DEPARTMENT for ENVIRONMENT, FOOD and RURAL AFFAIRS

Research and Development

Final Project Report

(Not to be used for LINK projects)

Project title	Optimising Production Systems for Organic Pig Production
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Executive summary (maximum 2 sides A4)

The overall objective of this project was to generate the scientific and financial information necessary to facilitate increased production of pigmeat on existing organic farms, and the conversion of conventional farms to this organic production. Information was collected through a series of experiments focusing on the effects of genotype, management and nutrition. The study was conducted on commercial organic pig farms, supported by literatures searches, financial appraisal, and survey data collection.

Organic production standards favour traditional breeds of livestock in preference to 'improved' genotypes, which may be less suited to the more extensive production systems. An experiment was carried out to compare performance, health and welfare of three different genotypes managed organically. These genotypes were chosen to represent different breeding strategies - British Saddleback (S), a pure-bred, traditional genotype; PIC Camborough 12 (C12), an improved modern genotype; and Saddleback x Duroc (SD) sow, suitable for 'criss-cross breeding' system by smaller organic farms. The modern improved genotypes of sows produced higher litter sizes than their more traditional counterparts, although the numbers of pigs weaned were similar across the genotypes studied. The results indicated that all three breeding strategies can be successfully adopted in organic production systems, and that choice of sow breed should depend on the ability of the farm to manage prolific sows, the implications for slaughter pig performance, and market requirements.

A factorially designed experiment was carried out to investigate the effects on performance and carcass quality of three different genotypes of growing pig, three feeding systems and two housing systems. Each combination of treatments was replicated in four groups of growing pigs from shortly after weaning (start weight 30 kg) until slaughter at a mean weight of 90 kg. The three genotypes used were the progeny of the three sow genotypes above, following mating to a Duroc boar. The housing systems compared were (1) maintenance at pasture with a simple arc shelter (OUT) or (2) housing in indoor straw bedded accommodation

with an outdoor concrete exercise area (IND). The feeding treatments comprised (1) *ad libitum* concentrate diet with roughage provided by either pasture or straw bedding (CONC), (2) as 1 but with *ad libitum* availability of grass/clover silage (SIL), (3) as 1 but with *ad libitum* availability of fodder beet (BEET). The results demonstrate the climatic penalties associated with paddock production systems. Although growth rate did not differ significantly, feed intake was increased for outdoor animals (OUT=2.47, IND=2.22, SEM=0.05 kg meal equivalent per day, $P<0.001$). This resulted in a significant increase in feed conversion ratio (OUT=3.47, IND=3.07, SEM=0.09, $P<0.01$). Paddock animals, consumed a significantly smaller proportion of their daily intake in the form of the additional forages offered (<1% of Dry Matter Intake). Forage intakes could be increased by restricting the amount of concentrate diets offered, but this would incur a penalty in terms of growth rate. Overall, there were few significant treatment effects on product quality. In fresh pork, progeny of pure-bred Saddlebacks scored slightly higher for 'off aroma' (S=1.0, C12 & SD=0.7, SEM=0.10, $P<0.10$), which might reflect their earlier maturing characteristics. Bacon from Saddlebacks was also scored as having darker colour (C12=4.8, S=5.5, SD=4.5, SEM=0.26, $P<0.01$), greater saltiness (C12=4.1, S=4.9, SD=4.1, SEM=0.25, $P<0.05$), and lower overall acceptability (C12=3.2, S=2.5, SD=3.5, SEM=0.36, $P<0.05$). However, no such differences in other processed products were apparent. In a further experiment, the herbage intake of growing pigs maintained at pasture was quantified. The results showed that, when offered a cereal- based concentrate *ad libitum*, the herbage intake of growing pigs from a good quality grass/clover sward contributed <5% to daily organic matter consumption. In these circumstances, modification of concentrate composition would not be appropriate. To facilitate efficient feed use in organic pig production, a 'Feed Handbook' (publication C3) was compiled, printed and made available to UK organic farmers.

The effect of paddock management on the ranging behaviour of sows was also studied, in a two by three factorial design, involving three sow genotypes. Two commercially applicable paddock management strategies were established: a) 'Rotational' (R) where a group of up to 6 sows was provided with a paddock measuring 40x40 m which was relocated to clean ground every four months, and b) 'Set stocked' (SS) where a group of up to 6 sows was provided with a paddock measuring 120x40 m which was relocated to clean ground every twelve months. Results suggest that during wet periods, the R paddocks may be advantageous as the pigs are moved off damaged pasture, whereas the SS may be unable to recover if pigs remain. In drier periods, the SS paddocks maintain grass cover for longer than R and therefore incur less labour for moving without significant pollution risk. The behaviour data show that pigs in the SS paddocks do use the further portions of the field, but this may require management manipulations to achieve satisfactory grass usage and distribution of excreted nutrients.

In a survey conducted between August 1999 and April 2002 on the commercial organic farms, the main welfare issues reported related to keeping stock clean and dry in periods of high rainfall, managing Porcine Dermatitis and Nephropathy Syndrome and Postweaning Multisystemic Wasting Syndrome (PDNS/PMWS) within their herd, and recruiting and retaining good quality personnel. Mange and lice were the highest-ranking current health concerns, and post-mortem reports of endo-parasitism was the highest-ranking historical health concern. Two of the five farms surveyed reported problems with scouring in young pigs. The presence of grey and clay-like faeces was consistent with the presence of *Coccidia* infection. *Coccidia* do not represent a threat to adult animals, which have generally become immune, but can cause severe scouring in young piglets. Whilst a five-year rotation policy is considered long enough to reduce nematode carryover, this is unlikely to be the case with *Coccidia*, which may survive for up to 11 years, and pose a significant risk in organic systems.

Data collected on physical performance, capital investment and operating costs were used to establish bench-mark production levels for organic pig herds, the cashflow implications of establishing an organic pig herd, profitability, and sensitivity to movements in productivity, costs and prices. Initial investment costs for a 100 sows herd established with bought in maiden gilts and boars, were estimated to be £82,000 for machinery and equipment and £22,000 for stock. Simulated cashflow requirements peaked at £200,000 in month 13, when the first bacon pig is sold. Net Farm Income for an established 100 sows herd was estimated at £24,600 per annum. However, a reduction in performance of one pig/sow/year, combined with a £12/tonne increase in feed price and a 10 p/kg reduction in pig price would reduce Net Farm Income from £24,600 to zero.

Information was disseminated widely through farmer conferences and talks at national conferences, scientific papers, conference proceedings, technical and press reports. The work supports Defra policy to promote welfare friendly and environmentally sound systems of livestock production, and to enhance the competitiveness of the agricultural sector within the UK.

Scientific report (maximum 20 sides A4)

1. Introduction

The current level of organic pig production within the UK is low, and under increasing price pressure from imported product. Despite low profitability in conventional pig production systems, as a result of product oversupply, only a few farmers have taken the opportunity to diversify into organic production. However, such diversification could be facilitated by reliable information on optimal production methods and the economics of production. The management systems that are required by current organic standards differ significantly from those used in conventional practice. Whilst some of the scientific information derived from experiments in the intensive situation can be extrapolated to an organic context, there remain a significant number of issues specific to organic production which require investigation in order to produce high-quality pigmeat in a welfare and environmentally friendly manner. These centre particularly on the interactions of genotype with the differing nutritional and environmental conditions found in organic systems. Generation of this information, closely linked to effective technology transfer to both organic and conventional farmers, will facilitate an increase in (i) the number of existing organic farms establishing organic pig units, (ii) the efficiency of organic pig production and (iii) the conversion of conventional farms to this production method.

At the outset of this project, MAFF (now Defra) indicated that it wished to promote welfare friendly and environmentally sound systems of livestock production, and to enhance the profitability of the agricultural sector within the UK. Facilitating the expansion of biologically and economically efficient organic pig production will achieve both of these objectives.

The overall objective of this project was to generate the scientific and financial information necessary to facilitate increased production of pigmeat on existing organic farms and the conversion of conventional farms to this production method. In this report, each of the scientific objectives will be addressed in turn.

2. Background

Organic production standards impose a different set of constraints on the biology of the pig to those operating in conventional intensive production systems. Whilst some knowledge gained from studies carried out in the intensive (indoor and outdoor) context can be used to predict responses in organic circumstances, certain aspects of organic production involve questions which are unique to organic farming, and lack scientific information.

2.1 Genotypes for organic production

A major area of uncertainty relates to the suitability of different genotypes for organic production. Traditional local or rare breeds are encouraged in organic production (Soil Association Standards) but these breeds, typically Saddleback, Tamworth and Gloucester Old Spot, have been superceded in intensive production by specialised genetic lines . The main reason for this has been the early maturing characteristics of traditional breeds which produces excess carcass fat at heavier slaughter weights (1). The breeds used for intensive production, predominately lines of the Landrace and Large White breeds, have higher lean tissue growth rate and can be slaughtered at heavier weights, without deterioration in lean content or associated feed conversion efficiency. Genetic selection in commercial pig breeding companies has, therefore, focused on improvement of leanness, feed utilisation efficiency, growth rate and prolificacy under circumstances where environment is closely controlled, nutritional constraints are minimised by use of high nutrient density diets, and where early weaning is practiced.

2.1.1 Genotype and maternal performance

In selection programmes for intensive production, maternal characteristics have been largely neglected in order to maximise selection for improved growing pig characteristics, since this does not impose any disadvantage when parturition and lactation take place under highly controlled conditions. Whilst selection for prolificacy has been pursued for some years, selection for good maternal behaviour and piglet rearing ability have only recently begun to be addressed. Furthermore, the greater leanness of some modern genotypes can directly compromise maternal ability through lack of adequate thermal insulation to buffer the variable climatic regimes experienced in outdoor situations, and limited possibility to mobilise body fat reserves to support the high metabolic demands of lactation. Such problems may be exacerbated by the longer lactation required to accommodate the greater weaning age required under organic standards. Prolonged lactation increases the metabolic demands made on the sow and, in the past, resulted in a significant incidence of 'thin sow syndrome' in intensive circumstances (2).

Currently, the most widely used traditional breed of pig in UK organic production is the Saddleback, which is reputed to have good mothering ability. However, there is a lack of good scientific data to support this observation. Modern White genotypes have been shown to have poorer maternal characteristics than genotypes incorporating the traditional Meishan breed in both intensive (3) and semi-intensive (4) conditions. In extensive circumstances, maternal behaviour in the peripartal period will have a much greater effect on piglet survival than in intensive conditions (5). Similarly, the growth and welfare of older suckling piglets will be influenced by the willingness of the sow to expend her own tissue reserves to benefit the piglets by allowing suckling at regular intervals. This willingness has been shown to vary widely between individuals (6). The parent-infant conflict associated with lactation becomes more pronounced as lactation progresses (7) and will therefore be of greater importance under organic management. Genotypes with a higher mature body size, seeking to maintain significant maternal growth in parallel to reproductive function, may be less willing to make such investment. Before this study, no scientific investigation of this question had been made (Project Objective 2).

A further issue in breed selection policy for organic production relates to the utilisation of hybrid vigour. In intensive production, a number of different pure breeding lines have been used at nucleus level by companies to generate hybrid sire and dam lines for use in commercial pigmeat production. The benefits of heterosis in crossbred dams are well documented in terms of prolificacy, rebreeding interval and neonatal survival (8). However in organic systems, where more closed systems are promoted, it has been more common to use purebred lines to produce replacement gilts on farm (9). To produce F1 sows from within a herds' own resources, it would be necessary to maintain a proportion of purebred sows within the herd, but the relatively small size of most units would result in very limited gilt selection if this option were adopted. Whilst it would be possible for an organic herd to specialise in producing F1 replacement stock for other herds, an alternative solution would be the use of a 'within-herd' reciprocal crossbreeding policy (i.e. criss-cross breeding). This gives a reduced benefit from heterosis in comparison with a first-cross dam (67% heterozygosity), but allows even small herds to exploit cross-breeding in a fully self contained and sustainable manner (10).

When considering possible breed combinations, many options exist . In conventional outdoor production, the Saddleback was crossed with the Landrace to produce the 'Blue' sow. In more recent years, this genotype has been superceded by Duroc crossbred sows in order to produce progeny of better carcass quality without compromising hardiness or reproductive performance (11, 12). Experience under organic circumstances (Browning, pers comm) has indicated that incorporation of the Landrace into the Saddleback maternal line was not successful, whereas a Duroc x Saddleback proved to have greater hardiness and potential as a crossbred sow for organic systems.

Reproductive traits are highly variable (with typical coefficients of variation of up to 30% for some parameters). Valid breed comparisons require a large number of animals. Since contemporary, within-herd comparison is essential to avoid confounding environmental effects, and most organic herds are of relatively small size, even multi-herd experiments (as proposed in this project to permit valid breed comparison) must be limited in scope if statistically meaningful results are to be achieved. Therefore, whilst an ideal scientific comparison would incorporate all relevant purebreds and their crosses to distinguish breed effects from those of different degrees of heterosis, this project addressed the most important practical questions by limiting comparison to three genotypes. Specifically, the project measured whether the most widely used outdoor genotype in intensive production (the Camborough 12) outperforms the most widely used traditional genotype in organic production (the purebred Saddleback), and whether using hybrid vigour in the damline (Saddleback F1 Crossbred) offers significant improvement in efficiency under organic circumstances (Project Objective 2).

2.1.2 Genotype and progeny performance

The introduction of breeds with greater mature body size into the damlines will have significant consequences for the growth and carcass characteristics of the progeny. It is well known that traditional breeds have a lower lean tissue growth rate, greater thickness of subcutaneous fat and, because of the increased ratio of fat: lean deposition as the growing stage progresses, have poorer feed utilisation efficiency (1). Any advantages in terms of maternal characteristics must therefore be set against consequences for the performance of the progeny. Intensively reared pigs are almost exclusively finished indoors. However, organic pigs are frequently fattened in outdoor or semi outdoor conditions. Hardiness and adaptability are therefore important additional characteristics to take into account in breed selection. For this reason, the project combined large scale comparison of progeny performance and health in a within-farm comparison on different farms (Project Objective 2) with a more detailed study of genotype-environment interaction in a controlled experiment at one site (Project Objective 4).

2.1.3 Organoleptic quality of meat

The most important consideration for the long term sustainability of an enterprise is the security of the market for the product. While consumers may purchase a product because they approve of the production method, consistent customer loyalty is only assured through good organoleptic quality (13). It is known that breed can have a very significant effect on meat quality, with traditional breeds giving good results (14). This is particularly linked to the degree of intramuscular fat (15) but may also reflect differences in muscle fibre type (16), and metabolism in relation to stress susceptibility (17). Lean White genotypes have reduced carcass fat content, both subcutaneous and intramuscular, in comparison with most other breeds (1). In many studies, the Duroc breed has been associated with an increase in quality parameters of fresh meat, for example darker, redder muscle colour, increased fat firmness and increased tenderness (18). However, the organoleptic benefits may depend on the nature of the cross in which it is involved and on the slaughter weight (19). Whilst organoleptic properties have been widely evaluated in fresh pork, relationships to such properties in processed products have been less well studied. In this project, it was therefore proposed to evaluate the organoleptic consequences of adopting the different breed strategies both at different slaughter weights and in a range of different fresh and processed product (Project Objective 5).

2.2 Diets for organic production

When considering growth and meat quality, the effects of breed cannot be considered in isolation from the production system and diet. Organic farming encourages self-sufficiency, and the logical role for pig production in the whole farm rotations to compliment other farm enterprises. Pigs are omnivores and evolved in traditional farming systems as scavengers that could make use of a wide range of by-product feedstuffs. Within modern intensive production systems, pigs are fed almost exclusively on high-density diets, based predominantly on cereals, and compete for feed resources that could potentially be fed to humans. Organic production, however, emphasises the desirability of providing pigs with a diet of lower nutrient density incorporating roughages. This has the advantage of providing greater diversity in the diet, increasing foraging time, complimenting other farm enterprises and limiting growth rate and fatness. Potential benefits to health have also been reported (20, 21).

Within organic farming, a wide range of potential fibrous feedstuffs and by-products exist. The utilisation value of many of these products has been studied in metabolic and growth trials under intensive production conditions (e.g. cereal by-products - 22, 23, 19, 24; root crops and by-products - 25, 26, 22, 27, 23, 24, 28, 29; fresh and dried grass, straw and silage - 30, 31, 25, 32, 33), and there is little reason to believe that these data once collated cannot be directly extrapolated to organic systems. Similarly, the ability to predict feeding values from chemical analyses has improved over recent years (34, 35, 36) making it possible to make good estimates of the nutritional value of raw materials without costly and time consuming animal experimentation. It was therefore proposed within this project to collate existing information on feeding values of raw materials available to organic producers and to determine via chemical analyses whether organically grown material differs significantly from that produced conventionally (Project Objective 3).

Whilst the use of fibrous raw materials has been relatively well studied in sows, less work has been carried out with the growing pig, although it is known that bulky feeds depress appetite (37). In these younger animals, determining voluntary intake is particularly important , since it will be the balance between appetite and lean growth potential that will establish the suitability of a genotype for an organic production method. Modern lines of pig, in the process of genetic selection for leanness and feed efficiency, have inadvertently been selected for reduced appetite (38) and may be less able to deal with diets of this nature. Evidence exists from metabolism studies that traditional breeds are better able to utilise fibrous diets than modern genotypes (39) but few results from longer term production comparisons exist. This project compared the ability of different genotypes of growing pig to utilise different high fibre diets, and monitored their voluntary intake characteristics over the growth period (Project Objective 4). It is known that both feed level and the nature of dietary ingredients can have implications for the organoleptic quality of meat (40) and that some types of roughage can reduce the organoleptic quality of pigmeat (41). For this reason, the organoleptic studies incorporated possible diet effects in addition to the main breed comparisons (Project Objective 5).

2.3 Housing and management systems for organic production

Organic production standards require outdoor systems for breeding animals, and recommended outdoor rearing for growing/finishing pigs. This approach raises a number of issues that will interact with genotype and nutrition.

2.3.1 Ranging behaviour of sows

In conventional production, an increasing number of sows are kept outdoors but, despite this, the system has still received relatively little scientific study (42). The keeping of sows on pasture provides both opportunities and hazards. Sows have greater space and diversity of environment, which might be expected to promote better welfare. General studies of behaviour show that the sows have distinct diurnal patterns of activity and spend large periods of the day in foraging behaviour (43, 44). This can lead to problems if pasture destruction is rapid, leading in turn to poorer ground surface conditions and increased pollution potential. Although the level of pasture damage can be reduced by feeding practice (44), it can only be prevented by use of nose rings. These are very effective and widely used in conventional outdoor production (45, 46), but are prohibited by the organic standards on the basis of increasing stress and restriction natural behaviour. The extent of foraging behaviour may differ between breeds (47) although hard data is scarce and further studies are needed (Project Objective 6). The extent to which pasture can be preserved will impact significantly on nutritional requirements. A study in Aberdeen (48) measured the nutrient intake from grazing by outdoor sows at different times of year. With early spring grass, up to 40% of nutrient requirements can be derived from this source, with a significant contribution to nutrient intake being maintained into the early autumn. Behavioural measures associated with this study indicated that sows do not graze evenly over the paddock, further confirmed by French studies (49). Sows also show marked localisation of excretory behaviour within a paddock, generating discrete regions of high nutrient deposition that might cause problems for subsequent cropping (50). The extent to which this variability in grazing and excretory behaviour is influenced by paddock size has not been quantified. However, the ability of sows to maintain separate grazing and excretory areas has potential health implications linked to the level of ingestion of parasites in organic systems, where routine prophylactic anthelminthic treatment is not permitted. A survey of organic herds in Denmark found a high level of parasitism (51), indicating a need for better understanding of the role of pasture management. The relative merits of a set stocking versus rotational grazing policy of paddock management have not been quantified. In the former (requiring less fencing and labour), sows will have a greater area at any given time for segregation of excretory and ingestive behaviours. However they may reduce the availability of good quality sward for extended periods of the year and generate high nitrogen 'hotspots'.. In a rotational system, sows have less space at any given time, but regular movement allows rest and recovery of paddock swards and more frequent novelty in their surroundings to stimulate exploratory behaviour. Management of paddocks for lactating sows has been more widely studied, confirming individual paddocks to be superior to larger group paddocks for promotion of good maternal behaviour and piglet survival (5). This project quantifies the consequences of adopting a rotational or set stocking approach to dry sow management, in terms of health, welfare, grass utilisation and pollution risk (Project Objective 6).

2.3.2 Systems for growing/finishing pigs

There has been very little scientific study of outdoor finishing of pigs. It would be expected that performance would be reduced by the additional climatic demands (52, 53). However a lack of reliable data was highlighted, in attempting to make an economic assessment of such systems (54). There are likely to be genotypic differences in suitability for outdoor finishing, but the few available data on this subject are inconclusive (55). It was therefore proposed within this project to assess the effects of finishing pigs in housed or free-range conditions and to investigate possible genotype interactions with these systems (Project Objective 4).

Organoleptic quality of meat might also be influenced by the finishing system adopted. Exposure to cold can change carcass conformation, giving rise to shorter carcasses with a higher proportion of fat in subcutaneous rather than internal depots (56). The killing-out proportion is also decreased as a result of greater relative weight of internal organs and digestive tract. In relation to meat quality parameters, there is an inverse relationship between the ambient temperature and the degree of unsaturation of subcutaneous fat, and there is faster post-mortem pH decline in cold exposed pigs and lower ultimate muscle pH. Such effects might give rise to seasonal quality differences in outdoor pigs. Animals reared in extensive conditions also have more opportunity to exercise, although this factor is unlikely to be important since forced exercise on a treadmill had no influence on muscle characteristics at slaughter (57). Since many factors which have been shown to influence pigmeat quality can differ between indoor and outdoor systems, measurable differences between animals from such systems might be expected, but evidence of this is sparse. In a controlled experiment in which pigs of the same genotypes were reared in barren indoor pens or outdoor paddocks, it was found that the latter had lower backfat thickness, associated with greater utilisation of feed for thermoregulatory purposes, but no economically important difference in lean meat quality was found (58). French studies have also shown that outdoor rearing, in comparison with indoor, does not significantly affect organoleptic parameters of pigmeat, including tenderness or flavour (59). Outdoor pigs showed a decrease in ultimate pH and in water retention capacity, suggesting that these pigs experienced greater pre-slaughter stress. Similarly, absence of differences has been found in comparison of Dutch 'Scharrel' (free range) pigs with those from intensive fattening systems (60). When tested in studies controlled for genotype, or in studies using pigs derived from typical genotypes for each system, no differences in carcass composition, post-slaughter meat characteristics or organoleptic parameters were detected. However, one study has reported improved quality (tenderness) from outdoor reared animals (61) and this possibility was therefore addressed in the current project (Project Objective 5).

In most studies, taste panel evaluations are scientifically conducted, with panellists unaware of the origin of the samples. However, it is known that sensory evaluation can be influenced by cognitive factors (beliefs and attitudes). Subjects with prior experience and a positive attitude towards 'free range' pork, rated this product less juicy but similar in most other attributes to conventional pork when unaware of the origin of the sample. However, when aware of the origin, they rated free-range pork as more juicy, less bland, less tough, more tender, less dry and more pleasant (63). Consumer perception of the merits of a production system is therefore highly likely to influence their perception of the quality of product produced from such a system. This phenomenon is obviously highly relevant to organic systems since, in general, consumers perceive such systems to be more humane, environmentally friendly, traditional and sustainable. It is important therefore to control such potential bias in taste panel studies. In this project, taste panel studies were carried out by an independent institution under fully controlled circumstances.

2.4 Health and welfare in organic production

Welfare is best assessed in the context of the Five Freedoms, which emphasise that health is also an important component of welfare (63, 64). In a recent, limited survey of organic livestock producers, it was reported that few health problems existed in pig enterprises (65). Outdoor production is generally believed to give rise to fewer health problems, a supposition supported by lower vet costs in national recording schemes (66), but with little information available from controlled studies. Physiological consequences of chronic stress can be retrospectively observed in post-mortem pathology e.g. gastric ulceration, cardiac lesions and adrenal hypertrophy. Such assessments have not been quantified for organic production systems. However, in one study using the same genotypes , pigs finished outdoors had lower skin lesion and stomach ulceration scores, than pigs in very intensive, slatted housing, but no better than pigs kept in less intensive straw yard housing (55).

Reduced space has been shown to be a social stressor, and a barren environment results in greater abnormal and aggressive behaviours. Low ranking animals may be particularly disadvantaged in outdoor systems in comparison with the more controlled indoor conditions, since they can receive only limited human assistance in attaining adequate access to resources such as shelter and food. Within this study the welfare of sows and growing pigs were assessed by collecting multidisciplinary measures of welfare combining production, health, physiological and behavioural parameters. Direct contemporary comparison between organic and non-organic pigs on the same farm is not possible, and also not really meaningful in the light of the wide variety of different variables that can arise under each heading. However, the data collected will allowed a welfare audit of the organic production systems to be carried out, enabling some comparison to be made with published results for these parameters in other production systems (Project Objective 7).

3. Scientific Report

3.1 Objective 01: To establish the trial, monitoring and management systems on three focus farms (on which the research work was undertaken) and at least four link farms (used to gather additional information on organic pig production).

The project was overseen by a Project Steering Group made up of a diverse representation from organic and conventional sectors including Defra Science Directorate, Defra Organic Unit, National Pig Association, PIC, RSPCA, Soil Association, Tesco (through the Tesco Centre for Organic Agriculture), the University of Aberdeen and collaborating scientists from ADAS, University of Newcastle, Eco-Stopes Consultancy and commercial organic farmers including Eastbrook Farm. Steering Group meetings were held on 08/04/1999, 15/10/1999, 12/05/2000, 21/12/2000, 22/06/2001, 13/12/2001 and 30/07/2002.

A full-time post-doctoral research assistant was recruited to co-ordinate research on the two focus farms and six link farms. Breeding sows were established on both focus farms. In the absence of an existing farm recording system, physical and financial data collection systems were set up for these farms. The project proposed a third focus farm. However, due to disease concerns associated with the requirement to import different genotypes, the unit that originally agreed to act in this capacity decided to withdraw and despite repeated attempts it was not possible to secure a third farm,. In order to supplement data collected from the two focus farms in the controlled comparisons, four of the participating link farms were recruited to provide additional individual sow production information on animals from several genotypes.

During the course of the project, an expert group, comprising members of the steering group including participating focus and link farmers, was established to review and recommend on best husbandry and management practice. This group met on 20/03/2000 and 17/04/2002.

3.2 Objective 02: To investigate the effect of breed type (conventional and traditional) on maternal characteristics (prolificacy, rearing ability and longevity) and growing pig characteristics (growth rate and carcass characteristics).

3.2.1 Materials and methods

Three genotypes were chosen to represent different breeding strategies. The British Saddleback (S) represented the strategy of using a purebred, traditional genotype. This breed was found to be the most numerous traditional breed on UK organic farms in a survey carried out at the onset of the project. At the other extreme, the PIC Camborough 12 (C12) represented an improved modern genotype. This commercial crossbred (Landrace x Large White) x Duroc) is the most widely used sow genotype in conventional UK outdoor production systems and has been bred for improved prolificacy and carcass leanness. Since the benefits of using a crossbred sow, rather than a purebred, are well documented, the third genotype was a Saddleback x Duroc (SD) sow, which was representative of the genotype which might be used in a self-contained 'criss-cross breeding' system by smaller organic farms.

Twenty gilts of each genotype were introduced contemporaneously over a 4-6 month period on each of two commercial organic farms at the start of the project. The animals of each genotype received standard feeding and management according to organic standards and the normal commercial practice of the farm on which they were located. Reproductive performance was recorded over 4 parities, together with health records and welfare assessments. All sows were served by natural mating using the same cohort of Duroc boars, with individual sires balanced across the different genotypes.

3.2.2 Results

No genotype showed a greater incidence of health or welfare problems when managed to organic standards. The proportion of sows successfully completing 4 parities (88-90%) was similar across genotypes. Over the four parities, mean total litter size at birth was significantly greater for the C12 genotype (C12=11.5, S=10.7, SD=10.4, standard error of the mean (sem)=0.25, P<0.01), but the number of stillborn piglets per litter was also higher for this genotype (C12=0.8, S=0.3, SD=0.6, sem=0.08, P<0.001) so that breed differences in number born alive per litter were reduced (C12=10.6, S=10.4, SD=9.8, sem=0.24, P=0.07). The number of piglets found dead during lactation was greatest for the more prolific, improved genotype (C12=1.6, S=0.9, SD=1.2, SEM=0.15, P<0.01). Some additional piglets were unaccounted for at the time of weaning, probably as a result of fox predation , but this 'missing presumed dead' category did not differ between genotypes. The net effect of initial litter size and survival rate on the number of piglets weaned at 60 days of age showed an advantage in favour of the traditional Saddleback genotype (C12=8.4, S=9.1, SD=8.0, sem=0.24, P<0.01). However, this result was biased by a small number of animals with very small litters, whose piglets were fostered to other sows and were considered to wean zero litter size. When these cases were excluded from the analysis, there was no significant breed difference in number of pigs weaned (C12=8.9, S=9.3, SD=8.8, sem=0.19, ns). Whilst the Saddleback sows weaned a slightly greater litter size, this was offset by a slightly longer farrowing interval (C12=194, S=200, SD=185, sem=3.6 days, P<0.05). Therefore, the annual piglet output of the three genotypes was similar. These results confirm the greater prolificacy of the modern hybrid and the better maternal behaviour characteristics of the traditional Saddleback. They indicate that all three genetic strategies can be successfully adopted in organic production systems, and that choice of sow breed should depend on the ability of the farm to manage prolific sows, the consequences for slaughter pig performance and the nature of the product market niche. Progeny from each of the three genotypes were monitored for performance between weaning and slaughter, carcass characteristics and meat quality. Results of these studies are reported under Objectives 4 and 5.

Results from sow performance during the first parity have been disseminated in a conference presentation (publication B2) and the full lifetime results are presented in draft publication B3.

3.3 Objective 03: To appraise the range and nutritional value of feeds available to organic producers.

3.3.1 Material and methods

To facilitate efficient feed use in organic pig production, a 'Feed Handbook' (publication C3) was compiled, printed and made available to UK organic farmers. This was designed to assist organic pig producers in selecting appropriate diets and feeding strategies by summarising the relevant knowledge from conventional pig nutrition, discussing the ways in which organic systems might differ, presenting simple rules for diet formulation and providing information on the nutritional value and feeding characteristics (such as voluntary intake and presence of anti-nutritive factors) of different raw materials. The data used in compiling the handbook were assembled by review of the available international scientific and technical literature, communication with international researchers currently active in this subject area and with UK feed compounders currently manufacturing organic pig diets, collation of results of laboratory analyses of organically grown crops and use of ration formulation software with an organic raw material database.

3.3.2 Results

Data included in the handbook also drew on results from the trial carried out during the project (see objective 4) and additional work carried out by a project student within the trial framework. This project (see publication B4) quantified the herbage intake by grazing of organic growing pigs maintained at pasture. There were no previous data on this subject on which to base advice regarding possible modification of the concentrate supplement offered to pigs maintained under these conditions. The results showed that, when offered a cereal-based concentrate *ad libitum*, the herbage intake of growing pigs from a good quality grass/clover sward contributed <5% to daily organic matter consumption. In these circumstances, modification of concentrate composition would not be appropriate.

To date, approximately 150 copies of the Handbook have been distributed. Recipients include attendees at industry meetings (The Project Conference and Tesco Masterclasses), project steering group and Link Farm participants, requests in response to advertisement of availability at the Soil Association library and direct requests consequent on press coverage of the project. Continuing availability of copies will be advertised through further press articles in 'Organic Farmer' commissioned for this summer, events organised by the Tesco Centre for Organic Agriculture and ADAS, and supplies to the Sector Bodies for display at National Events.

3.4 Objective 04: To investigate the separate and interactive effects of breed type, feed type and housing on grower pig performance, carcass characteristics and meat yield.

2.4.1 Materials and methods

A factorially designed experiment was conducted at a single 'focus farm' site to investigate the effects on pig performance and carcass quality of three different genotypes, three feeding systems and two housing systems. Each combination of treatments was replicated in four groups of growing pigs from shortly after weaning (start weight 30 kg) until slaughter at a mean weight of 90 kg. The three genotypes used were the progeny of the three sow genotypes compared under Objective 2 (C12, S, SD) following mating to a Duroc boar., representing traditional and improved breeds with different degrees of heterosis. The housing systems compared were (1) maintenance at pasture with a simple arc shelter (OUT) or (2) housing in indoor straw bedded accommodation with an outdoor concrete exercise area (IND). The feeding treatments comprised (1) *ad libitum* concentrate diet with roughage provided either from pasture or straw bedding (CONC), (2) as 1 but with *ad libitum* availability of grass/clover silage (SIL), (3) as 1 but with *ad libitum* availability of fodder beet (BEET). Growth rate, feed intake and feed conversion ratio were monitored over monthly intervals. Finished pigs were individually identified when slaughtered at an organically approved abattoir and carcass weight and backfat thickness measured according to normal grading practice. Additional data on the condition of the internal organs were collected as part of the welfare assessment process (objective 7).

2.4.2 Results

Liveweight gain of the experimental pigs was good, averaging 0.73 $\pm$ 0.01 kg/day, and did not differ between genotypes. Total feed intake (kg meal equivalent/day) and the proportion of intake comprised by the roughages supplied also showed no difference between genotypes. Feed conversion efficiency was poor by conventional standards (3.20-3.34 $\pm$ 0.11 kg meal equivalent per kg gain). Although FCE was better for the C12 groups, there were non statistically significant differences between genotypes. Carcass backfat thickness at the P_2 position was significantly lower for progeny of the improved C12 genotype, and highest for the progeny of the traditional Saddleback purebred (C12=11.4, S=14.3, SD=13.4, sem=0.27 mm, P<0.001). This equated to a difference of >3% in carcass lean content (C12=57.4, S=54.1, SD=55.1, sem=0.31, P<0.001), and would impact significantly on carcass value under many current grading schedules.

Under conditions where a cereal-based concentrate was available *ad libitum*, voluntary intake of the forage supplements offered was very low. Fresh weight intakes over the whole period averaged only 0.12 kg/day for the silage and 0.16 kg/day for the fodder beet, representing <2% of total Dry Matter Intake (DMI). There were no differences in performance or carcass quality parameters between the three diets. . Evidence from other studies suggests that forage intakes could be increased by restricting the amount of concentrate diet offered, but that this would penalise growth rate. Further studies into these trade-offs are required to help develop the most cost-effective strategy for incorporating a range of feed raw materials.

The experiment clearly demonstrated the climatic penalties associated with paddock production systems for the growing pig. Although growth rate did not differ significantly, feed intake was increased for outdoor animals (OUT=2.47, IND=2.22, sem=0.05 kg meal equivalent per day, P<0.001). This resulted in a significant increase in feed conversion ratio (OUT=3.47, IND=3.07, sem=0.09, P<0.01). Paddocked animals, which had grazing available, consumed a significantly smaller proportion of their daily intake in the form of the additional forages offered (<1% of DMI). The likelihood was that this was responsible for the higher killing-out percentage observed. Carcass backfat thickness did not differ between finishing systems.

The results confirm the reduction in the efficiency of feed use and economic gross margin from outdoor finishing and the use of traditional, fatter genotypes. For organic production to be financially sustainable, these disadvantages would need to be offset by a substantial market premium for pigs reared by these methods.

Results are presented fully and discussed in a draft scientific paper (publication A4).

3.5 Objective 05: To investigate the separate and interactive effects of breed type, feed type and housing on the organoleptic qualities of fresh pigmeat and processed product.

3.5.1 Materials and methods

To evaluate the extent to which different production systems might influence the organoleptic quality of the final products, meat samples were taken at slaughter from a subsample of the pigs produced in the production experiment described under objective 4.

From each combination of the three breed types, two housing systems and three feeding systems (described above), two male and two female pigs provided a sample of fresh pork loin and a second pair of each gender provided meat which was used to produce bacon, ham and sausages according to the standard organic processing techniques of Eastbrook Farm Organic Meats. All samples were deep-frozen and transported to Robert Gordon University, Aberdeen for organoleptic assessment. This was carried out by a trained taste panel of 10 assessors who scored a number of traits for each product on a 0-8 scale, where low values signified low/weak/poor expression of the trait and high values signified high/strong/good expression.

3.5.2 Results

Overall, there were few significant treatment effects on product quality. In fresh pork, progeny of purebred Saddlebacks scored slightly higher for 'off aroma' (S=1.0, C12 & SD=0.7, sem=0.10, P<0.10), which might reflect their earlier maturity. Bacon from Saddlebacks was also scored as having darker colour (C12=4.8, S=5.5, SD=4.5, sem=0.26, P<0.01), greater saltiness (C12=4.1, S=4.9, SD=4.1, sem=0.25, P<0.05), and lower overall acceptability (C12=3.2, S=2.5, SD=3.5, sem=0.36, P<0.05). However, no such differences were apparent in other processed products. No consistent positive or negative effects of housing and feeding system on product quality were found.

Results are presented fully and discussed in a draft scientific paper (publication A5).

3.6 Objective 06: To assess ranging behaviour exhibited by different breed types under alternative systems of dry sow paddock management (rotational and set stocking) and the implications for sward utilisation, animal welfare, manure deposition and parasite levels.

3.6.1 Materials and methods

A two by three factorial design was employed to investigate the separate and interactive effects of two types of paddock management and the three experimental genotypes on the ranging behaviour of sows. Two commercially applicable paddock management strategies were established: a) 'Rotational' (R) where a group of up to 6 sows was provided with a paddock measuring 40x40 m which was relocated to clean ground every four months, and b) 'Set stocked' (SS) where a group of up to 6 sows was provided with a paddock measuring 120x40 m which was relocated to clean ground every twelve months. Accordingly, both strategies of paddock management used the same area of land per year. Groups of sows of each genotype were allocated to one of the two paddock management treatments at the start of the first parity, and remained in the same treatment until the third parity was completed; thus the two types of paddock were assessed over two years (1999 - 2001). The use of space and foraging behaviour were scanned at the start, middle and end of gestation using a time sampling technique; the location of any dunging or urination was recorded *ad libitum* during these sessions. Vegetation cover was assessed at each behaviour session, using a regular pattern of 0.5 m x 0.5 m quadrats in a W-formation across each paddock. Faecal samples were collected on entry to the dry sow paddocks, at farrowing and weaning, and tested for the presence of worm eggs.

3.6.2 Results

In the R paddocks, 33.9% of observations recorded in the hut or straw area, compared with 29.9% of observations for the SS paddocks; indicating that the hut and straw doormat areas were dominant features in the paddocks. All the 'living' areas, General Feeding, Hut and Water, as well as the area where food was provided on the observation day were used similarly in the two paddock types.

There were no significant differences between breeds or paddock types for the number of observations recorded in surface foraging, rooting, total foraging, or feeding plus foraging. This was true when expressed both as a percentage of the total number of observations in each session, and when considered as % of active observations. However, significantly more total foraging occurred (P<0.05) with 20-40% green cover than with 60-80% green cover (55.69% and 42.65% of total observations).

When excretory behaviour was examined using the same classification of regions as for the daytime behaviour given above, significantly fewer dunging events were recorded in the area around the Hut than any other; the number of urination events was significantly higher in the Water area than any other. There was no significant difference between the R and SS paddocks in the pattern of excretory behaviour recorded, but in both paddock types, areas bordering other sows were favoured, as was the water/wallow area, and, to a lesser extent, the feeding area.

There was no significant difference between the paddocks in mean vegetation cover over the study period, although the pattern of pasture loss over the season was different. In the R paddocks, vegetation cover was lost quickly, and the mean minimum grass cover after grazing was lower than in the SS paddocks. However, grass cover was then restored as the pigs were moved to a new paddock. In the SS paddocks, vegetation cover was lost initially and then usually regrew later in the season.

The mean number of faecal worm eggs per affected pig was not significantly related to paddock type, stage in the cycle or breed, but was significantly lower in parity 1 than parities 2 or 3 ($P<0.05$). The data indicated that, although the mean incidence might not be considered severe, individual sows were shedding high numbers of worm eggs (>1000 epg), which might indicate a welfare problem for these animals or their progeny.

Overall, results of the present study suggest that during wet periods, the R paddocks may be advantageous as the pigs are moved off damaged pasture, whereas the SS may be unable to recover if pigs remain. In drier periods, the SS paddocks maintain grass cover for longer than R and therefore incur less labour for moving, without significant pollution risk. The behaviour data show that pigs in the SS paddocks do use the further portions of the field, but this may require manipulating feeding and management to achieve satisfactory grass usage and distribution of excreted nutrients. On a practical level, the very large paddocks used in this study for the SS paddocks may be undesirable, as they require a very large land area at any one time. Their continuous use for one year would also result in deeply rutted trackways, with potential access and soil compaction problems. Farmers may find a six-monthly rotational pattern more practical. In a mixed farming system, with pigs fully integrated into the crop rotation, paddock rotation policy must be partially influenced by the use required of the land, and available nutrients, before and after pigs. Thus a paddock movement system, which permits spring or autumn cultivations is likely to be favoured.

Results have been disseminated in conference presentations (publications B1, B6, B7) and are presented fully and discussed in a draft scientific paper (publication A2).

3.7 Objective 07: To assess the welfare parameters of organic pig production, including the effect of breed type, feed type and housing system, through appraisal of health, physiology and behaviour of sows and growing pigs.

3.7.1 Materials and Methods

In the initial phases of the project, a two-part literature review was conducted to capture and summarise the scientific literature relevant to the welfare of organic pigs. This revealed a scarcity of published information on the subject, and found that there was work in progress within the EU that would be completed during the same time frame as the present project.

In addition to the above, a survey was conducted between August 1999 and April 2002 on nine organic pig farms located predominantly in the South West of England, UK. This combined direct measurements of animals and facilities with structured questions to staff. The mean herd size (±standard error of mean) was 212±74 sows with all progeny being reared outdoors from farrowing to finish. The herds had been in existence for an average of 37±7.0 months.

3.7.2 Results

3.7.2.1 Sow welfare indicators

Sow condition scores were not significantly different during pregnancy from accepted target values (median=4.0, Q1=2.7, Q3=4.0 vs. 3.25 for actual vs. target respectively; W=18.0; P=0.142), at farrowing (median=4.0, Q1=3.3, Q3=4.0 vs. 3.5 for actual vs. target respectively; W=9.0; P=0.201), or at weaning (median=3.0, Q1=2.5, Q3=3.7 vs. 2.5 for actual vs. target respectively; W=13.0; P=0.170). None of the sows examined had a condition score less than 2. Levels of lameness and skin damage in sows were, on average, not significantly different from zero during pregnancy, at farrowing, or at weaning. When compared with a value of 1 (cleanest rating on the 5-point scale), the sows were, on average, very clean during pregnancy (median=1.8, Q1=1.2, Q3=2.2 vs. 1 for actual vs. target respectively; W=17.0; P=0.208), at farrowing (median=1.5, Q1=0.5, Q3=2.2 vs. 1 for actual vs. target respectively; W=14.5; P=0.463), and at weaning (median=1.9, Q1=0.8, Q3=2.0 vs. 1 for actual vs. target respectively; W=11.0; P=0.418).

3.7.2.2 *Welfare indicators for other classes of stock*

When compared with a value of 1 (cleanest rating on the 5-point scale), the boars had significantly poorer cleanliness scores (median=2.0, Q1=1.5, Q3=2.3 vs. 1 for actual vs. target respectively; W=21.0; P<0.05), whereas weaners (median=1.6, Q1=1.0, Q3=3.0 vs. 1 for actual vs. target respectively; W=17.5; P=0.173) and growing/finishing pigs (median=1.6, Q1=1.0, Q3=2.0 vs. 1 for actual vs. target respectively; W=16.5; P=0.249) had comparable cleanliness scores. The level of skin damage in boars, weaners and growing/finishing pigs did not differ significantly from zero.

3.7.2.3 *Visual examinations of the husbandry system and facilities*

None of the farms observed had a mean wetness rating greater than or equal to 3 in their farrowing paddocks during the Summer; however, 57% of farms surpassed this criterion during the Winter (median rating=3.0, Q1=1.0, Q3=3.5). Twenty-five percent of the farms observed had a mean wetness rating greater than or equal to 3 in their dry sow paddocks during the Summer (median=1.5, Q1=1.0, Q3=2.7), and 57% during the Winter (median=3.0, Q1=1.0, Q3=4.0). Twenty-five percent of the farms observed had a mean wetness rating greater than or equal to 3 in their paddocks for other classes of stock during the Summer (median=1.5, Q1=1.0, Q3=4.0), and 57% during the Winter (median=2.0, Q1=1.0, Q3=3.5).

None of the farms observed had a denudation rating greater than or equal to 3 (i.e. significantly denuded) in their farrowing paddocks during the Summer; however, 29% of the farms observed exceeded this criterion during the Winter (median=2.0, Q1=2.0, Q3=3.0). One of the two farms where data could be collected had a denudation rating greater than or equal to 3 in their dry sow paddocks during the Summer, and 43% during the Winter (median=2.0, Q1=1.0, Q3=4.0). In the farrowing paddocks, without exception, ample, clean, dry bedding was provided (median ratings=5). Similar data were observed for both the dry sows and the other weaner/grower/finisher progeny housing.

3.7.2.4 *Interviews with the primary stockperson*

The main welfare issues reported by the primary stockperson related to 1) keeping stock clean and dry in periods of high rainfall, 2) managing Porcine Dermatitis and Nephropathy Syndrome and Postweaning Multisystemic Wasting Syndrome (PDNS/PMWS) within their herd, and 3) recruiting and retaining good quality personnel. Mange and lice were the highest-ranking current health concerns, and post-mortem reports of endo-parasitism was the highest-ranking historical health concern noted by producers from a structured list.

3.7.2.5 *Endo- and Ecto-parasitism*

Dung samples were collected from five different farms participating in the study during February 2001. The samples were analysed using the MacMaster method, which allows identification of nematode eggs between Ascaris *suis*, *Trichuris suum* and Strongyle-type. As a routine quality control check, a number of samples were sent for analysis at VLA Langford. In these samples, the presence of certain types of coccidia was also recorded in parallel to the nematode test (*Eimeria* spp. would be detectable, *Isospera* spp. would not). It was reported that none of these farms use anthelmintics routinely; however, the producers commented that they would do so if there was evidence of a problem.

Coccidia levels in individual samples were highly variable, ranging from <50 to 33,950 epg on the two farms tested. Two of the five farms surveyed reported problems with scouring in young pigs. The presence of grey and clay-like faeces reported above is consistent with the presence of *Coccidia* infection. *Coccidia* are unaffected by anthelmintics, and persist in the environment. *Coccidia* do not represent a threat to adult animals, which have generally become immune, but can cause severe scouring in young piglets. . Whilst a five-year rotation policy is considered long enough to reduce nematode carryover, this is unlikely to be the case with *Coccidia*, which may survive for up to 11 years, and pose a significant risk in organic systems.

Results have been disseminated in a conference presentation (publication B5) and are presented fully and discussed in a scientific paper in press (publication A1).

3.8 Objective 08: To establish Best Practice for organic herd management, the range of systems which are acceptable and the suitability of different breed types, feed types and housing systems for organic production.

3.8.1 Materials and Methods

Information on current practice was collected during visits to the focus and link farms, and involved a tour of the pig herds, face-to-face interviews with the farmers and their staff, and completion of a standard questionnaire. The findings were summarised in a review of Current Practice (publication D2). Best Practice for organic herd management was synthesised through meetings of the expert group to review and develop: 1) current commercial practice, 2) information obtained on UK organic pig production, 3) literature reviews, and 4) results from this project and overseas research. The findings of these meetings were disseminated to relevant parties through an end of project conference and through the publication of a conference booklet (publication C2). The topics covered by this booklet included investment requirements and the need to secure an outlet prior to committing any expenditure; choice of site, whole farm rotations, and paddock stocking policies; staffing, stockmanship including care and handling of organic pigs; factors influencing the choice of breed type and replacement systems; bio-security and herd health plans; and housing and mechanisation.

3.9 Objective 09: To assess the economic implications of organic pig production.

3.9.1 Materials and Methods

Data on physical and financial performance were collected over the course of the project. The original data collection periods were proposed as the year to December 1999, 2000, and 2001. In order to remove the disrupting direct and indirect effects of Foot and Mouth Disease, the final year's data collection was revised to the period ending April 2002.

Data collected on physical performance, capital investment and operating costs were used to establish bench-mark production levels for organic pig herds, the cashflow implications of establishing an organic pig herd, profitability, and sensitivity to movements in productivity, costs and prices. This information has been disseminated through the conference booklet (publication C2).

3.9.2 Results

Given costs and prices pertaining to the data collection periods and the achievement of bench mark production levels as identified through the project, initial investment costs were estimated to be in the order of £82,000 for machinery and equipment and £22,000 for stock (assuming a 100 sows herd established with bought in maiden gilts and boars). The cashflow requirement peaked at £200,000 in month 13 (before interest charges) when the first bacon pig is sold. Where interest is charged at 6%, the peak credit balance would be £210,000. Net Farm Income for the established 100 sows herd was estimated at £24,600 per annum based on a budgeted depreciation of machinery and equipment over 5 years and a rental cost for the pig buildings, which house finishing pigs for the last 5 weeks prior to sale, based on the depreciation cost over 10 years.

Interest charges incurred by individual farmers may reflect money borrowed to undertake the investment, or the opportunity cost of alternative investment options. Assuming an interest rate of 6%, interest on the average capital tied up in the enterprise would be in the order of £8,000 per annum.

The profit assessment describes profitability under a given set of assumptions. The investment in organic pigs was found to be sensitive to performance and price changes. A reduction in performance of one pig/sow/year, combined with a £12/tonne increase in feed price and a 10 p/kg reduction in pig price would reduce Net Farm Income from £24,600 to zero.

3.10 Objective 10: To transfer technology to the organic and non-organic sectors.

3.10.1 Materials and Methods

During the course of the project, the research programme was overseen by a project Steering Group Committee representing different sectors of the stakeholder bodies. The project team produced extra documentation for use by this committee which included a review of current practice on the UK organic pig production sector and a statement on enteric parasitic infection measured on UK-based organic pig production units. In addition to these publications, information was disseminated widely with the permission of Defra and the other members of the Steering Group Committee through farmer conferences and talks at national conferences, scientific papers, conference proceedings, and technical reports and press reports. A full list of the project outputs is given below.

3.10.1.1 Conference

In October 2002, a conference was held at the Royal Agricultural Showground in conjunction with the Royal Agricultural Society of England. The agenda incorporated the following presentations:

- Introduction by Chair of Workshop by Christopher Stopes of the Eco-Stopes Consultancy
- The business of organic pig farming by Helen Browning of Eastbrook Farm
- Marketing organic pig products by Prof. Carlo Leifert of the Tesco Centre for Organic Agriculture
- What to feed the organic pig by Prof. Sandra Edwards of the University of Newcastle
- What breed of organic pig by Prof. Sandra Edwards of the University of Newcastle
- How to manage the organic pig at pasture by Dr. Jon E. L. Day of the ADAS Pig Research Unit
- Organic pig production from the producer's perspective by Sam Wade of Wade's Pigs.

Approximately 50 delegates attended the conference from many different backgrounds including, existing organic producers, producers considering conversion, advisors, sector bodies , scientists and members of the press. The project booklets were launched at the conference. A subsequent press article increased the demand for copies to be sent to producers.

A full list of technology transfer activities and outputs is given below.

Knowledge transfer talks

1. Kelly, H. R. C. (1999). Presentation of the organic pig project. Eastbrook Farm open day, 1999.
2. Martins, A. P. (1999). Objective 5b Funded Organic Special Interest Group, Derbyshire August 1999 presentation on the MAFF funded project .
3. Martins, A. P. (2000). Organic research, Conversion to organic pig production Soil Association. Presentation at the conversion course April 2000.
4. Edwards, S. A. (2000). Royal Agricultural Society of England, Pig Fair, Stoneleigh April 2000 ‘Improving efficiency of organic pig production’.
5. Kelly, H. R. C. (2002). 14th Soil Association National Conference The Future of Agriculture Workshop Presentation.
6. Edwards, S. A. (2002). Tesco Organic Masterclass Conference, University of Newcastle, October 2002. ‘Organic pig production: solutions for nutrition, welfare and health’.

<u>Scientific papers (target 4)</u>

1. Day, J. E. L., Kelly, H. R. C., Martins, A., Edwards, S. A. (2002). Towards a baseline assessment of organic pig welfare. Animal Welfare, in press.
2. Kelly, H. R. C., Day, J. E. L., Martins, A., Browning, H. M., Pearce, G. P., Shiel, R. S., Edwards, S. A. (2003). A comparison of paddock rotation systems for organically managed dry sows. Draft paper for submission.
3. Kelly, H. R. C., Day, J. E. L., Martins, A., Browning, H. M., Pearce, G. P., Edwards, S. A. (2003). The effect of breed type on reproductive performance of sows managed under organic conditions. Draft paper for submission.
4. Kelly, H. R. C., Day, J. E. L., Martins, A., Browning, H. M., Pearce, G. P., Edwards, S. A. (2003). The effect of breed type, housing and feeding system on performance of growing pigs managed under organic conditions. Draft paper for submission.
5. Kelly, H. R. C., Day, J. E. L., Martins, A., Browning, H. M., Pearce, G. P., Leifert, C., Edwards, S. A. (2003). The effect of breed type, housing and feeding system on quality of meat and meat products from pigs managed under organic conditions. Draft paper for submission.

<u>Conference proceedings (target 6)</u>

1. Kelly, H., Browning, H., Day, J., Martins, A., Edwards, S. A. (2001). The effect of paddock rotation management on pasture damage by organic dry sows. Proceedings of the ISAE/BSAS Meeting, PC5.
2. Kelly, H. R. C., Browning, H. M., Martins, A. P., Pearce, G. P., Stopes, C., Edwards, S. A. (2001). Breeding and feeding pigs for organic production. Proceedings NAHWOA workshop, Wageningen 24-27 March. Eds M Hovi and T Baars. University of Reading. p86-93.
3. Martins, A. P. (2001). Organic pig production. Proceedings of the Organic Livestock Farming Principles, Practicalities and Profits Conference. Heriot-Watt University, Edinburgh and University of Reading. p159 - 176.
4. Mowat, D., Watson, C. A., Mayes, R. W., Kelly, H., Browning, H., Edwards, S. A. (2001). Herbage intake of growing pigs in an outdoor organic production system. Proceedings of the British Society of Animal Science, p169.
5. Day, J. E. L., Kelly, H. R. C., Martins, A., Edwards, S. A. (2002). Towards a baseline assessment of organic pig welfare. Proceedings of the 2nd International Workshop on Assessment of Animal Welfare at Farm and Group Level. Bristol, 4 - 6 September 2002.
6. Kelly, H., Shiel, R., Edwards, S., Day, J., Browning, H. (2002). The effect of different paddock rotation strategies for organic sows on behaviour, welfare and the environment. Proceedings of the UK Organic Research 2002 Conference. Colloquium of Organic Researchers. p273-276.
7. Marcellis, J., Kelly, H., Browning, H., Day, J. E. L., Edwards, S. (2002). Excretory behaviour of lactating sows in an outdoor organic production system. Proceedings of the British Society of Animal Science, p 225.

Industry booklets and information leaflets (target 2)
1. Optimising Production Systems for Organic Pig Production (OF0169) Newsletter, January 2001.
2. Martins, A., Kelly, H., Day, J. E. L., Stopes, C., Browning, H., Edwards, S. (2002). Optimising organic pig production. A guide to good practice. ADAS Consulting Ltd, Terrington. 40pp.
3. Edwards, S. A. (2002). Feeding organic pigs. A handbook of raw materials and recommendations for feeding practice. University of Newcastle. 59pp.

Steering group reports
1. Assessment of welfare parameters, November 1999, 17pp.
2. CONFIDENTIAL: Report on current Practice for Organic Pig Production, December 1999, 10pp.
3. Assessment of welfare parameters (addendum), December 2000, 7pp.
4. UK Organic pig production survey, May 2000, 12pp.
5. Preliminary statement on the results from the faecal worm egg survey of focus and link farms, February 2001, 3pp.

Press releases and popular press articles (target 6)
1. Organic pig project aims for quality and quantity, ADAS press release, July 1999.
2. Conference press release, ADAS press release, September/October 2002.
3. Perowne, C. (1999) How to Sell Your Pigs for £200. Pig Farming. October 1999.
4. A question of breeding, Tesco Organic News 2001, p14.
5. Cheaper home grown forage sources for organic producers can save costs, Farmers Guardian, 8 November 2002, p69.
6. Warning of lower premiums for organic pigmeat farmers. Farmers Guardian, November 2002,
7. Pig worms survive in a rotation, Farmers Weekly, 22 November 2002, p38,
8. Day, J. E. L., Martins, A., Kelly, H. R. C. and Edwards, S. A. (2003). Managing the organic pig at pasture. Organic Farming Magazine, Winter 2003, (in press).
9. Organic pig nutrition. Organic Farming Magazine, January 2003 (commissioned for Spring 2003).

Other
1. Kelly, H. R. C. (in press). Contribution to two chapters of a book on organic livestock production by the EU Network on Animal Health and Welfare in Organic Agriculture.
2. Mowat, D. (2000). The benefit of including pigs in an organic rotation. MSc Thesis, Scottish Agricultural College, Aberdeen.
3. Marcellis, J. (2002). Ing. Thesis, Den Bosch University of Applied Agriculture, The Netherlands.

4. Conclusions and Implications for Defra Policy

This project has generated significant scientific, technical and financial information on organic pig production, which was previously unavailable in the UK.

The results highlight important interactions between breed type, rearing system and diet that affect animal performance, product quality and potential profitability. The data provides valuable baseline information on the strengths and weaknesses of organic pig production in the UK.

Economic analyses show the level of investment required and likely profitability of organic pig production. However, the results also indicate the sensitivity of net margin to relatively small movements in input prices and the returns for organic pigmeat. This highlights the future importance of good technical performance, marketing and financial control if the developing UK industry is to compete with imported product.

Despite the disruption caused by the outbreak of Foot and Mouth Disease during 2001, the project was able to achieve virtually all of its original objectives. The study provided a good example of successfully combining on-farm research involving commercial farmers, and more scientific approaches of literature review and replicated experiment.

5. Future Research Requirements

While a significant body of data has been produced, the project has also identified topics that would benefit from further research.

<u>5.1 The effects of lactation length and genotype on sow and piglet behaviour</u>
The organic standards require a lactation length of at least six weeks. Whilst this is compatible with the length of lactation expected for wild and feral pigs, some of the more improved genotypes of pigs may be ill-equipped to cope with the metabolic demands imposed by rapidly growing piglets beyond three weeks of age. There is a requirement to investigate how both genotype and length of lactation affect the behaviour of both sows and their litters in organic production systems.

<u>5.2 The consequences of indoor housing and feed restriction on the behaviour, welfare and eating quality of organic finishing pigs</u>
In some circumstances it is necessary to move organic finishing pigs indoors for the last few weeks prior to slaughter, and feed restrict them to reduce the proportion of body fat in the carcass. Feed restriction is known to elevate the expression of foraging and exploratory behaviours, and in an environment where stocking densities are higher and animals are behaviourally restricted, animal welfare may be compromised. Further research is proposed to determine how indoor housing and feed restriction affects the behaviour, welfare and eating quality of organic finishing pigs.

<u>5.3 Endo and ectoparasite control in organic pig systems</u>
As part of the present study, endoparasite levels were measured under two different systems of sow rotation . However, much more information is required on how producers can control of endo- and ecto-parasites without resorting to conventional pharmaceutical products. There are a number of husbandry practices (e.g. nutritional management; rotation policy; homeopathy/phytopathy) whose effect on parasite burden is unknown.

<u>5.4 Virtual organic pig farm</u>
Effective transfer of knowledge into the developing organic pig industry is fundamental to its future competitiveness and economic prosperity. It is important that producers are informed of best practice in terms of management, husbandry and biosecurity in order to protect the animal welfare, optimise productivity and meet increasingly stringent environmental constraints. One method of demonstrating best pig farming practice could be through the development of a virtual farm; enabling the largest cross section of organic and prospective organic pig producers to benefit, without geographical barrier, while at the same time eliminating the biosecurity risks associated with the operation of a real pig unit.

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