrive in the conditions provided are used.

Kuehn and Kahler (2005) mentioned parasites and sunburn as potential problems of outdoor systems. It is known that runoff and soil erosion is likely to increase with the use of outdoor pens. In Suffolk England, a group of properties adjacent to fields of outdoor pigs was flooded at frequent intervals in 1998 and 1999 (Evans 2004). The risks of flooding and drowning of sows and piglets should be considered in designing outdoor pens.

Keeping of large populations of pigs outdoors has also been recently recognised as increasing biosecurity risks for spread of disease epidemics. Notable examples have been the UK Foot and Mouth (FMD) epidemic of 2001 when large populations of outdoor pigs were associated with amplified wind-borne spread of the FMD virus (Gloster *et. al.* in press) and the recent outbreak of suspected Post Weaning Multisystemic Wasting Syndrome (PMWS) in Canterbury. In the latter outbreak, vectors such as wild birds were suspected as being responsible for the rapid spread of the disease through the large outdoor pig population.

6.2.2 Indoor group housing

Indoor group housing is a common housing system for pregnant sows, which arose primarily from the difficulties of managing sows in outdoor systems, including issues related to climatic conditions, provision of feed to individual pigs and the cost of land. Group housing of sows is predominately indoors on slatted/ concrete floors, with group sizes ranging from 2 to 20 (Barnett, et. al. 2003), although more recently larger group sizes are being employed (Morrison, *et. al.*, 2003a). Alternative systems in use include large indoor groups with electronic feeding systems (Bressers et al, 1993) and deep litter systems, although there is little published information that relates specifically to conditions in New Zealand.

6.2.3 Deep litter systems

These systems are sometimes referred to generically as 'ecoshelters' (Barnett, *et. al.*, 2003) however this is a registered company trademark name. These deep litter systems were developed originally as an alternative housing system for grower and finisher pigs, compared to conventional pen confinement. They consist of large groups of pigs (typically 150-200) in naturally ventilated shelters, with a floor base of rice hulls, straw, corn stalks or other bedding material, with space allowances of approximately 1.0 m^2 per pig (Morrison et. al. 2003a). In deep litter systems, the total area occupied by the animals needs to be maintained in a hygienic state by regular provision and removal of absorbent bedding material. In such systems, the animals will often subdivide the pen area into

separate lying and excretory areas, choosing to lie in the most thermally comfortable and undisturbed areas and excreting in areas of the pen which are cold, wet or draughty.

Whilst straw is the most commonly used material in such systems, there has recently been development of deep litter systems using sawdust beds, in some cases with anaerobic digestion of waste being promoted by regular application of an enzyme/microbe mixture.

By comparison, in conventional indoor pens, pigs are housed in groups of 5-50 with floor space allowance ranging up to around 1.4m^2 per pig (with actual space allowance depending on average weight), often with liquid feeding, on partially or fully slatted floors (Honeyman, Harmon and Kleinbenstein, 2003). Recently, interest in deep litter systems, given their low cost and efficiency in terms of the use of bedding to absorb faeces and urine, and provision of more space (1.0 m^2 per pig) for large groups (Barnett, *et. al.,* 2003), has increased. Some research (Conner et. al. 1997) has compared these systems on the basis of reproductive performance, indicating that performance is comparable with conventional systems (Barnett, *et. al.*, 2003). In contrary to these reports, while it is recognised that deep litter systems are cheaper to establish, perceived to be more 'welfare friendly' and more environmentally sustainable, recent industry records suggest that pigs grown from 2 weeks to 22 weeks show a number of growth performance problems compared to conventionally housed pigs. More recent research, (Honeyman, Harmon and Kleinbenstein, 2003, Morrison, et. al. 2003a, Morrison et. al. 2003b) indicated the need for further examination into the production related differences of these systems. These authors also reported that pigs housed in deep litter systems can be up to 10% less efficient in terms of feed conversion and present higher levels (by 1-2mm) of backfat than pigs raised in conventional systems. Nevertheless, despite the large variation of factors within the deep litter system (such as climate, disease, litter, space and location) it may be possible that the variation in growth and performance observed in some of the literature is due to behavioural interactions, rather than environmental factors. The understanding of these factors is still yet to be fully explored.

In comparison to the literature available for conventional housing systems, there is still only limited research available on these newer deep litter systems. Recent research into the application of these systems to sow housing is occurring more recently (Karlen *et. al.*, in press) as is the increased investigation into housing sows in larger groups of more than 40 animals. Deep litter systems can house groups of sows from less than 20 to several hundred sows. There is some research available that investigates the effect of deep litter systems on the welfare of sows, looking at interactions of aggression, leg and feet problems, immunology, behaviour and stress (Karlen *et. al.*, in press). This research reported aggression occurring with some increases in stress and injury at week one after introduction into the deep litter group situation, but that these issues had reduced by week nine with

sows establishing a social hierarchy. It is thought that if sows had more experience from rearing in these type of systems, that some of the agonistic behaviour may reduce earlier.

There was a reduction in leg and foot injuries and reduced lying behaviour in the deep litter system compared to stall housed sows (Karlen *et. al.*, in press). The reduced lying behaviour was thought to be directly related to the higher incidence of injuries and the reporting of injuries related to the increased opportunity to observe and detect sows in the deep litter system, compared to the stall system. The research also indicated there may be improved immunological function in the deep litter system, reported to be due to decreased stress compared with stall systems. It was also reported that the level of fear exhibited in sows in stalls was higher than in the deep litter system, another contributor of stress and consequently reduced immunological function (Hemsworth and Coleman, 1998, Karlen, *et. al.* in press). However it was recommended that further research be conducted into growth, reproductive performance, immune response and stress with respect to deep litter systems. Thus, further investigation is needed into environmental variables and response of pigs to deep litter systems, and in addition there is a need for more comparisons to be conducted between the various modifications of deep litter systems or between the deep litter system, large group and conventional housing systems.

6.2.4 Swedish deep-bedded group housing system

The Swedish Animal Welfare Institute's 'Animal Welfare Approved Standards for Pigs' (Anon. 2006a) describes two systems for indoor bedding of pigs – deep-bedded and non-deep-bedded.

Deep-bedded pig housing refers to a method of bedding in which approximately 30 cm of fresh straw is laid down before the pigs enter the area. Fresh bedding is added to the top surface as often as necessary to keep a layer of fresh, dry bedding for the pigs. The fresh bedding may be made available to the pigs to spread themselves, for example, in a large bale put in the pen. The farmer also spreads the fresh bedding as needed. The entire bedding pack remains in place and is not removed until the animals are removed. Wet spots of soiled bedding may be removed as needed during the period when pigs are living on the pack. A sufficient amount of litter must be maintained to create a 'deep-litter bed' in which composting can start and be sustained at temperatures that will provide warmth to pigs in cold weather, and destroy pathogens. This housing system is based on the sow's biology and natural social behaviours and has been used in Sweden for nearly three decades.

Brook (1971) reported 2 outbreaks of Battey tuberculosis (mycobacterial lymphadenitis, *Mycobacterium intracellulare*) at intensive deep litter piggeries located near Toowoomba, Queensland. The deep litter consisted of sawdust, which was not completely renewed between batches. It is believed the lesions in pigs regress after the bacon stage as of 117 culled breeding sows

on deep litter only 2 had small lesions. The Battey bacillus is widespread in the environment. In both cases it appears that constant exposure to urine and faeces contaminated deep litter and feed was responsible for the outbreaks.

One of the authors of this report has also had previous experience of problems with persistent swine erysipelas occurring on such a deep-bedded sawdust system. (A. Pearson, pers. Comm.. to M. Edge February 2007).

6.2.5 Swedish non-deep-bedded group housing systems

This system may be used with the scraped or part-slatted floor systems. Straw or other approved material is provided to animals in quantities sufficient to give the pigs opportunities to play, explore and root (Anon. 2006a). This includes during hot weather when animals may prefer resting on cooler, unbedded floors. The minimum depth of fresh straw or other materials in bedded but non-composting, systems is regulated as at least 15 cm, to ensure comfortable lying areas and opportunities for playing, foraging and rooting. Additional dry, clean straw must be provided in quantities that ensure pig comfort as temperatures fall. Bedding must be checked daily and topped up by the farmer as needed, so that all pigs can lie on dry bedding.

Pigs have a preference for insulated or bedded flooring providing physical and thermal comfort (Anon. 2001b). However, in hot conditions, possibilities for being cooled by the floor may be more important to the pigs than physical comfort or insulation provided by a bedded area. Hence deep litter or compost systems may create thermoregulatory problems in pigs kept under high ambient temperatures. Bedded flooring not only influences comfort, it also provides for investigatory and manipulatory activities and, in the case of straw, may provide dietary fibre and allow pigs to express feeding behaviour.

6.2.6 Scraped systems

In these systems the lying and excretory areas are made structurally distinct and the manure is removed at frequent intervals from the excretory area, often daily. Such systems have the advantage of requiring little or no bedding and operating successfully at lower space allowances for the animal.

6.2.7 Slatted systems

Slatted housing systems are the most widely used throughout the EU. In these systems hygiene is maintained, usually in the absence of any bedding, by installation of slatted floors through which the excreta can fall and be stored in a physically separate place from that occupied by the animals. Removal of the need for bedding makes such systems applicable for use in non-arable locations and minimises overall farm labour requirements. Systems may be fully slatted over the entire pen area, or

have a solid floored lying area combined with a slatted dunging area. More recently, slatted systems designed especially to reduce ammonia emissions have been developed.

6.2.8 Group housing feeding systems

The design of group housing systems is highly influenced by the constraints imposed by current sow feeding practice. Precise rationing of each individual animal without aggression can only be guaranteed by individually confining the animals at the time of feeding.

Dry sows are typically fed an amount of a concentrate diet in one or two daily meals. The main feed delivery systems available for group housed animals are (Anon. 2001b):

a individual feeding stalls
b automated flat rate individual feeding stalls
c automated individual identification and rationing (feeding stations)
d ad libitum feeding systems.

Gonyou (2005) noted 72 combinations of sow housing options, in the design of which there are a number of interacting parameters. Optimising space allowance provided is one of the many aspects of making the overall design workable. The four major considerations are based around:

1 feeding

– floor or ground; short feeding stalls or trickle; individual feed stalls; electronic sow

2 management options

– slatted floor; partial slatted floor; bedded floor

3 social group strategy

– static; dynamic

4 timing of regrouping

– weaning; prior to implantation; after implantation

The four feeding systems described above are discussed below:

a. *Floor or ground feeding* – this is very competitive with dominant sows able to monopolise the feed and subordinates being socially and nutritionally deprived. The intense competition may require 10–15% of sows being removed from the system. This can be partly overcome by housing similar size sows, using relatively small groups i.e. about 5, having a static basis of occupants, and having a large feeding area with feed widely spread. One concept is to keep sows in stalls for about 5 weeks to ensure that embryonic implantation is complete before entering the group system.

b. *Short feeding stalls* – sows are fed in partial stalls which protect the head and shoulders of sows. This method conserves space compared with feeding stalls. Feed is delivered at a set rate representing the eating rate of sows (trickle feeding). There is no feed accumulation in the stall thus no value in sows moving from stall to stall to steal feed. An alternative method uses a single drop of feed (short stall system). Animals must be sorted by eating rate as sows eat quicker than gilts.

c. *Individual feed stalls* – are located in each group pen. Costs are reduced by having a centralised feeding stall system with laneways to rotate pens through the system. This results in increased labour costs. Preliminary results indicates that that sows in such groups had fewer lameness problems and abrasions but more agonistic related injuries than sows in time-shared feeding stalls (Karlen, 2006). It is not clear whether the reduction in lameness problems was a result of the daily movements to the feeding area or the use of bedded loafing areas.

d. *Electronic sow feeders* – provide the greatest individual control of feed intake. The system involves electronic identification of each animal plus individual rationing for the feeding of each animal. It is recommended that sufficient feeders be provided that the entire group can complete feeding in 14–18 hours. This limits the number of animals per station to 55–65 mature sows. Gonyou (2005) experienced a number of management problems with electronic sow feeding systems. The sows developed lameness problems, which were identified as being caused by slippery floors related to the dunging pattern. It was not directly related to the electronic system. Another problem was inadequate training of gilts on the use of the electronic system prior to breeding. The solution was to wait until after implantation had occurred before gilts were trained on the use of electronic sow feeding system.

Sow productivity is often raised as a concern by producers but few differences are reported in the scientific literature (Pajor 2005). Similar production levels have been reported for sows housed in gestation stalls versus alternative systems including electronic sow feeding systems. Barnett *et. al.* (2001) wrote, *"the data on individual versus group housing are equivocal, on the basis of weaning-to-mating interval and mating, conception, or pregnancy rates."*

The data in the literature are often contradictory on this as are farmer's own experiences as it appears that the productivity outcomes are so multi-factorial and dependent on stockpersonship, genetics, climate and husbandry that it is difficult to compare performance between systems simply on the basis of differences in housing. Individual sow longevity may be longer in group housed sows that are well-managed compared with stall housed sows, however mortality rates may be higher in groups.

6.2.9 Indoor individual housing

Sows are individually housed during gestation in stalls (variously know as 'dry sow stalls', 'gestation stalls' or 'gestation crates'), or during farrowing in crates or pens. Stalls were predominately introduced to control feed intake and reduce aggression in pigs. They are used in a variety of ways, either for housing pigs for the majority of the reproductive cycle or for only part of their reproductive cycle, followed by group housing, farrowing in crates and group housing around mating. This is similar internationally, and pressure is increasing to reduce the time pigs spend in individual stalls and essentially, eliminate stalls altogether. Further pressure has arisen following a review of the codes of welfare, in both Australia and New Zealand, where discussion on recommending a minimum time that sows are held in stalls and how this is interspersed with group housing, has occurred and continues to occur. A series of considerations have been raised from the revisions of the code of practice in both these countries. These include: the need for clarity in terms of "clear space" with respect to feeder and drinker position and in relation to the length of stall required; the need to investigate the implications of incorporating longer stalls (2.2m) and the associated time frames for industry; the logical extension of these considerations to farrowing crate dimensions; and further investigation into other interactions, such as aggression and risks to animal welfare.

Stalls offer challenges to sow welfare as they considerably restrict movement particularly foraging, which is an important component of behaviour in these food-restricted animals (Appleby 2005). Frustration of foraging instinct often results in stereotypic behaviours, which are generally interpreted as indicators of reduced welfare. There are also welfare problems in group housing such as aggression between sows however these problems are mostly amenable to management whereas the problems of stalls and tethers are more integral to those systems. On the other hand, proponents of the stall system, argue that stalls do a least provide a consistency of outcomes.

Group systems, whilst capable of delivering good outcomes, can also provide very poor animal welfare if the level of supervision and stock management is not consistently high, which can be difficult to achieve in some situations where a skilled labour force is hard to find or maintain.

The FMI-NCCR June 2002 Animal Welfare Progress Report (Anon. 2002a) reported that most individual housing systems (stall, tethers) prevent normal movement such as walking and turning, whilst many group housing systems have the potential to foster aggression and unequal food intake. They accordingly issued a challenge to the U.S. pork industry to 'develop an action plan for implementing systems that will improve the welfare of pregnant sows'.

Individual housing may be in fully enclosed stalls or in partial stalls where the sow is tethered by a collar or girth belt. From 1 January 2006 the use of tethers for sows and gilts shall be prohibited in the

EU as provided by Council Directive 91/630/EEC (Anon. 2001a) and were banned on 1 January 2005 in New Zealand.

The most common method of housing gestating sows worldwide involves the use of gestation stalls. In Europe, 70% of gestating sows are individually housed; Australia 63%; New Zealand 50%; and United States 70% (Pajor 2005). However, stalls are used for varying lengths of time during the sow's gestation period and we note that in fact fewer than 30% of sows are currently estimated to be housed in stalls in New Zealand for their entire gestation (Barugh, pers. comm. 2007).

Economic pressure, rather than science or welfare, is the driving force behind the practice of gestation crate housing in the US pork industry according to Anon. (2006b) and McGlone (2006). Although gestation stalls are already banned in Sweden and the United Kingdom and, for welfare reasons, will be restricted in the European Union by 2013 to the first four weeks after mating until one week before farrowing, they remain a customary animal agribusiness practice in the United States.

In countries where there are few or no agricultural subsidies, various studies have shown that the costs of group housing may be higher because of the requirement for more building space combined with less efficient utilisation of feed and labour. Such studies include unpublished work carried out in both Australia and New Zealand (A. Pearson pers comm. to M. Edge, February 2007).

In the EU, the economic climate is also impacted by EU farm policies, which confer a degree of subsidisation on production costs and/or market protection. For example, the costs and financial return have been analysed on a farm in the Netherlands in relation to complying with the provisions of Council Directive 91/630/EEC. This study compared the keeping of sows in individual stalls without any straw with the different ways of keeping sows in groups (Anon. 2001b).

This paper concluded that, even with the addition of electronic feeding systems, the production costs of keeping sows in groups were lower than those related to individual stalls, based on EU cost inputs and market returns. However, the production costs are now rising since straw must be provided (due in particular to the high costs of straw in the Netherlands) and would rise further when the floor area is increased (over what is included in the Commission proposal).

Other references on this topic suggest different results, indicating that the overall economics is heavily influenced by farmers' individual situations as well as the availability and cost of different resources such as land, labour, feed, building materials, bedding substrates and capital.

Individual stalls typically allow the sow an area of 2.0–2.1 m x 0.6–0.7 m (refer Table 1), such that she cannot turn around and excreta are deposited at a fixed location. There are many different stall designs. Well designed stalls will suit the body size of the sow, the partitions are barred or meshed to allow visual contact but prevent aggression and the height and fixing position of the bottom rail are appropriate to avoid injury. Flooring is most commonly partially slatted, although both fully slatted and bedded systems do occur. Sows commonly have a trough which is either individual or communal (4–6 sows) to allow the possibility of keeping sows of the same body size or condition in adjacent stalls. Feeding may be manual or automatic (1–3 times per day) and feed may be given dry or wet.

Turnaround stalls are roughly the same size as gestation stalls but have a swinging side that allows the sow to turn around. It is considered that turnaround and wider gestation stalls are both compromises but do not offer the highest level of freedom of movement and welfare (Gonyou, 2005, and Kuehn and Kahler 2005).

Conventional gestation stalls are criticised for denying freedom of movement to sows. Gonyou (2005) has completed preliminary studies on the width of sow stalls at the 14th week of gestation in which sows spent 50–60% of their time lying laterally. Applying the Food Marketing Institute (FMI) and National Council of Chain Restaurants (NCCR) (Anon. 2002a) criteria a 70 cm wide stall would be sufficient for all animals but a 65 cm wide stall would only be sufficient for gilts and small sows. This trial used 50% criteria of acceptability that the udder was protruding into the adjoining stall. McGlone *et. al.* (2004) used regression modelling to identify changes in sow body size in relation to parity, body weight, and stage of gestation within and among genotypes. Based on mean values and a 95% confidence upper interval then stall width would need to be at least 72.4 cm to accommodate all sows.

On the other hand, work by Barnett (1995), showed that having stalls wider than 60 cm can be disadvantageous to sow welfare because of unresolved aggressive interactions between neighbouring sows. These workers found reduced cortisol levels and reductions in other indicators of sow stress in studies where the stalls were instead lengthened to allow sows to move forward without trying to turn around. This study recommended a stall length of 2.2m as optimal with a width of 60 cm preferred over 75 cm.

These results of the latter have been used in the development of the draft revised Australian code of practice for the welfare of pigs.

Another aspect of stall design that needs further clarification is the placement of feed and water facilities.

A more recent innovation in terms of regulating animal welfare in sow stalls is to develop outcome-based measures for what the sow can do in the stall, rather than simply relying on measurement. This extends on the approach noted in the current Australian code and also is the method used in Denmark. The benefit of this approach is that it allows for a variety of designs of stalls to be used, in line with current practice, whilst on the other hand safeguarding the welfare of the animals housed in them.

Table 1: Dimensions for Dry Sow Stalls

New Zealand (Ministry of Agriculture and Forestry 2005)	0.6 m x 2.0 m – regulated Minimum Standard	Pregnant sows in individual stalls, centre-to-centre measurements
Australia (Anon. 1998)	0.6 m x 2.0 m	2.0 m does not include feed and water facilities
Australia (Consultation Draft of revised Code 2006)	0.6 m x 2.2 m – for all new installations Smaller stalls may continue to be used for smaller sows	Internal dimensions, inclusive of feed and water facilities, provided the latter do not compromise the sow's movement and lying space
Canada	Gestation pen stall -Width 0.66 m (2 ft 2 in.) -Length 1.8 m (6 ft) -Height 1.06 m (3 ft 6 in.)	Some voluntary guidelines suggest larger stalls for larger sows
USA	Gilts = .558 m x 1.828 m Sows = .609 m x 2.133 m	Converted from imperial measures
Denmark	There are no exact minimum requirements for dimensions of stalls. However, legislation requires that any pig should be able to stand up, lie down, and rest without difficulties. Furthermore, that if the stall is used for gestating sows, 0.9 m of the flooring is based on solid floor.	Audit guidelines are as follows: 1. The legislation requires that any pig should be able to stand up, lie down, and rest without difficulties; 2. When the sow is lying down in the stall, her snout and back end must not be simultaneously touching the ends of her stall; and 3. The width of stalls is largely determined on the requirement to prevent a sow from trying to turn around.

6.3 Farrowing/ Lactating Sows

6.3.1 Farrowing Crates

Sows are typically moved from dry sow to farrowing accommodation 3–7 days before the expected farrowing date. In outdoor systems, farrowing and lactating sows are housed in either individual or group paddocks, with access to individual farrowing huts. These systems and loose housing systems, where farrowing sows are kept in straw bedded pens, outdoors in straw yards or on pasture with various types of huts or shelters, were predominant prior to the development of farrowing crates, however there is evidence that farrowing pigs have been kept in more intensive type housing systems for several centuries. In indoor systems, the use of farrowing crates for this period predominates. These crates, typically 2.0–2.4 m x 0.6 m in size (refer Table 2), are designed to restrict the movement of the sow and placed centrally or offset in a pen which has specialised provision for the young piglets.

Table 2: Dimensions for Farrowing Crates and Pens

New Zealand (Ministry of Agriculture and Forestry 2005)	3.2 m^2 total area Also a table of recommended dimensions for **crates** is included	Farrowing crates and creep areas
Australia (Anon. 1998)	0.5 m x 2.0 m	Lactating sows and litters in **stalls** 3.2 m^2 and in individual **pens** 5.6 m^2
Canada	Farrowing **pen** dimensions -With side creeps: early weaning 1.5 x 2.1 m (5 x 7 ft) late weaning 1.8 x 2.1 m (6 x 7 ft) -With front creep 1.5 x 2.7 m (5 x 9 ft)	**Crate** dimensions not specified
USA	24" by 84" = .609m x 2.133m	**Crate** dimensions only

Denmark	Farrowing **pen** width: 1.7 m or 1.8 m Length: 2.7 m	The width of the **pen** is determined to make room for the creep area, and to ensure, that when the sow is lying down in full recumbancy, with her back towards one or the other side of the **crate**, the distance from the udder of the sow to the side of the **pen** should be the length of a piglet (also at four-five weeks of weaning). The length of the **pen** is based on the size of the trough, the length of the **crate** and that in addition, by legislation, it is required that there should be room for providing assistance at farrowing. So it is recommended that there 20 cm from the back gate of the **crate** to the back 'gate' of the **pen**

In New Zealand it has been reported that 76% of sows farrow in crates, however only 68% were held in crates until weaning (Gregory and Devine, 1999). The development of farrowing crates was initiated to reduce high rates of piglet mortality (reported to be between 12-30% of piglets before weaning, (English and Morrison et. al. 1984). Crates are reported to contribute to reduced piglet mortality, however the degree in reduction is hard to determine, although data suggests mortality in crates is more likely to be around the 13% mark, reported for the U.K, Australia and the United States (Edwards and Fraser, 1997, Meo and Cleary, 1999). Contributing factors to reduced piglet mortality include minimising space for young piglets, reducing temperature variation and in particular, cold temperatures, improved hygiene as well as improved management and observation of piglets around feeding and in general (Arey and Sancha, 1996). Thus, criticism of farrowing crate systems for pigs predominately focuses on the confinement of the sow rather than any reduction in welfare resulting for the piglet. Issues raised for the welfare of the sow include; restriction on the physical movement for the sow; dimensions of the farrowing crate and design features; the restriction of nesting and bedding behaviours (Arey, 1992); the restriction of ability to conduct maternal behaviour and other social behaviours; the duration of confinement and interactions with other housing systems, such as previous housing in stalls or groups (Arey *et. al.*, 1997).

There is more research required into the effects of providing nesting material or litter to sows during the pre-farrowing period as sows have been shown to be highly motivated towards nesting behaviour, especially during the 24 hours pre-partum (Barnett *et. al.*, 2001, Jensen, 1989). There is a volume of research available in relation to space, social contact and bedding (Barnett, *et. al.*, 2003, Jensen, 1986, (Stolba and Woodgush, 1984). Is appears that bedding provision may increase nesting behaviours and it has been indicated that sows will utilise materials such as straw when provided (Hutson, 1988). It should be mentioned however, that although it has been shown that sows have a high tendency towards nesting behaviour (Arey, et al, 1991), there is little literature available on the consequences in welfare terms, either by physiological effect or alternative behaviours and stereotypies for the sow if she is inhibited from carrying out this behaviour despite reference to acute stress responses (Jarvis *et. al.*, 1988).

In addition, research into the comfort needs of sows may require further examination including interactions with flooring types as a contributor to sow comfort. Lameness and injuries are reported to be high in breeding sows and there has been a wealth of literature published on these issues in relation to housing sows, particularly in stalls, some of which refer also to farrowing crate flooring and design (D'Allaire *et. al.*, 1989) where it is reported that slip resistance, traction, comfort, posture change abilities and sow preference determined the best types of flooring for sows.

A realm of research is already available on other issues relating to farrowing systems, including stress in sows (Cronin et. al. 1991, Lawrence et. al. 1994), maternal behaviour and piglet survival (Baxter and Petherick, 1980, Cronin and van Amerongen, 1991, Edwards and Furniss, 1988), sow and piglet injury (Leonard, O'Connell and Lynch, 1997, Paterson, Cargill and Pointon, 1995), piglet mortality (English and Morrison, 1984, Svendsen et. al., 1986) and alternative farrowing systems (Higgins and Edwards, 1996, Phillips and Fraser, 1993, Arey and Sancha, 1996).

Therefore the focus of future research into farrowing systems is likely to be invested into interactions across farrowing and group housing systems, flooring, comfort and nesting requirements, dimensions (in relation to the latest considerations for sow stalls), improved management for sow and piglet survival, determining stress in farrowing sows and further development of alternative systems and designs.

6.4 Other Related Issues

6.4.1 Endocrinology of stress in the sow and welfare implications

Stress can be defined in many ways but can be observed by the inability of an animal to cope with its environment, a phenomenon that is often reflected in a failure to perform according to the genetic potential (Dobson & Smith, 2000). Moberg (1993) describes stress as the biological response to an event that the individual perceives as a threat to its homeostasis. This event will be defined as a stressor. Perception of stressful stimuli leads to activation of the hypothalamic-pituitary-adrenal (HPA) axis, which in turn results in the release of a variety of peptides, principally corticotrophin-releasing hormone (CRH) and vasopressin (VP; lysine vasopressin in pigs) from the hypothalamus (Buckingham, Cowell & Gillies, 1997). CRH stimulates the release of adrenocorticotropin (ACTH) and other pro-opiomelanocortin (POMC) derived peptides, such as endorphin from the anterior lobe of the pituitary gland. ACTH acts on the adrenal cortex and causes secretion of glucocorticoid hormones, e.g. cortisol and corticosterone. Stress involves the activation of the sympathetic nervous system and the adrenal medulla. This causes the release of catecholamines e.g. adrenaline and noradrenaline into the bloodstream, leading to an increase in the glucose supply by accelerating the degradation of glycogen in the liver (Vellucci and Parrott, 1997). The glucocorticoids also stimulate lipolysis and gluconeogenesis (the conversion of amino acids to glucose), which leads to an increased metabolism that promotes the ability to cope with stress. Stress induced release of CRF (Rhodes, *et. al.* 2005) will cause increased heart rate and blood pressure, reduced gut motility, dilation of pupils, mobilisation of nutrients such as glucose and raised cortisol levels. These result in behaviour associated with fear and anxiety as well as stereotyped behaviour.

Stress also suppresses the immune system by increasing the number or percentage of neutrophils in the blood and reductions in natural killer cell activity, lymphocyte response and chemotaxis and phagocytosis of neutrophils.

Possible interactions with genetics

The review by Barnett *et. al.* (2001) provides the recommendation that the consequences for welfare of housing pigs in stalls for varying durations should be evaluated. Stall housing will remain a controversial issue from the view of public perception, but as there are some reproductive and welfare advantages, housing in stalls for a defined period that is considerably less than the period of gestation may be a reasonable compromise. One issue that is yet to be examined is the genetic influence on behaviours such as aggression (Beilharz, 1982). It may be likely that where less aggressive pigs were bred, indoor group housing systems may have greater success.

Temple Grandin (2001) suggested that different genetic lines of group housed sows in the same building will have different amounts of injuries and abnormal behaviour such as belly rubbing and ear sucking and that large groups of over a hundred sows may help reduce aggression. It has already been mentioned in this review that large groups of over a hundred finishing pigs, mixed from different pens, engage in relatively little fighting.

Interactions between housing systems and endocrinology

It has been established (Barnett *et. al.* 1989) that pigs housed in stalls show a significant increase in basal free cortisol concentrations compared with pigs housed in groups. Broom, Mendl and Zanella (1995) reported that the welfare of pigs housed in stalls was reduced by the fourth parity, compared with pigs housed in groups, predominately due to the prevalence of stereotypical behaviour, increased aggression and reduced body weight. There has been however, no reported difference in terms of physiological, immunological or reproductive indicators, and Nind, Cameron and Blackshaw, 1997 reported no treatment effect at farrowing, from sows housed in stalls and groups in terms of lymphocyte count. There are reported behavioural differences, as reviewed by Barnett *et. al.* 2001,and Barnett et al, 1985 where pigs in stalls have been shown to be less responsive to external stimuli. There is however, some evidence that the actual design of the stall may lead to differences in chronic stress response, with Barnett *et. al*. 1991 reporting that pigs in stalls with horizontal bars showed a chronic stress response, whilst pigs housed in stalls with vertical bars showed a similar cortisol concentration to that of group housed pigs.

In other studies, there were no reported differences in serum cortisol concentrations (Rhodes *et. al.* 2005) or ACTH responsiveness (von Borell, *et. al.* 1992), between sows housed in stalls and those housed in group pens. In another study involving replicate group housed sows showed that sows with low social rank had higher serum cortisol concentrations. Also sows housed in turnaround stalls had lower serum cortisol concentrations than sows in conventional stalls however their immune measures did not differ (Bergeron, Gonyou and Eurell, 1996). Rhodes *et. al.* (2005) concluded after reviewing controlled trials that that stall housing is not more physiologically stressful to sows than group housing.

Although there is clear evidence of reduced reproductive performance when space allowance is insufficient (Hemsworth *et. al.*, 1986b, Barnett *et. al.* 1992), there is a lack of research available to assess any genetic implications that may play a part in the levels of stress exhibited in pigs housed in either stalls or groups. Investigation is also needed into the physiological implications in relation to mixing of sows at different stage of pregnancy. Effects of social rank and the ease of establishing hierarchy can lead to problems for certain animals.

Nicolson, McGlone and Reid (1993) reported that socially intermediate sows (neither dominant nor submissive) exhibited signs of stress and had lower farrowing rates and smaller litter sizes that pigs that were dominant or submissive in the same group.

In addition, it has been reported (Mendl, Zanella and Broom, 1992) that these intermediate sows typically exhibited higher concentrations of cortisol, exhibited indications of chronic stress through elevated response to ACTH challenge and produced piglets with reduced liveweights.

Karlen *et. al.*, (in press) examined sows in stalls vs. sows in large group deep litter systems and reported that there was no significant difference in salivary cortisol, although there was a tendency for higher cortisol concentrations in the deep litter system treatment than in stalls during the first week of placement. Karlen *et. al.* (in press) reported that lymphocyte counts were lower in sows in stalls, however farrowing rate and reproductive performance was higher in the stalls, possible due to the higher incidence of irregular return to oestrus in the deep litter system housed sows. Stall housed sows in this study exhibited a lesser number of piglets weaned per farrowed sow in the stalls however piglet liveweight tended to be higher than in the deep litter systems.

Stress and embryonic survival

One aspect of the group-housing system is that regrouping of sows is unavoidable. In many group-housing systems, sows remain together after weaning for heat check and insemination. In some herds, sows are kept in intact groups until just before expected parturition when they are placed in separate pens with the exception of replacement gilts that are introduced to the group during the gestation period. In other herds, the sows are regrouped after insemination in smaller groups where they are kept until they are placed in farrowing pens. Regrouping is stressful and sows require up to 48 h to establish a new rank-order (Varley and Stedman, 2004). During this time, fighting and aggression may occur, leading to increased cortisol levels and sometimes food deprivation of the more submissive animals (Mendl, Zanella & Broom, 1992; Brouns & Edwards, 1994; Tsuma *et. al*., 1996b).

Since regrouping is often scheduled during the mating and early pregnancy period, further research is required to evaluate the influence of stress on reproductive performance. Similar issues may be expected to occur with grouping of sows taken out of individual stalls at various stages of pregnancy. Unfortunately, how and to what extent stress affects embryo survival is not yet clearly evident. Heat stress has been reported to reduce implantation success and impair embryo development (Dutt, 1963). Gilts are more sensitive to heat stress before day 15 of pregnancy than during days 15-30 post-breeding (Edwards *et. al*., 1968).

Omtvedt *et. al.* (1971) illustrated a greater reduction in the number of viable embryos among gilts exposed to elevated temperatures during days 8-16 post-breeding than days 0-8, indicating that the time of implantation would be the stage of pregnancy most sensitive to heat stress. However, the activation of the HPA-axis is only one of several mechanisms involved when pigs are exposed to severely elevated temperatures.

Adrenal activation due to aggressive interactions occurs when pigs are mixed with unfamiliar individuals, but the effect of grouping on pregnancy is still somewhat ambiguous. Bokma (1990) reported that sows placed in groups consisting of 25-30 animals during the first week after mating had 20% return to service and 10.5 piglets per litter compared with 10% and 10.7 respectively in sows grouped during the fourth week after mating. In contrast, gilts regrouped into groups consisting of 6 gilts around the time of mating had a higher overall pregnancy rate (86%) compared with gilts kept in tether-stalls (65%) during the same period (Barnett & Hemsworth, 1991).

Low-ranked sows have higher plasma cortisol levels and a lower total weight of live-born piglets compared with more dominant sows (Mendl, Zanella & Broom, 1992; Tsuma *et. al.*, 1996b). Consistent with these results, Bokma (1990) also reported that gilts group-housed with sows had lower litter size at birth compared with gilts grouped with gilts. From these studies, it might be concluded that the effect of group housing on the adrenal activation in an individual female depends on the rank-order of the individual itself, as well as the composition and size of the group.

The effect of grouping on the prolificacy of the female pig is also dependent on the stage of pregnancy at which the grouping is performed. Regrouping of sows might lead to food deprivation of the more submissive animals (Brouns & Edwards, 1994). This results in an adrenal activation, observed in the form of elevated levels of cortisol and progesterone (Tsuma *et. al.*, 1996a; Mburu *et. al.*, 1998). Prolonged food deprivation of gilts leads to embryo loss, increasing with the duration of starvation (Andersson, 1975). Food deprivation for 48 h after ovulation, which is a duration seen in regrouping situations, has been reported to have a negative effect on the cleavage rate of embryos and on the number of spermatozoa attached.

Food deprivation during days 10 and 11, on the other hand, did not cause a significant difference in embryo recovery rate at day 17 of pregnancy (Tsuma *et. al.*, 1996a). Booth, Cosgrove & Foxcroft (1996); Prunier and Quesnel (2000), indicated that a negative energy balance could directly lead to a decreased ovarian activity. However, the mechanism behind the effect of food deprivation on early pregnancy is not yet clearly evident and needs to be further evaluated.

Razdan *et. al.* (2003) reported that food-deprived sows had an increased progesterone concentration, which was positively correlated with the weight of the placentas, suggesting that progesterone influenced placenta size among food-deprived animals, although further research is needed to examine the consequent effects on litter size and liveweights.

Possible affects of progesterone levels on aggressive behaviour

After implantation of the embryo and as the pregnancy becomes firmly established, progesterone levels rise (Flowers, 2002). It has been shown in some species that increased progesterone levels have a calming effect on behaviour (Bitran, Shiekh and McLeod, 1995). It has therefore been suggested that this effect may partly explain why grouping of sows four weeks after mating has been associated by some observers with lower levels of aggression than when grouping is undertaken earlier in pregnancy (Anon, 2006a).

6.4.2 Individual housing and reproductive performance

Although housing in tethers adversely affects reproductive performance (Barnett and Hemsworth, 1991) compared with group housing, the data on individual compared with group housing are equivocal, on the basis of weaning to mating interval and mating, conception, or pregnancy rates (Barnett et al, 1981, Barnett et al, 1987, Barnet and Hutson, 1987).

A number of studies have reported that sows housed in groups have a shorter weaning to mating interval than tether or stall-housed sows (Hemsworth, 1982; Schmidt, Stevenson and Davis, 1985), although some authors found contradictory results (Lynch, O'Grady and Kearney, 1984; Vessuer, Kemp and Hartog, 1994). Barnett and Hemsworth (1991) found that in 15 studies reviewed, 8 showed better reproduction in group-housed pigs, whereas only 4 showed better reproduction with individual housing. However, it should be noted that in groups, sows can be exposed to stress resulting from low social rank and aggressive interactions (Vessuer *et. al.* 1994). In a recent study in an Australian piggery, a comparison was made of about 220 sows housed in stalls for 5 weeks post-mating prior to being housed in groups and about 450 sows housed in groups; measurements were taken at 4 different times. Notwithstanding the constraints of the comparison involving different units within the farm and the limited statistical power (degrees of freedom = 6), the stall-housed sows had more piglets born alive (11.6 v. 10.8; $P < 0.05$; Agribiz Engineering 1999). This study suggests that there may be some advantage in terms of biological fitness, and hence welfare, from stall housing, at least for a limited time. The survey data of Paterson, Pointon and Cargill (1997) similarly showed improved overall performance, on the basis of a lower removal rate due to a combination of reproductive failure, lameness and locomotor problems, age, death, and euthanasia, in farms that had both pens and stalls compared with those that only had pens. Our interpretation of 'pens and stalls' in the study of Paterson *et. al.* (1997) is that after mating, sows were housed for a time in stalls followed by the remainder of gestation in groups, although they did not define 'pens and stalls'.

The consequences of housing in stalls for shorter or longer periods of time and the advantages/disadvantages for overall welfare remain to be determined. Baker (1996) noted that, because stall housing is a controversial issue from the view of public perception, housing in stalls for a defined period that is considerably less than the period of gestation may be a reasonable compromise.

6.4.3 Housing around mating

The social, physical and climatic environment at mating has been shown to influence sexual motivation and mating competency (Hemsworth et al 1991). Issues to consider include those encountered at other times of the production cycle, including aggression, mixing, individual housing, space and provision of resources.

However more specific to the mating period are factors such as injuries, in particular during introduction or natural mating with the boar, and stress incurred as a result of the changing environment and contact with the boar. Certainly environmental stressors at this time have influence on welfare, although there is limited direct evidence for pigs (Hemsworth et al, 1991). The intensity of the sexual behaviour shown by gilts and sows during oestrus is of great importance for the reproductive performance under commercial conditions as well as in nature. Sexual appetitive behaviour characterised by the behavioural changes occurring in the female when actively searching for a male (Beach, 1976), is the primary determinant for the stockperson to select prepuberal gilts for breeding. Animals showing a low sexual appetite are difficult to detect in oestrus and are often bred at a high age. In addition, it is likely that detection of oestrus through introduction of boars to female pigs when they are not sexually receptive or have low sexual appetite may be aversive. In addition this may lead to further stress when the boar is able to attempt courting the female within a confined space. When oestrus is detected by applying pressure to the back of the pig, where oestrus is officially characterised by a rigid stance, arched back and erect ears in response to boar stimulation or back-pressure (Signoret, 1970), during fence line exposure to boars, there is not direct contact with the boar. Turner *et. al.* 1998 showed that plasma cortisol concentrations in non-oestrus females were higher following introduction to the boar than after a back-pressure test. Hughes and Hemsworth (1994) recommended supervising introductions to the boar and promptly removing sows detected to be in oestrus. Signs of oestrus include swelling and reddening of the vulva and behavioural attraction to the boar, increased restlessness, vocalisation and attempts to mount pen mates. Housing sows and gilts that are to be mated near to boars can assist with oestrus detection and some farms run boars around the female pens or place females for testing in a pen with a boar to see if they exhibit the 'standing response'. It has been reported as good practice to test sows in small groups of two or three with a boar (Hughes and Hemsworth, 1994).

Social conditions during rearing and oestrus have been shown to interfere with both sexual appetite (Soede,et al 1997, Welcock *et. al.*, 2003) and receptivity (Hemsworth et. al., 1982; Turner, et al) in gilts and sows. In addition, low intensity of sexual behaviour has been attributed to chronic stress caused by intensive rearing conditions in general (Moberg, 1985). Treatment of adult female pigs with synthetic corticosteroids to mimic the effects of chronic environmental stress has revealed that glucocorticoids inhibit oestrus behaviour both via reduction in the secretion of oestradiol (Liptrap and Peter, 1973; Liptrap and Cummings, 1991) and also by acting directly on behavioural centres in the CNS (Esbenshade and Day, 1980).

Paterson, Pointon and Cargill (1997), showed that oestrus detection in another pen or specific mating pen resulted in lower removal rates than mating in the boar or sow's pen. Similarly, housing systems can have influence on welfare during the mating stage, with higher removal rates reported for housing sows in pens for the first 3 weeks after mating, compared with housing sows in stalls and pens, indicating that stalls may have some benefits for pigs following the mating phase.

It is recommended that a specialised setup for the boar's pen with separate mating pens should be used. This type of setup should incorporate a detection mating area (DMA) as indicated in the review by Barnett *et. al.* (2001). Studies have shown that the boar's pen may not be ideal for mating. Important considerations for welfare include sufficient area and absence of sharp or small/narrow corners in an arrangement that will not cause injury or lameness in sows or boars. Similarly, pens for mating need to be assessed for the ability for female contact with the boar, the pen size, floor type and condition, obstructions in the pen and the surrounding temperature prior to mating. It has been shown that specific mating pens which are large and octagonal shaped with non slip flooring result in higher percentages of successfully copulation in pigs, (Hemsworth, 1986b). Ideally, matings should take place in a separate pen specifically designed for mating, with dry, non-slip flooring. The mating area should be free from obstructions and an octagonal/hexagonal shaped pen is a good design, as it removes corners where the female is inaccessible to the boar, hence reducing the need for operator interference.

Just prior to mating it is important to observe the behavioural response of the boar to a receptive gilt/sow in the mating area and the ease of movement by the boar. Provided that the boar is rested (for around 24 hours), when introduced to a female, he should engage in mating behaviour and attempt to mount within approximately two minutes. Inspection during mating is important to ensure health and absence of injury or disjunction.

A boar should be located close to females (less than 15 m away) as odour from the male has been shown to be a sexual stimulus for females, but needs to be separated by at least one metre.

The environment of the sow and gilt also has a marked effect on the synchronisation and expression of oestrus and in addition in gilts, the onset of puberty.

The absence of boar contact during rearing appears to affect adversely both the reproductive efficiency of the gilt and the regulation of oestrus in the sow. Furthermore; there is some evidence to suggest that individual housing during rearing of gilts or immediately after weaning sows may reduce the onset of oestrus.

6.4.4 Measurements of welfare in gestation stalls

Assessing the welfare of sows in various housing systems has mainly involved measuring the physiology, behaviour and productivity of animals. Physiologic measures of stress have yielded contradictory findings, mostly negative (Pajor 2005). Some studies have reported higher basal cortisol concentrations in sows housed in stalls than sows housed in small groups without straw but others have found no difference. No difference has been found in the cortisol response to ACTH injection or the status of the immune system.

Studies have consistently reported a higher incidence of stereotypy in sows housed in stalls than in sows housed in small groups without straw but this finding is difficult to interpret (Pajor 2005). It is not clear whether confinement, hunger or other causes are the motivation underlying the development of stereotypy in sows.

The measurement of motivation is widely used in animal welfare science but has only been used in a limited way with gestating sows (Pajor 2005). A recent trial comparing the strength of a dominant sow's motivation for access to a group of familiar and subordinate sows provided little evidence that sows are highly motivated to spend time in a group pen (Kirkden and Pajor 2004). Combining traditional measures of animal welfare with measures of motivation and preferences can yield a balanced picture of animal welfare: a quantitative assessment of how badly animals want access to a resource; a confirmation that they miss it when absent; and an assessment of whether access to the resource is good for their health in the long term.

6.4.5 Sow behaviour

Behaviour can be an indicator of welfare problems for example interactions between dominance, aggression and injury (Rhodes *et. al.,* 2005).

Few behavioural studies specifically address gestation stalls. Areas of behavioural inquiry and concern identified by the American Veterinary Medicine Association Task Force on the Housing of Pregnant Sows included the subjects discussed below:

Social interactions – in the wild sows live in relatively small groups of familiar individuals during pregnancy and after farrowing but isolate themselves a few days before parturition and the first few days of lactation. Aggression is rare under extensive conditions. In group housing a dominance order is formed and some sows particularly of lower dominance status can exhibit signs of stress. There is little in the literature to suggest that individual sow housing is averse as long as there is visual and other contact with other animals. Also pigs will work for social contact although motivation for social contact is more elastic than motivation for food.

Available space and freedom of movement – public concern about how sows are housed most often relates to restrictions on sow's freedom of movement. Sow behaviour in stalls is generally influenced by the size of the sow in relation to the stall. However, some researchers have suggested that lameness, reduced muscle tone and mass, reduced agility and reduced bone strength as a result of inactivity contribute to the problem. Marchant-Forde and Marchant-Forde (2004) found that pregnant sows in straw bedded pens on a restricted diet walked 1–3% of the time compared with feral pigs who spend 14–27% of their time walking, probably necessary to obtain food. Lying increased from 54% to 73% of the time by week 15 of gestation. When high quality feed and water are readily available in a comfortable environment sows are relatively inactive. During farrowing and early lactation restriction of movement can reduce the risk of sows injuring their piglets. However, preventing pregnant sows from walking or turning appears to serve no direct animal health or welfare purpose *per se*.

Feed restriction and environmental complexity – limited amounts of concentrated low fibre diets are fed to sows because bulkier higher fibre diets are more costly to formulate and transport (Rhodes *et. al.* 2005). Digestion of concentrated diets results in less manure to manage. Limited intake prevents sows from becoming obese and related health problems. This hunger intensifies competition for food in housed groups. There is no evidence that providing a bulkier diet would satisfy the sow's hunger drive since it solves only one component of satiety (i.e. gut fill) and does not change nutrient concentrations in the blood and tissue. Limited feed appears to make sows restless and more motivated to forage for feed. This may leads to seemingly abnormal Oral-Nasal-Facial (ONF) behaviour. This is especially so where environmental complexity such as straw is absent in stalls or pens. Pigs appear to react positively to complexity and cortisol concentrations are lower where bedding is provided (Peterson, *et al* 1995).

Stereotypic behaviour – stereotypies are characterised as movements or behaviours that are abnormal, repetitive, and seemingly have no function or goal (Anon. 2006b). Researchers attribute these behaviours to boredom and frustration resulting from an impoverished environment, confinement, restraint, and unfulfilled needs (Arellano et al, 1992, Broom, 1986b).

Stereotypic behaviours are common among gestation stalled sows. Stereotypies in pigs include bar biting, head weaving, pressing their drinkers without drinking, and making chewing motions with an empty mouth, called sham or vacuum chewing. Some stereotypic behaviours lead to physical injury, such as sores from excessive rubbing again the crate bars or damage in the mouth from bar biting and sham chewing (Arellano et al, 1992).

Sows in all production environments show some form of oral, nasal or facial type behaviours (Dailey, 1997). Sows kept outdoors chew sticks and stones, in bedded systems they chew bedding and pen surfaces, and those in stalls show bar biting, rubbing on pen surfaces and mouthing nipple drinkers (Dailey, 1997). Morris, Hurnik and Friendship (1993) showed the time spent on stereotypic behaviour varied considerably from less than 1% to as high as 46% of the day. In one study there was considerable variation amongst individuals in the sow herd (0–61%) (Appleby and Lawrence 1987). Some research suggests that stereotypies may have more to do with limited feeding and lack of opportunity for productive foraging than with restriction of movement. In one study (Terlouw and Lawrence and Terlouw 1993) sows were housed in tethers and group pens and fed two amounts of feed. A similar level of repetitive behaviour was observed in both environments when access to feed was restricted. Stereotypies can sometimes be reduced in sows housed in stalls by providing dietary bulk, but was not always successful.

Whilst stereotypies are not fully understood, there was a strong consensus amongst nearly all authors whose work was reviewed that stereotypies are an indication of welfare problems (Rhodes *et. al.*, 2005). den Hartog, Backus and Vermeer (1993) found no significant difference in sham chewing, bar biting or failure to react to external stimuli between sows housed individually and in groups. Both systems were housed on partially slatted concrete floors without bedding.

Observations during a tour of a Swedish deep-bedded sow farm (McGlone 2006) indicated ONF behaviours despite being a reportedly high welfare system. Being on a limited calorie diet is more likely to influence the expression of ONF behaviours than will the housing system (individual vs. grouped). Some ONF behaviours might be quite normal and some may develop into pathologic stereotypies.

Further evaluation is required before an ONF behaviour can justifiably be labelled a stereotypy. Three controlled comparisons of ONF behaviours performed by sows in pens versus crates were essentially similar (McGlone 2006). Hulbert and McGlone (2006) found the occurrence of ONF behaviours (chewing, rooting, and rubbing) and active behaviours increased, and lying behaviour decreased significantly from 0800 to 1200 for all sows. During the 0800 to 1200 period, stall drop-fed sows displayed more significant ONF and active behaviours than did sows in the 3 other treatments.

Sows housed in groups of 5 had a significantly greater duration of standing in the 0400 to 0800 period compared with stalled sows. Housing systems had complex effects on sow behavioural sequences, but penned sows had more sequences associated with stress than did stalled sows. Also, stall drop-fed gilts and sows expressed more ONF behaviours than gilts and sows in other treatments.

In summary, stereotypical and ONF behaviours indicate a form of coping behaviour, particularly in the short term, although it is still unknown whether they exert benefits or disadvantages in the longer term. There are some specific reviews on the issue of stereotypies and other behaviours (Terlouw and Lawrence, 1993; Cronin, 1986a and Rushen, 1993) that have reported evidence of the associations between stereotypies and ONF behaviours and physiological signs of coping such as reduced corticosteroid concentrations, reduced adrenal gland weights and reduced gastric ulceration, indicating that these behaviours are a coping response exhibited by the animal as a result of deficiencies in its environment. The existence of stereotypy or ONF behaviour is indicative of a past problem that the animal is coping with and certainly stereotypies that result in physical damage or illness to the animal (e.g. pigs that develop lesions) have obvious implications for animal welfare. These behaviours should be assessed in various housing systems and environments as part of combined approach with assessment of other physiological responses to determine consequent effects and implications for animal welfare.

Aggression in group housing can be reduced through improved system design (Morris, Hurnik and Friendship, 1993) or by better management techniques. One expression of serious aggression is vulva biting. Sows are social animals and tend to eat simultaneously.

It has been shown that trickle-feeding can reduce aggression and that it would appear important to feed pigs either concurrently or in a systematic manner (Barnett *et. al.,* 2001). Electronic sow feeding systems do not allow simultaneous feeding therefore vulva biting and other aggressive behaviours may be increased, although recently this has been solved somewhat, through more innovative design and application of improved management techniques. Although aggression tends to increase as group size increases for conventionally housed sows, the more recent adoption of deep litter systems to house grower/finisher pigs in large groups appears to offer some benefits in terms of minimising aggression,

where feeding occurs on platforms and pigs tend to feed less frequently, with feeding bouts over longer durations (Morrison et. al., 2003a). Aggression may be reduced in these systems as pigs have more freedom to select feeding times and the greater availability of resources and increased social tolerance (Barnett et al, 2001). The changing feeding patterns of pigs in deep litter systems compared to conventionally housed pigs is also thought to be related to the larger distance to travel to feeders, reduced social facilitation to feed and reluctance to frequent the feeders as a result of reduced opportunity to interact with the pigs away from the feeders (Hsai and Wood-Gush, 1983).

The insertion of individual stalls into group pens to feed pigs individually and still satisfy their social requirements appears to have some advantages in terms of providing 'escape areas' for subordinate pigs during bouts of aggression. The review by Barnett *et. al.* 2001, indicated that there is some advantage in placing partial stalls into group systems to reduce aggression around feeding in pens. Despite some literature indicating similar benefits from the provision of partial stalls into group pens in terms of reduced aggression either by introducing individual feeding or by providing further areas and barriers for escape from aggressive pigs, other research has indicated there is not any obvious benefit unless pigs are regularly fed in the stalls. Some research has indicated the pen shape and size can influence the occurrence of aggression. For example rectangular pens of a certain shape can be associated with reduced aggression, provided there was effective space allowance (1.4 m^2/pig) (Barnett, *et. al.*, 2001, pers comm. Australia Pork Limited) and that pens were not too large beyond these recommended allowances.

The review by Barnett *et. al.* (1993a) indicated that aggression can be reduced in gilts by: (i) modifying pen size and shape (Barnett *et. al.* 1993a) on the basis that pigs require a minimum space in which to fight; (ii) modifying pen design (Barnett 1997; Petherick 1985; Petherick, Bodero and Blackshaw 1987) on the basis that the provision of escape areas reduces aggression; (iii) pre-exposing pigs to auditory and olfactory stimulation in their new pen (Kennedy and Broom 1996); (iv) grouping after dark (Barnett *et. al.* 1994), on the basis that it is the 'normal' sleeping time, or providing feed ad libitum (Barnett *et. al.* 1994; Petherick 1985) on the basis that restrictively fed pigs may prefer to feed than fight; (v) using masking odours (Leuscher *et. al.* 1990; McGlone 1985; McGlone, Kelley and Gaskins, 1981) on the basis that anosmic pigs show reduced aggression (Meese and Baldwin 1975); and (vi) using 'mood-altering' drugs (Barnett *et. al.* 1993b, 1996) on the basis of their positive effects in animal models (Gustafsson and Christensson 1990).

It is clear that the area requires further research as it is not obvious whether the effects of aggression are simply delayed by these pen modifications and other techniques, or avoided altogether. Furthermore, there is little research on aggression in systems other than conventional stalls or pens, such as deep litter systems for large groups of sows, and outdoor systems. There may be possible

advantages from modifying pen designs for group housed sows by incorporating partial feeding stalls, however some previous research has suggested there is a compromise between space allowance and incidence of aggression (Barnett *et. al.*, 2001). This research indicated from an experiment that compared feeding in full or partial stalls and feeding troughs and space allowances of 1.0, 1.4 and 2.0 m^2 per pig that full stalls reduced the level of stress and aggression around feeding. 1.4 m^2 in addition to the provision of full stalls was recommended. It is not known, however, if more space is required for larger sows and this work suggests that where partial or full stalls are included in group housing systems, more space is required.

6.4.6 Injuries in different sow housing systems

As a result of the intensive confinement, stalled sows may suffer a number of welfare problems, including poor hygiene, risk of urinary infections, weakened bones, overgrown hooves, poor social interaction, lameness, behavioural restriction, and stereotypies (Anon. 2006b). It has been found that stalled sows suffer substantially higher incidences of traumatic injuries (by about a factor of 9) than group-housed sows kept in pens, as well as body sores that are often caused by being forced to stand and lie in residual faeces and urine (Backstrom, 1978). In another study, Broom (1987) found that 25% of stalled sows required removal from production as a result of health problems, compared with less than 5% of group-housed sows.

On the other hand, Deen (2005) compared injury levels in sows in stalls versus sows in a group housing system that used an electronic sow feeding system. Total injury scores were lower for sows in stalls than for sows in group housing. Injuries to the skin of the shoulder region and neck after mixing and to the vulva during late gestation were the major injuries seen among sows in the group housing system. Injuries to the shoulder and neck were due to fighting and vulva injuries were associated with jockeying among sows as they attempted to enter the feeding station. This points to the need for better socialisation and to prevent queuing for food. Conversely, sows in stalls had injuries that were best predicted by the height of the sow relative to the width of the stall. As sows grew larger the number of injuries increased showing that a standard sized stall does not necessarily fit the general population.

Anil *et. al.* (2006) housed pregnant sows in dynamic, twice mixed and static groups in pens with electronic sow feeders. The total injury score was significantly higher in the dynamic group. The total number of aggressive acts was positively and significantly correlated with the duration of queuing in all the groups.

Anil *et. al.* (2003) compared the location and severity of injuries in sows housed in individual gestation stalls and in dynamic groups in pens with electronic feeders. Injury scores were higher in group pens with electronic feeders. As body weight increased injury scores decreased for sows housed

in group pens with electronic feeders and increased for sows housed in gestation stalls. There was a significant negative correlation between second parity and total injury scores.

Anil *et. al.* (2005) reported that total injury scores of sows in pens were significantly higher at initial introduction and mixing compared with group pens with electronic sow feeders. In stalls the total injury score was significantly higher during late lactation. The total injury scores and cortisol concentrations were significantly lower in stall housed sows compared with sows in pens. As parity increased the total injury scores decreased significantly in pen housed sows and increased significantly in stall housed sows. The proportion of sows removed was significantly higher in pens than stalls. Lameness was the major reason for removal for both systems.

In pregnant grouped sows, integrity of feet and the ability to lie down is improved and exercise and rooting activity are also increased when the concrete floor is covered with straw than when it is slatted (Anon. 2004).

A welfare assessment of injuries in group housed sows that had been weaned 5 days previously revealed that 46% (23/50) had severe wounds and all sows had wounds of some kind (McGlone 2006). A similar assessment in sows at mid to late gestation revealed that 26% (13/50) of sows had mild wounds. No sows had severe wounds in this group.

The author's experience when evaluating U.S. sows in stalls was that the incidence of mild wounds was much lower than 5% and severe wounds were rarely observed. Hulbert and McGlone (2006) evaluated the effects of pen vs. stalled housing systems and drop vs. trickle fed feeding systems on 160 gilts during 2 consecutive gestation periods. Lesions scores did not differ among treatments. In pens, drop-fed sows had significantly greater neutrophil phagocytosis than trickle-fed sows, but in stalls, drop-fed sows had a tendency for lower phagocytosis than trickle-fed sows. All other immune measures were not different among treatments. Generally, productivity, skin lesions, and immune measures were not different, but behaviours at certain times of day and behavioural sequences were different for sows in pens and stalls with drop or trickle-feeding systems.

None of the environments evaluated were associated with significant physiological stress responses among the sows. Thus, sows were able to adapt within each environment through behavioural mechanisms without the need to invoke major physiological adjustments.

Gestation stall design – one reference claims that welfare concerns were not the primary consideration in the design of many current housing systems (Anon. 2006b). This reference, along with a lot of other published material quoted by animal welfare organisations, states that space restriction in dry sow

stalls is a major cause of injuries to pregnant sows. However, it is important to note that a number of other references indicate that many of these disadvantages may be able to be overcome or alleviated by attention to particular features of stall design (Barnett *et. al.,* 2001, Boyle *et. al.,* 2000, Cronin *et. al.*, 2000, Turner *et. al.,* 2000, European Commission, review of the welfare of intensively housed pigs, 2001).

Foot and leg problems – Some of the literature reviewed, albeit from sources other than refereed scientific journals, states that the unnatural flooring of gestation stalls has changed the stresses on sows' feet and is considered to be a significant contributor to hoof lesions with some reports finding up to 80% of stall housed sows suffering from these disorders (Anon. 2006b). Concrete floors, slatted floors, and poor slat quality can all increase the incidence of foot lesions in sows. Erosion of the cement floor from water and feed can leave rocks and sharp edges exposed which contribute to foot, leg, and shoulder sores. Bolts, which fix the crates in place, can contribute to similar injuries. The occurrence of leg weakness is claimed to increase as the size of the stall is reduced and successive pregnancies exacerbate the problems of diminished muscle mass and bone strength. The risk for hoof injuries is less on solid flooring than on perforated flooring (Anon. 2001b). Some perforations or slats in floors may trap hooves and the solid section between perforations or slats may be too narrow to support the foot evenly (Anil, 2003). Again, careful attention to design and maintenance of stalled housing environments, is clearly required as to prevent or alleviate many of these potential problems.

6.4.7 Dynamic and static groups – social implications of sow housing systems

The welfare issues associated with group housing relate to agonistic events of aggression and injury. Breeding sows may be housed individually, in stable groups (formed at weaning or service and remaining unchanged until farrowing) or in large dynamic groups (where existing sows are removed to farrow and replaced by newly served sows on a regular basis) (Anon. 2001b). Replacement gilts are typically reared in groups, in the same way as slaughter pigs, until transfer to the breeding herd. It is most common for these gilts to be housed separately from older sows until completion of their first lactation.

Pigs display a dominance hierarchy, which is established within a group of unacquainted pigs when they are mixed together for the first time (Blackshaw and McVeigh, 1986). This dominance hierarchy is important as a group stabiliser when pigs are introduced into a new group, but under adverse, intensive conditions, animals low on the hierarchy may be disadvantaged by lack of food and water (Blackshaw and McVeigh, 1986). English et. al., (1988), indicated that this can lead to poor performance, increased variation in body weight, and higher incidence of agonistic responses. Morrison et. al. (2003) monitored factors such as increased group size and space allowance, and

suggested these may affect the social behaviour and performance of pigs. They compared the social and feeding behaviour of growing pigs housed in deep-litter, large group (200 pigs) and conventional housing systems (20 pigs per pen). The results indicated that pigs in the deep-litter, large group treatment had a higher frequency of social tactile interactions including offensive, defensive and submissive behaviours, compared with the conventionally housed pigs in the study. Large numbers of pigs housed in the deep litter system may lead to greater agonistic or social behaviours, as the estimated numbers of group members that can be recognised by an individual pig is only 20-30 pigs (Fraser & Broom, 1998). Consequently the pigs in the larger group may not have formed a stable hierarchy, accounting for the increased social behaviours.

In the study by Morrison *et. al.,* (2003), the authors noted that the greater availability of resources such as total free space and availability of feeding places may eliminate the influence of a dominance hierarchy, which functions to control aggression when resources are limited. This would explain the finding that very large groups of pigs can function well under some circumstances with minimal aggression observed. Results from Schmolke *et. al.,* (2003) concur with this theory, and also suggest that housing pigs in groups of up to at least 80 is not detrimental to productivity and health if space allowance is adequate and feed resources are evenly distributed.

Sows studied in static groups for 5 weeks, followed by placement into a dynamic group of 40 sows indicated that there was an increase in injury and aggressive encounters (O'Connell et. al., 2003). Results also indicated that sows of low social status were positioned lower in the feed order, lower in the drinking order, and were displaced from feeder queue more often.

Lower body weight correlated with lower social ranking, and O'Connell et. al., (2003) suggested that increased body weight may enable sows to attain higher social status by making it physically easier to dominate pen mates in aggressive encounters. Gonyou (2005) compared static and dynamic (i.e. new animals added to existing groups every five weeks) groups. Animals were also added to the pens either before (within a week of breeding) or after (six weeks after breeding) embryonic implantation. It was found that grouping sows prior to implantation reduced farrowing rates by 5% compared with rates when sows were grouped after implantation. Overall productivity, farrowing rate and litter size was reduced among sows grouped prior to implantation but did not differ between sows housed in stalls and those grouped after implantation. Blackshaw and McVeigh (1986) reported that an ideal husbandry system would provide a stable social organisation and avoid changes in social groups from birth to slaughter, reducing disturbance and agonistic behaviours.

6.4.8 Space and group size

Indoor group housing is a common housing system for pregnant pigs, and whereas some attention has been given to factors such as space allowance and group size (Barnett *et. al.* 1986; Ford and Teague 1978; Hemsworth *et. al.* 1986b; Jensen *et. al.* 1970; Kuhlers *et. al.* 1985, Curtis, 1989a), particularly for reproductive performance, less consideration has been given to other factors such as social contact, dominance order, and design features in pens that may affect welfare. A common criticism of individual housing systems for pigs is that social contact is disrupted. However, the effects of social rank on reproductive success of group-housed sows indicate potential problems for certain animals. For example, Mendl, Zanella and Broom (1992) reported that socially intermediate pigs had higher concentrations of salivary cortisol, were more responsive to an ACTH challenge, indicative of a chronic stress response, and had lighter piglets. Social rank during pregnancy can also affect maternal behaviour, with subordinate sows subsequently displaying more stereotypies, increased restlessness, and more interrupted suckling bouts than dominant sows after farrowing (Csermely and Woodgush 1990). Similarly, Nicholson, McGlone and Reid (1993) reported that, compared with dominant and submissive sows in the same group, socially intermediate sows showed specific signs of stress (elevated cortisol and reduced natural T killer-cell activity) and had lower farrowing rate and smaller litter size. Other factors such as space allowance are also likely to be involved. Recommendations for space requirements for adult pigs are few, probably based on current practice, and are in the range of 1.4–1.8 m^2/pig (Cale 1979; Anon. 1998a, 1998b). There is clear evidence of a chronic stress response and reduced reproductive performance if space allowance is insufficient (e.g. 1.0 m^2/pig; Hemsworth *et. al.* 1986b; <1.0 m^2/pig; Barnett *et. al.* 1992). Although the former study indicated that there may be reproductive performance advantages of housing at 3.0 m^2/pig over 2.0 m^2/pig, the physiological criteria indicated no differences between these space allocations.

None of the recommendations takes into account the amount of additional 'free space' available to pigs kept in large groups and the potential to reduce space allocation per pig in such group pens, and this aspect warrants research.

Some limited research by Taylor, Barnett and Cronin (1997) has shown that varying group sizes, of 5, 10, 20, and 40 sows with a space allowance of 2.0 m^2/sow, had no effects on reproductive performance (proportion of sows that farrowed, piglets born per sow, and piglets born per sow alive, stillborn, or mummified). Although aggression, which was measured on Days 1 and 2 after grouping, increased as group size increased, the number of lesions, measured on Days 5 and 53, were similar across treatments.

In the same study, reducing space allowance for groups of 10 sows from 2.0 to 1.2 m^2/sow increased aggression. Similarly, Olsson, Svendsen and Reese (1994) reported increased injuries as group size increases and Weng (1998) reported increased aggression and injuries with decreasing space

allowance. The latter study recommended a space allowance between 2.4 and 3.6 m^2/sow for groups of 6 pregnant sows. The latter study also emphasised that the results could not be extrapolated to other group sizes and space allowances.

There currently are no recommendations on group size for adult pigs in the codes of practice relating to welfare (Anon. 1998a, 1998b). Nevertheless, this management factor may vary widely in commercial practice and may affect both welfare and sexual behaviour. Studies by Barnett *et. al.* (1984, 1986) showed that housing of sexually mature gilts in pairs resulted in a chronic stress response compared with housing in groups of 4–8. Both large group size (24 v. 8 pigs) and small group size (3 v. 9, 17, or 27 pigs) may have detrimental effects on oestrus expression (Christenson and Ford 1979; Christenson and Hruska 1984). Increasing group size and concomitantly decreasing space allowance may have detrimental effects on oestrus expression (Cronin *et. al.* 1983). Broom, Mendl and Zanella (1995) compared sows in groups of 5 fed in stalls and a group of 38 sows that had an electronic feeding station. Although there was increased aggression in the larger group, particularly after initial mixing, any differences in aggression and stereotypies had disappeared by the fourth parity. Further research is required to determine the optimum group size for pregnant pigs and in addition address issues surrounding feed provision and the use of electronic feeders (Bressers, *et. al.* 1993). There are no data on space allowance/ group size interactions for adult pigs.

7.0 Stockpersonship and Competency

7.1 Human—Animal Relationship

It is becoming increasingly recognised that the role of the stockperson, irrespective of the housing system, can have a considerable effect on farm animal welfare and productivity. In a commercial system, there are often brief periods of intense contact with humans, which may have a marked influence in regulating the human-animal relationship and in particular, the level of fear experienced in the animals. The role of the stockpersons has only recently become recognised as a major factor in determining the welfare and productivity of farm animals. Furthermore, stockperson behaviour has been shown to be strongly related to fear and reproductive performance in animals (Hemsworth *et. al.*, 1989). Several research investigations have demonstrated that the strongest predictors of stockperson behaviour, and consequently the impact on the level of fear in the animals, have been found to be stockperson attitudes. It has been demonstrated that both the capacity and the willingness of the stockperson to manage livestock in their care will have substantial effects on the welfare of the livestock in both intensive and extensive production systems. It has also been proposed that empathy of the stockperson may be related to the welfare and productivity of animals under the stockperson's care (English, 1991).

Research into the effect of stockpeople on animal welfare has been conducted by English, (1991), Hemsworth *et. al.*, (1989), Hemsworth, Barnett and Coleman (1993) and Seabrook, (1972) with further investigation into related elements including stockperson selection, personality attributes, job-related characteristics, motivation and training (Coleman, Hemsworth and Hay, 1998; Coleman, et. al. 1998, Hemsworth *et. al.*, 1994, 2002; Seabrook, 1972). Intensive animal husbandry systems allow, and during certain periods of the animal's production cycle, often require frequent contact between humans and animals. In addition to the welfare implications of human-animal relationships, productivity has also been reported to be affected. Hemsworth *et. al.* (1981b) found that the behavioural response of sows on commercial farms to humans was related to reproductive performance.

Extensive research indicates clearly that human-animal interactions, by influencing the level of the animal’s fear of humans, can have marked effects on the welfare and productivity of farm animals (Hemsworth *et. al.*, (1989), Hemsworth et. al., (1993).

In a number of experiments (Gonyou, Hemsworth and Barnett, 1986; Hemsworth, Barnett and Hansen, 1987; Hemsworth *et. al.* 1981a, 1986a), it has been shown that pigs that were highly fearful of humans, as a result of being aversively handled, exhibited depressed growth rates and reproductive performance.

Conclusions from these and other studies indicate that these depressions in growth and reproductive performance are a likely consequence of chronic stress responses, since pigs that were highly fearful of humans exhibited a sustained elevation of plasma free corticosteroids in the absence of humans. Supporting the assessment of human animal interactions resulting in fear and chronic stress responses was another study by Gonyou, Hemsworth and Barnett (1986), where it was concluded that aversive handling treatments for pigs resulted in adrenal morphology (increased area of cortex) that was indicative of chronic stress and that if frequent handling of animals is necessary, non-aversive methods should be employed to avoid deleterious growth responses.

Hemsworth *et. al.* (1981b) reported a relationship between the approach behaviour of sows and their productivity. In this controlled study, Hemsworth *et. al.* (1981a) demonstrated that an aversive handling regime resulted in reduced growth relative to gentle handling in pigs, and it was found that the level of fear of humans by pigs in standard testing situations was associated with reproductive performance on the farm. Sows tended to display avoidance behaviour when the experimenter was present and the average number of piglets born for sow per year was low. The association between fear and reproduction is demonstrated in sows that have been shown to be highly fearful of humans experience a stress response in situations where there was frequent human contact that results in limited reproductive performance. Hemsworth, Barnett, and Hansen, (1981), studied the influence of handling by humans on pigs using four different handling treatments and measuring impacts on behaviour, growth and free corticosteroid concentrations for young female pigs housed in individual pens. It was shown that gilts in the unpleasant and inconsistent handling treatments had higher free corticosteroid concentrations in the absence of humans at 14 weeks of age and were more fearful of humans, than gilts in the pleasant and minimal handling treatments.

Seabrook (1991) reported that regular handling and stroking by stockpersons resulted pigs being more passive and had a positive influence on their performance. In another study by Paterson and Pearce (1988) the opposite was found, whereby no effect of regular aversive handling was determined on the growth performance of the pigs. Differences in these studies may be a result of the difference in the nature of aversive handling treatment applied, the amount and imposition of the treatment and perhaps genetic differences, although Gonyou *et. al.* (1986), reported that although there were differences in basal concentrations of cortisol between the two genotypes of pigs, both exhibited similar stress responses to being on tethers. There is still some work to be done to determine the nature of positive and negative interactions, although some of this has been established by Hemsworth (2003) and other studies have indicated similar results. For example Pederson, *et. al.* (1998) found that positive handling could ameliorate the negative aspects of tether stall designs on pigs.

These and a number of similar studies have concluded that unpleasant and inconsistent handling treatments result in chronic stress responses with consequent adverse effects on animal welfare, productivity and growth performance.

7.2 Human Behaviour

In previous research (Coleman, Hemsworth and Hay 1998; Coleman, et. al. 1998 Hemsworth *et. al*., (1989), Hemsworth et. al., (1993). Hemsworth *et. al.*, 1994, Seabrook, 1972), whilst there was variation in terms of stockpeople's characteristics between farms, the factor identified to have had the most influence on the fear of humans by pigs was determined to be the behaviour of the stockperson towards the pig. Consequently, variation in the fear of humans, suggested to be caused by the variation in stockperson behaviour towards the pigs, can result in considerable variation in welfare and productivity, indicated by reproductive performance in the studies aforementioned. These and other studies have indicated that the behaviour of the stockperson is highly associated with high levels of fear of humans by pigs and that high levels of fear can have can limited reproductive performance via a chronic stress response. Upon manipulating the fear response, it was shown that the level of fear of humans by pigs could be reduced by the stockperson displaying a lower proportion of negative behaviours.

These reported effects are not necessarily as result of a direct cause and effect relationship (Hemsworth and Coleman, 1998). Certainly there is a clear relationship between the attitude and behaviour of the stockperson and the resultant fear, behaviour and consequent welfare and productivity of pigs. In previous study (Hemsworth and Coleman, 1998, it was demonstrated that there may be other characteristics influencing the behaviour of the stockperson and the interaction with pigs and consequently pig welfare. These characteristics have been demonstrated to include attitude towards the pigs by the stockperson, together with factors of knowledge and skills, job satisfaction and personality. It is appreciated that knowing and being skilled at the techniques that must be used to accomplish a task are clearly pre-requisites of being competent as a stockperson. Some of the key characteristics for stockpeople have been identified to include:

1. Good general knowledge of animal care, including the nutritional, climatic, social and health requirements of the animal;
2. Practical experience in the care and maintenance of the animal; and
3. The ability to identify any departures in the behaviour, health or performance of the animal and promptly provide or seek appropriate support to address these departures.

The success of these characteristics has been shown to depend on the other factors previously mentioned, including motivation, job satisfaction, and personality traits.

Ajzen and Fishbein (1980) proposed a theory of reasoned action, whereby 'a person's intention to perform a behaviour is a function of the person's attitude towards the behaviour and the persons' perceptions of the social pressures on the performance of the behaviour, referred to as the subjective norm'. Consequently, recent research (Hemsworth, Barnett and Coleman, 1993) has investigated further into the variety of human factors, both attitudinal and behavioural, in order to gain further insight on the human-animal relationship and consequential impacts on welfare and productivity of livestock. Forming the basis for this further investigation was studies including one that examined the relationships between a stockperson's attitude and behaviour and the level of fear of humans by pigs (Hemsworth et. al., 1989). In this study, significant correlations were found between the stockpersons behaviour and their attitude towards characteristics of pigs and their own behaviour towards pigs. Since it was determined from this work that both the behaviour and the attitude of the stockperson were related to the level of fear of humans by pigs, which can result in chronic stress, it was also found that both related to the consequent productivity of pigs on the farm, indicated by level of reproductive performance.

Considerable research into the role of the stockperson's attitude and behaviour on the behaviour, productivity and welfare of commercial pigs has been conducted and well documented (Gonyou, Hemsworth and Barnett, 1986, Hemsworth and Barnett, 1991, Hemsworth *et. al*., 1981a, Hemsworth *et. al.*, 1981b, Hemsworth *et. al.*, 1986, Hemsworth, Barnett and Hansen, 1987 and Hemsworth *et. al.*, 1989. The practical implications of improving stockperson attitudes and behaviour in the pig industry have also been demonstrated by the results of a study at 25 commercial farms (Hemsworth *et. al.*, 1994). The objectives of this study were to examine to the possibility of improving the attitudinal and behavioural profiles of stockpeople towards pigs and, if successful, the consequences of these attitudinal and behavioural changes on the behaviour and productivity of commercial breeding pigs. The effectiveness of applying an intervention (training) programme was assessed by monitoring the changes in the attitudinal and behavioural profiles of stockpeople and the behaviour and reproductive performance of pigs at the two groups of farms.

The analysis showed that significant improvements were made following the intervention treatment on the attitude and behaviour of the stockpeople towards pigs, the behavioural response of pigs to humans and a trend towards improvement in pig reproductive performance. It is important to note, however that while the changes in fear levels are observed in the short term, a greater period of time may be required before stress responses, either acute or chronic, in those highly fearful animals are reduced to the extent where reproductive performance is not limited. This is a key consideration, given that stockpeople in commercial pig units tend to move across the facilities, often operating in different areas for periods of time i.e. farrowing to finish systems.

Furthermore, studies by Peterson *et. al.* (1997) indicated that the removal of breeding animals from herds due to reproductive failure was less in smaller herds, due to the combination of fewer non-pregnant sows, post mating and lower post weaning anoestrus. However, it was pointed out that the improved reproductive performance was also due, in part, to the time that stockpeople spent with the animals.

Further studies utilising the same principles have since been conducted, (Hemsworth and Coleman, 1998, Hemsworth 2003) in the dairy and pig industries. These studies have shown the potential of cognitive-behavioural intervention techniques designed specifically to target these key attitudes and behaviours of stockpeople that have a direct effect on animal fear, productivity and welfare. An underlying hypothesis of these studies and previous research on stockpeople is that if handling methods can be developed which result in pigs being less fearful of humans, and stockperson behaviours can be modified resulting in reduced fear of humans in pigs, effects on welfare and productivity can also be reduced.

As a result of this research, training programs using a cognitive-behavioural technique have been developed and introduced in the pig and dairy industries in Australia, New Zealand and the United States (ProHand – professional handing of pigs) to improve the attitudes and behaviour of stockpeople. It should be recognised from the research, however, that achieving change in the manner in which stockpeople handle their animals is not simply related to knowledge transfer, but most importantly due to the intricacies involved in forming and changing attitudes and behaviours, it involves cognitive-behavioural training techniques. In other words, to achieve changes in attitude and behaviour that result in changing established habits, this means altering well-established attitudes and beliefs, targeting denial and offence in the stockpeople and preparing the stockpeople to handle reactions from both pigs and other people towards the individual following change.

7.3 Conclusions

In summary, there is room for continual improvement in stockperson behaviour and livestock handling that can result in improved welfare and productivity. Application of training in this area has demonstrated such improvements, and is likely to become a key element of management systems in livestock industries in the future. Certainly, in order to underpin growing quality assurance requirements, technical systems and legislative requirements, the emphasis on training and/or competency at a number of levels across the industry is only likely to increase in the future.

8.0 Industry, Community and Consumer Issues

8.1 Public Education

Consumer attitudes towards animal welfare can influence the sustainability of the livestock industries. In addition, the communities also have similar influence, with increasing concerns being provided in mainstream news on various welfare issues. It is important for both consumers and the community that effective and accurate information is provided to avoid misconceptions in relation to animal welfare practices. Certainly, education on agriculture in general is becoming identified as a key requirement for urban communities, particularly school aged children, to increase understanding in relation to food production and the role of farming systems. A recent review of internationally published research on young people's understanding of food, farming and land management concluded that young people's knowledge of how their food is produced, from farm to plate is extremely limited (Rickinson, et. al., 2003). Furthermore, research is now beginning to indicate that concerns about animal welfare might be very influential in young people's food choices (Coleman, 2004) as while concerns about animal welfare expressed by adults are commonly associated with the pork and poultry industries (Worsley, 1998), young people's concerns tended to be broader with focus on pigs, poultry, fish, cows and lambs (Worsley, 1997). Consequently, the lack of knowledge in terms of how food is produced and the associated farm practices; coupled with an increasing divide in rural and urban communities and the differences observed in concerns relating to food choices between adults and young people, indicate a need for focus on education to ensure industries remain sustainable.

As example of this is the recent interest in providing the introduction of farm based modules into the education frameworks for secondary and primary school children, which are being considered in a number of States in Australia (pers comm.). In addition, many companies and welfare organisations are also attempting to provide information relating to their production systems for consumers to provide clarity and enable effective consumer choice.

It will be increasingly important that effective and accurate information on industries and their production practices is provided to avoid misconceptions developing. There are many ways in which this may be done, with some recent examples including the development of information packages, education modules, training packages, marketing material and forming linkages with customers and governments to provide accurate and clear information on animal care, husbandry and for specific issues or concerns. The RSPCA has also begun a process of providing information for consumer products through their labelling systems.

The education of consumers and the general community may aid in reducing the emotional debate, thus developing a more informed and rational basis upon which the diverse groups involved in animal welfare can communicate more effectively.

8.2 Industry Extension and Education

Just as critical as the search for answers on how animals respond to these practices, and the dissemination of this information to the general public, is industry education. Effective industry education on welfare issues will lead to improvements in animal welfare and productivity and promote industry sustainability. There are many models for extension of materials and the previously mentioned poster by NZPIB is one of the better examples. Similarly, in other industries in Australia these types of activities have aided in better understanding and integration of the Code and other good practice principles into industry knowledge. One key example of this is the Meat and Livestock Australia's *fit to load guide*, a simple, hard plastic flip folder provided to transport operators that is small enough for them to carry in the truck and not subject to being wet or damaged easily.

8.2.1 Welfare provisions in quality assurance systems

One major development occurring in many of the livestock industries around the world is the integration of welfare provisions into industry extension and quality assurance programs. Many issues that producers focus on daily such as animal health, production and food safety, also have impact on animal welfare, however only in recent times is this information being consolidated into similar programs. There are many examples of this including the aforementioned U.S. SWAP program and the Australian Pork Industry Quality (APIQ) Program. The main objective of the US SWAP program is to maintain and promote the pork industry's tradition of responsible animal care through the application of scientifically sound animal care practices. Since its introduction in 2003 the National Pork Board reports that producers of all sizes and types have adopted SWAP.

Similarly, in Australia, the pork industry developed an animal welfare audit, comprising of a HACCP-based approach, with key audit questions, associated targets and background information. This document was subsequently integrated into standards and became a component of the Australian Pork Industry Quality Program (APIQ). The audit questions have been incorporated into the APIQ auditor manuals, giving the industry opportunity not only to demonstrate compliance with key practices, but to benchmark and promote specific areas of practice in the industry.

In the Australian example, the information obtained on animal welfare through the APIQ program will contribute significantly in future reviews of Codes of Practice, plus provide the basis for continual improvement and industry extension or education. In addition, as regulatory standards develop and governments require feedback on the level of uptake of these quality assurance programs that have the ability to demonstrate compliance with key standards or provisions, programs like APIQ will become more useful in delivering animal welfare outcomes. Clearly, in other areas, such as food safety, the majority of mandatory regulatory (and commercial) requirements are met and demonstrated through described quality assurance programs, usually within an HACCP and ISO framework. As the breadth of these programs increases beyond food safety, to the inclusion of other aspects such as animal health, traceability and environment, it appears a logical step for animal welfare, whereby outcomes can be demonstrated as part of regular business practice.

In New Zealand, the pork industry embarked on the PQIP (Pork Quality Improvement Process) some ten years ago. PQIP is a quality management program, involving the application of HACCP for meeting industry agreed minimum standards. Whilst PQIP standards cover the entire pork industry, it unfortunately has very little uptake, apart from the pork processing sector. Currently, there is a requirement for all slaughter pigs to be accompanied by an Animal Status Declaration (ASD). However, it too does not cover animal welfare, but rather focuses on specific food safety issues. Notwithstanding that, incorporating a voluntary/ industry-driven declaration of compliance with agreed animal welfare requirements as part of a pre-slaughter declaration may be a useful further step in providing assurances to regulators, the supply chain and the wider community that producers are aware of these requirements and adhering to them.

The place of quality assurance programs in terms of providing a means for demonstrating compliance to required animal welfare standards or provisions is becoming more important. Animal welfare policy development is changing. There is a move from purely regulating from a cruelty 'angle' towards a duty of care and increasing regulation for specific practices and standards, such as New Zealand's Animal Welfare Act (1999). Currently the Codes of Practice provide the basis for how animals should be managed. However, one difficulty with the current Codes of Practices is that they are written in the form of guidelines to underpin the various Acts and regulations for animal welfare.

As guidelines, they typically contain information of different types, some of which is explicitly stated as minimum standards (as in the New Zealand Code) and other information categorised as best practice or guidelines. They also provide information that is presented as background or commentary for specific issues.

For a production system or business, these provisions are not necessarily easily incorporated into operating procedures. Thus industries are increasingly working with experts to customise Code provisions into quality assurance or system based requirements that can more easily be integrated with other provisions, such as animal health requirements or national vendor declarations and associated recording.

By building the provisions in the Code into an industry quality assurance system, industries are then able to i) more easily integrate the requirements into their daily business, ii) measure compliance and keep the relevant records and iii) demonstrate compliance through similar verification pathways to that of food safety or other key elements of assurance. Furthermore, internationally labelling in accordance with key provisions for welfare is beginning to occur, as seen in New Zealand and Australia with the RSPCA accredited eggs. Governments too are commencing some form of benchmarking in certain instances, recognising that this information is continually needed for two areas i) to gain further understanding of the practices that are carried out in general for setting policy and ii) to measure compliance and changes to practices over time. Industries across a broad spectrum are now are beginning to carry out similar research into the changes in practices over time.

Streamlining and targeting these programmes to make them 'producer friendly' whilst at the same time robust and flexible enough to be credible, along with getting supply chain buy-in from the marketplace back to the farm are seen as key attributes for the success of such programmes by the authors of this report, who have all had considerable experience with the design and implantation of such programmes in practice.

8.3 Benchmarking Animal Welfare Performance

Once an effective program is in place, there is an ability to measure aspects of the program over time, demonstrating continual improvements, compliance with Code(s) and uptake of specific practice. Currently many industries do this through industry wide surveys. For animal welfare, providing data on aspects such as industry training and knowledge, compliance with Code(s), changes in practices or conversely the reduction of controversial practices can aid in demonstrating improvement. Furthermore, this kind of data, when utilised strategically and in a transparent manner, can be used to underpin education schemes for consumers and the general public.

New Zealand is appropriately positioned to be able to deliver such information over time. An approach that might aid in demonstrating compliance and providing key data could be the development of some key indicators for animal welfare that would be determined by impact, key issues and the ability to demonstrate change over time.

These indicators could be a combination of specific practices, knowledge or aspects of production systems. The welfare performance indicators should be objective measures wherever possible in terms of animal welfare outcomes. This, coupled with the introduction/increase in uptake of a program like an enhanced, streamlined and/or re-branded PQIP would provide the basis for the industry to i) integrate standards for welfare, health, food safety and production, ii) deliver data on compliance and iii) provide a vehicle for implementation of key aspects of the Code(s) and other industry information. Furthermore, as governments move towards the development of standards or continue to mandate Code(s) of practice, these initiatives could provide the framework by which industry would meet these requirements without the need for a separate extension, compliance or verification system.

8.4 Development of Competencies for stockpeople

As highlighted in the NZPIB's Strategic Plan, stockpersonship is vital. The health and welfare of pigs is probably more dependent on the farmer's ability to properly manage the system, rather than on the specific type of housing system itself. Good stockpersonship is therefore vital in achieving the good health and welfare of the herd.

Already in New Zealand, there are a number of applications to demonstrate i) the importance of stockpersonship and ii) deliver training to underpin this principle. One primary example of this is the training program ProHand, currently provided to producers which targets the behaviour and attitude of the stockperson and the consequent impact welfare and productivity by influence the level of fear and stress in the animal. This program, coupled with additional methods of training through other courses and extension programs can contribute to meeting the required animal welfare outcomes.

The focus on competency of the stockperson internationally is increasing in parallel with the increasing development of standards and requirements. Therefore, in future strategic planning the need to consider training programs that deliver outcomes for areas of animal welfare, in line with other aspects such as animal health and food safety, is obvious. In the future, the need for training for other sectors of industry and government, such as veterinarians, inspectors, auditors and extension personnel in specific areas of animal welfare such as assessment may also increase.

Internationally, there has been an increase in the need to demonstrate competency and training to meet standards for retailers in all areas, including animal welfare, as well as an increase in full accreditation programs for specific practices, such as mulesing in sheep. The recent European Council regulation (EC No. 1/2005) that applies from 5 January 2007 stipulates for livestock transport that drivers and attendants of animals in transit will be subject to compulsory training and by 2008 will have to be certified to care for livestock being transported. In Australia, there are some similar requirements, where various States have legislated schemes relating to livestock loading, primarily from a safety and prime mover weight perspective, rather than welfare, although in the meat processing sector, there are animal welfare competencies available.

9.0 Conclusions

Pig farming is a highly complex, multi-faceted livestock production system. The result of this is that there is no simple nor straightforward single 'best practice' way of farming pigs and this is particularly so for breeding animals. Furthermore, the remarkable topographical difference between the North and South Islands results in polarised production systems between the two islands. Accordingly, appropriate solutions for the industry need to accommodate the somewhat land-restricted indoor-based North Island farming system as well the South Island system, where outdoor farming dominates.

The increasingly intensive nature of pig farming in many countries has unfortunately meant that over the past decade the global pork industry has drawn considerable attention to itself as a 'factory farming' style operation, with negative connotations (either deservedly or through public ignorance) and the authors envisage the resultant pressure from this heightened attention remaining for the foreseeable future. The provision of education on current (and future) farming practices for younger members of the wider community is an essential long-term strategy that needs to be pursued.

The lack of agreement over a suitable definition for animal welfare will mean that the debate both within the scientific and lay communities will also continue for some time yet. This does not help the current situation.

Internationally there has been dichotomy in addressing animal welfare standards, with the EU following a regulatory route and the US using a more market focussed approached. To date, New Zealand has taken a more middle of the road approach using outcome-based legislation combined with an industry code of practice.

On the specific issue of sow housing systems, and recognising that the confinement of breeding sows and gilts is one of the most controversial issues in livestock production, the scientific evidence is still equivocal. Unfortunately, no sow housing system is 'perfect'; be that for gestating sows or farrowing/ lactating sows. Accordingly, at present there does not appear to be any silver bullet. The empirical evidence tends to suggests that gestating sows are better off in stalls in early gestation and in group-housed systems in late gestation.

Equally, evidence is available that indicates extended periods in farrowing crates is detrimental to sows and limiting their use is an appropriate strategy as contained in the current Code of Welfare. Finding a viable alternative to the farrowing crate that can give the sow more freedom of movement and ability to perform a wider range of behaviours whilst at the same time protecting piglet welfare and being economic to implement for indoor housed operations would appear to be some time way yet.

The role of good stockpersonship is abundantly clear in ensuring that the best animal welfare outcomes are achieved within the limitations of each particular housing system. Thus demonstrable stockpersonship competency is vital.

In closing, the industry must move forward in terms of demonstrating compliance with existing practices. That in itself will be an important step in maintaining the confidence or the public and regulators.

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