# Pig Herd Health and Production in Ireland : a Study of some Major Influences

A thesis submitted for a Fellowship of the
Royal College of Veterinary Surgeons

by

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# SYNOPSIS



The introduction to the thesis is documented in section 1. Since the Irish pig industry competes on a world-wide market this section compares global pig-meat consumption with that of other meats, describes pig production in the world, EU, Ireland and the author's practice. Pig health is influenced by the quality of veterinary and laboratory services, so trends in the types of services provided by the practice and laboratory are briefly outlined. The potential impact of regulatory changes and consumer demands on systems of pig production are discussed, particularly as they relate to EU competitiveness in a global market.

Section 2, which is entitled "monitoring herd health and production economics; disease surveillance and eradication", describes a procedure for monitoring herd biosecurity and health status. The impact of a range of procedures on pig health and production efficiency is examined, which include changing from multi-source pig supply to minimal disease (MD), followed by three studies on methods of disease eradication without depopulation. The economics of depopulating a herd and repopulating it with MD stock is described. The results of a slaughterhouse survey of pigs from 34 herds, and a case study is presented of an investigation into the health status of an AR-free herd in which toxigenic *Pasteurella multocida* type D was isolated.

Section 3, entitled "Aujeszky's disease; epidemiology, and eradication, and monitoring herd status by piglet serology or meat juice", describes a study comparing piglet serology with sow serology, as a method of monitoring herd Aujeszky's disease (AD) status. Since meat juice is currently used for the detection of *Salmonella* antibodies, by the mix ELISA test in the Irish *Salmonella* control programme, a study was carried out in order to determine if meat juice could be used instead of serum as a method of establishing the AD status of pig herds, with a view to incorporating this procedure into an Irish Aujeszky's Disease Eradication Programme. A low-cost method of eradicating AD from the Irish pig herd is presented. An initial study into the AD status of practice herds in 1992 was followed by a further study in 2003. The results of the two studies are compared.

Section 4, initially reviews *Salmonella* control in Ireland and reports on the results of a study into the influence of feeding whey to finishers on the *Salmonella* sero-prevalence of pigs at slaughter. The final studies in this section describe the antibiotic resistance patterns of *Salmonella* isolates from pigs in Ireland and compare the results of a comparative study of four commercial *Salmonella* ELISA kits.

# A Study of Some Factors that influence Pig Herd Helath and Production Efficiency in Ireland

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# SECTION I INTRODUCTION

Although this thesis will concentrate on past , present and future factors that have or could have an influence on the health and productivity of the Irish Pig Industry, the Irish Industry cannot stand in isolation. Ireland is a member of the European Union (EU) and as such has to work in partnership with the other member states. Furthermore, barriers to world trade are politically unfashionable and therefore the EU Pig Industry must be seen within the framework of world pig meat production.

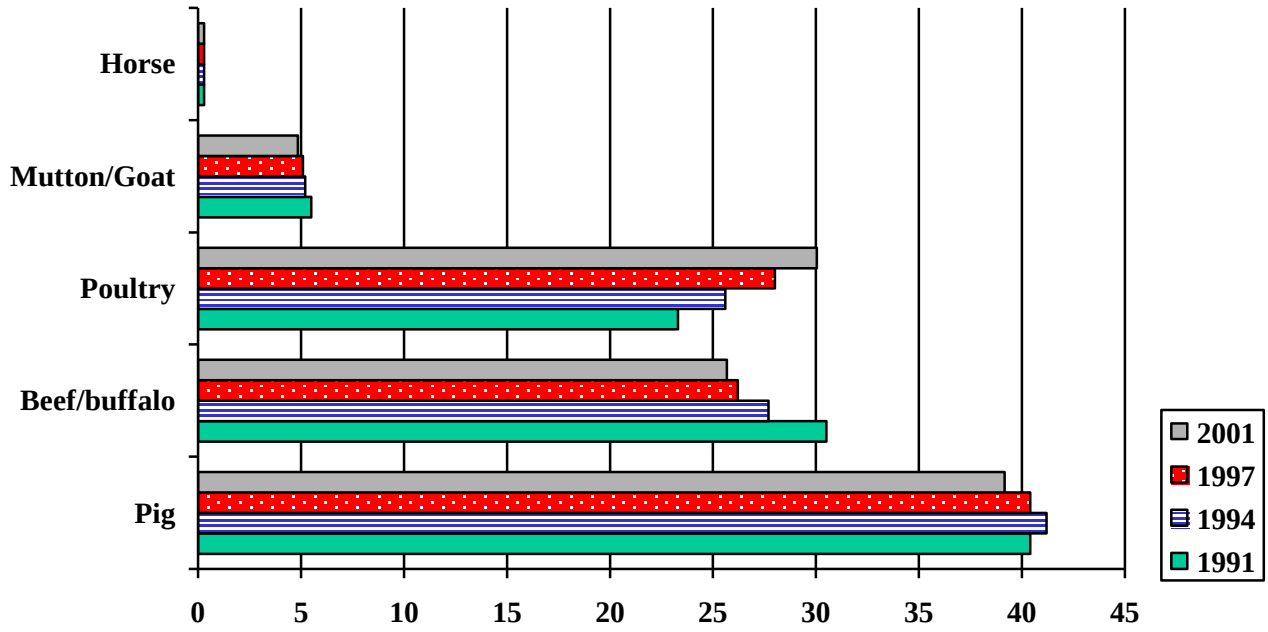
Ireland, like Great Britain, is an island-based pig industry. Traditionally, this offered a significant biosecurity advantage over that of mainland Europe. This was reflected in the superior health status of the Irish and UK pig industries as compared with mainland Europe (Anon, 1993). However, since approximately 60% of pig meat produced in Ireland is exported and most of the high protein pig food raw materials imported, the Irish pig industry operates at a significant economic disadvantage relative to its European neighbours. As the global pig industry has evolved, herd size has increased. A similar trend is evident in Ireland. The increase in herd size has been accompanied by the development of corporate-owned multiple herd pig enterprises. This has placed new demands on pig practice. In addition to advising the individual production units on methods of improving pig health and productivity, the pig veterinarian now has a very important role to play at boardroom level, advising the group on a wide range of veterinary related topics, such as health, welfare, pig production economics, management and food safety. To an extent the wider role played by the veterinarian has been influenced by the development of supermarket multiples who stipulate that the pork which they sell be sourced from pigs which are produced to a set of standards laid down by them. As food safety has assumed a role of increased importance, quality assurance programmes have been developed which require increased veterinary input at farm level. The EU pig industry has higher feed costs than that of the USA, yet they compete on the same export markets, so the USA has a significant advantage over the EU in terms of the cost of production. The EU may be further disadvantaged on the global market in the future, since the use of six in-feed growth enhancers were recently banned in the EU.

Most minimal disease (MD) herds out-perform normal health status herds with endemic disease. This has been the driving force behind the development of MD herds in the author's practice, such that over 35% of the pig population in the practice was set up as MD between 1984 and 1996. Since depopulation and restocking programmes are expensive, alternative methods of improving health status must also be investigated and developed, such as medicated early weaning (MEW), isowean and multisite production, disease eradication by management, medication and hygiene programmes and disease eradication by vaccination and culling of sero-positives. MEW was used to create a new MD herd by a combination of vaccination, MEW and removal of sero-positives in a herd which was positive for progressive atrophic rhinitis (AR), Aujeszky's disease (AD), *Streptococcus suis* type 2 meningitis, enzootic pneumonia (EP), *Actinobacillus pleuropneumoniae* (AP), swine dysentery (SD) and sarcoptic mange. Management, hygiene and medication programmes were introduced for the purpose of SD eradication from a 150 sow weaner-producing herd.

Before reaching a decision on the most cost efficient method of improving the health status of a pig herd, many factors must be taken into account such as biosecurity, management efficiency, economics etc. So, in addition to carrying out an overall appraisal of the relevant decision making factors, each project must be subjected to a cost benefit study so that the owner and his financial advisers are acutely aware of the financial implications of the proposed project. In this instance, modern technology comes to the aid of the veterinarian, since depopulation and restocking cash flows can be conducted on a spreadsheet-based model of a pig unit undergoing repopulation and the financial implications of programmes designed to improve production efficiency measured on a spreadsheet based "what if" programme which predicts the economic impact of the decision by comparing a pig unit model of the existing herd with that of the herd following the introduction of the proposed programme. New technology has also come to the aid of the veterinarian who is involved in population preventive medicine programmes, in the form of laboratory tests. To operate to a high standard the veterinarian must have the use of a modern laboratory capable of carrying out the appropriate tests to a recognised international standard. In order to satisfy the above demands, the author developed a laboratory which is accredited to the International ISO 9001-2000 standard.

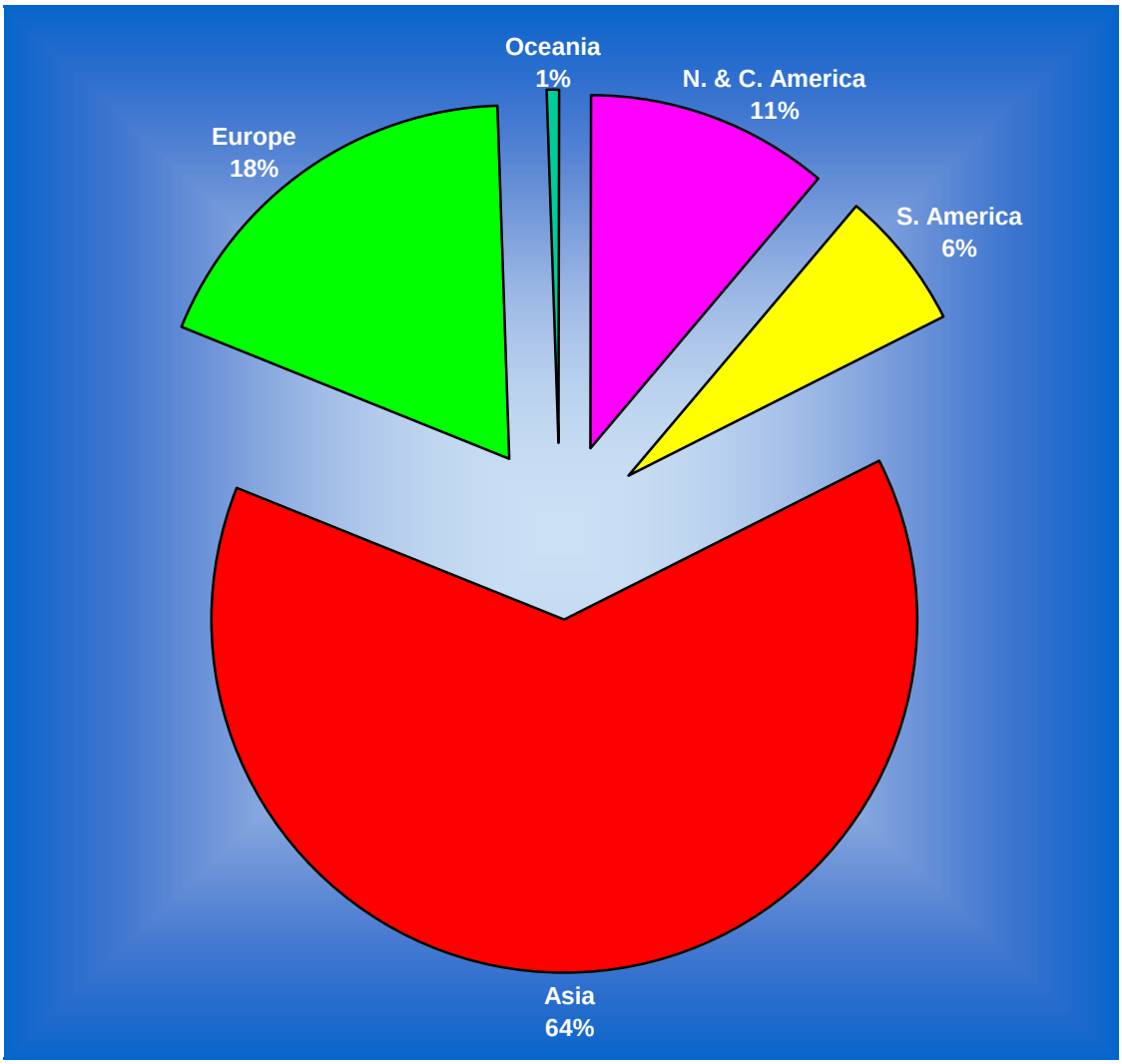
In 1991 approximately 40% of meat consumed in the World was of pig origin, so pig meat was the most popular meat in the World, with beef at 30% lying second and poultry third. Between 1991 and 1997 pig meat consumption, remained at 40 - 41% (Anon, 1998) (Fig. 1), however pig meat consumption as a percentage of total meat consumption, declined to 39% between 1997 and 2001. Poultry meat consumption increased from 23 to 30% between 1991 and 2001, whilst beef/ buffalo consumption declined to 26%.

**Fig. 1: TRENDS IN WORLD MEAT CONSUMPTION (1991-2001) (%)**



Asia continues to dominate World pig production in terms of sheer volume, by contributing 64% to the total pigs slaughtered in the world in 2001, with Europe coming a distant second at less than 20%, followed by North and Central America (Fig. 2). A total of 923 million pigs were slaughtered in the world in 2001.

**Fig. 2: WORLD PIG PRODUCTION BY REGION IN 2001 (* 1000 PIGS SLAUGHTERED)**




It is interesting to examine the trends in pig production of the top 20 nations in the world between 1989 and 2001 (Table 1). A massive expansion of approximately 71% took place in China, and Brazil expanded by almost 100% followed by The Philippines, Korea and Vietnam (Anon, 2001a). So, most of the major expansion in pig production in the world over the past 15 years has taken place in Asia. In Europe, Spanish pig production expanded by 55%; the only country in Europe to show a marked expansion. In contrast, large contractions were experienced in other European countries, such as the U.K which contracted by approximately 25% and the Netherlands by 8%. The USA experienced a modest expansion over the period studied of 12% in pig production as defined by number of pigs slaughtered.

**TABLE 1: Trends in pig production ( 1000 pigs slaughtered) of the top 20 Nations in the world between 1989 and 2001**

| Name | 1989-1991 | 2,001 | % change |
|---|---|---|---|
| China | 325,323 | 557,382 | (+) 71.33 |
| USA | 87,681 | 97,944 | (+) 11.7 |
| Germany | 47,443 | 43,992 | (-) 0.73 |
| Spain | 23,628 | 36,630 | (+) 55.03 |
| France | 21,347 | 27,020 | (+) 26.58 |
| Brazil | 12,657 | 24,594 | (+) 94.31 |
| Denmark | 16,484 | 21,100 | (+) 28.00 |
| Russia | NA | 20,500 | NA |
| Poland | 20,907 | 19,600 | (-) 6.25 |
| Phillipines | 12,052 | 19,000 | (+) 57.65 |
| Vietnam | 11,690 | 18,200 | (+) 55.69 |
| Netherlands | 19,448 | 17,800 | (-) 8.47 |
| India | 11,900 | 17,000 | (+) 42.86 |
| Japan | 20,719 | 16,530 | (-) 20.22 |
| Korea | 8,828 | 13,955 | (+) 58.08 |
| Mexico | 11,504 | 13,850 | (+) 20.39 |
| Italy | 12,098 | 13,153 | (+) 8.72 |
| Bel-Lux | 9,445 | 11,348 | (+) 20.15 |
| UK | 14,161 | 10,629 | (-) 24.94 |
| Thailand | 7,159 | 9,500 | (+) 32.70 |

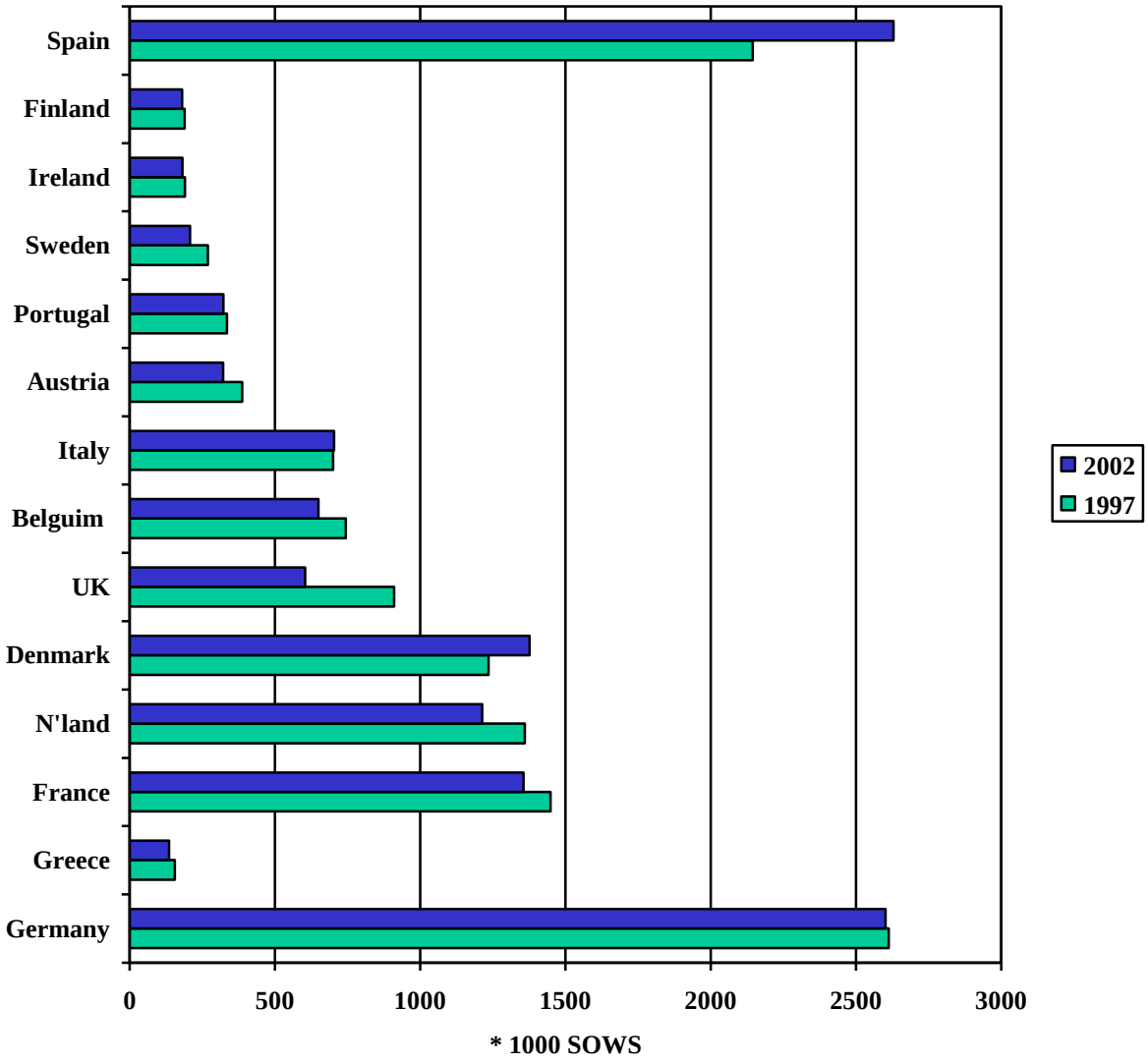
It is difficult to foresee an expansion in the EU pig population, based on economic factors and environmental regulations. In 2002, the EU had a total stock of approximately 12.5 million sows. The top three countries were Germany 2.6m, Spain 2.6m and France 1.36m. Ireland with 0.18m sows (Anon, 2003a) contributes approximately 1.4% to EU sow numbers (Table 2). The EU sow population marginally contracted between 1997 and 2002, however, there were marked variations in sow population trends within states in the EU (Table 2) An expansion of approximately 23% in sow numbers in Spain was counteracted by a contraction of almost 34% in the UK. Other states within the EU also showed marked contractions in sow numbers, including the Netherlands, Belgium, Greece, Sweden and Austria. Only Spain and Denmark showed a significant expansion, of 23 and 11% respectively. The German industry showed little change. The sow population in Spain now matches that of Germany and the combined population of the two countries contributed over 40% to the EU sow population in 2002 (Fig. 3). The EU pig industry is competing in a global market. For example, the recent expansion of pig production in the USA has resulted in it becoming a net exporter of pig meat. This was achieved in conjunction with low production costs associated with cheaper pig food. Further liberalisation of the world trade in pig meat is likely to follow the next round of GATT/WTO negotiations. This will allow cheaper

US pork access to Europe. In addition, expansion of the EU will allow Poland and Hungary with their very low production costs access to Western European markets. In order to maintain Europe's competitiveness in a Global market, it is important that changes in the systems of pig production be developed, such that these changes do not have a negative impact on the economics of pig production.

**TABLE 2: Breeding pig population trends in the EU; * 1000 sows (1997-2002)**

| Country | 1997 | 2002 | Trend % |
|---|---|---|---|
| Germany | 2,613 | 2,602 | (-)0.42 |
| Greece | 155 | 136 | (-)12.9 |
| France | 1,449 | 1,356 | (-)6.42 |
| Netherlands | 1,360 | 1,213 | (-)10.81 |
| Denmark | 1,235 | 1,376 | (+)11.42 |
| United Kingdom | 910 | 604 | (-)33.63 |
| Belgium | 744 | 650 | (-)12.63 |
| Italy | 700 | 704 | (+)0.57 |
| Austria | 387 | 322 | (-)16.8 |
| Portugal | 335 | 323 | (-)3.89 |
| Sweden | 269 | 208 | (-)22.68 |
| Ireland | 190 | 182 | (-)4.21 |
| Finland | 189 | 181 | (-)4.23 |
| Spain | 2,144 | 2,629 | (+)22.62 |

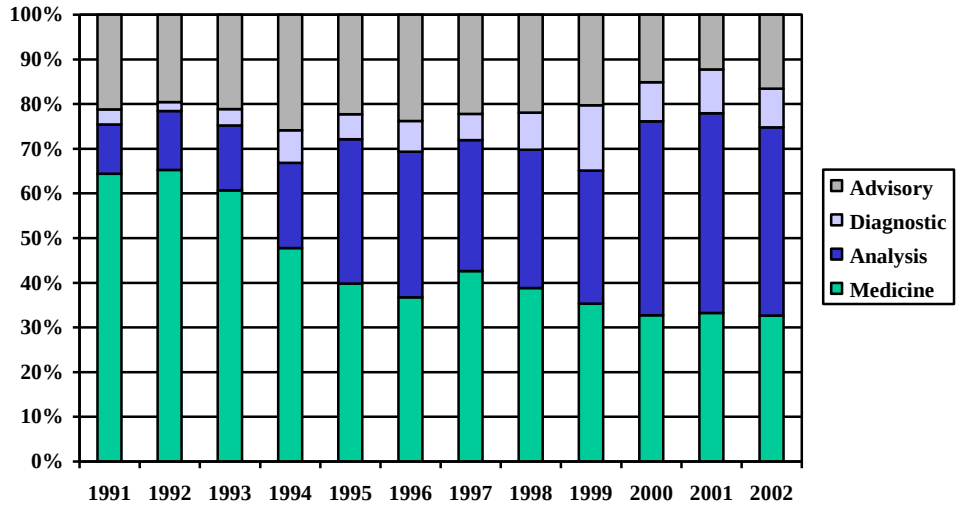
**Fig. 3: BREEDING PIG POPULATION TRENDS IN THE EU;* 1000 SOWS (1997-2002)**




The expansion of the Irish pig industry over the past 13 years was initially driven primarily by a restructuring of the processing industry such that it reached a peak of 190, 000 sows in 1997. However, due to low profit margins, the sow population has declined to 170,000 between 1997 and 2003. It is difficult for a small industry, which only represents approximately 1.4 % of EU production, to compete successfully in the International market to which it must export approximately 60% of its produce. The impact of pig production on the environment is an area where regulatory changes may have an influence on pig farming. In Ireland, the integrated pollution control licence, which is administered by the Department of the Environment, stipulates that regular environmental impact assessments and spread-land-soil analysis be conducted. The EU Rural Environment Protection Scheme (REPS) is aimed at protecting the rural environment. Both programmes place a strong emphasis on controlling nutrient use, especially phosphates and nitrates, in agriculture and so require regular analysis of soil, surface (streams, run off) and ground water (deep well). These trends are already placing demands on nutritionists to formulate diets providing phosphates with a higher biological availability so

that the overall phosphate content of the diet is reduced, resulting in reduced slurry phosphate levels. The cost of providing major elements of higher bioavailability has to be weighed against the cost of spreading slurry across a larger area of land in order to adhere to the limitations on soil phosphorus levels imposed by EU regulations. As a result the demand for laboratory analysis of soil, herbage, water and effluent has increased during the past 10 years. Diagnostic laboratory services are primarily geared towards pig producers and veterinarians in large animal practice. Veterinarians in general practice seem to be using diagnostic laboratories more frequently to support their diagnosis (Kavanagh, 1998a). New commercial diagnostic tests, using enzyme-linked immunosorbent assay (ELISA) and polymerase chain reaction (PCR) technology, provide an opportunity for diagnostic laboratories to expand and develop a wider range of services. The range of services provided by the author's laboratory has expanded to satisfy the changes in agriculture, such that non veterinary services now account for upwards of 80% of laboratory turnover. The author's laboratory and advisory services have expanded over the past 10 years to the extent that their combined contribution to the gross profit of the business increased from approximately 35% to 68% between 1991 and 2002 (Fig. 4).

**Fig. 4 : CHANGES IN GROSS PROFIT BY TYPE OF VETERINARY SERVICE PROVIDED (1991 - 2002)**




There is potential for pig veterinarians to broaden the range of services they provide into areas that might initially appear to be non veterinary. In order to compete successfully for this market, the veterinarian must be educated in a wide range of ancillary areas and must demonstrate expertise for which the producer is prepared to pay. Regulatory changes could create new opportunities for veterinary services. Opportunities exist for greater involvement in quality assurance schemes, animal welfare, disease control and eradication programmes, biosecurity procedures, environmental programmes, and enhancement of food safety, all of which are influenced by pig health. Food safety programmes will require close liaison between veterinarians, government agencies, producers, meat processors, pharmaceutical manufacturers, consumer associations and transporters. Because the veterinary consultant will need to play an active role in developing programmes designed to improve food safety and the consumer's image of pork, food-safety related veterinary services, as well as laboratory, consultancy,

and quality assurance services, are likely to expand in the future. Although food safety concerns have been expressed periodically since the 1970s, there can be little doubt that the recent BSE and *Escherichia coli* 0157:H7 problems have raised consumer perception and have been driving the politicians to contemplate serious, or even drastic measures. The first signs of this were observed when the European Commission decided to suspend the licence of avoparcin from April 1997. There is a tendency in Europe for politics to take precedence over science in policy decisions. This is highlighted by the banning of certain bovine growth promoters which had World Health Organisation (WHO) approval.

In the EU consumer pressure could radically influence systems of pig production and trigger regulatory changes in intensive pig production relating to the confinement of sows, the use of totally slatted floors and the use of farrowing crates for lactating sows. Will EU policy on pig housing and antibiotic growth enhancers in the future have a scientific basis or be driven by political motives? The recent ban of four antibiotic growth enhancers against the recommendations of the Scientific Committee of Animal Nutrition (S.C.A.N.) suggests that political motives will continue to be the main driving force behind E.U. policy, as it relates to pig production.

# SECTION II MONITORING HERD HEALTH AND PRODUCTION ECONOMICS: DISEASE SURVEILLANCE AND ERADICATION

## 2.1 INTRODUCTION

Some systems of pig production that were profitable in the past are now non-viable. The majority of pig farmers that have survived the economic climate of the recent past are progressive and innovative. They have been forced to make major policy changes in order to survive in business. There is now a greater awareness of the advantages of single-source finishing herds with minimal disease (MD) status, over multi-source herds that fight a constant battle against disease and suffer the financial burden of increased costs and reduced profit margins. New technology in feed and ventilation systems have allowed feed levels to be accurately controlled and have created a superior environment, due to improved ventilation. It is doubtful if the multi-source finishing herds that are purchasing weaners from upwards of 20-40 suppliers will survive in the long term unless they are under expert management. Not only do they generally experience higher production costs and lower profit margins but they are also subjected to the constant requirement for medications to control disease outbreaks. Regulations defining acceptable antibiotic residue limits in slaughtered pigs make it impractical to regularly medicate pigs on the farm without violating tissue residue regulations. As a result, a further deterioration in health and production could be anticipated in these herds unless major policy changes are adopted.

The financial implications of a depopulation and restocking programme are primarily related to the actual cost associated with the "no sale" period and the loss of potential profit, so the programme is best carried out during a period of low industry profitability. To achieve a 22-week "no sale" period, gilts are served in isolation and moved in to the clean depopulated unit at 14 weeks of gestation. When the last sow farrows sales of weaners commence so that the weaner and finishing areas are depopulated simultaneously. Alternatively, semi-intensive housing is rented for a 12 week period, thus avoiding sales of weaners. Repopulation is expensive, so alternative methods of improving health status should be given careful consideration and a detailed cashflow produced before reaching a decision. Such methods include disease control or eradication by medication and hygiene, medicated early weaning (MEW) and disease eradication by vaccination and culling of sero-positives, all of which are documented in this section. The likelihood of disease breakdowns subsequent to restocking have to be considered carefully. Trends in the economics of pig production are difficult to predict and diseases often follow unpredictable patterns, so a careful appraisal of each herd should be carried out before adopting a policy. In some herds depopulating and restocking with MD stock offers the only opportunity of maintaining a viable enterprise in an increasingly competitive industry.

Toxigenic *Pasteurella multocida* type D is recognised as the primary causative agent of progressive atrophic rhinitis (AR). A study was conducted in a 300 sow MD unit, in which toxigenic *Pasteurella multocida* type D

was isolated from two pigs, in order to establish if the isolation of toxigenic *Pasteurella multocida* type D gives conclusive evidence of the presence of AR in pigs on a farm. The diagnostic investigations involved clinical studies, ELISA testing of nasal swabs and slaughterhouse examination of snouts. A slaughterhouse survey of pigs derived from 34 herds was carried out with a view to establishing the prevalence of lesions in pigs at slaughter under Irish conditions. The lesions monitored were AR, enzootic pneumonia (EP), *Actinobacillus pleuropneumoniae* (AP), pleurisy, pericarditis, gastric ulcers, liver "milk spot" and mange. Approximately 35% of the practice pig population, which was set up in MD herds, were excluded from this survey; it being confined to *Mycoplasma hyopneumoniae* positive herds.

## 2.2 HEALTH STATUS TRENDS IN THE AUTHOR'S PRACTICE

The presence of disease adversely affects daily liveweight gain (D.L.G.), food conversion ratio (F.C.R.) and sow productivity. The cost of pig production is consistently higher in Ireland than in other EU states; these two factors have created a major incentive to improve efficiency, with a view to exploiting the economic advantages of MD herds over normal health status herds. An intensive depopulation and restocking programme gathered momentum in the mid and late 1980's with the result that in 1992 approximately 35% of the breeding stock in the author's practice herds were set up as MD compared with 1% in 1984 (Kavanagh, 1984). Only a marginal increase in the percentage of sows in MD herds took place between 1992 and 1996 (Table 3). Since 1996 the percentage of sow herds which were set up as MD herds has remained stable. The economics of the pig industry have been poor since 1997, so there has been little enthusiasm amongst pig farmers to invest in improving health status. This fact is supported by industry trends in the UK where they have experienced a reduction of approximately 34% in sow population from 910,000 to 604,000 between 1997 and 2002 (Table 2).

**TABLE 3: Changes in health status of practice herds (1984-1996)**

| | **1984** | **1992** | **1996** |
|---|---|---|---|
| No. Herds | 120 | 138 | 95 |
| Total Sows | 31,000 | 36,000 | 39,000 |
| No. Herds MD | 1 | 32 | 23 |
| No. Sows MD | 300 | 12,600 | 14,000 |
| % of Total Sows MD | 0.97 | 35 | 35.9 |

MD = Minimal disease

It is natural that the trends in the global, EU and Irish pig industries are similar to that in the author's practice, where herd size has increased over the past 20 years or so. In most cases the smaller herds have higher production costs compared to their larger counterparts, because their feed costs are higher and food constitutes

approximately 60 - 70% of the cost of pig production. Furthermore, they are unable to command as high a price for the pigs they produce as compared with the larger producers. Also, the smaller herds are less likely to opt for depopulation and restocking programmes than the larger corporate-type herds, in part due to a lack of finance but more importantly due to a lack of confidence and motivation to make the major decisions which are necessary when a depopulation and restocking programme takes place. It is probable that the trend towards increasing herd size will continue. However, the development of herds in Ireland in excess of 1,500 sows will be limited due to man management constraints and environmental controls relating to slurry disposal. Looking to the future, the successful pig veterinarian will require expertise in a range of disciplines allied to his veterinary qualification, in such areas as production economics, food safety, welfare, management and staff training.

The development of new laboratory techniques, which facilitated more accurate assessment of herd health status, enhanced the efficiency of herd health monitoring. As a result pig farmers and their veterinary advisers developed more confidence in their ability to successfully monitor their systems of pig production. At the same time many farmers had come to realise that the survival of their enterprise in an increasingly competitive environment might be dependent on their ability to make and finance major policy changes. The more progressive farmers have made major policy changes which have resulted in improved herd performance and profitability .

In the 1990's, with the emphasis on traceability and quality assurance, the author's laboratory obtained accreditation in a number of areas. Department of Agriculture and Food (DAF) approvals were obtained for *Salmonella* monitoring and microbiological analysis, residue testing, water testing and soil analysis for environmental schemes. A food science and a science graduate were added to the staff to support the demand for food safety related services. In the mid 1990's the laboratory obtained certification to the **ISO 9001** standard and in 2002 the **ISO 9001-2000** standard for all analytical services, which ensures that it operates to a recognised International quality standard.

Recently, laboratory facilities were upgraded to class 3 so it is now equipped to provide laboratory services relating to class 3 pathogens which include *Escherichia coli* type 0157:H7. A new clean room facility has also been installed for vaccine production. External ring trials are conducted on an ongoing basis in conjunction with DAF and also with other private laboratories in order to reduce the amount of inter laboratory variation in test results and maximise the standardisation of test procedures across the range of laboratories operating to high professional standards. The laboratory is currently expanding its range of services to the food processing sector. To this end it is in the final stages of gaining accreditation to the International ISO 17025 standard and EN 45,011. The International Standards Organisation is known as ISO 9000 and the Committee for European Standardisation as EN 29000. These standards define the technical and administrative mechanisms and systems that a well run organisation should have in place in order, consistently, to provide the standard of product, or service, that the consumer needs. The concept of good laboratory practice (GLP) initially developed in the USA when the FDA introduced regulations in 1976 which included the concept of "good laboratory practice" and this

was rapidly followed by the development of GLP standards and regulations internationally. Only laboratories carrying out health and environmental safety studies, the data from which are to be submitted to a National regulatory authority, need to be officially recognised as following GLP principals. Such laboratories are referred to as "GLP compliant". Currently, a number of accreditation schemes are operated in the United Kingdom which include the United Kingdom GLP compliance programme (GLP), The British Standards Institute (BSI), The Clinical Pathology Accreditation Scheme (CPA) and the National Measurement Accreditation Service (NAMAS).

## 2.3 A PROCEDURE FOR MONITORING HERD HEALTH STATUS

Herd health monitoring is primarily carried out in MD herds that sell breeding stock. The herd health investigations are carried out with the objective of establishing the current health status of the herd for the purpose of compiling a herd health status report. The herd health status report is distributed to potential purchasers of breeding stock for the purpose of health matching the donor and recipient herds and ensuring that the health status of the donor herd is equal, or superior, to that of the recipient herds. Whilst diseases of pigs can be spread by a variety of routes, including pig transporters, windborne etc, the primary method of spread is by the pig itself. Therefore, in addition to carrying out regular herd health monitoring of herds selling breeding stock, it is important that a biosecurity system be in operation in order to prevent diseases being introduced to the elite herds and that the system of distribution of breeding stock for sale should also be operated in conjunction with a strict biosecurity system. Health monitoring of nucleus and multiplication herds is normally carried out at two-monthly intervals. The diseases covered by the health declaration will vary in different parts of the world, depending on the health status of the pig population in the region involved. The data presented in this thesis relates to the Irish situation.

**Production records.**

Initially, production records are examined and compared with targets in order to obtain an overall appraisal of production trends in the unit, including mortality over the previous two to 12 months (Table 4). Any deviations from normal are discussed and their significance examined, particularly in relation to mortality levels which could be associated with the introduction of a new disease to the farm.

**The clinical herd health check.**

A clinical appraisal is carried out of pigs in each section of the unit, including the hospital area.

**Pig movement.**

Pig movement through the breeding pyramid is reviewed, taking into account the health status of herds higher up the pyramid and those lower down which received stock from within the pyramid.

**Postmortem examinations.**

Postmortem examinations are carried out on the farm and in the interim period, in the laboratory where there is an increase in mortality which could be indicative of a change in herd health status.

**Slaughterhouse monitoring.**

Slaughterhouse monitoring is carried out at two-monthly intervals, when lungs, heart, liver, skin and snouts are examined from a representative sample of pigs being slaughtered. Under normal circumstances a total of 25 to 54 carcasses are examined.

**Laboratory assays.**

The clinical and postmortem examinations are supported by laboratory assays, based on a combination of serology, toxigenic *Pasteurella multocida* (TPM) ELISA, examination of faeces samples, and skin scrapings. Serum samples are monitored for PRRS, AD, *Mycoplasma hyopneumoniae*, TGE/PRCV and occasionally for antibodies to *Sarcoptes scabiei* var suis. The TPM ELISA test is carried out on nasal swabs for AR diagnosis. Faeces samples are examined by flotation for worm eggs and, where appropriate, skin scrapings are taken for the purpose of examining for the presence of mange mites.

**Herd biosecurity.**

Herd biosecurity is normally reviewed at six-monthly intervals, or more often as necessary. A checklist system is used (Appendix 1).

**The report.**

The herd health status declaration is submitted in the form of a report, which highlights the status of the herd in relation to the diseases covered by the declaration, together with the dates of testing and the methods used (Appendix 2).

**TABLE 4: Herd monthly production targets for a 1000 sow unit on 21-day weaning**

| Category | Target |
|---|---|
| No. of gilts | 120 |
| Boar: sow ratio | 1:20 to 1:25 ( 1:100 for AI) |
| No. sows farrowed | 200 |
| Farrowing rate % | 87-89 |
| No. piglets born alive | 2,260 |
| % piglets born dead | 5-7 |
| Litter size born alive | 11.3 |
| Total piglet mortality % | 6 |
| No. piglets weaned per litter | 10.5 |
| Weaner mortality % | 1 |
| Finisher mortality % | 1 |
| Litters per sow per year | 2.4 |
| No. piglets born alive per sow per year | 27.1 |
| No. piglets sold per sow per year | 25.2 |
| Total services | 230 |
| Sow mortality per annum % | 4 |
| Repeat breeders (1st) % | 8 |
| Abortions % | <1 |
| NIP % | <1 |
| Culling rate % | 40-45 |
| FCR 8-32 kg | 1.6:1 |
| FCR 32-100 kg | 2.5:1 |
| DLG 8-32 kg (g) | 520 |
| DLG 32-100 kg (g) | 850 |

AI= artificial insemination, FCR= food conversion ratio, DLG= Daily liveweight gain, NIP= not in pig.

## 2.4 THE EFFECT OF ALTERING HEALTH STATUS ON THE PRODUCTION EFFICIENCY OF FINISHING HERDS.

**INTRODUCTION.**

With the rapid development of MD herds an opportunity arose for some multi-source units to depopulate their herds and purchase weaners from a single MD source or, alternatively, to build their own MD weaner production sow units to supply the finishing herds. The first study examines the effect of depopulating a multisource finishing herd and restocking it with MD stock on the economic and production efficiency of the herd. The economic and production efficiency of four semi-intensively housed MD herds is compared with the first herd in which the pigs were housed intensively. The data used was sourced from the original unit records. Information collected from depopulating and restocking programmes forms the basis of data presented on depopulating and restocking with MD stock. Cash flows were computer generated from typical farm data.

## 2.4.1 EFFECT ON PRODUCTIVITY OF CHANGING FROM A MULTI-SOURCE SYSTEM TO MD IN A FINISHING HERD.

Depopulating and restocking a finishing unit is not necessarily a very expensive process. Multi-source units that change to purchasing from a single source of either normal health status or MD status would need to depopulate the diseased stock and then repopulate with stock of known health status. If the depopulation is carried out during the summer months, alternative semi intensive cattle housing is usually available which could temporarily house the clean pigs whilst the finishing unit is being depopulated. Using this system, sales continue as normal and the cost of the depopulation is primarily that associated with the expense of cleaning the unit and carrying out routine maintenance. This is an ideal opportunity to upgrade the quality of the houses and environment by repairing damaged floors and troughs, and upgrading the ventilation system. Changing from a multi-source system to one supplier of MD status invariably results in a marked improvement in pig performance (Tables 5 and 6).

Changing from a multi-source system, with approximately 45 suppliers, to a single source of MD weaners resulted in improvements in FCR of 0.6, a 38% improvement in D.L.G. and a mortality reduction from 1.8 to 0.6% in 1990 (Table 5). Feed costs were approximately € 185 per tonne and the pigs gained an average of 54 kg from transfer in until the point of sale. The improvement in physical performance was accompanied by a marked reduction in production costs, of over € 8.75 per pig or € 105,000 per annum (Table 6).

**TABLE 5: Finishing herd performance: The response to changing from a multi-source, normal health status to single source M.D. system in 1990**

| | **Multi-source 1989** | **MD 1991** |
|---|---|---|
| FCR | 3.24 | 2.62 |
| FCD (kg) | 1.89 | 2.11 |
| D.L.G. (g) | 582 | 805 |
| Cost/kg/gain (€) | 0.59 | 0.48 |
| Mortality % | 1.84 | 0.60 |
| Labour costs/pig (€) | 4.42 | 3.44 |
| Medicine/pig (€) | 1.12 | 0.17 |
| Energy (€) | 0.32 | 0.55 |
| Maintenance (€) | 1.08 | 1.09 |

FCR= food conversion ratio, FCD= Food consumption per day, DLG= Daily liveweight gain, MD= Minimal disease

**TABLE 6: Cost benefit of changing from multi-source normal health status to a single source MD system on a per pig basis in 1990 (€)**

| | |
|---|---|
| Total pigs sold | 12,000 |
| Improvement in FCR | 6.16 |
| Reduction in mortality | 0.65 |
| Reduction in labour | 0.98 |
| Reduction in medication | 0.95 |
| Total savings per pig | 8.74 |
| Total unit savings per annum | 104,900 |

FCR= food conversion ratio, FCD= Food consumption per day, DLG= Daily liveweight gain, MD= Minimal disease

### 2.4.2. PRODUCTIVITY OF FOUR SEMI-INTENSIVE (STRAW BEDDED), MD FINISHING UNITS.

The performance of four herds was examined, all of which were operating an all in/all out system so that each herd was stocked over a period of seven days and then fully depopulated when the pigs reached slaughterweight (Table 7). The price of feed was approximately € 185 per tonne. All of the pigs were dry fed ad-lib in feed hoppers. Overall, there was a marked variation in performance between herds, with F.C.R. varying from 2.8 to 3.15, mortality from 0.3 to 2.4% and the cost per kg gain from € 0.51 to € 0.58. Mean F.C.R. was 2.96, mortality 2.4% and cost per kg gain € 0.55. When compared with the performance achieved in the intensive MD herd (Table 5), the performance was inferior by 0.3 F.C.R. and 1.8% mortality. The inferior performance of the semi-intensive system was partially offset by the higher interest and repayments on buildings of the intensive system. The intensive system had interest and repayments of approximately € 3.80 - € 4.45 per pig, based on 50% borrowings and repayments being made over a 10-year period. In the semi-intensive system, housing costs were approximately € 0.64 per pig and the cost of straw € 1.30 per pig sold. As a result the overheads in the semi-intensive system were € 1.90 - € 2.50 less than that of the intensive system. However, this was offset by the inferior F.C.R. which resulted in extra feed costs of about € 3.40 per pig in the semi-intensive system. Economically, the results favoured the intensive system by approximately € 1.00-1.50 per pig over the semi-intensive.

**TABLE 7: The performance of four MD finishing herds, housed in a semi-intensive system with straw bedding**

| | **Herd 1** | **Herd 2** | **Herd 3** | **Herd 4** | **Mean** |
|---|---|---|---|---|---|
| No. pigs | 300 | 693 | 600 | 581 | 544 |
| Weight in kg | 27 | 31.9 | 30 | 28 | 29.2 |
| Weight out kg | 86.5 | 80.0 | 87 | 86 | 84.9 |
| Days on farm | 80 | 67 | 75 | 79 | 75.3 |
| FCR | 2.78 | 2.8 | 3.15 | 3.12 | 2.96 |
| DLG (g) | 741 | 719 | 757 | 741 | 740 |
| FCD (kg) | 2.07 | 2.03 | 2.4 | 2.3 | 2.2 |
| % Mortality | 2.0 | 0.3 | 3.3 | 4.1 | 2.4 |
| Cost kg/gain | 0.51 | 0.52 | 0.58 | 0.58 | 0.55 |

FCR= food conversion ratio, FCD= Food consumption per day, DLG= Daily liveweight gain, MD= Minimal disease

## 2.5 THE COST OF HERD DEPOPULATION AND RESTOCKING WITH MINIMAL DISEASE STOCK

Total depopulation of a diseased herd, followed by cleaning and disinfection of the premises, and repopulation with MD stock is quite commonly carried out. However, it is very expensive so other methods of eradicating disease without depopulation should be carefully considered before reaching a decision. A simple "rule of thumb" system for estimating the cost of a depopulation and restocking programme is based on a cost of € 13,000 to € 20,000 per 1,000 sow herd size per week of no sale period under Irish conditions. The following formula could be used to assist the calculation (Fig. 5).

**Fig. 5: Formula for approximating the cost of a depopulation and restocking programme in a breeding herd selling finishers**

$$\{J \times (A + B + C + D + E)\} + G + F(K \times 1.1) + \{(H \times K \times 1.1)/6\} + i$$

Where:

**A** = interest and repayments per week, **B** = labour per week, **C** = energy cost per week,

**D** = insurance cost per week, **E** = miscellaneous cost per week, **F** = gilt, cull sow price difference per gilt, **G** = cost of rent and service of isolation units, **H** = gilt feed costs per tonne, **I** = total cost of boars, **J** = no sale period in weeks, **K** = herd size

**Decision making factors.**

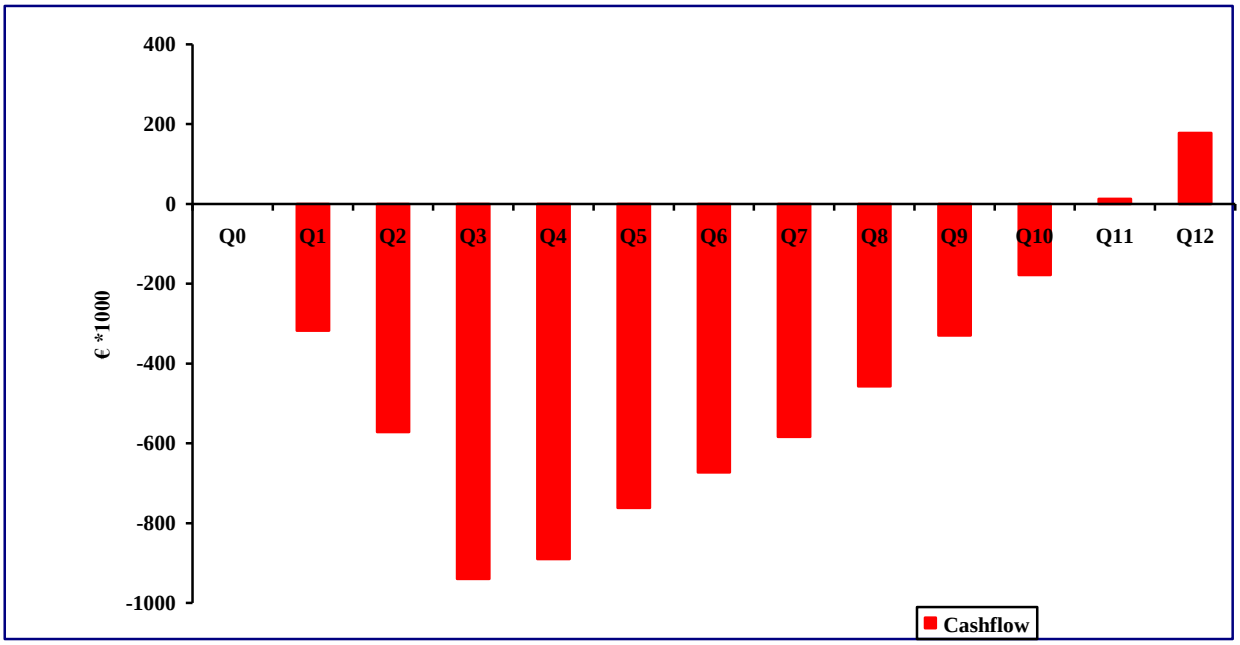
Before advising on a depopulation and restocking programme, a careful appraisal of the key decision making factors should be conducted.

1. Current health status.
2. Current performance.
3. Site and location of unit, proximity to other pigs.
4. Current and projected cashflows.
5. Availability of finance.
6. The current and projected financial state of the pig industry.
7. Alternative methods of disease eradication.
8. Unit layout.
9. The availability of breeding stock.
10. Management quality.
11. Owner ambition.

**Current and projected cash flows.**

Cash flow projections should be made, based on the probable performance of an M.D. herd. The minimum objective in establishing a high health herd is to retain its health status for at least two years, reduce the days to slaughter by 10 to 21 and improve the food conversion rate by 0.1 to 0.4. Ideally, a farrowing rate of 90% should be considered together with a grower mortality of less than 2.5% (Muirhead, 1989). In practical terms the cost of a depopulation/restocking programme is closely related to the weekly margin over feed, multiplied by the number of weeks without sales, together with cleaning and maintenance costs. To establish how long it would take to recoup the costs and loss of cashflow associated with the depopulation and repopulation programme a computerised cashflow programme was developed by the author which is run on the spreadsheet Lotus 123. Key data is entered in relation to herd performance prior to destocking. The programme is set up to present a five year cashflow on a four-weekly basis. Projected annual performance is documented on the input report and this information is then used to compile the final report, taking into account projected pig output per sow per year, F.C.R., litter size, food prices etc (Appendix 4). The depopulation and repopulation programme (Appendix 5) adopted will have an impact on the cashflow. It is also important to compare the profitability on a before and after basis (Appendix 6). A negative cashflow is generated during the first 11 months following restocking, such that a 1,000 sow unit would require approximately € 1,000,000 to finance the negative cashflow generated during the first 11 months of production (Fig. 6), having started with a zero cashflow prior to restocking. In practice the sale of stock from the diseased herd makes a contribution to the cashflow.

**Fig. 6: RESTOCKING CASHFLOW IN A 1,000 SOW BREEDING HERD (€* 1000)**




Q=Quarter

In Table 8 the performance of a typical herd with endemic disease is compared with that projected for an MD herd; a difference of approximately € 10.25 per pig.

Many normal health status herds, with a stable host parasite relationship, achieve target performance, so all factors must be carefully examined before embarking on an expensive programme. In examining the feasibility of a depopulation and restocking programme careful consideration should be given to a range of decision making factors, as outlined by Kavanagh (1989). In particular, a cashflow should be projected and appropriate financial facilities arranged to provide finance during the period of restocking .

**TABLE 8: Production efficiency: MD herd v herd with endemic disease**

| | **Production efficiency** | | **Cost €** | | |
|---|---|---|---|---|---|
| | **NH** | **MD** | **NH** | **MD** | **Diff. €** |
| D.L.G. 8-100 kg (g) | 567 | 680 | - | - | 2.25 |
| F.C.R. 8-100 kg (ratio) | 2.5 | 2.3 | 55.88 | 51.63 | 4.25 |
| Mortality (%) | 4.5 | 1.5 | NA | NA | 2.48 |
| Medication/pig (€) | NA | NA | 2.86 | 1.59 | 1.27 |
| **Total** | | | | | **10.25** |

NH = Normal health status, FCR= food conversion ratio, DLG= Daily liveweight gain, MD= Minimal disease, NA = Not applicable

## 2.6 ERADICATION OF SWINE DYSENTERY BY PULSE MEDICATION IN A 150 SOW, WEANER PRODUCING HERD

**INTRODUCTION.**

Swine dysentery (SD) is an infectious, transmissible disease, with lesions confined to the large intestine. It is caused by *Brachyspira hyodysenteria*e and is characterised clinically by a mucohaemorrhagic diarrhoea. A variety of techniques have been developed for the eradication of SD from pig farms. The most common method involves depopulation, clean up, disinfection and repopulation with SD-free stock. Swine dysentery has also been eradicated using a system of MEW (Kavanagh, 1992). Under practical on farm conditions, *Brachyspira hyodysenteria*e usually has an incubation period of greater than seven days. Tiamutin premix had a five day withdrawal recommendation in Ireland prior to 1996, when this study was conducted. The SD eradication programme described here was based on pulse medication with tiamulin on a seven day on, seven day off basis, which allowed the recommended five day withdrawal period to be observed as pigs were sold at two weekly intervals. It also reduced medication costs, as compared with a continuous medication regime.

## MATERIALS AND METHODS.

### Pre-eradication programme.

The programme was carried out in a 150 sow unit producing weaners for sale at 35 kg bodyweight. This herd had experienced severe clinical problems with SD during the previous three years. A pre-eradication clean-up and housing improvement programme was carried out, as follows:

Slurry levels were reduced to a minimum.

All pens were power washed and disinfected, including yards and the loading ramp.

The plastic pipe drinking system which was used in the weaner pens was replaced by nipple drinkers. This was aimed at reducing the mechanical spread of infection from pen to pen via the drinking water system.

Slats were modified to improve drainage. This involved grinding the lateral edges of the top surface of the slats to increase the aperture.

Rough floors were resurfaced using Evo-stik levelling compound, to a thickness of 12mm.

An intensive rodent control programme was introduced.

Replacement breeding stock were purchased from a SD free source.

A disinfectant foot bath was placed at the entrance to each area of the unit.

During the six month pre-eradication clean-up programme all diets were pulse medicated with tiamulin hydrogen fumarate at an inclusion rate of 120g/tonne on a seven day on, seven day off basis. All pigs were medicated for seven days post weaning with Tiamutin (Novartis) soluble powder at a concentration of 0.006% in the drinking water.

**Final eradication programme.**

All diets were medicated simultaneously for a period of 10 days with tiamulin hydrogen fumarate at a rate of 120g/tonne. During this period all areas of the unit, including the yards, were thoroughly power washed and disinfected on two occasions.

## RESULTS AND DISCUSSION.

The eradication programme was successfully completed in September 1990 based on freedom from clinical signs of the disease and the absence of anti-dysentry medications over the following five years, when monitoring ceased.

## 2.7 ESTABLISHMENT OF A NEW MD HERD BY A COMBINATION OF VACCINATION, MEDICATED EARLY WEANING AND REMOVAL OF SERO POSITIVES

**INTRODUCTION.**

MEW was originally devised to provide a practical and economic method for setting up new herds of high health status (MD, SPF) without resorting to depopulation and restocking (Alexander *et al*, 1980). Harris *et al* (1998) simplified the original MEW technique and named it ISOWEAN. In ISOWEAN sows farrow on the source farm and the piglets are weaned to an isolated weaner house at 5-21 days of age. The choice of weaning age, vaccines and medications used are based on the type of infectious diseases present in the donor herd. The object of this MEW programme was to develop a 50 sow nucleus herd containing stock of MD health status without resorting to hysterectomy and artificial rearing. The 500 sow donor herd was positive for the following major diseases; AR, AD, *Streptococcus suis* type 2 meningitis (Strep), EP, AP, SD and sarcoptic mange.

**MATERIALS AND METHODS.**

**Piglet rearing system.**

A non -intensive isolation unit was set up away from the main sow unit. The sows were transferred to the isolation unit at 96 days of gestation. They were injected on day 114 of gestation with 2ml of Dinolytic (Upjohn) to induce farrowing on day 115. Personnel involved in supervision of pigs in the isolation unit had no contact with other pigs and no other personnel were permitted to enter the buildings. The isolation unit was operated on an all in / all out system. Sows were supervised at farrowing to ensure that each piglet received an adequate supply of colostrum. At five days of age the heaviest pigs (2 kg bodyweight) were identified and moved to separate clean accommodation. The sows and the lighter piglets were then transferred out of the isolation unit to the herd of origin. The programme was restricted to sows of second parity or greater.

**Weaned pigs.**

The accommodation for weaned pigs was cleaned down and disinfected once daily for seven days post-weaning and bedded with straw. The pigs were fed on milk substitute and a milk-based creep diet.

**Immunisation.**

Each sow was vaccinated with 2ml of Nobivac ART (Intervet) and 2ml of Suvaxyn Aujeszky's vaccine (Fort Dodge) at six and three weeks before farrowing.

**Antimicrobials and antiparasiticides.**

Ivomec (Merial) injection was selected for its activity against mange mites. Tiamulin hydrogen fumarate (Tiamutin; Novartis) was chosen for its activity against *Mycoplasma hyopneumoniae* (Goodwin, 1979) and *Brachyspira hyodysenteriae*. Trimethoprim sulphonamide combinations (Trivetrin, Tribrissen; Schering Plough) were chosen because of their activity against a wide range of gram positive and gram negative bacteria particularly *Pasteurella multocida* type D, toxigenic strains of which are associated with AR.

**Medication regime.**

Individual sows were weighed so that dosages could be calculated accurately. Sows were injected with Ivomec at a rate of 1.5ml per 50 kg body weight at the point of transfer to the farrowing accommodation at 96 days of gestation and again at 110 days. They were also injected with Trivetrin at a rate of 4ml per 50 kg bodyweight at transfer to the farrowing accommodation, and then their feed was medicated on a daily basis with sulphadiazine 10mg/kg, trimethoprim 2mg/kg, and tiamulin hydrogen fumarate 11mg/kg bodyweight. Piglets were dosed with Tribrissen oral (Schering Plough) at a dosage rate of 2ml once daily from birth to five days and at a rate of 2.5ml from weaning to seven days post-weaning. Piglets received 0.1ml of Tiamutin 200 by injection daily from birth to five days and 0.2ml daily from weaning to five days post-weaning.

**Health monitoring of the MEW herd.**

Health monitoring was carried out at three to four-monthly intervals, which involved clinical inspections of the herd, lung and snout examinations in the slaughterhouse and serological testing.

## RESULTS AND DISCUSSION.

The MEW programme successfully eliminated AR, Strep, EP, AP, SD and mange (Table 9, 10). However, five animals proved positive on serology for AD (Table 11). Three of the positive sows had been transferred into the herd by MEW and two were daughters of one of the positive sows. This suggests that the virus had spread from mother to daughter although there was no other evidence that the virus had circulated in the herd. The AD sero-positive animals were removed immediately and the herd was tested again 30 days and six months later,

with negative results. The modified MEW disease eradication programme successfully eradicated the six diseases targeted.

**TABLE 9: Results of herd health monitoring in a herd established by M.E.W.**

| Disease | Test | | Results |
|---|---|---|---|
| AR | Clinical, | Snout scoring, TPM. | - |
| AD | Clinical, | Serology | + |
| Strep | Clinical. | | - |
| EP | Clinical, | Lung checks, Touch preparations | - |
| AP | Clinical, | Lung checks, Cultures | - |
| SD | Clinical | | - |
| Mange | Clinical | | - |

+ = Positive, - = Negative, AD= Aujeszky's disease, AR= Progressive atrophic rhinitis, EP= Enzootic pneumonia, AP= *Actinobacillus pleuropneumoniae*, SD= Swine dysentry, TPM= Toxigenic Pasteurella multocida, MEW= Medicated early weaning

**TABLE 10: Slaughterhouse results in a herd established by M.E.W.**

| | | No. With lesions | |
|---|---|---|---|
| **Date** | **No. examined** | **E.P.** | **AP** |
| 28/5/91 | 12 | 0 | 0 |
| 9/9/91 | 5 | 0 | 0 |
| 7/10/91 | 20 | 0 | 0 |
| 2/3/92 | 8 | 0 | 0 |
| 21/3/92 | 15 | 0 | 0 |

EP= Enzootic pneumonia, AP= *Actinobacillus pleuropneumoniae*, MEW= Medicated early weaning

**TABLE 11: Aujeszky's disease serology in a herd established by M.E.W.**

| Date | No. tested | No. positive |
|---|---|---|
| 9/9/91 | 53 | 5 |
| 7/10/91 | 76 | 0 |

## 2.8 ISOLATION OF TOXIGENIC *PASTEURELLA MULTOCIDA* TYPE D FROM PIGS IN A HERD FREE FROM PROGRESSIVE ATROPHIC RHINITIS

**INTRODUCTION.**

The aetiological importance of toxigenic *Pasteurella multocida* type D in AR in pigs is well established. Epidemiological studies have revealed a close correlation between the occurrence of the clinical disease and the presence of toxigenic *Pasteurella multocida* (Pedersen, 1982; Jong de, 1985). Toxin-producing strains of *Pasteurella multocida* are not confined to pigs; they have also been isolated from rats, calves, cats, dogs, rabbits and turkeys (Kamp *et al*, 1990); Furthermore, Kamp *et al* (1990) noted that atypical *Pasteurella* strains of bovine origin also produce a toxin which is closely related to the dermonecrotic toxin of *Pasteurella multocida* subspecies multocida.

This study describes an instance where two isolations of toxigenic *Pasteurella multocida* type D were made in the course of routinely monitoring the health of an integrated MD unit containing 300 sows. The herd in question was closed, no pigs having been introduced into it since it was established in 1990 on a farm that had been free of pigs for more than two years. The original stock were supplied from one monitored source. The herd of origin, which was monitored at three- monthly intervals was free of progressive atrophic rhinitis when the foundation stock was obtained and has remained so since. Health monitoring of this herd involves clinical examinations, snout checks in the slaughterhouse and ELISA testing of nasal swabs taken randomly. The herd was near the top of a multiple breeding pyramid. Monitoring was carried out at three monthly intervals, which also involved clinical examinations, snout scoring, and nasal swabbing. Mean snout scores of less than one were consistently recorded using the Pig Health Control Association (PHCA) scoring system (Goodwin, 1993).

**METHODS AND RESULTS OF INVESTIGATIONS.**

The nasal swabs (one per pig) which were taken randomly from this herd were examined by the Dako ELISA test (Dako)* for toxigenic *Pasteurella multocida* type *D.* In June 1991, two of 16 specimens were positive to this test. In view of the history of the undoubted clinical and pathological freedom from progressive atrophic rhinitis in the herd, further investigations of the positive samples were made which involved inoculating selective medium with the swabs (Rutter *et al*, 1984). Putative colonies were then subcultured on blood agar to obtain pure cultures. Two isolates were then submitted to the AFRC Institute for Animal Health, Compton Laboratory, UK, where they were examined for toxin production in embryonic bovine lung (EBL) cells (Rutter and Luther, 1984) and subsequently for mouse lethality in the author's Laboratory[1] (Il'ina and Zasukhin,1975), which involved inoculating mice with a bacteria free filtrate of the *Pasteurella multocida* cultures. Both isolates (348, 349) were positive to the two tests. Characterisation of cultures of 348 and 349 were carried out (Table 12). Both isolates were identical but differed from *Pasteurella multocida* LFB3 (The UK reference pig strain)

in tests for ornithine decarboxylase, inositol, rhamnose and trehalose and from "Bovine Atypical *Pasteurella*" in tests for indole, ONPG, xylose, inositol, rhamnose, trehalose and glycerol.

Heddleston (1976) concluded from the results of 29 physiological tests on 1286 cultures of *Pasteurella multocida* from various hosts that none of the tests was capable of indicating from which host the bacteria was isolated. Physiological characteristics that were not shared are detailed in Table 13.
The two isolates were also submitted to Dr. de Jong, Gezondheidsdienst Voor Dieren Zwolle, Netherlands, who confirmed that they were toxigenic type D.

After the identification of toxigenic *Pasteurella multocida* type D in the herd, nasal swabs were taken from 16 growing and finishing pigs and tonsil swabs from the adult breeding stock, including all the selected gilts. One sow was positive to the ELISA test and was immediately removed from the herd. A further swabbing programme, using the procedure described above, was carried out some 30 days later. On this occasion all samples were negative to the ELISA test. All the feeds used in this herd were free of therapeutic antibiotics and growth promoters. Recently weaned pigs were supplied with medicated water, as occasion required, to treat postweaning enteritis. In the absence of control programmes involving medication and vaccination, recently established herds with AR usually experience an upsurge in the clinical disease during the winter months. In the herd in question it was decided therefore to delay further action until the end of the winter and then to conduct further investigations, involving clinical examinations, snout scoring and examination of tonsil and nasal swabs. During the winter period the stocking rates were high and environmental conditions were poor, thereby creating ideal circumstances for triggering an outbreak of the disease.

Further testing indicated that the herd was free from progressive atrophic rhinitis. Finishing pigs in the abattoir had an average snout score of 0.5 and all nasal swabs were negative by ELISA. Further checks which were conducted during the following seven years failed to reveal any evidence of the presence of toxigenic *Pasteurella multocida* type D, or AR. Moreover, there was no evidence of transmission of AR to farms receiving breeding stock from this herd.

Monitoring of the health of pigs on the farms has likewise been conducted at three-monthly intervals and involved clinical examinations, snout scoring and the examination by ELISA of 16-25 nasal swabs taken randomly on each occasion.

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* Dakopatts A/S, Produktinosvej 42, Postbox 1359, DK-2600 Glostrup, Denmark.
[1] Oldcastle Laboratories Ltd, Cogan St., Oldcastle, Co.Meath, Ireland.

**TABLE 12: Comparison of porcine isolates 348, 349, "Atypical bovine strains" and LFB3 *Pasteurella multocida***

| TEST | "atypical bovine strain" | 348,9 | LFB3 |
|---|---|---|---|
| Gram's Stain | GNB | GNB | GNB |
| Motility | - | - | - |
| Catalase | + | + | + |
| Oxidase | + | + | + |
| D (+) Glucose acid | + | + | + |
| Gas glucose | - | - | - |
| Citrate Simmons | - | - | - |
| $H_2S$ (TSI) | - | - | - |
| $H_2S$ (LI) | NT | - | - |
| Nitrate | + | + | + |
| Urease | - | - | - |
| ADH | - | - | - |
| LDC | - | - | - |
| ODC | - | - | + |
| Indole | - | + | + |
| Gelatinase | - | - | - |
| Aesculin | - | - | - |
| ONPG | + | - | - |
| Lactose | + | + | + |
| D (+) Galactose | + | NT | NT |
| Glycerol | + | - | - |
| Inositol | - | + | - |
| D (-) Mannitol | + | + | + |
| Rhamnose | - | + | - |
| D (-) Sorbitol | + | + | + |
| Sucrose | + | + | + |
| Trehalose | + | - | + |
| D (+) Xylose | - | + | + |
| Smell | P. haemolytica like | 'P.multocida like | 'P.multocida like |

GNB = Gram negative bacillus + = Positive, - = Negative, NT = Not tested.

**TABLE 13: Physiological characteristics of *Pasteurella multocida* 348/349 that were not shared with other *Pasteurella multocida***

| | Heddleston# isolates | "Atypical Bovine strain" | 348/9 | LFB3 |
|---|---|---|---|---|
| ODC | - | - | - | + |
| Trehalose | V(11.4) | + | - | + |
| Inositol | - | - | + | - |
| Rhamnose | - | - | + | - |
| Indole | + | - | + | + |
| ONPG | NT | + | - | - |
| Xylose | V (78.2) | - | + | + |
| Glycerol | V (89) | + | - | - |

Variable data (V) are expressed as % positive. + = positive, - = negative. # Heddleston (1976)

**CONCLUSIONS.**

The results of this study suggest that:

(1) The positive isolation of toxigenic *Pasteurella multocida* type D in a herd of pigs does not provide conclusive evidence that the herd is positive for AR. In this case the organism did not produce clinical signs or lesions of AR.

(2) Declarations of freedom from AR should not depend solely on the results of laboratory tests on nasal or tonsil swabs. For a given herd the results of such tests are best interpreted in conjunction with the results of regular clinical and abattoir inspections of stock. As snout scores show marked seasonal variations, with higher snout scores being associated with recurring husbandry problems, especially overstocking and unsatisfactory environmental conditions for weaners (Goodwin 1988), health declarations should only be made following a careful appraisal of all the evidence.

(3) The herd remained free of AR seven years after the isolation of toxigenic *Pasteurella multocida* type D from pigs, when monitoring ceased The particular toxigenic type D which was isolated from it differed in four biochemical reactions from the standard UK pig isolate of toxigenic *Pasteurella multocida* type D, LFB3 and it may be that the pig was not their natural host. This might explain why the organism did not spread and cause disease, but seems to have spontaneously disappeared from the herd.

## 2.9 DISEASE SURVEILLANCE AT SLAUGHTER: A STUDY OF SLAUGHTERHOUSE LESIONS IN PIGS FROM 34 HERDS IN 1995

**INTRODUCTION.**

Regular slaughterhouse monitoring of pigs for evidence of disease, if combined with clinical and laboratory investigations, can provide valuable data based on which programmes designed to improve production efficiency and reduce disease levels can be developed and monitored. The primary objective of slaughterhouse monitoring is to facilitate the diagnosis of sub-clinical diseases and to monitor the response to control programmes being operated at farm level. Slaughterhouse monitoring is also routinely carried out on stock derived from MD herds as part of herd health monitoring. The slaughter check system has been used widely in Northern Europe, Australia and in the United States (Pointon and Hueston, 1990). In most cases, clinical and slaughterhouse investigations are supported by serological tests. In particular, a range of ELISA tests are now available which are relatively low cost and can be used to establish whether a disease is present or absent on a pig farm. Such tests can also be used to establish the point of exposure of pigs to organisms in different areas of the unit, thus facilitating the design and development of disease prevention and control programmes. Typically, *Salmonella* serology, using the Mix ELISA test can be used to establish the point and location of exposure to *Salmonella* on

a pig farm. This can be achieved by taking random blood samples from pigs at various ages and also in different houses. A similar system is used in AD eradication programmes based on vaccination. Aujeszky's disease virus may continue to circulate in individual houses, particularly those operated on a continuous throughput system. Random sampling of pigs can be used to identify the area in which the virus is circulating so that management procedures, designed to eliminate virus circulation from the farm, can be introduced.

Mycoplasma pneumonia (EP) has been reported from many countries and is one of the most common and economically important diseases in countries with modern pig production systems. Economic losses associated with EP infection is often the result of complex interaction between Mycoplasma, secondary bacterial infections, poor management and adverse environmental conditions ( Ross, 1992). Muller and Abbott (1986) reported that 99% of the herds in the USA had slaughter pigs with EP lesions. Pointon *et al* (1990) demonstrated that 100% of the herds, and 79.4% of the pigs had lesions which were typical of EP infections. Paisley *et al* (1993) recorded a *Mycoplasma hyopneumoniae* lesion prevalence rate in Denmark of 63 to 79%.

The operation of continuous production systems in which pigs of different age groups are mixed in the same air space may lead to an increase in the incidence and severity of EP compared to all in all out production systems. Overstocking can increase the incidence of pneumonia (Pointon *et al*, 1985). Straw *et al,* (1984) and Gardner and Hird (1990) found that pneumonic lesions were more extensive in pigs sired by Yorkshire boars than those sired by pigs of other breeds. Pigs reared during the winter are more likely to become clinically affected with EP and to develop typical EP type lung lesions (Straw *et al*, 1986b). Control of respiratory disease becomes more difficult if more than 200-300 pigs are housed in the same air space (Pointon *et al,* 1985). Adverse environmental conditions including dust, high levels of gasses, draughts and extremes of humidity may compound the effect of secondary infection in natural outbreaks of EP (Clark *et al,* 1993). Migrating *Ascaris suum* larvae damage lung tissue and decrease the defence mechanism involved in the clearance of bacteria and Mycoplasma (Curtis *et al,* 1987). Backstrom and Bremer (1976) reported that the prevalence of pneumonia in a herd was positively associated with the prevalence of Ascaris liver lesions in the herd.
A slaughterhouse survey of pigs derived from 34 herds was carried out with a view to establishing the prevalence of lesions in pigs at slaughter under Irish conditions. The lesions monitored were EP, AP, pleurisy, pericarditis, gastric ulcers, liver "milk spot" and mange. Approximately 35% of the practice pig population, which was set up in MD herds, were excluded from this survey; it being confined to *Mycoplasma hyopneumoniae* positive herds.

## MATERIALS AND METHODS.

A total of 34 herds were monitored during 1995.

Progressive atrophic rhinitis snout scoring was conducted in accordance with the procedure described by Done *et al* (1964) where snouts are scored from 1-5, 1 being a normal snout and 5 showing extreme turbinate atrophy.

Mange scoring was carried out using the procedure described by Pointon *et al*, (1987), whereby pigs with mange-like allergy lesions are classified from grade 1 where mild lesions are present involving localised clusters of papules generally 2-5mm in diameter behind the ears and on the thinner skin of the belly and thighs, whilst grade 3 carcases have generalised lesions with intense papular areas. Grade 2 and 3 are highly specific for mange (Davies and Moore, 1990).

The presence of liver white spots which are associated with migrating *Ascaris suum* larvae was based on visual examination of livers on the slaughter line and recording the percentage of livers that gave a positive result on visual examination.

Classification of gastric ulcers by severity was conducted using the guidelines documented by (Kavanagh, 1994a) where lesions were classified from zero which was a normal stomach to stage three chronic ulcers.

The presence or absence of pericarditis lesions was based on visual examination of hearts.

Lung scoring for EP-type lesions was conducted by using the procedure described by Straw *et al*, (1986b) in which 10% of lung volume was allocated to each of the apical, cardiac and the intermediate lobe and 25% allocated to each of the diaphragmatic lobes. The results were expressed as a percentage of the lung volume affected with pneumonic lesions.

The presence of pleurisy lesions and their location on the apical cardiac and diaphragmatic lobes were recorded by visual examination. Interpretation of the results was facilitated by recording the distribution of pleuritis lesions, where the presence of high levels of diaphragmatic lobe pleuritis would point towards the involvement of AP.

**RESULTS**.

Approximately 25% of lungs had pleurisy lesions whilst 1.5% of hearts had pericarditis. Forty three percent of lungs had EP type lesions of which 8.5% of volume was affected or 4.5% when expressed as a percentage of the total lungs examined (Table 14). The ratio of pleuritis between apical cardiac and diaphragmatic lobes was approximately 1:2:5. Less than 2% of lungs had AP-type lesions, however, the sensitivity of monitoring pleuropneumonia lesions at slaughter as an indicator of herd infection is low. A mean score of 0.11 was recorded for mange, with 9% of pigs having lesions which were confined to seven out of 15 herds examined (Table 15). Excluding parakeratosis, 3% of stomachs had a score of two or three, with the balance of 97% recorded as zero or one (Table 16). Approximately 2% of livers had ascaris lesions, which were confined to six out of 34 herds examined (Table 17). A mean snout score of 1.1 was recorded for turbinate atrophy. Three herds had a snout score of greater than two and the remainder less than 1.5 (Table 18).

**TABLE 14: The results of lung examinations of pigs slaughtered in 1995**

| | N = | Mean % ± SD | Median |
|---|---|---|---|
| No. herds | 34 | NA | NA |
| Population size | 136,368 | NA | NA |
| No. examined | 1,194 | NA | NA |
| Pericarditis | 18 | 1.50 ± 3.36 | 1.26 |
| Pleuritis | 304 | 25.45 ± 17.74 | 21.92 |
| AP-type lesions | 19 | 1.59 + 3.41 | 1.32 |
| EP-type lesions | 518 | 43.36 ± 22.50 | 44.84 |
| Lung vol. affected[2] | NA | 8.49 ± 5.21 | 7.98 |
| Lung vol. All pigs[3] | NA | 4.54 ± 3.97 | 3.16 |

**Distribution of pleuritis**

| | Mean % ± SD | Median |
|---|---|---|
| Apical | 2.95 ± 3.76 | 1.58 |
| Cardiac | 6.56 ± 7.14 | 5.72 |
| Diaphragmatic | 16.95 ± 14.47 | 11.79 |

[1]Total finishing pig population. [NA] Not Applicable, [2] Pigs with lesions, [3] All pigs, AP= *Actinobacillus pleuropneumoniae*, EP= Enzootic pneumonia

**TABLE 15: Mange scores of pigs slaughtered in 1995**

| | | |
|---|---|---|
| No. Herds | 15 | |
| Population | 41,639 | |
| No. Examined | 277 | |
| **Score** | **No** | **%** |
| 0 | . 253 | 91.4 |
| 1 | 17 | 6.13 |
| 2 | 6 | 2.1 |
| 3 | 1 | 0.4 |
| Mean ± SD | 0.11 ± 0.16 | |
| Median | 0.08 | |

**TABLE 16: Stomach scores of pigs slaughtered in 1995**

| | | |
|---|---|---|
| No. herds | 15 | |
| Population size | 41,639 | |
| No. examined | 262 | |
| **Score** | **No.** | **%** |
| 0 | 195 | 74.4 |
| 1 | 60 | 22.9 |
| 2 | 4 | 1.5 |
| 3 | 3 | 1.1 |
| Mean ± SD | 0.25 ± 0.19 | |
| Median | 0.17 | |

0=Normal, 1=Parakeratosis, 2= Erosions, 3=Fibrosis

**TABLE 17: Liver ascaris lesions of pigs slaughtered in 1995**

| | |
|---|---|
| No. herds | 34 |
| Population Size | 136,364 |
| No. examined | 1,194 |
| No. positive | 29 |
| Mean ± SD | 2.43 ± 7.03 |
| Median | 1.78 |

**TABLE 18: Snout scores of pigs slaughtered in 1995**

| | |
|---|---|
| No. herds | 19 |
| Population size | 56,615 |
| No. examined | 362 |
| Median | 0.64 |
| Mean score ± SD | 1.13 ± 0.69 |

**CONCLUSIONS**.

Mange scores were low, suggesting that current control procedures are quite effective. Liver ascaris lesions were confined to pigs derived from less than 20% of herds. There was little evidence of gastric ulceration; perhaps wet meal feeding was beneficial, since, with the exception of three herds, all of the finishing pigs were fed wet meal by pipeline. Almost 9% of lung volume (pigs with lesions) was affected with EP-type lesions which is similar to that recorded for 1994 (Kavanagh, 1995). If the above results are extrapolated to the Irish Pig Industry, based on the correlation between lung lesions and food conversion ratio (F.C.R.) (Pointon *et al*, 1987), it is estimated that complicated EP costs the Industry approximately € 3 million annually.

## 2.10 DISCUSSION OF SECTION II

Depopulation - repopulation programmes are expensive, costing in the region of € 300,000 - € 400,000 per 1000 sow herd size, therefore a strict biosecurity system is required in order to minimise the risk of introducing disease in association with a range of factors which are covered in the biosecurity health audit.

The pig itself is one of the most important methods for the dissemination of pig diseases. Therefore, a standardised system of health monitoring is required so that those purchasing breeding stock can have confidence that the health status of the incoming stock is equal to, or superior to, that of their own herd. Alternatively, they can utilise health matching in order to minimise disease risks in association with the introduction of non-immune stock to a diseased herd. The financial gain associated with improvements in D.L.G., F.C.R. or reduced mortality are dependent on overheads, feed costs and stock value which can vary significantly between farms. In some circumstances, the cost of feed medication far exceeds the financial return associated with reduced mortality and improved pig performance.

The ability of a pig to reach its genetic potential is influenced by its health status. There will be a requirement to reduce the quantity of routine antibiotics administered on farms in order to satisfy quality assurance and residue avoidance programmes, so the emphasis on improving herd health status will increase with the objective of maximising the economic efficiency of pig production whilst satisfying food safety standards. Improvements in herd health status could be achieved by depopulation and restocking programmes, age-segregated weaning, segregated early weaning, vaccination, all-in / all-out systems of pig production, and improved environment and management. Whilst almost all programmes geared towards improving the health and production efficiency of pig farms must have a sound economic basis, this does not necessarily apply to *Salmonella* control. Indeed, the availability of a market for pigs from farms containing multi-antibiotic resistant *Salmonella*, in the future, may be limited. So the modern pig veterinarian must have at his disposal an electronic system which facilitates the dissemination of information relating to advice given in a clear and concise way, so pig farmers are made acutely aware of the projected financial implications of important decisions. Modern windows-based spreadsheets and databases facilitated the development of such electronic systems. Pig production is economy driven, therefore, many decisions on disease control/prevention programmes must be subjected to a cost benefit analysis before finalising the programme. A formula for estimating the cost of a depopulation and restocking programme in a typical integrated herd is presented. A typical MD herd out-performs a herd with endemic disease by approximately € 7.50 - 13.00 per pig, in which circumstances the cost of a depopulation and restocking programme, excluding loss of potential profit could be recovered within two years. There is also a requirement to reduce the routine use of medicated feedstuffs in order to avoid the risk of violative tissue residues occurring in pigs at slaughter and to reduce the potential build up of antibiotic resistant bacteria on the farm. In many cases depopulation of a herd and restocking with MD stock is the favoured method of improving health status, particularly where a number of diseases are endemic on the farm. However, a depopulation and restocking programme involves major expenditure so it is vital that the owner and staff be fully briefed on all decision making factors and that appropriate financial arrangements be made to provide finance to cover, in particular, the first 12 months following restocking. However, provided the herd can maintain its MD health status, there is a major financial incentive to repopulate, provided the criteria outlined in the decision making factors can be satisfied.

Over the past 10 years production costs have increased at a greater rate than the price of slaughter pigs. As a result, the pig industry has gone through periods of very low profitability. The most dramatic improvement in finishing unit efficiency was achieved by depopulating a multi-source finishing unit and restocking it with MD pigs. This resulted in a 0.6 improvement in FCR and a total reduction in production costs per pig of € 8.74.

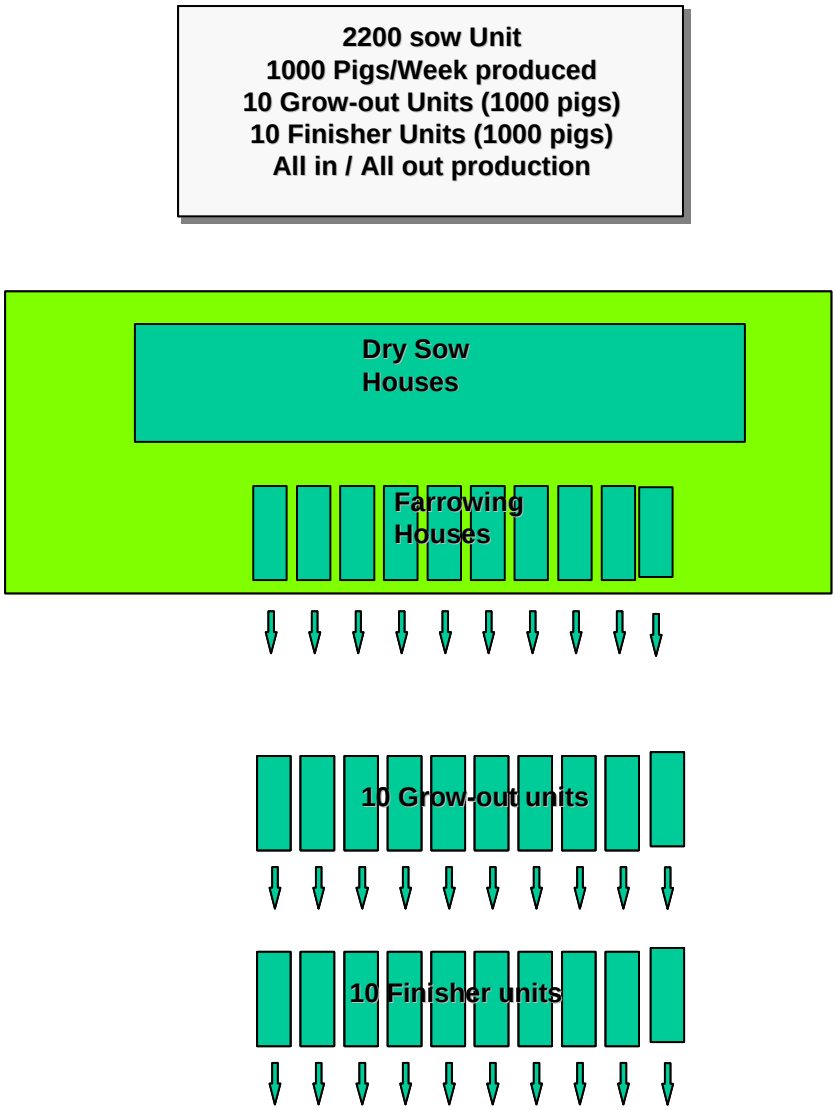
The isolation of toxigenic *Pasteurella multocida* type D in a MD herd selling breeding stock was alarming. In such circumstances the sale of breeding stock must cease immediately. Likewise, raised snout scores in the slaughterhouse can also arouse fears that an outbreak of AR may be imminent. In this case, the isolation of toxigenic *Pasteurella multocida* type D was not associated with the development of AR in 1991 and the herd in question remained clinically free for the following seven years, when monitoring ceased. The results of this

study highlight the importance of basing AR health declarations on a combination of clinical, slaughterhouse and ELISA testing of nasal or tonsil swabs, rather than on one of these methods alone.

A number of SD eradication programmes have been described in the literature which involved a combination of sanitation and medication (Fujioka *et al*, 1990, Martinez *et al*, 1990 and Wilkinson, 1989). Many of the earlier eradication programmes involved continuous medication of the feed which necessitated careful planning of pig sales to avoid selling pigs with violative antibiotic tissue residues at slaughter. More recently the successful eradication of SD using injectable tiamulin, combined with a sanitation and rodent control programme, has helped to overcome this problem (Blagovic *et al*, 1990, Ontanu *et al*, 1990).

MEW is primarily used as a method of setting up new herds of high health status without resorting to depopulation and restocking. Therefore, the use of MEW is restricted to nucleus herds which have contracted specific diseases which can be eliminated by MEW. MEW has evolved into isowean which has currently gained popularity, particularly in the USA, where the development of large units has facilitated multisite production. Multi-site has the advantage that production can be operated on an all in all out basis, so the pigs which are weaned each week are transferred to a separate unit which is operated on an all in / all out system of pig movement. The total complex, typically, consists of one sow unit producing pigs at weaning and a further 20 units consisting of 10 grow-out and 10 finishing units (Fig. 7)

**Fig. 7: A DIAGRAMMATIC PRESENTATION OF THE MULTI-SITE PRODUCTION SYSTEM**




*Mycoplasma hyopneumoniae* vaccines are currently widely used in the pig industry. Quantitative assessment of the level of circulating *Mycoplasma hyopneumonia*e organisms in vaccinated and non -vaccinated pigs cannot be achieved by serological monitoring because the currently available tests do not differentiate between antibodies resulting from vaccination and infection. If a selective ELISA test becomes available in the future, which is based on the same principal as the G1 antibody ELISA test for AD, it would then be possible to discriminate between field and vaccinal antibodies. This would facilitate investigations into the efficacy by which Mycoplasma vaccines reduce or interrupt the circulation of *Mycoplasma hyopneumoniae* in chronically infected herds.

Slaughterhouse monitoring can be used to detect the presence of disease or to estimate the prevalence of diseases such as EP, where increasing levels of disease have an impact on pig productivity. The sample size required to achieve 10% accuracy with 90% confidence for a prevalence estimate is larger than that required to detect the presence of disease at a 5 to 10% prevalence (95% confidence level) for all population sizes. For a given level

of accuracy and statistical confidence the largest sample size for a population is required at prevalence estimates of approximately 50% and lowest where the prevalence is at the extremes approaching zero or 100% (Cannon and Roe, 1982). Incidence is defined as the number of new cases of a disease that develop in a defined period of time. Prevalence is defined as the number of cases of the disease that exist at a specific instant in time (point prevalence) or over a period of time (period prevalence).

Straw *et al* (1986a) recorded a description of a typical AP-type chronic lesion as one with abcessation, fibrotic capsule and overlying pleuritis located on the dorsal aspect on the diaphragmatic lobes. *Actinobacillus pleuropneumoniae* lesions resolve over a period of 12 weeks in both clinical and experimental studies so classic AP lesions detected in slaughtered pigs may only reflect the presence of disease during the last 12 weeks of production. However, a high incidence of diaphragmatic lobe pleurisy would provide evidence of the likely presence of AP which would warrant further and more in-depth studies.

In studies carried out by van der Wolfe (2000a), herds with more than 16% of livers affected with "white spot" in pigs at slaughter were associated with a higher *Salmonella* sero prevalence than herds with a lower percentage of affected or condemned livers. Possibly, the damage to the intestine caused by adult worms and migrating larvae offer an entry point to other infections such as *Salmonella*. A similar correlation was found in chickens in relation to coccidiosis infection and *Salmonella* (Fukata *et al*, 1984). This highlights the importance of maintaining an efficient internal parasite control programme since *Ascaris suum* has been associated with an increase in *Salmonella* sero prevalence, a negative impact on growth rates, food conversion ratios and on lung infections associated with Swine influenza and *Mycoplasma hyopneumoniae.* A severe infection with *Ascaris suum* can result in pulmonary oedema and consolidation, and infection with other diseases such as Swine influenza and *Mycoplasma hyopneumoniae* is favoured because the bacterial clearance of the lungs is depressed (Curtis *et al*, 1987). Studies conducted in Northern Ireland by Menzies *et al* (1994) demonstrated a steady increase in the presence of liver condemnations in the 1990's such that approximately 10-15% of entire livers were condemned due to " milk spots". Milk spots are associated with extra intestinal migration of *Ascaris suum* larvae through the liver (Corwin and Stewart, 1999). The main organ which is damaged during the course of ascaris infections is the liver, through which the larvae migrate. This has a negative impact on growth rates and food conversion efficiency ( Hale *et al*, 1985). The number of animals that undergo ascaris infection before slaughter is estimated to be higher than 10-15% because lesions heal as early as 35 days following infection provided animals are removed from the source of infection.. So, contrary to popular belief modern management methods and some strategic anthelmintic therapy do not adequately control this parasite.

Pleurisy lesions were detected in 25% of lungs examined, which is higher than that recorded by Done and Penny (1998), however MD herds were excluded from the authors study. In their investigations in the UK 18% of lungs had pleurisy lesions and, most interestingly, the lesions were more common in the right caudal lobe than the left. They suggested that, in the case of haematogenous spread of bacteria, this might be due to the fact that the right caudal lobar pulmonary artery is larger than the left one, so the blood supply is greater to the right caudal lobe than the left.

# SECTION III AUJESZKY'S DISEASE: EPIDEMIOLOGY, ERADICATION AND MONITORING HERD STATUS BY PIGLET SEROLOGY OR MEAT JUICE

## 3.1 INTRODUCTION

The development of G1-deleted or negative Aujeszky's disease vaccines made it possible to differentiate pigs which were vaccinated against AD from those which were exposed to the field virus, thus allowing vaccination to continue for the purpose of AD eradication, whilst animals which were exposed to the field virus could be identified by serology and culled. However, blood-sampling of sows for the purpose of monitoring herd AD status is tedious and so a study was performed to establish if piglet serology would give similar results to that of their dam. Where piglets have consumed colostrum it can be anticipated that the serological status of the piglet would be similar to that of its dam.

In order to establish if a procedure, similar to that used for *Salmonella* monitoring, could be developed for monitoring herd AD status, a study was performed in the author's laboratory with the objective of modifying the existing AD ELISA test which is used on serum to give comparable results on meat juice, thus allowing meat juice samples to be used for monitoring the Irish pig herd for circulating AD virus. The presence of circulating virus indicates that pigs within the herd are shedding AD virus. If all herds could be monitored for circulating virus on an ongoing basis and strategic control programmes introduced on those farms with circulating virus, then virus circulation could be eliminated, and, as mature sero-positive sows are replaced by sero-negative gilts, the virus would be eliminated over a period from the Irish pig herd.

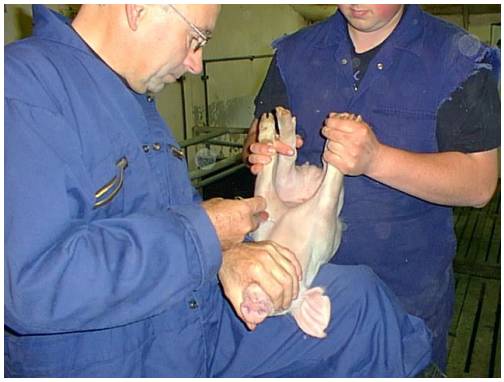
Surveys of the AD status of practice herds were conducted in 1992 and 2003. The epidemiological data collected from the practice AD survey was used to design an AD eradication programme for a 12,000 multi-source finishing unit. The objective was to eliminate the virus from the farm and the supplying breeding units, and to compare unit production efficiency when AD was endemic, with that achieved after it was eradicated, with a view to estimating the cost of endemic AD to a multi-source finishing unit. When the 2003 survey was completed the AD status of practice breeding herds in 2003 was compared with 1992 and a study conducted of the methods and results of the eradication programme.

## 3.2 PIGLET SEROLOGY: A METHOD OF MONITORING HERD AUJESZKY'S DISEASE STATUS

**INTRODUCTION.**

Traditionally, serological monitoring of herds for the presence of AD antibodies has been carried out on blood samples taken from the jugular vein of sows using the technique described by Douglas (1978). More recently, Banks (1985) described a system where filter paper disks saturated with whole blood were tested by an ELISA method for AD antibodies. With the introduction of the new G1 negative or deleted AD vaccines a selective G1 antibody ELISA test was developed which was capable of identifying sows that were positive to the field virus in AD vaccinated herds without interference from vaccinal antibodies (van Oirschot and de Waal, 1987). A simple filter paper system of taking blood samples has yet to be developed for use with the G1 antibody ELISA test, so, for this test, a 2ml sample volume is still required. Colostrum sampling of sows offers an alternative cheap and practical method of ascertaining the AD disease status of sows to that of blood sampling sows (Bouwkamp *et al*, 1992). In some herds, depending on the design and layout of the sow housing, blood sampling of sows can prove quite tedious. Blood sampling piglets instead of sows could have certain advantages. Blood samples can be collected from piglets without stressing the sow or piglet; it is quicker and as a result cheaper. Where piglets have consumed colostrum it can be anticipated that the serological status of the piglet would be similar to that of its dam. This study compares the results of piglet serology with that of sow serology as a method of monitoring herd AD status (Plate 1).

**PLATE 1: A METHOD OF BLOOD-SAMPLING A PIGLET AND SOW**



**MATERIALS AND METHODS.**

Paired blood samples were taken from lactating sows and one of their piglets aged between one and four weeks. A heavier piglet in each litter was selected for testing, in order to reduce the risk of testing colostrum-deprived or fostered piglets.

The blood samples were identified with the sow's ear tag number and further identified as a sow or piglet sample, as appropriate. A total of 280 paired blood samples were taken from 19 herds. Blood samples were centrifuged at 3000rpm for 10 minutes and tested by the Idexx[1] Aujeszky's G1 antibody test. Serum samples from the sow and her piglet were tested on the same microtitre plate.

**RESULTS.**

The herd AD disease test results for 19 herds are presented in Table 19. There was a 100% correlation between the results of sow and piglet serology on a herd basis, since both procedures identified 15 out of a total of 19 herds as AD disease positive.

Individual herd results are presented in Table 20, where a total of 77 sows and 76 piglets, respectively, were identified as positive, to give an overall correlation of 99%. The correlation between piglet and sow results was statistically significant on the chi squared test ($P<0.001$). However, a total of seven piglet samples gave different results to those of their dams. As a result, the AD status of 133 out of a total of 140 sows was correctly identified by piglet serology. This discrepancy could have been associated with transferring of piglets to foster dams. It is quite normal for stockmen to foster piglets after they have received their dam's colostrum in order to enhance the survival prospects of the smaller piglets in the litter. In the circumstances a small number of foster piglets may have been blood sampled, in which case their serological status might not be identical to that of their foster dam.

**CONCLUSION.**

On a herd basis there was a 100% correlation between the results of piglet serology and that of sow serology as a method of establishing the AD status of the 19 herds that were sampled. The variations in results that were experienced with seven of the samples could have been associated with the transferring of piglets to foster dams. These variable results would only be significant if it were attempted to relate the piglet test results to individual sows.

Depending on the layout of the sow housing, this system of blood sampling, if used in conjunction with random blood sampling of a small number of sows and selected gilts, offers a convenient method of serologically monitoring the AD status of pig herds for eradication purposes.

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1 [1]Idexx Corp, 100 Fore St., Portland Maine, 04101, U.S.A.

2

**TABLE 19: A comparison of Aujeszky's disease G1 antibody ELISA test results by herd**

| Herd No. | Sows | Piglets |
|---|---|---|
| 1 | + | + |
| 2 | + | + |
| 3 | + | + |
| 4 | - | - |
| 5 | + | + |
| 6 | + | + |
| 7 | + | + |
| 8 | + | + |
| 9 | + | + |
| 10 | + | + |
| 11 | + | + |
| 12 | + | + |
| 13 | + | + |
| 14 | + | + |
| 15 | - | - |
| 16 | - | - |
| 17 | + | + |
| 18 | - | - |
| 19 | + | + |
| **Total positive** | 15 | 15 |

+ = Positive, - = Negative

**TABLE 20: A Comparison of Aujeszky's disease G1 antibody ELISA test positive results in sows and piglets**

| | Total No. Tested | | No. positive | |
|---|---|---|---|---|
| **Herd No.** | **Sows** | **Piglets** | **Sows** | **Piglets** |
| 1 | 8 | 8 | 8 | 7 |
| 2 | 2 | 2 | 2 | 2 |
| 3 | 8 | 8 | 7 | 8 |
| 4 | 6 | 6 | 0 | 0 |
| 5 | 12 | 12 | 8 | 7 |
| 6 | 14 | 14 | 8 | 9 |
| 7 | 5 | 5 | 4 | 3 |
| 8 | 8 | 8 | 8 | 8 |
| 9 | 10 | 10 | 2 | 2 |
| 10 | 11 | 11 | 8 | 8 |
| 11 | 6 | 6 | 5 | 4 |
| 12 | 6 | 6 | 6 | 6 |
| 13 | 4 | 4 | 4 | 4 |
| 14 | 6 | 6 | 1 | 1 |
| 15 | 6 | 6 | 0 | 0 |
| 16 | 6 | 6 | 0 | 0 |
| 17 | 6 | 6 | 2 | 2 |
| 18 | 6 | 6 | 0 | 0 |
| 19 | 10 | 10 | 4 | 5 |
| **Total** | 140 | 140 | 77 | 76 |

## 3.3 A COMPARISON OF MEAT JUICE WITH SERUM AS A METHOD OF ESTABLISHING THE AUJESZKY'S DISEASE STATUS OF PIG HERDS

**INTRODUCTION.**

A number of studies have been conducted in order to establish if meat juice samples could provide a suitable alternative to serum for serological detection of a range of diseases in pig herds, thus providing a convenient method of monitoring herds for the presence of such diseases without resorting to blood sampling.

In a study conducted by Kapel *et al* (1998), the antibody response after experimental infection of pigs with *Trichinella spiralis*, *T. britovi* and *T. nativa* was recorded. High antibody responses were found in all experimental groups including pigs in which no muscle larvae were recovered. The strong and consistent antibody response found with meat juice indicates the usefulness of this material where a blood sample is not available or where it is more convenient to conduct the assays on meat juice from slaughterhouse materials rather than blood samples. Wingstrand *et al* (1997) experimentally infected pigs with *Toxoplasma gondii* and analysed meat juice samples and serum. They then compared the ELISA test results on meat juice samples with that of serum and recorded that meat juice samples provided a suitable alternative to serum for serological detection of Toxoplasma infection in pigs. Mortensen *et al* (2001) monitored PRRS virus infection status in pig herds by conducting ELISA tests on meat juice samples and then comparing the results with that of blood samples collected from the same herds. A total of 18 herds were classified as PRRS negative by both test systems and 29 as PRRS sero-positive, thus an acceptable level of herd classification accuracy was achieved using this test. Lunden *et al* (2002) used a meat juice ELISA test to conduct a serological study of Swedish pigs for Toxoplasma antibodies, in which he found a 5.2% prevalence of sero-positives.

Meat juice is currently used for the detection of *Salmonella* antibodies by the Mix ELISA test. The objective of the study was to establish if the ELISA test could be modified to give comparable results on meat juice to that of serum so that meat juice could provide a low cost method of monitoring the AD status of pig herds.

The test must correctly classify the AD status on a herd basis, therefore, it should not classify any AD-free herds as positive (high specificity) and the sensitivity of the test should be such that few false negative results occur in positive herds (high sensitivity). The study was divided into two phases. The objective of phase 1 was to devise a procedure which would give acceptable sensitivity and specificity in a small number of herds. The objective of phase 2 was to use the new procedure in nine herds of varying AD status and to further refine the procedure, if necessary.

## 3.2.1 A COMPARISON OF MEAT JUICE WITH SERUM AS A METHOD OF ESTABLISHING THE AUJESZKY'S DISEASE STATUS OF PIG HERDS : PRELIMINARY STUDIES

### MATERIALS AND METHODS.

The AD status of the positive herd was verified by conducting an ELISA test on blood samples taken at slaughter using the Idexx G1 antibody ELISA test kit. Herds two and three were known to be negative for AD based on clinical freedom and regular serological monitoring of sows. Pigs selected from all three herds for the trial were tagged before slaughter. Pigs were identified using metal tags inserted in their ears. Metal tags were chosen to ensure they survived heat treatment during processing. A blood sample was taken from all pigs selected for trial at slaughter and the samples identified by herd and tag number. A muscle sample was then taken from the corresponding carcass identified by the metal tag and labelled with the herd number and tag number. The samples were then transferred to the laboratory for testing. All blood samples were centrifuged and the serum analysed for AD antibodies using the Idexx G1 antibody ELISA test kit. The procedure followed was as outlined in the kit, with serum samples diluted 50:50 and incubated for one hour at room temperature. Meat juice was extracted from the muscle samples following freezing and thawing. The meat juice samples were analysed using the Idexx G1 antibody ELISA test kit at the following concentrations ;

Concentrated meat juice.
Meat juice, 75% concentration.
Meat juice, 50% concentration.
Meat juice, 25% concentration.
Meat juice, 10% concentration.

All meat juice samples were incubated overnight at 2-7$^{o}$C in accordance with Idexx recommendations. A number of samples were also analysed at a concentration of 25% meat juice with one hour incubation at room temperature ie. without overnight incubation. It was found that the sensitivity was too low without overnight incubation and therefore this procedure was abandoned.

The actual result for each test in terms of being positive, negative or inconclusive was determined by comparison with the positive and negative control in the Idexx kit which was included in each test batch. The positive and negative controls were also used as the controls in the test of meat juice. The Abbotstown (DAF, Dublin) positive control sample was included in each test batch. The cut-off point for positive, negative and inconclusive on each test run was relative to the negative control for that test run as defined in the Idexx test procedure.

**RESULTS.**

Detailed results are presented in Appendix 4.1 and summaries of numbers tested, percentage positive, inconclusive and negative for serum and the paired meat juice samples, at different concentrations, for the positive and negative herds are presented in Tables 21 and 22.

In the positive herd a concentration of 10% meat juice resulted in the highest percentage of false negatives, whilst higher concentrations of meat juice resulted in an increase in the level of false positives. Test results at a concentration of 25% meat juice gave results which most closely resembled those of serum. Similarly, in AD negative herds the percentage of false positives (and inconclusives) increased with increasing concentrations of meat juice. No false positives were recorded at a concentration of 25% meat juice. A concentration of 25% meat juice produced results which most closely satisfied the objectives of the preliminary study (Fig. 8).

**TABLE 21: A comparison of Aujeszky's disease G1 antibody ELISA test results in serum and meat juice: Aujeszky's disease positive herd**

| | **Serum** | | **Juice undiluted** | | **Juice 75% conc.** | | **Juice 50% conc.** | | **Juice 25% conc.** | | **Juice 10% conc.** | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **No.** | **%** | **No.** | **%** | **No.** | **%** | **No.** | **%** | **No.** | **%** | **No.** | **%** |
| Tested | 64 | | 64 | | 64 | | 64 | | 61 | | 56 | |
| Positive | 51 | 79.7 | 60 | 93.8 | 61 | 95.3 | 60 | 93.8 | 52 | 85.2 | 31 | 55.4 |
| Inconclusive | 0 | 0 | 2 | 3.1 | 2 | 3.1 | 2 | 3.1 | 4 | 6.6 | 7 | 12.5 |
| Negative | 13 | 20.3 | 2 | 3.1 | 1 | 1.6 | 2 | 3.1 | 5 | 8.2 | 18 | 32.1 |

conc. = concentration

**TABLE 22: A comparison of Aujeszky's disease G1 antibody ELISA test results in serum and meat juice: Aujeszky's disease free herds**

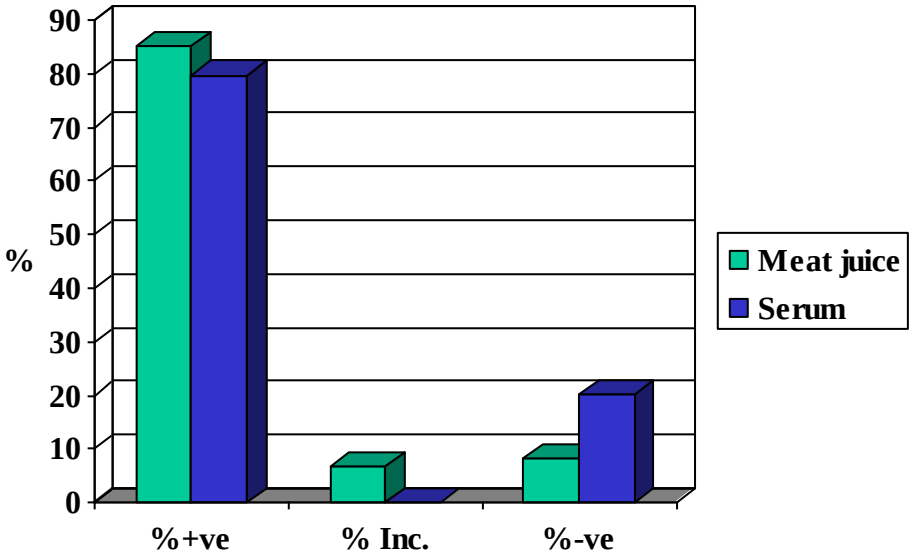
| | **Serum** | | **Juice Undiluted** | | **Juice 75% conc.** | | **Juice 50% conc.** | | **Juice 25% conc.** | | **Juice 10% conc.** | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **No.** | **%** | **No.** | **%** | **No.** | **%** | **No.** | **%** | **No.** | **%** | **No.** | **%** |
| Tested | 21 | | 21 | | 21 | | 21 | | 21 | | 20 | |
| Positive | 0 | 0 | 2 | 9.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Inconclusive | 0 | 0 | 1 | 4.8 | 1 | 4.8 | 3 | 14.3 | 1 | 4.8 | 0 | 0 |
| Negative | 21 | 100 | 18 | 85.7 | 20 | 95.2 | 18 | 85.7 | 20 | 95.2 | 20 | 100 |

conc. = concentration

**CONCLUSIONS.**

Since false positives (and inconclusives ) were identified at concentrations of meat juice undiluted, 75% meat juice and 50% meat juice in the AD free herds, and false negatives increased in the AD positive herd at a concentration of 10% meat juice, it was concluded that a concentration of 25% meat juice combined with overnight incubation produced results which satisfied the objectives of the study in that it was at least as sensitive as serum in an AD positive herd and gave no false positive results in two AD free herds.

**Fig. 8: A COMPARISON OF AUJESZKY'S DISEASE G1 ANTIBODY ELISA TEST RESULTS OF SERUM AND MEAT JUICE (25% CONCENTRATION) IN AN AUJESZKY'S DISEASE POSITIVE HERD**




### 3.2.2 A COMPARISON OF MEAT JUICE WITH SERUM AS A METHOD OF ESTABLISHING THE AUJESZKY'S DISEASE STATUS OF PIG HERDS : FOLLOW UP STUDIES

**INTRODUCTION.**

In phase 1 of this study it was concluded that a concentration of 25% meat juice gave the closest correlation to that of serum in the ELISA test. However, this work was only carried out on three herds, two of which were free of AD. The objective of phase 2 of this study was to use the modified AD G1 antibody ELISA test, developed in phase 1, on samples from nine herds of varying AD status in order to establish if it would satisfy the original objectives of the study, as follows:

The test must correctly classify the AD status on a herd basis, therefore, it should not classify any AD-free herds as positive (high specificity) and the sensitivity of the test should be such that few false negative results occur in positive herds (high sensitivity).

Samples from nine herds were used in phase 2 of this study. Paired muscle and serum samples were collected at the slaughterhouse. Four of the selected herds had a history of AD freedom, based on clinical and serological tests. The AD status of a further four herds was unknown. The remaining herd selected for the study was positive for AD. The samples were labelled and transferred to the laboratory. Ten samples per herd were taken from all herds except the known AD positive herd from which 20 samples were taken, to a total of 100 samples.

## MATERIALS AND METHODS.

Serum samples were analysed for AD antibodies using the Idexx G1 antibody ELISA test kit. The procedures outlined in the test kit were followed. The first 80 serum samples were incubated for one hour at room temperature in accordance with the original procedure described in the Idexx test kit. The final 20 sera samples were diluted 50:50 and incubated overnight at 2-7$^{o}$C in accordance with the alternative procedure described in the Idexx test kit. Meat juice was extracted from the muscle samples following freezing and thawing. The meat juice samples were analysed by the same Idexx G1 antibody ELISA test kit. The first 80 samples were analysed using the modified protocol developed in the preliminary studies ie. 25% meat juice and 75% diluent incubated overnight at 2-7$^{o}$C followed by one hour incubation at room temperature.

## RESULTS.

The detailed results of the first 80 serum samples and the corresponding meat juice samples are presented in Appendix 4.2 and summarised in Table 23. A total of six false positive and 18 inconclusive test results were recorded for meat juice samples, as compared with serum . As a result it was deemed necessary to further modify the test procedure.

**Table 23: A comparison of Aujeszky's disease G1 antibody ELISA test results in serum and meat juice: based on herd Aujeszky's disease status.**

| | Positive herd | | Unknown herds | | Negative herds | |
|---|---|---|---|---|---|---|
| | **Serum** | **Meat juice** | **Serum** | **Meat juice** | **Serum** | **Meat juice** |
| No.Positive | 20 | 20 | 1 | 5 | 0 | 2 |
| No. Inconclusive | 0 | 0 | 0 | 13 | 0 | 5 |
| No. Negative | 0 | 0 | 39 | 22 | 20 | 13 |
| **Total** | 20 | 20 | 40 | 40 | 20 | 20 |

## MODIFIED ELISA TEST METHOD.

Four of the false positive, six inconclusive and four positive samples were retested at concentrations of 20% and 15% meat juice respectively. The same procedure was followed ie. incubation overnight at 2-7$^{o}$C followed by one hour incubation at room temperature. Detailed results are presented in Appendix 4.3 and summarised in Table 24. Using the above test procedure the false positives became inconclusive and positive samples in the positive herd remained positive. However, a high number of samples continued to give an inconclusive test result. So, a further modification was made to the test procedure by repeating it on the selected samples, using overnight incubation at 2-7$^{o}$C, but omitting the one hour incubation in the morning at room temperature. Detailed results are presented in Appendix 4.4 and summarised in Table 25.

**Table 24: A comparison of Aujeszky's disease G1 antibody ELISA test results in serum and meat juice at variable concentrations of meat juice, on samples giving inconsistent results.**

| | Serum | Meat juice 20% | Meat juice 15% |
|---|---|---|---|
| No. Positive | 4 | 4 | 4 |
| No. Inconclusive | 0 | 8 | 8 |
| No. Negative | 10 | 2 | 2 |
| **Total** | 14 | 14 | 14 |

**Table 25: A comparison of Aujeszky's disease G1 antibody ELISA test results in serum and meat juice, at variable concentrations of meat juice, with overnight incubation only.**

| | Serum | Meat juice 20%, Overnight incubation only | Meat juice 15%, Overnight incubation only |
|---|---|---|---|
| No. Positive | 4 | 3 | 3 |
| No. Inconclusive | 0 | 1 | 1 |
| No. Negative | 10 | 10 | 10 |
| **Total** | 14 | 14 | 14 |

By following the above procedure in which the one hour incubation was omitted the inconclusive samples became negative, three out of four positive samples in the positive herd remained positive and the 4th became inconclusive. This occurred at meat juice concentrations of 15% and 20%.

Since the original studies were conducted at a concentration of 25% meat juice and the omission of a one hour incubation period at room temperature resolved the inconclusive problem the same 14 samples were again tested at a concentration of 25% meat juice, with overnight incubation at 2-7$^{o}$C and no further incubation at room temperature. Detailed results are presented in Appendix 4.5 and summarised in Table 26. Using this procedure there was a 100% correlation between the meat juice and serum test results.

**Table 26: A comparison of Aujeszky's disease ELISA test results between serum and meat juice (25%), with overnight incubation only.**

| | Serum | Meat juice 25%, Overnight incubation only |
|---|---|---|
| No. Positive | 4 | 4 |
| No. Inconclusive | 0 | 0 |
| No. Negative | 10 | 10 |
| **Total** | 14 | 14 |

Finally 100 meat juice samples were tested following the above procedure ie. 25% meat juice incubated overnight at 2 - 7$^{o}$C with no further incubation at room temperature.

**RESULTS.**

Detailed results for 100 sera samples and 100 meat juice samples from all nine herds, in which meat juice was tested at a concentration of 25% with overnight incubation only at 2-7$^{o}$C., are presented in Appendix 4.6 and

summarised in Tables 27, 28, 29 and Fig. 9. All samples in the negative herds produced negative results on the serum and meat juice tests. Of the 20 samples tested from the AD positive herd all 20 sera gave a positive result, compared with 17 meat juice; the balance of three meat juice samples gave an inconclusive result. All samples from three herds of unknown AD status gave negative results on sera and meat juice; in the fourth herd nine sera gave a negative and one a positive test result compared with eight and two of the paired meat juice samples.

**Table 27: A comparison of Aujeszky's disease G1 antibody ELISA test results in serum and meat juice: Aujeszky's disease positive herd**

| | Serum | | Meat juice 25% conc. | |
|---|---|---|---|---|
| | No. | % | No. | % |
| Tested | 20 | | 20 | |
| Positive | 20 | 100 | 17 | 85 |
| Inconclusive | 0 | 0 | 3 | 15 |
| Negative | 0 | 0 | 0 | 0 |

**Table 28: A comparison of Aujeszky's disease G1 antibody ELISA test results in serum and meat juice, in four herds, unknown Aujeszky's disease status.**

| | Serum | | Meat juice 25% conc. | |
|---|---|---|---|---|
| | No. | % | No. | % |
| Tested | 40 | | 40 | |
| Positive | 1 | 2.5 | 2 | 5 |
| Inconclusive | 0 | 0 | 0 | 0 |
| Negative | 39 | 97.5 | 38 | 95 |

**Fig. 9: A COMPARISON OF AUJESZKY'S DISEASE (AD) G1 ANTIBODY ELISA TEST RESULTS IN SERUM AND MEAT JUICE, IN NINE HERDS**

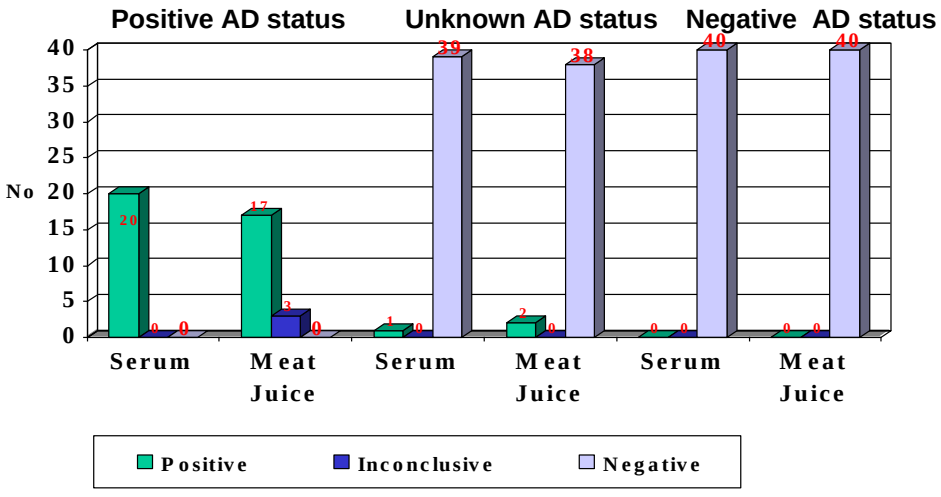
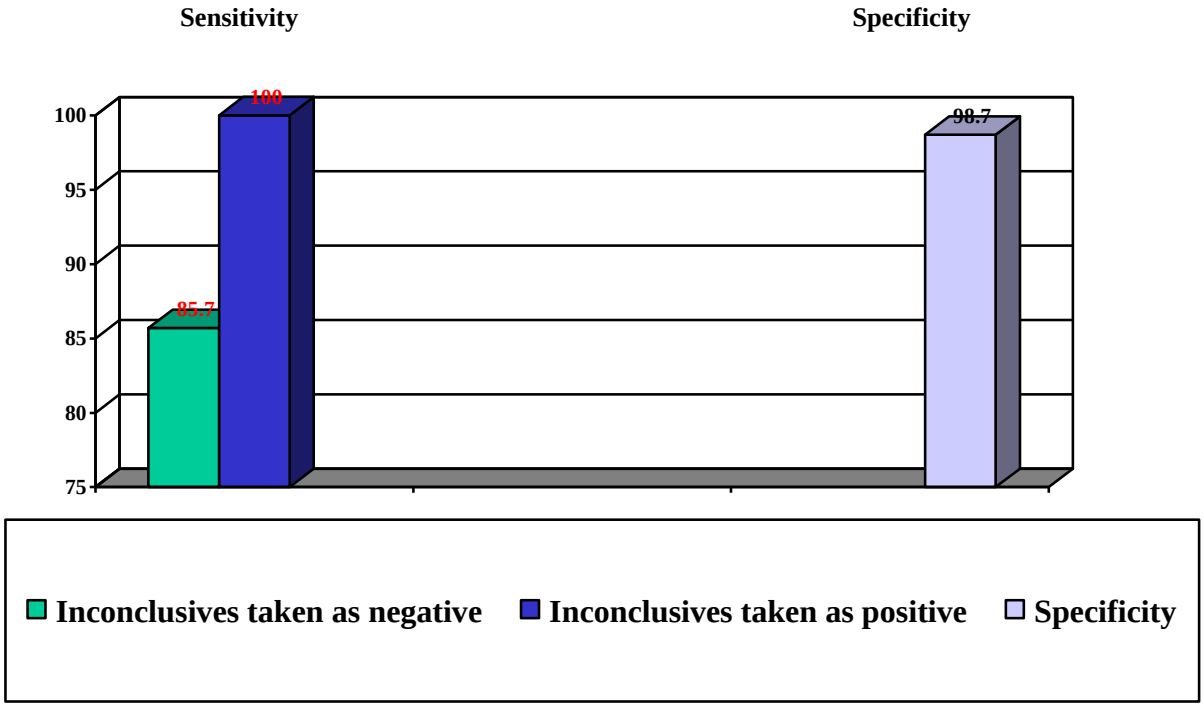


**Table 29: A comparison of Aujeszky's disease G1 antibody ELISA test results in serum and meat juice, in four herds, negative Aujeszky's disease status.**

| | Serum | | Meat juice 25% conc. | |
|---|---|---|---|---|
| | No. | % | No. | % |
| Tested | 40 | | 40 | |
| Positive | 0 | 0 | 0 | 0 |
| Inconclusive | 0 | 0 | 0 | 0 |
| Negative | 40 | 100 | 40 | 100 |

The sensitivity of meat juice versus serum, which is defined as the percentage of positive serum samples giving a positive result on the meat juice test under investigation was 85.7% if inconclusive samples are interpreted as negative, or 100% if inconclusive samples are interpreted as positive. The specificity which is defined as the percentage of negative serum samples giving a negative result on the meat juice test under investigation was 98.7% (Fig. 10), however, meat juice ELISA achieved a 100% specificity in the AD negative herds in which no false positive results were recorded.

**Fig. 10: THE SENSITIVITY AND SPECIFICITY OF THE MEAT JUICE ELISA TEST.**




**CONCLUSION**

Since the meat juice ELISA test gave comparable results to that of serum, meat juice could replace serum and provide a low cost method of monitoring the AD status of pig herds Serum

continues to be the method of choice of sampling live animals for the purpose of establishing their individual AD staus.

## 3.4 EPIDEMIOLOGICAL STUDIES OF AUJESZKY'S DISEASE: ERADICATION FROM A MULTIPLE HERD ENTERPRISE

**INTRODUCTION.**

Aujeszky's disease (AD), or Pseudorabies was first reported in the United States in 1813 and with the intensification of the pig industries world-wide in the 1960's, AD was recognised as one which had a major impact on pig health and production efficiency. Subsequently, in the 1980's, AD eradication programmes were introduced in the U.S.A and many European countries. Initially, eradication programmes were based on identification of AD positive herds followed by slaughter. This system was adopted in Great Britain and Denmark. With the development of live adjuvanted vaccines shedding of AD virus was virtually eliminated in vaccinated animals. The differentiation of animals infected by field virus from those with vaccinal antibodies was facilitated by the development of Glycoprotein one (G1) negative vaccines. The genome of AD virus consists of identifiable genes which code for a variety of structural glycoproteins on the surface of the virus. One such glycoprotein is called glycoprotein One (G1). G1 is a virulence factor. Viruses which do not posses the G1 protein are termed G1 deleted or G 1 negative and are normally non pathogenic.

The development of G1 negative AD vaccines was accompanied by the introduction of a selective ELISA test which facilitated the differentiation of pigs infected with AD field virus from AD-free pigs vaccinated against AD with G1 negative vaccines. The modern National AD eradication programmes are based on the principal of vaccinating the herd with AD vaccine to prevent virus shedding and then monitoring the herd for virus circulation by regular sampling of animals and testing with the G1 antibody ELISA test. Over a period of time as AD free replacement breeding stock are introduced to the AD positive herd, provided they are vaccinated, (low level of virus shedding), the number of animals within the herd which are positive for the AD field virus decreases over a two to three year period until eventually the herd becomes free from AD. In the Netherlands where a National AD eradication programme has been operational for a number of years Elbers *et al* (2000) reported that the proportion of sow herds that were certified AD free increased steadily from approximately 40% in 1996 to 96% in 1999.

Aujeszky’s disease, as a clinical entity, in Ireland, almost ceased in association with the introduction of AD live vaccine in 1994. The objective of the first part of this study was to examine the ability of inactivated AD vaccine, administered to breeding stock twice yearly, to eliminate the virus from pig herds and to review factors which may have contributed to the survival and dissemination of the virus within and between farms. The epidemiological data collected from the practice AD survey was used to design an AD eradication programme for a 12,000 multi-source finishing unit. The objective was to eliminate the virus from the farm and the supplying breeding units and to compare unit production efficiency when AD was endemic, with that achieved after it was eradicated, with a view to estimating the cost of endemic AD to a multi-source finishing unit. Muirhead (1983) examined the total cost of an AD outbreak in four herds and concluded that the cost of the

disease varied from € 11,900 to € 26,700 per 100 sow herd size depending on its severity in individual herds. Kavanagh (1984) conducted an investigation into the cost of an AD outbreak in a 370 sow herd selling finishers and estimated the total cost of an outbreak of the disease at € 43,000 or € 11,400 per 100 sows.

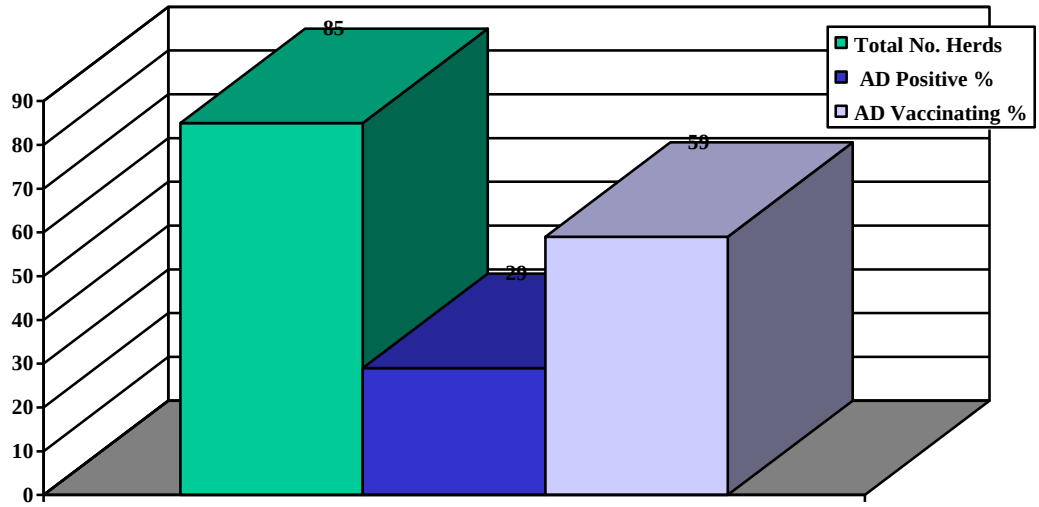
## THE PRACTICE SURVEY.

The survey involved random serological testing of 25 - 30 adult breeding stock per herd by the Idexx[2] G1 antibody test in 1992. Herds which were vaccinating against AD used inactivated vaccine; free of the G1 antibody. A database was set up to co-ordinate herd statistics that were considered relevant to the eradication or dissemination of AD virus.

### Practice survey results.

10.6% of samples gave a positive result on the Idexx G1 antibody ELISA test and 29% of herds were identified as sero-positive (Fig. 11).

**Fig. 11: THE PREVALENCE OF AUJESZKY'S DISEASE (AD) SERO-POSITIVE HERDS IN THE PRACTICE IN 1992**




Sixty percent of herds regularly vaccinated against AD on a twice yearly basis. Fifty three percent of herds used home reared gilts as replacements and 37% purchased health monitored gilts from herds which were known to be free of AD. It was encouraging to note that only eight herds (9.4%) purchased gilts from sources which were not health monitored (Table 30). This is in marked contrast to the situation that prevailed in the Diesen trial in the Netherlands where, in the initial stage, the majority of replacement breeding stock were of unknown health



[2]Idexx Corp, 100 Fore St., Portland Maine, 0401, U.S.A.

status and probably AD positive (Stegeman and Kimman, 1992). Of the 25 herds which proved sero-positive to AD only 19 were vaccinating so six were at risk of a major AD outbreak (Table 31).

**TABLE 30: Aujeszky's disease survey; practice herd statistics**

| | No. Herds | Positive % | Vaccinating % | MD %[a] | HRG %[b] | HMG %[c] | Other % |
|---|---|---|---|---|---|---|---|
| Total | 85 | 29 | 59 | 27 | 53 | 37 | 9.4 |
| BW[d] | 47 | 27 | 51 | 25 | 47 | 43 | 10.6 |
| BF[e] | 38 | 31 | 68 | 29 | 61 | 32 | 7.9 |

[a] Minimal disease (SPF) [b] Home reared gilts [c] Health monitored gilts
[d] Breeder weaner [e] Breeder finisher

**Aujeszky's disease eradication with vaccination.**

Seven herds, varying in size from 70 to 900 sows, which had a positive clinical and serological history of AD proved serologically negative in the survey, suggesting that AD had been eradicated in association with the vaccination and management procedures which had been adopted over the previous 10 years.

Eradication of AD was not achieved in a total of four out of seven breeding herds which were vaccinating and selling weaners at approximately 32 kg bodyweight, indicating that successful eradication of AD by vaccination alone was not achieved even when no finishers were present on the farm.

**Aujeszky's disease dissemination to AD free farms**.

One AD positive farm was associated with the spread of the disease to five farms that were previously free of the disease through the sale of sero-positive replacement gilts. The farmers in question, who were unaware that their stock were sero-positive, were not vaccinating for AD and as a result were at risk of a major outbreak of the disease (Table 31). A sixth farm, which purchased gilts from an MD herd, seroconverted to AD without developing clinical signs of the disease. The probable source of the AD virus in this case was from a multi-source finishing unit belonging to the same organisation. The breeding stock on this farm were vaccinated at six-monthly intervals, demonstrating that the virus can circulate in the presence of the above vaccination regime.

**TABLE 31: Aujeszky's disease vaccination in Aujeszky's disease positive herds**

| | No.+ve herds | No. +ve herds vaccinated | No.+ve herds unvaccinated |
|---|---|---|---|
| Total | 25 | 19 | 6 |
| BW[a] | 13 | 7 | 6 |
| BF[b] | 12 | 12 | 0 |

[a] Breeder Weaner [b] Breeder Finisher

**Herds with a sero-positive prevalence >/= 15%.**

Nineteen herds were identified by this system, 13 of which were vaccinating regularly, suggesting that twice yearly vaccination of breeding stock was capable of controlling the clinical signs of AD but failed to eradicate the virus from the farm. Four of the problem herds purchased health monitored gilts or MD gilts. Ten herds used home-reared gilts which increased the risk of virus circulating in them before they reached maturity as replacement stock. Five herds purchased replacement breeding stock of unknown health status (Table 32).

**TABLE 32: Aujeszky's disease survey of herds a sero-positive prevalence >/= 15%**

| | No. herds | No. sows | Mean herd size | Vac[a] | HRG | HMG | Other |
|---|---|---|---|---|---|---|---|
| Total | 19 | 6,945 | 365 | 13 | 10 | 4 | 5 |
| BW[b] | 10 | 3,845 | 385 | 4 | 5 | 2 | 2 |
| BF[c] | 9 | 3,100 | 344 | 9 | 5 | 2 | 3 |

[a] Aujeszky's disease vaccinated [b] Breeder Weaner [c] Breeder Finisher
HRG= Home reared gilts, HMG = Health monitored gilts, Other = Unknown health status

**CONCLUSIONS OF THE PRACTICE SURVEY.**

1 Twice-yearly vaccination of breeding stock with inactivated AD vaccines controlled the clinical signs of AD but failed to eradicate the virus from the farm. This also applied in breeder weaner units, where no finishers were present, since eradication of AD was not achieved in four out of seven breeding herds which were vaccinating breeding stock and selling weaners at a weight of approximately 32 kg.

2 There is a risk of sero conversion occurring in home reared replacement breeding stock, so they should be reared in isolation from the grower stage and vaccinated twice as growers and a third time before they reach six months of age.

3 Where replacement breeding stock are purchased they should only be purchased from sources that are health monitored and known to be free of AD. Indeed, failure to follow this procedure was the major cause of Aujeszky's disease spread in the practice herds between 1984 and 1992. Purchased sero negative replacement breeding stock should be quarantined and fully immunised against Aujeszky's disease before being introduced to the breeding herd, thus reducing the risk that they could sero convert to the virus.

4 Identification of herds in which the virus was circulating should be accompanied by on-farm investigations of management, housing, systems of pig movement, and identification of areas in which the virus was circulating. The objective was to maximise the probability of eliminating circulating Aujeszky's disease virus from the farm in the shortest practical time in conjunction with intensive vaccination and culling of sero-positive animals, otherwise virus shedding may continue in the presence of vaccination.

**ERADICATION OF AUJESZKY'S DISEASE FROM A 12,000 PLACE MULTI-SOURCE PIG FINISHING UNIT**

Weaners were sourced from 23 breeding herds. Blood-testing of pigs in the finishing unit and at slaughter by the G1 antibody ELISA test for AD gave a positive result on almost all pigs tested, so it was concluded that AD virus was continually circulating in the finishing unit (Table 35). A decision to attempt AD eradication from the farm was prompted by the presence of persistent respiratory disease problems in pigs on it; the objective was to eliminate a known disease and then to establish if other complicating diseases would become less problematic.

The results of the 1992 practice AD survey were used to identify AD positive suppliers; a random serological survey of weaners derived from all suppliers (June 1994) identified herds with circulating virus (Table 33). "Problem" suppliers (herds in which the virus was circulating) were identified by random sampling of pigs from all suppliers on arrival in the finishing unit. Of the eight AD positive suppliers two were categorised as positive for circulating virus (Table 33).

**TABLE 33: The prevalence of Aujeszky's disease sero-positive supplying farms in 1992 (sows) and in 1994 (weaners)**

| | Sows (1992) | Weaners (1994) |
|---|---|---|
| No. Farms | 23 | 23 |
| No. Positive | 8 | 2 |

All suppliers were advised to purchase replacement breeding stock from AD-free sources and to isolate and vaccinate them on arrival so they were immune to AD before being introduced to the herd.

"Problem" suppliers were advised to vaccinate weaners at 8 - 10 weeks of age; a booster injection was administered on arrival in the finishing unit. Pigs were vaccinated with a live AD vaccine, Intervet[3] Aujeszky's Live Begonia. All other pigs were vaccinated on arrival in the finishing unit. Home reared gilts were vaccinated at 8 - 10 weeks of age, 14 weeks and again at six months. Sows, boars and replacement gilts were vaccinated three times per annum. In each case the dosage rate was 2ml.

**Monitoring AD eradication progress.**

When the programme was set up on the 1st July of 1994, the AD status of pigs derived from AD "problem" supplying herds was monitored over the following six months by blood sampling random pigs on arrival in the finishing unit in order to check for the presence of circulating virus (Table 34). By October 1994, three months after the introduction of weaner vaccination to "problem" supplier farms, virus circulation had ceased. Also,



[3]Intervet Scandinavia AS, 5 Roennegade, 2100 Copenhagen, Denmark.

blood-samples from random weaners derived from all supplying farms were tested in October 1994 and again in December 1994, with negative results.

**TABLE 34: The prevalence of Aujeszky's disease sero-positives in pigs derived from farms with circulating Aujeszky's disease virus**

| Date | No. tested | No. positive |
|---|---|---|
| 01/06/94 | 6 | 4 |
| 01/06/94 | 6 | 4 |
| 06/10/94 | 6 | 0 |
| 31/10/94 | 6 | 0 |
| 21/12/94 | 6 | 0 |
| 22/12/94 | 6 | 0 |
| 20/01/95 | 6 | 0 |
| 20/01/95 | 6 | 0 |
| 20/01/95 | 6 | 0 |

**The response to vaccination.**

The prevalence of AD sero-positives in pigs slaughtered fell from 96% before the commencement of vaccination on July 1st 1994 (Table 35) to 15% in October 1994, three months later (Table 36). By November 1994, four months after the introduction of vaccination in the finishing unit, all serum samples tested were negative for AD and have remained so since then (Fig. 12). The changes in sero-positive incidence were statistically analysed by the chi square test ($P< 0.001$).

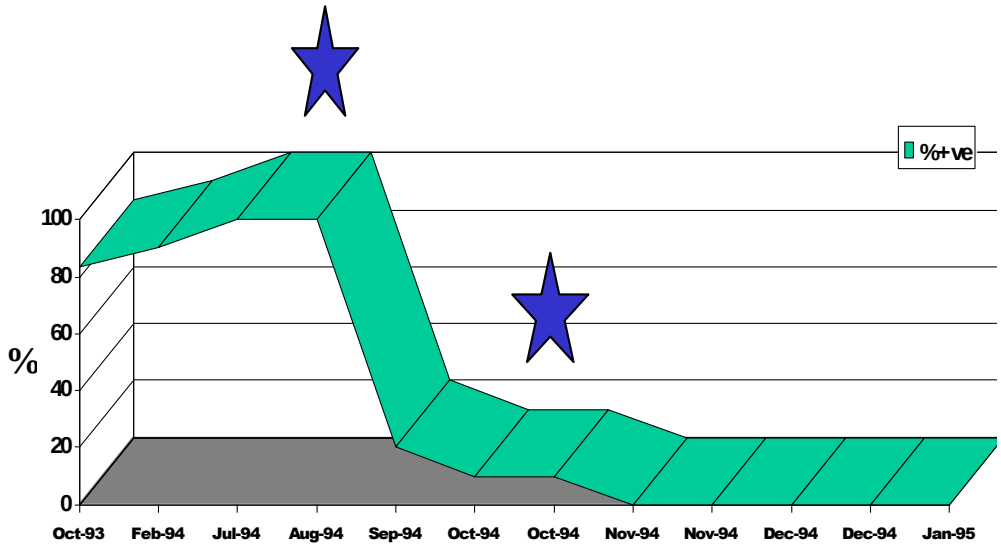
**TABLE 35: The prevalence of Aujeszky's disease sero-positives before vaccination in a 12,000 pig finishing unit**

| Date | No. tested | No. positive | % positive |
|---|---|---|---|
| 21/10/93 | 6 | 5 | 83.3 |
| 26/02/94 | 10 | 9 | 90 |
| 13/07/94 | 16 | 16 | 100 |
| 11/08/94 | 18 | 18 | 100 |
| **Total** | **50** | **48** | **96** |

**TABLE 36: The prevalence of Aujeszky's disease sero-positives after vaccination in a 12,000 pig finishing unit**

| Date | No. tested | No. positive | % positive |
|---|---|---|---|
| 28/09/94 | 10 | 2 | 20 |
| 04/10/94 | 10 | 1 | 10 |
| 13/10/94 | 10 | 1 | 10 |
| 16/11/94 | 17 | 0 | 0 |
| 19/11/94 | 26 | 0 | 0 |
| 02/12/94 | 10 | 0 | 0 |
| 21/12/95 | 10 | 0 | 0 |
| 10/01/95 | 10 | 0 | 0 |
| **TOTAL** | 103 | 4 | 3.9 |

**Fig. 12: THE RESPONSE TO AUJESZKY'S DISEASE VACCINATION IN A 12,000 PLACE PIG FINISHING HERD IN 1994**




**Monitoring of vaccine usage on weaners in a supplier farm.**

The efficiency of weaner vaccination was monitored by subjecting bloodsamples to the total ELISA and G1 antibody test. A positive result to the total ELISA test and a negative result to the G1 antibody test confirmed that the pigs had been vaccinated against AD.

**Aujeszky's disease dissemination.**

One MD herd seroconverted to AD between July and October of 1994. It was interesting that this herd remained free of *Mycoplasma hyopneumoniae.* The source of the disease was most probably aerial spread from an AD positive breeding herd which is located approximately one mile distant from the herd in question. The changed AD serological status of this herd was identified on routine serology of random pigs in the finishing unit. Evidence of long distance airborne spread of AD has been presented by Christensen *et al*, (1990) in Denmark. Gloster *et al* (1984), in an investigation of 11 outbreaks of AD, suggested that seven out of 11 outbreaks of AD could have resulted from airborne spread.

**MODIFIED ERADICATION PROGRAMME**.

The programme was modified on January 1st, 1995 since AD virus circulation had ceased on all supplying farms and all pigs tested in the finishing herd over the previous two months had given negative results.

**Breeding stock vaccination.**

All breeding stock were vaccinated three times per year.

**Weaner vaccination.**

Weaner vaccination was restricted to "problem" supplier farms; at 8 to 10 weeks of age and again on arrival in the finishing unit.

**Register of approved breeding stock suppliers.**

Purchase of breeding stock was restricted to approved suppliers, based on negative AD test results on a minimum of 25 adult (or equivalent) breeding stock at six-monthly intervals. A copy of the declaration, declaring clinical and serological freedom from AD was furnished by the unit's veterinarian and the list of approved suppliers maintained in the finishing unit.

**Testing of AD sero-positive units.**

Aujeszky's disease sero-positive units submitted colostrum or translet[#] samples from all sows of parity five or greater for the AD G1 antibody ELISA test. Initially, colostrum samples were collected shortly after farrowing. Subsequently, "translet" samples were collected from an ear vein. The "translet" aspirates approximately a 50 micro litre sample volume by capillary action. All samples were tested on the G1 antibody ELISA test. Aujeszky's disease sero-positive sows were culled at weaning.

**Serological testing of weaners.**

A random serological survey of weaners derived from all suppliers was conducted at six-monthly intervals.

**RESULTS.**

1. No sero-positive pigs were identified on routine serological monitoring of slaughter pigs, subsequent to October 1994, a period of four months after the commencement of vaccination.

2. Circulating AD virus was eliminated from all supplying farms within four months of the date of commencement of vaccination.

[#] L.C. Trading65 BV, Postbus, 410, 1800AK Alkmaar, Netherlands.

3. A further serological survey of all supplying farms was conducted in January 1995 using the procedure described by Kavanagh (1994b) where he reported that the AD serological status of sows could be determined by the simple and cost effective technique of blood sampling one of their piglets. The time and effort involved in sampling was reduced by blood-sampling one piglet per litter of selected lactating, random pregnant sows and replacement gilts. The survey results indicated that the number of AD sero-positive sow units had reduced from eight to four (Table 37).

**TABLE 37: The prevalence of Aujeszky's disease sero-positive supplier herds in 1995**

| | No. farms | No. positive |
|---|---|---|
| Sows | 22 | 4 |
| Weaners | 22 | 0 |

4. Further serological monitoring of the four sero-positive supplying farms was conducted in September 1995, as follows:

All adult breeding stock were blood-tested in herd one and the owner advised to cull the sero-positives by April 1996.

Random testing of herds two, three and four (30 samples per herd) revealed that with the exception of one sample all sows of third parity or less gave negative results to the G1 antibody ELISA test. Based on the above results all sows of sixth parity or greater and those that gave a positive result on the G1 antibody ELISA test on colostrum were culled at weaning. Initially, colostrum sampling was chosen instead of blood-sampling because it offers an alternative, cheap and practical method of ascertaining the AD status of sows (Bouwkamp *et al*, 1992). However, since it was associated with occasional "false positive" test results it was replaced by "translet sampling". Subsequent serological monitoring of all supplying herds and the finishing herd gave negative results to AD.

## THE COST OF AD IN A 12,000 PLACE FINISHING UNIT

Key performance parameters were compared for the nine months period November 1993 to July 1994, when AD was endemic (Table 38), with a similar period from November 1994 to July 1995, when AD was absent from the herd (Table 39) and summarised in Table 40.

**TABLE 38: The performance of a 12,000 pig place finishing unit before Aujeszky's disease eradication**

| | Nov-93 | Dec-93 | Jan-94 | Feb-94 | Mar-94 | Apr-94 | May-94 | Jun-94 | Jul-94 |
|---|---|---|---|---|---|---|---|---|---|
| No. sold | 5,424 | 4,967 | 5,182 | 5,045 | 5,452 | 4,726 | 5,686 | 4,979 | 5,004 |
| Sale Weight (kg) | 77.2 | 77.3 | 80 | 76.3 | 77.4 | 78 | 77.7 | 75.7 | 76.3 |
| Purchase Weight (kg) | 38 | 37 | 37.9 | 36.7 | 36.9 | 37.6 | 37.4 | 36.6 | 37.5 |
| Weight gain (kg) | 39.2 | 40.3 | 42.1 | 39.4 | 40.7 | 40.4 | 40.3 | 41.1 | 38.8 |
| Food cost/kg gain (P) | 41.6 | 45 | 41.3 | 39.4 | 40 | 36.1 | 34.3 | 38.8 | 39.2 |
| Food cost/tonne (€) | 173 | 176.2 | 176.53 | 181.53 | 175.3 | 167.6 | 167.64 | 167.64 | 167.64 |
| Food conversion ratio | 2.97 | 3.19 | 3.04 | 2.8 | 2.85 | 3.06 | 2.6 | 2.94 | 2.97 |
| Food consumption/day(kg) | 1.87 | 1.83 | 1.88 | 1.74 | 1.8 | 1.75 | 1.7 | 1.64 | 1.65 |
| Daily liveweight gain(g) | 630 | 574 | 618 | 621 | 632 | 572 | 654 | 558 | 556 |
| Mortality % | 1 | 1.4 | 1.14 | 1.3 | 1 | 1.31 | 1.21 | 1 | 1.5 |

**TABLE 39: The performance of a 12,000 pig place finishing unit after Aujeszky's disease eradication**

| | Nov-94 | Dec-94 | Jan-95 | Feb-95 | Mar-95 | Apr-95 | May-95 | Jun-95 | Jul-95 |
|---|---|---|---|---|---|---|---|---|---|
| No. sold | 5,119 | 4,409 | 4,569 | 4,220 | 4,538 | 4,037 | 4,403 | 4,711 | 4,643 |
| Sale Weight (kg) | 79.9 | 81.2 | 83.2 | 82.9 | 83.2 | 83.8 | 84.2 | 84.1 | 82.5 |
| Purchase Weight (kg) | 39.1 | 38.2 | 38 | 36.7 | 36 | 35.7 | 36.7 | 36.6 | 36.8 |
| Weight gain (kg) | 40.8 | 43 | 45.2 | 46.2 | 47.2 | 48.1 | 47.5 | 47.5 | 45.7 |
| Food cost/kg gain (P) | 39 | 40.34 | 36.3 | 37.9 | 38.6 | 38.9 | 38.72 | 33.67 | 34.97 |
| Food cost/tonne (€) | 165.89 | 166.8 | 169.65 | 166.15 | 164.36 | 164.36 | 164.47 | 164.47 | 165.1 |
| Food conversion ratio | 2.97 | 3.05 | 2.87 | 2.81 | 2.92 | 3.01 | 2.99 | 2.6 | 2.69 |
| Food consumption/day (kg) | 1.97 | 1.74 | 1.76 | 1.81 | 1.86 | 1.77 | 1.85 | 1.7 | 1.65 |
| Daily liveweight gain (g) | 663 | 570 | 613 | 644 | 637 | 588 | 619 | 654 | 613 |
| Mortality % | 0.9 | 1.4 | 1.9 | 1.4 | 1.34 | 1.35 | 0.91 | 1.1 | 1.24 |

Seasonal variations in pig performance were accounted for by examining similar periods in each year. No significant change took place in the number of suppliers, which changed from 23 to 22 during the periods under examination. The weight of pig at purchase remained unchanged, however the weight at sale was 5 kg higher in the second period than the first. Medication costs were similar in both periods when the variation in weight gain per pig sold was taken into account. No significant enteric disease problems were experienced, however, there was an upsurge in the incidence of swine influenza during the first period, which continued through the second period.

The number of pigs sold during the second period was lower than in the first due to the increase in weight at sale. The 0.06 improvement in F.C.R. resulted in a reduction in costs of € 0.29 per pig, whilst the improvement in D.L.G. from 602g to 622g contributed a further € 0.29 per pig, to give a total reduction in costs of € 0.58 per pig. The estimated cost of AD on a per pig basis was € 0.013 per kg of bodyweight gain, or € 0.58 per pig. The cost of AD to the unit was € 32,000 per annum. The monthly F.C.R. and DLG figures, before and after AD eradication were statistically analysed by Paired t tests. The changes recorded were not statistically significant.

**TABLE 40: A comparison of unit performance before and after Aujeszky's disease eradication**

| | Before | After |
|---|---|---|
| No. sold | 46,465 | 41,041 |
| Sale Weight (kg) | 77.32 | 82.78 |
| Purchase Weight (kg) | 37.29 | 37.09 |
| Weight gain (kg) | 40.26 | 45.69 |
| Food cost/kg gain (€) | 50.2 | 47.75 |
| Food costs/tonne (€) | 170.75 | 165.7 |
| Food conversion ratio | 2.94 | 2.88 |
| Food consumption/day (kg) | 1.76 | 1.79 |
| Daily liveweight gain (g) | 602 | 622 |
| Mortality % | 1.21 | 1.28 |

## 3.5 CHANGES IN THE AUJESZKY'S DISEASE STATUS OF PRACTICE HERDS BETWEEN 1992 AND 2003

**INTRODUCTION.**

In 1992 a practice survey of breeding herds for the purpose of establishing the prevalence of AD was conducted. A further AD survey of practice breeding herds was conducted in 2003 as part of the National AD eradication programme (Table 41). The vaccination programme was altered in 1994 when live G1 antibody negative AD vaccine was introduced. All herds changed from the inactivated to live vaccine over a period of approximately 12 months following its introduction.

**MATERIALS AND METHODS**.

A total of 60 blood samples were collected from breeding herds selling weaners and 120 from breeding herds selling finishers, with 60 samples being taken from breeding stock and their progeny and 60 from finishers within the herd. In order to facilitate an accurate comparison of the 1992 results with that of 2003, the results of 70 breeding herds surveyed in 1992 were compared with the same herds in 2003 (Table 41). The balance of herds from the 1992 survey were eliminated from the study because records were not available.

The following classification system was adopted for the methods of eradication that were conducted:

1. Depopulation without restocking

2. Depopulation and restocking with MD stock.
3. Vaccination of breeding stock accompanied by all in all out production systems.
4. Vaccinating of breeding stock and growing pigs.
5. Vaccination of replacement gilts, only.
6. No action.

The DAF, in recognition of the research conducted by Kavanagh (1994b), where he demonstrated a 100% correlation between the results of piglet serology to that of sow serology as a method of establishing the AD status of pig herds, authorised sampling of one piglet per litter instead of blood sampling the sow. In the circumstances, in herds of 300 sows or greater, the majority of breeding stock samples could be taken from piglets in the farrowing area and the balance from random sows and replacement gilts of greater than six months of age in the dry sow and gilt areas. Samples were analysed for AD antibodies by the IDEXX G1 antibody ELISA test.

**RESULTS.**

In the 1992 survey 29% of the herds were deemed AD positive based on the results of the serological study . An intensive AD eradication programme was conducted in pig herds in the authors practice between 1992 and 2003. Herd size in the AD positive herds varied from 55 sows to 1200. Table 42 summarises the results of the changes in AD status of the 22 sero-positive herds between 1992-2003. The methods and results of AD eradication are summarised in Table 43. Two herds were depopulated and the units have remained vacant since then. In some cases disease eradication by depopulation and restocking with MD is the favoured option, particularly, when disease is endemic and unit location is such that the bio-security risk of reintroducing disease is at an acceptable level. Four herds fell into the above categories and so were depopulated and restocked with MD stock. All four herds have remained AD free since then. Approximately 60% of the herds opted for Aujeszky's diseases eradication programmes involving breeding stock vaccination combined with all in all out production systems, or, breeding stock and grower vaccination. Grower vaccination was introduced where there was evidence of AD virus circulation in pigs on the farm. A number of the supplying breeding units to the multi-source finishing herd from which AD was eradicated were included in these categories. Since AD positive replacement breeding stock played a major role in the spread of the disease prior to 1992 breeding stock replacements were restricted to health monitored AD free stock during the period of the eradication programme. One herd opted for replacement gilt vaccination only whilst AD was eradicated from two herds without any action being taken. The two herds involved were 150 sow units and both were breeding units selling weaners, where virus circulation spontaneously ceased

Aujeszky's disease was eradicated from all 22 AD positive herds in the period 1992-2003 (Table 43), so all herds in the authors practice were AD free in 2003.

**TABLE 41: Changes in the Aujeszky's disease (AD) status of practice breeding herds between 1992 and 2003**

| Herd No. | Herd Size | Herd Type | AD status | AD status | Eradication |
|---|---|---|---|---|---|

| Sows | | | 1992 | 2003 | Method |
|---|---|---|---|---|---|
| 1 | 130 | BF | - | - | |
| 2 | 100 | BW | - | - | |
| 3 | 420 | BF | - | - | |
| 4 | 70 | BF | - | - | |
| 5 | 60 | BF | + | - | 2 |
| 6 | 200 | BF | + | - | 2 |
| 7 | 500 | BF | + | - | 2 |
| 8 | 55 | BF | - | - | |
| 9 | 400 | BF | + | - | 3 |
| 10 | 250 | BW | - | - | |
| 11 | 90 | BW | - | - | |
| 12 | 500 | BW | + | - | 3 |
| 13 | 800 | BF | + | - | 3 |
| 14 | 800 | BW | - | - | |
| 15 | 700 | BW | + | - | 1 |
| 16 | 400 | BF | - | - | |
| 17 | 130 | BW | - | - | |
| 18 | 80 | BF | - | - | |
| 19 | 220 | BW | + | - | 3 |
| 20 | 240 | BF | - | - | |
| 21 | 90 | BF | - | - | |
| 22 | 280 | BW | - | - | |
| 23 | 500 | BF | - | - | |
| 24 | 300 | BW | - | - | |
| 25 | 50 | BF | - | - | |
| 26 | 150 | BW | + | - | 4 |
| 27 | 230 | BF | - | - | |
| 28 | 800 | BW | - | - | |
| 29 | 140 | BW | - | - | |
| 30 | 120 | BF | - | - | |
| 31 | 800 | BF | - | - | |
| 32 | 350 | BW | - | - | |
| 33 | 300 | BW | - | - | |
| 34 | 200 | BF | - | - | |
| 35 | 120 | BW | - | - | |
| 36 | 200 | BF | + | - | 4 |
| 37 | 150 | BW | + | - | 6 |
| 38 | 105 | BF | - | - | |
| 39 | 350 | BF | - | - | |
| 40 | 150 | BW | + | - | 6 |
| 41 | 30 | BW | - | - | |
| 42 | 330 | BF | - | - | |
| 43 | 200 | BF | - | - | |
| 44 | 450 | BF | + | - | 3 |
| 45 | 1,000 | BF | - | - | |
| 46 | 260 | BF | - | - | |
| 47 | 55 | BW | + | - | 4 |
| 49 | 330 | BF | - | - | |
| 50 | 40 | BW | - | - | |
| 51 | 150 | BW | - | - | |
| 53 | 400 | BW | + | - | 3 |
| 54 | 450 | BF | - | - | |
| 55 | 100 | BW | + | - | 5 |
| 56 | 80 | BW | + | - | 1 |
| 57 | 330 | BW | - | - | |

| | | | | | |
|---|---|---|---|---|---|
| 58 | 2,000 | BF | + | - | 4 |
| 59 | 90 | BF | - | - | |
| 60 | 200 | BW | - | - | |
| 61 | 130 | BW | - | - | |
| 62 | 200 | BF | - | - | |
| 63 | 1,200 | BW | + | - | 3 |
| 64 | 700 | BF | - | - | |
| 65 | 400 | BW | + | - | 4 |
| 66 | 250 | BF | + | - | 2 |
| 67 | 300 | BF | - | - | |
| 68 | 500 | BW | - | - | |
| 70 | 200 | BF | + | - | 3 |
| 71 | 1,000 | BF | - | - | |
| 72 | 500 | BF | - | - | |
| 73 | 525 | BF | - | - | |

1 = Depopulation**,** 2 = Depopulation and restocking**,** 3 = Breeder vaccination and all in all out, 4 = Breeder and grower vaccination, 5 = Replacement gilt vaccination, 6 = No action, BW = Breeding herd selling weaners BF = Breeding herd selling finishers, AD= Aujeszky's disease

**TABLE 42: Changes in the Aujeszky's disease status of 22 herds which were positive in 1992**

| Herd No. | Herd size sows | Herd type | Ad status 1992 | AD status 2003 | Eradication method |
|---|---|---|---|---|---|
| 5 | 60 | BF | + | - | 2 |
| 6 | 200 | BF | + | - | 2 |
| 7 | 500 | BF | + | - | 2 |
| 9 | 400 | BF | + | - | 3 |
| 12 | 500 | BW | + | - | 3 |
| 13 | 800 | BF | + | - | 3 |
| 15 | 700 | BW | + | - | 1 |
| 19 | 220 | BW | + | - | 3 |
| 26 | 150 | BW | + | - | 4 |
| 36 | 200 | BF | + | - | 4 |
| 37 | 150 | BW | + | - | 6 |
| 40 | 150 | BW | + | - | 6 |
| 44 | 450 | BF | + | - | 3 |
| 47 | 55 | BW | + | - | 4 |
| 53 | 400 | BW | + | - | 3 |
| 55 | 100 | BW | + | - | 5 |
| 56 | 80 | BW | + | - | 1 |
| 58 | 200 | BF | + | - | 4 |
| 63 | 1,200 | BW | + | - | 3 |
| 65 | 400 | BW | + | - | 4 |
| 66 | 250 | BF | + | - | 2 |
| 70 | 200 | BF | + | - | 3 |

1 = Depopulation**,** 2 = Depopulation and restocking**,** 3 = Breeder vaccination and all in all out, 4 = Breeder and grower vaccination, 5 = Replacement gilt vaccination, 6 = No action, BW = Breeding herd selling weaners BF = Breeding herd selling finishers, AD= Aujeszky's disease

**TABLE 43: Methods of Aujeszky's disease eradication adopted in 22 Herds between 1992 and 2003**

| Method | No. herds AD positive 1992 | No. herds AD positive 2003 | % Success |
|---|---|---|---|
| Depopulation only | 2 | 0 | 100 |
| Depopulation and restocking | 4 | 0 | 100 |
| Breeding stock vaccination and all in all out production | 8 | 0 | 100 |
| Breeding stock and grower vaccination | 5 | 0 | 100 |
| Replacement gilt vaccination only | 1 | 0 | 100 |
| No action | 2 | 0 | 100 |

1 = Depopulation**,** 2 = Depopulation and restocking**,** 3 = Breeder vaccination and all in all out, 4 = Breeder and grower vaccination, 5 = Replacement gilt vaccination, 6 = No action, AD= Aujeszky's disease

## 3.6 STRATEGIES FOR ERADICATING AUJESZKY'S DISEASE FROM THE IRISH PIG HERD

### INTRODUCTION

Since it was established that meat juice could be used in the AD ELISA test in addition to serum the following eradication programme was designed with the objective of initially eliminating circulating virus from the National pig herd, at minimum cost, and subsequently achieving OADF status in accordance with EU Regulations. The projected cost of AD eradication using different vaccination programmes was estimated in order to assist agricultural economists in calculating the cost of eradicating the disease from the Irish pig herd. The meat juice G1 antibody ELISA test is geared towards identifying herds with circulating virus. Circulating virus is deemed present in a herd when positive G1 antibody test results are recorded in samples taken from finishing pigs of greater than 12 weeks of age and/or replacement gilts and first parity sows. Positive results in the above circumstances is indicative of recent exposure to the field virus. The proposed programme design is presented in Figs. 13 and 14. It is proposed that herds be categorised as follows:

**Category 1: AD negative.**

This category includes all herds that are known to be AD free. All of these herds would have been set up as AD free and tested on a regular basis for clinical, pathological and serological freedom from AD. Herds that fall into this category make up a sizeable portion of the National breeding herd, since most of them were originally set up as MD herds following depopulation and restocking programmes, or, following the establishment of new herds on green-field sites. The majority of these herds don't vaccinate against AD at the present time. Where the risk of introducing AD is deemed low due to their location and biosecurity system the requirement for vaccination should be waived.

**Category 2: AD positive, circulating virus negative (CV-ve).**

Compulsory vaccination of breeding stock and replacement gilts three times per year. A herd is deemed circulating virus negative where there is no serological evidence of recent exposure to the AD field virus in an AD positive herd.

**Category 3: AD positive, circulating virus positive (CV+ve) and herds within 3km of a CV+ve herd.**

Compulsory vaccination of breeding stock and replacement gilts three times per year.

Compulsory vaccination of growers until the herd is deemed circulating virus negative.

A herd is deemed circulating virus positive where there is serological evidence of recent exposure to the AD field virus.

**Category 4: Finishing herd, AD negative.**

Negative AD results based on serology or meat juice tests.

**Category 5: Finishing herd, AD positive.**

Positive AD results based on serology or meat juice tests.

**Fig. 13: PROPOSED AUJESZKY'S DISEASE ERADICATION PROGRAMME FOR BREEDING HERDS.**

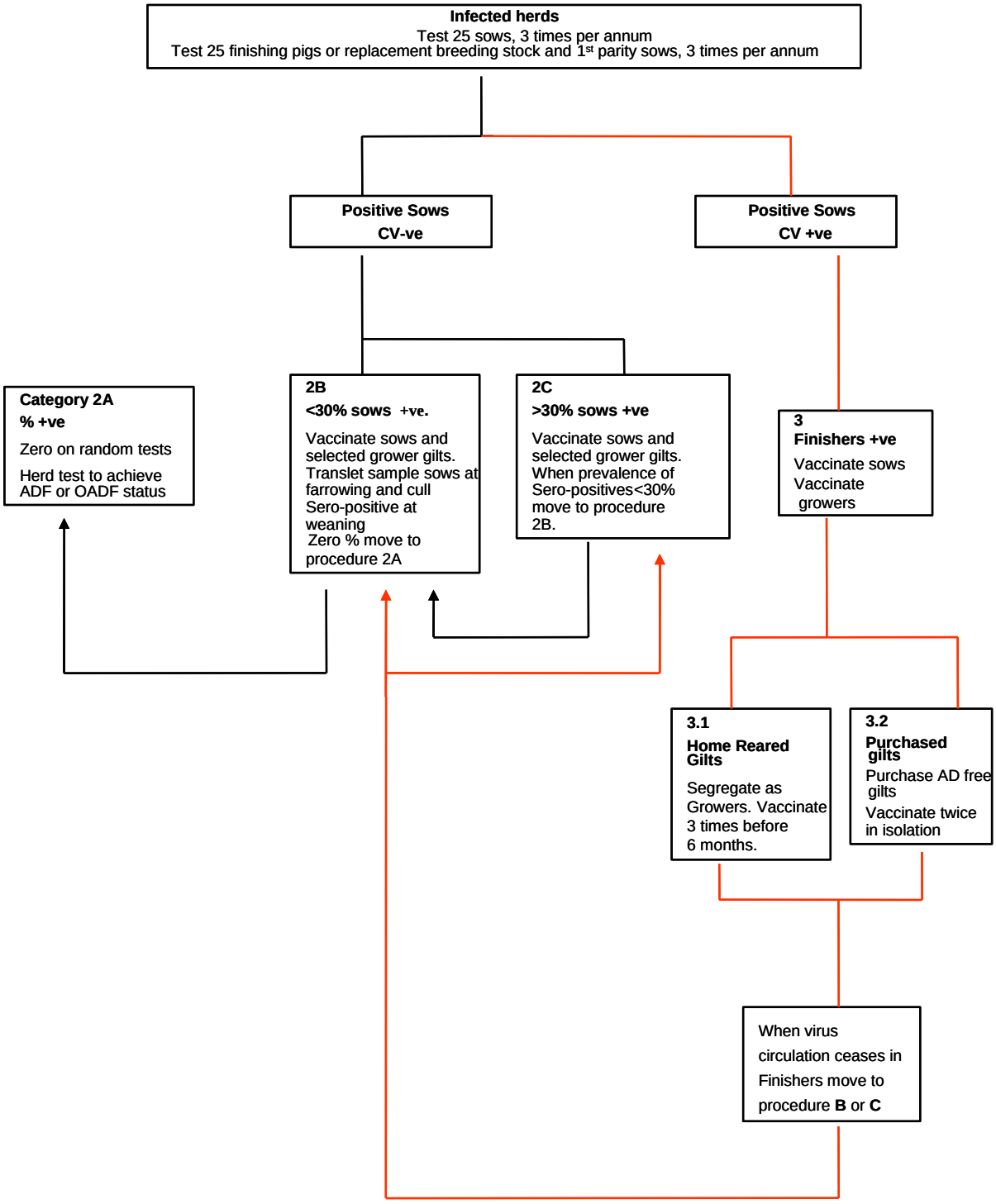
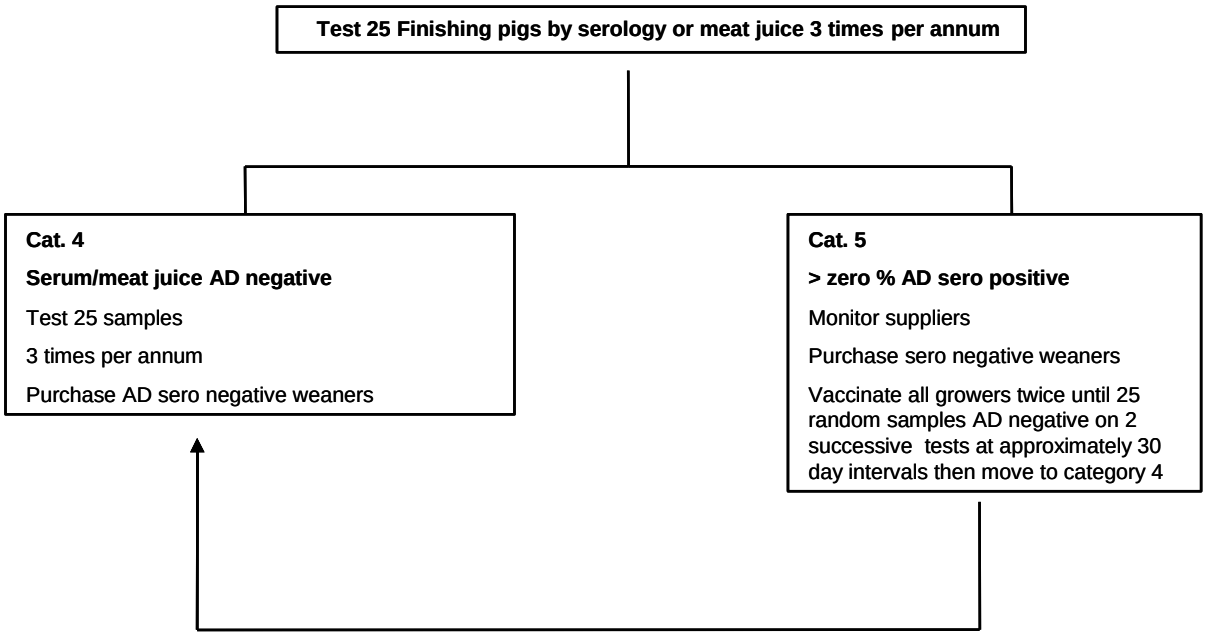


**FIG. 14: PROPOSED AUJESZKY'S DISEASE (AD) ERADICATION PROGRAMME FOR FINISHING HERDS.**




## 3.5.1 THE COST OF A THREE-YEAR PERIOD OF AUJESZKY'S DISEASE ERADICATION IN A 500 SOW UNIT

The cost of testing, vaccination, veterinary visits and advice are influenced by the ability of the farm to eliminate circulating virus. The ability to eliminate circulating virus is influenced by the quality of management, housing and systems of pig movement.

The cost of vaccination in a 500 sow unit increases from € 5,000 in a CV-ve herd where only breeding stock are vaccinated, to € 14,000 in a CV+ve herd where growers are vaccinated for a 6-month period to eliminate circulating virus in addition to vaccination of breeders (Tables 44 and 45). Vaccination costs are highest, at € 60,000, when breeders and all growers are vaccinated over a three-year period (Table 46). The projected cost of translet[#] testing was based on it being introduced when less than 30% of breeding stock are sero-positive, so less than 50% of breeding stock would need to be tested by this method over a six-month period, at which point the remainder of the sero-positive sows should have been culled at weaning. It is proposed that the DAF cover the cost of ELISA testing samples where herd testing is conducted for the purpose of obtaining OADF status. The projected cost of ELISA testing was € 4,000 in a 500 sow unit (Table 47). The cost of veterinary input was approximately € 5,100 based on two negative herd tests being required to achieve AD freedom (ADF) or official AD freedom (OADF) status (Table 48). A comparison of the projected cost of AD eradication in a 500 sow unit by a range of methods is summarised in Table 49.

**Table 44: Aujeszky's disease vaccination costs in a 500 sow breeding herd, circulating virus negative, over a three-year period of eradication (€, excluding VAT).**

| | |
|---|---|
| Breeding sows 3 times per annum, 6,000 doses @ € 0.76 per dose | 4570 |

**Table 45: Aujeszky's disease vaccination costs in a 500 sow breeding herd, circulating virus positive, over a three-year period of eradication (€, excluding VAT).**

| | |
|---|---|
| Sows 3 times per annum 6,000 doses @ € 0.76 per dose | 4570 |
| Growers 6 month period 2 x 6,000 doses @ € 0.76 | 9150 |
| **Total** | 13,720 |

**Table 46: Aujeszky's disease vaccination costs in a 500 sow breeding unit, with full vaccination, over a three-year period of eradication (€, excluding VAT).**

| | |
|---|---|
| Sows 3 times per annum, + Replacement gilts, 6000 doses @ 0.76 | 4,570 |
| Growers, 36,000 pigs x 2 doses, 72,000 doses @ 0.76 | 54,900 |
| **Total** | 59,470 |

**Table 47: Projected cost of ELISA testing in a 500 sow herd selling finishers, over a three-year period of Aujeszky's disease eradication (€, excluding VAT).**

| | |
|---|---|
| **Monitoring of sows and finishers.** | |
| 3 x 25 sows per annum @ 5.70 | 1,,280 |
| 3 x 25 finishers per annum (meat juice) @ 5.70 | 1,280 |
| Translet testing 250 @ 5.70 | 1,425 |
| 2 Herd tests 1,100 Breeders | FOC |
| **Total** | 3985 |

**Table 48: Veterinary costs of sampling and consultancy in a 500 sow herd over a three-year period of Aujeszky's disease eradication (€, excluding VAT).**

| | |
|---|---|
| **Monitoring of sows and finishers.** | . |
| 3 x 25 breeders per annum | 572 |
| 3 x 25 finishers per annum (meat juice) | N/A |
| 2 Herd Tests, 1100 x € 3.25 per sow | 3,575 |
| Consultancy services | 2,000 |
| **Total** | 6147 |

**Table 49: Aujeszky's disease eradication costs in a 500 sow unit under various regimes, over a three-year period (€, excluding VAT).**

| | Vaccination costs. | ELISA | Veterinary services |
|---|---|---|---|
| Full vaccination | 59,470 | | |
| Selective vaccination (CV+ve) | 13,820 | | |
| Breeder vaccination (CV-ve) | 4570 | | |
| ELISA testing | | 3,985 | |
| Veterinary advice and blood testing | | | 6,147 |

CV+ve= Circulating virus positive, CV-ve = Circulating virus negative

### 3.5.2 NATIONAL AUJESZKY'S DISEASE VACCINATION COSTS, USING DIFFERENT SYSTEMS

The assumptions are based on the results of studies by Lenihan (1994) and Kavanagh (1996). The proposed AD vaccination programme outlined in Table 50 is projected to cost an additional €1 million (above current vaccination costs) over a three-year period compared with € 21 million for full vaccination, (Table 51) a difference of € 20 million (Table 52).

**Assumptions.**

20% of Irish sow herds contain sero-positives.

A total of 38,000 sows in AD positive herds.

A total of 10,000 sows in herds with circulating virus.

A total of 10,000 sows in herds within 3km of CV+ve herds.

75% of herds currently vaccinate.

**Table 50: Breakdown of the increase in Aujeszky's disease vaccination costs in Ireland over a three-year period based on vaccination of sows and growers in CV +ve herds and in-contacts (€, excluding VAT) .**

| | |
|---|---|
| Increase vaccination from 2 to 3 times per year in 150,000 sows<br>150,000 extra doses per year @ € 0.76 = € 114,000 per annum.<br>Extra sow vaccination costs, three-year total | 342,000 |
| 12 month period of grower vaccination of the progeny of<br>10,000 sows, circulating virus positive + progeny<br>of 10,000 in-contacts 460,000 x 2 x € 0.76 | 700,000. |
| **Total increase in vaccination costs over three-year period** | **1,042,000** |

CV+ve= Circulating virus positive

**Table 51: Net full Aujeszky's disease vaccination programme costs in Ireland over three-year period based on 190,000 sows (€, excluding VAT).**

| | |
|---|---|
| 190,000 x 4 x 3 x € 0.76 | 1,732,800 |
| 4,400,000 x 2 x 3 x € 0.76 | 20,064,000 |
| **Total** | 21,796,800 |
| Less 75% of sows 2 doses per annum (existing vaccination) | 540,000 |
| **Net increase** | 21,256,800 |

The cost of vaccination is projected to increase by € 20 million over a three-year period when all herds are fully vaccinated compared with selective vaccination of CV+ve and in contact herds (Table 52). Selective vaccination of CV+ve and in contact herds is the method of choice since it offers the most economical method of eradicating the disease from the National herd.

**Table 52: Summary of the increase in three year Aujeszky's disease vaccination costs in Ireland, full vaccination v proposed system (€, excluding VAT).**

| | **Full vaccination costs** | **Proposed system** |
|---|---|---|
| Full vaccination (less 75% of sows twice per annum | 21,256,800 | |
| 12 month vaccination growers (CV+ve herds) and in-contacts | | 700,000 |
| Increased breeder vaccination | 342,000 | 342,000 |
| **Total (net)** | 21,598,800 | 1,042,000 |

CV+ve= Circulating virus positive

### 3.5.3 COST/BENEFIT OF AUJESZKY'S DISEASE (AD) ERADICATION IN A 5,000 PLACE PIG FINISHING UNIT PURCHASING AD FREE PIGS

Recent research into AD eradication at farm level has demonstrated that the cost of the disease in a herd with circulating virus is approximately € 0.64 per pig and that it can be eradicated from a finishing herd in four months where almost all pigs were sero-positive before the eradication programme commenced (Kavanagh 1996). The costings described below are based on a six month period of eradication (Table 53).

**Table 53: Cost benefit of Aujeszky's disease eradication in a 5,000 place pig finishing unit purchasing Aujeszky's disease-free pigs (€, excluding VAT).**

| | **Cost/Benefit of eradication** |
|---|---|
| Vaccination costs | 7,600 |
| Labour (Vaccination) | 650 |
| Serology | 1,300 |
| Total cost | 9,550 |
| Aujeszky's disease cost per month | 1,050 |

If AD costs € 0.64 per pig, a break-even point would be reached approximately nine months following the completion of the eradication programme. There are therefore very significant economic advantages to be

gained by eradicating the disease from finishing herds, where it is invariably associated with an increased incidence of pneumonia.

### 3.5.4 AUJESZKY'S DISEASE ERADICATION: KEY POINTS

3.5.4.1 It is proposed that the programme be controlled by Department of Agriculture and Food (DAF) regulations and that details of the current AD status of all herds be maintained on a central database. Ongoing monitoring of the AD serological status of all herds could be achieved by testing meat juice samples derived from slaughtered sows and finished pigs.

3.5.4.2 All culled sows should be identified using the official pig identification system.

3.5.4.3 Culled sows should be monitored at slaughter for AD antibodies so that current information is available at all times on the AD status of all breeding herds.

3.5.4.4 Slaughterhouse meat juice monitoring of finished pigs is an economic method of monitoring herds for circulating AD virus.

3.5.4.5 Airborne spread of infection can occur between adjacent pig farms in pig-dense areas to a distance of approximately 3km.

3.5.4.6 Farmers that fail to establish the AD status of their herd should be classified as CV+ve so they and in contact herds must operate a full vaccination programme.

3.5.4.7 Grower or finishing pigs should be vaccinated against AD in breeding herds where it has been demonstrated that the virus is circulating in the grower or finishing area. All herds within 3km of CV+ve herds should also be required to operate an intensive vaccination programme until the CV+ve herds revert to CV-ve.

3.5.4.8 Purchase of replacement breeding stock should be restricted to Officially Aujeszky's disease free (OADF) or Aujeszky's disease free (ADF) herds.

3.5.4.9 If replacement gilts are home reared in AD positive herds they should be segregated as weaners and reared in isolation. They should be vaccinated twice as growers and a third time before they are six months of age. They should be monitored serologically to confirm that they are sero-negative.

3.5.4.10 An register of all herds with circulating virus should be maintained. In each case an overall appraisal should be made of the health status of the farm, the management systems operated on the farm, the location of the farm in relation to other pig farms and, based on these investigations, a recommendation should be made regarding the pros and cons of each system of AD eradication. The system that is most likely to prove economical and successful on the farm should be highlighted.

Where a herd is positive for most of the major diseases, consideration should be given to depopulating and restocking it with MD stock.

3.5.4.11 Rooms should be operated on an all in/all out system. Otherwise, a continuous challenge is presented to incoming pigs in each area.

3.5.4.12 All houses should be thoroughly powerwashed and disinfected between batches, as the organism can survive in the environment. AD generally survives for less than seven days in nasal washings in the environment at 25$^{o}$C but can survive for months at temperatures below 4$^{o}$C (Beran, 1982).

3.5.4.13 Avoid overstocking as this causes stress which can increase the amount of circulating virus.

3.5.4.14 The presence of other viral diseases, such as PRRS, may cause immunosuppression.

3.5.4.15 Ensure that all eligible stock are vaccinated at the correct time.

3.5.4.16 Use the correct vaccination technique.

## 3.7 DISCUSSION OF SECTION III

Blood-sampling of sows, for the purpose of monitoring herd AD status is tedious. It was established that herd AD status could be ascertained by taking one piglet sample per litter and that the results closely matched that of samples taken from their dams. This system provides a convenient and cheap method of monitoring herd AD status. DAF, in recognition of the above research which achieved a 100% correlation between the results of piglet serology to that of sow serology as a method of establishing the AD status of pig herds, authorised sampling of one piglet per litter instead of blood sampling the sow in the current Irish AD eradication programme. With this system, in herds of 300 sows or greater, the majority of breeding stock samples are collected from piglets in the farrowing area, and the balance from random sows and replacement gilts, of greater than six months of age, in the dry sow and gilt areas.

Modern AD vaccines are capable of eliminating virus shedding in vaccinated stock. As a result, the level of clinical AD in the Irish herd has almost disappeared over the past nine years. In the circumstances it is difficult to justify an expensive National AD eradication programme. However, if a cheaper alternative system could be found, then the objective of eradicating AD could be achieved without the massive costs associated with a standard programme.

A modified ELISA test for detecting AD antibodies was developed for use on meat juice. This gave comparable results to that of serum samples, thus creating a cheap and efficient method of monitoring for the presence of circulating AD virus in finishing herds throughout the Irish pig industry, without having to resort to on farm investigations and sampling. This system permits the collection of samples for AD monitoring in conjunction with the National *Salmonella* control programme, in which meat juice samples are routinely collected at slaughter for the purpose of monitoring for the presence of *Salmonella* antibodies. The objective is to identify herds with circulating AD virus and then to introduce an AD eradication programme in these herds. This facilitates the operation of a low cost eradication programme designed to eradicate AD from the state. Herds could then be tested in accordance with E.U. regulations with a view to obtaining official AD free status.

The results of research studies, to date, would suggest that there is potential for meat juice to replace serum for herd disease monitoring and the evidence presented indicates that the results closely match that of serum for such diseases as Trichinellosis, Toxoplasmosis, Salmonellosis, AD and PRRS diseases. Since the meat juice ELISA test gave comparable results to that of serum, meat juice could replace serum and provide a low cost method of monitoring the AD status of pig herds. Serum continues to be the method of choice of sampling live animals for the purpose of establishing their individual AD status.

In a 1992 survey of 85 herds representing 28,000 sows, 10.6% of samples gave a positive result to the G1 antibody ELISA test for AD and 29% of these herds contained sero-positive animals. Sero-positive animals were identified in six herds which were not vaccinating and therefore they were at risk of a major AD disease outbreak. Aujeszky's disease spread occurred primarily in association with the purchase of breeding stock of unknown health status. The disease was eradicated from seven herds by twice-yearly vaccination, but failed in 13 herds, suggesting that twice-yearly vaccination with inactivated vaccine controlled the clinical signs of AD but failed to eradicate the virus from the farms. Aujeszky's disease was eradicated from a 12,000 place finishing unit over a period of four months by vaccinating weaners derived from CV+ve herds with live AD vaccine, twice, and all others once only, on arrival on the farm. The cost of AD was calculated at € 0.13 per kg bodyweight gain or € 0.58 per pig, by comparing similar nine-month periods of production, before and after eradication. The total cost of AD to the unit was estimated at approximately € 32,000 per annum.

The development of a new ELISA G1 antibody test made it possible to distinguish AD vaccinated pigs from infected pigs thus allowing selective culling of infected pigs from a vaccinated herd for eradication purposes (Van Oirschot and Waal, 1987). This system was subsequently to form the basis of large scale AD eradication programmes (Stegeman and Kimman, 1992).

In the practice survey AD sero-positive replacement breeding stock were a major cause of AD spread in practice herds since 1984. This was in line with the experience in the Netherlands where a similar trend was reported in their pilot AD eradication programme (Diesen trial) in the late 1980's. This highlights the importance of purchasing replacements gilts from herds supplying a current health declaration, and also isolating purchased breeding stock and sero-testing them before introducing them to the breeding herd. In the case of AD

positive herds breeding stock replacements should be fully immunised before being introduced to the diseased herd. Whilst the multi-herd AD eradication programme described in this section was successful, it was interesting to note that the greatest risk of failure was not associated with the technical ability of the vaccine to prevent virus shedding but more associated with the management abilities, commitment and enthusiasm of the participants, since in two herds the failure of the programme could have been associated with a reluctance on the part of two suppliers of weaners to maintain their vaccination programme and to identify and cull sero-positive sows. This highlights the importance of management advice and veterinary intervention in such eradication programmes in order to avoid expensive failures.

A further AD survey of practice breeding herds was conducted in 2003 as part of the National AD eradication programme. Approximately 60% of the herds opted for AD eradication programmes involving breeding stock vaccination and all in all out production systems or breeding stock and grower vaccination. Grower vaccination was introduced where there was evidence of AD virus circulation in pigs on the farm. The balance of the herds either depopulated the herds or vaccinated replacement gilts, or, in the case of two herds, the disease disappeared without any intervention being reported. The two herds in question were 150 sow units and both were breeding units selling weaners, where virus circulation spontaneously ceased. Since AD positive replacement breeding stock played a major role in the spread of the disease prior to 1992, breeding stock replacements were restricted to health monitored AD free stock during the period of the eradication programme.

The following classification system was adopted for the methods of eradication that were applied in the 1992-2003 eradication programme which was conducted in AD positive herds:

1. Depopulation without restocking
2. Depopulation and restocking with MD stock.
3. Vaccination of breeding stock accompanied by all in all out production systems.
4. Vaccinating of breeding stock and growing pigs.
5. Vaccination of replacement gilts, only.
6. No action.

Aujeszky's disease was eradicated from all 22 AD positive herds in the period 1992-2003 , so all herds in the author's practice were AD free in 2003.

Aujeszky's disease in a finishing herd costs approximately € 0.64 per pig so a return on the cost of eradication could be achieved nine months following completion of an AD eradication programme. The cost of production losses associated with AD to the Irish pig industry has been estimated at approximately € 400,000 per annum so the potential benefit of an AD eradication programme is primarily associated with the marketing advantages of AD-free pigs and/or pig meat. The cost of AD vaccination in the National herd is projected to increase by € 20 million over a three-year period when all herds are fully vaccinated, compared with selective vaccination of CV+ve and in contact herds. Selective vaccination of CV+ve and in contact herds is the method of choice since

it offers the most economical method of eradicating the disease from the Irish pig herd at a cost of approximately € 1 million.

# SECTION IV *SALMONELLA*: CONTROL, MULTIPLE ANTIBIOTIC RESISTANCE AND ELISA TESTING

## 4.1 INTRODUCTION

*Salmonellae* are widespread in man and animals (Cooper 1994) and are of increasing significance as causative agents of food-borne diseases in man (Wegener and Bager, 1997). The European Union, National Authorities and the Pig Industries are therefore increasingly interested in the *Salmonella* status of the pig population (Baggesen *et al*, 1996). Salmonellosis in pigs, as a clinical problem, is relatively uncommon in the Irish Pig Industry.

Multi resistant *Salmonella typhimurium* DT104 constitutes the second most common strain of *Salmonella* isolated from human gastro-enteritis in England and Wales (Threlfall *et al*, 1997).

In 1994 the World Health Organisation Scientific working group on monitoring and management of bacterial resistance to anti-microbial agents recommended that the unnecessary use of antibiotics for prophylaxis in food animals should be discouraged and that anti-microbial agents should not be used as a substitute for adequate hygiene in animal husbandry (Anon, 1994). Subsequently, a range of feed additives was banned in the E.U., including Olaquindox, Zinc Bacitracin, Avoparcin, Virginiamycin, and Carbadox.

In Denmark, a "Veterinary Antibiotic Policy " which outlines the prudent use of anti-microbial agents was launched in 1999, with the objective of providing a set of guidelines for veterinarians in order to ensure efficient clinical treatment of sick animals or groups of animals, whilst at the same time limiting the negative consequences of antibiotic usage as far as possible (Anon, 1999). The British Veterinary Association launched a booklet entitled "code of practice on medicines" in 2000 which provides guidelines on the use of medicines in veterinary medicine (Anon, 2000).

The implementation of anti-microbial therapy must be based on an aetiological diagnosis, which could be initially based on clinical signs. However it should also be supported by a laboratory diagnosis when necessary, so that the antibiotic susceptibility of the bacterial species involved can be ascertained with greater certainty. This applies particularly in relation to bacteria in which the antibiotic susceptibility patterns may vary, including *Escherichia coli, Salmonella* species and *Staphylococci.* Mackinnon (1992) questioned the rationale for oral use of antibiotics on a herd basis and cited examples which included the treatment of vulval discharges in sows without determining the cause and origin of the discharge. Meredith (1989) reported that infertility and vulval discharges in sows are associated with a wide range of organisms, which supports the view that clinical investigations should be accompanied by laboratory assays so that the indiscriminate use of antibiotics is minimised and the success rate of disease control programmes enhanced.

Fluoroquinolones and gentamycin are important anti-microbial agents in the treatment of gastrointestinal infections, septicaemia and meningitis in humans. Methicillin is important in the treatment of Staphylococcal infections in humans. As a result it is recommended that treatment of animals with such antibiotics should be severely curtailed.

The traditional method of identifying *Salmonella* carrier pigs involved specialised culture techniques using pre-enrichment procedures in order to enhance the isolation rate. A range of procedures have been documented for isolation of *Salmonella* (Bager and Peterson, 1991). The ELISA test is the preferred method over bacteriological assays in large scale monitoring programmes, primarily because the ELISA test is a cheaper and more sensitive method of detecting previous infection in pigs. However it may not detect recently exposed pigs due to the lag period between exposure and the development of humeral antibodies.

## 4.2 *SALMONELLA* CONTROL IN IRELAND

A National *Salmonella* control programme was introduced in Ireland with a view to reducing the prevalence of *Salmonella* in pigs at slaughter. Strict hygiene procedures were introduced in the slaughterhouses with a view to reducing the mechanical spread of *Salmonella* between carcasses.

The procedure for *Salmonella* isolation from faeces samples and carcass swabs which is approved for use in accredited laboratories in Ireland, requires pre-enrichment of the sample in buffered peptone water, enrichment in rappaport vassiliadis broth, plating out on brilliant green agar and finally confirmation of the presence of typical colonies. Uniformity of test results is achieved by maintaining standard quality control procedures which involve including a positive, negative and a blank (un-inoculated media) control in each test. The positive and negative controls are supplied by the National collection of type cultures, Central Public Health Laboratory, Collindale, London NW9. The positive control is a non-pathogenic strain of *Salmonella* and the negative control an *Escherichia coli*. This procedure produces the highest sensitivity and therefore the greatest chance of isolating *Salmonella* organisms, if present. However, enrichment culture procedures are expensive and for this reason ELISA tests were developed, initially in Denmark, and later in other countries. The exposure rate of pigs to *Salmonella* at farm level is measured by a mix ELISA test which was originally developed in Denmark. The test is most commonly carried out on meat juice which is collected from the pigs at slaughter. The test may also be performed on serum samples collected from pigs on the farm.

In Ireland, a sample cut-off value of 40% (percentage optical density, OD% = 40) is used. The sample cut-off value is the demarcation between a positive and a negative test result. A sample cut off value of 10% most accurately reflects the demarcation between a positive and a negative test result. However, the higher cut-off value of 40% was used in Denmark (Mousing *et al* 1997) in order to achieve a workable number of herds undergoing compulsory intervention. As the programme of *Salmonella* control in Ireland progresses and the

percentage of herds in category 3 falls, the cut-off value may be reduced in order to bring more herds into compulsory *Salmonella* control.

The ELISA test can be applied to meat juice and serum. The ELISA system offers the most sensitive and economic method of monitoring the incidence of exposure of pigs to *Salmonella*. With this system the rate of exposure of pigs to *Salmonella* can be monitored, at the slaughterhouse, and at various stages of the production cycle, in order to establish the point of exposure, and then to facilitate the introduction of control procedures designed to reduce the exposure rate. For example, pigs could be exposed to *Salmonella* in one house at a particular stage of the production cycle and so all pigs going through that house could experience a high exposure rate. At the same time, pigs in other houses could remain unexposed. Identification of the area of exposure facilitates tailoring the control programme to focus on the area of exposure.

The meat samples are identified, collected and frozen at the slaughterhouses. All samples are forwarded to the laboratory and the meat juice obtained when the frozen meat samples are thawed. All the meat juice samples are examined by an indirect enzyme-linked immunosorbent assay based on a combination of the Lipopolysaccharide (LPS) antigens 0:1,4,5,6,7 and 12 (Table 54). The mix-ELISA detects about 95% of all *Salmonella* serotypes occurring in Irish pigs (Fig. 15) (Kavanagh, 1998b). Herds are categorised on the basis of the prevalence of sero-positives using a weighted average of the three previous tests at the ratios of 1:1:3; the last test having a three times greater impact on the results compared with either of the two previous tests. Tests (24 samples per test) are conducted at four-monthly intervals.

**Herd Categorisation.**

| | |
|---|---|
| Level 1 herds: low sero-prevalence | $\leq$10% |
| Level 2 herds: moderate sero-prevalence | 11 - 50% |
| Level 3 herds: high sero-prevalence | >50% |

**TABLE 54: Lipopolysaccharide (LPS) O Antigens of common *Salmonella* serotypes**

| **Serovar** | **L.P.S.** |
|---|---|
| *Salmonella typhimurium* | 1, 4, 5, 12 |
| *Salmonella cholerae suis* | 6, 7 |
| *Salmonella infantis* | 6, 7 |
| *Salmonella london* | 3, 10 |
| *Salmonella derby* | 1, 4, 5, 12 |
| *Salmonella bredeney* | 1, 4, 12, 27 |
| *Salmonella enteritidis* | 1, 9, 12 |
| *Salmonella dublin* | 1, 9, 12 |
| *Salmonella panama* | 1, 9, 12 |

## 4.3 THE INFLUENCE OF WHEY ON THE SERO-PREVALENCE OF *SALMONELLA* IN PIGS

### INTRODUCTION

*Salmonella* infected pigs are an important source of zoonotic Salmonellosis in humans consuming meat products derived from these pigs (Berends *et al*, 1998).

To reduce the number of *Salmonella* infected pigs entering the slaughterhouse, control measures at herd level are necessary. These could involve batch production with all in all out procedures, followed by thorough cleansing and disinfection of the houses between batches (Madec *et al*, 1999).

The composition of the feed given to the pigs can also influence the S*almonella* status of finishers (Dahl, 1997).

A risk factor analysis of *Salmonella* infections in finishing pigs in the Netherlands showed that feeding acidified or fermented by-products to finishers reduced the level of *Salmonella* infections (van der Wolfe *et al*, 1999).

The protective effect of fermented by-products is probably a result of the combined effect of large amounts of organic acids and large numbers of lactic acid-producing bacteria. The organic acids reduce the pH of the feed to a level of about 4.2, at which point enterobacteriaceae do not multiply (van Winsen *et al*, 1999).

### MATERIALS AND METHODS

Seven commercial farms in which the finishing pigs received a diet containing whey were selected and the *Salmonella* mix ELISA test results compared with those of a further six commercial farms in which finishing pigs received a whey-free diet. In all herds, the wet feed which consisted of meal and water or meal and whey was fed by a computerised pipe line wet feeding system.

The objective of the study was to compare the prevalence of positive *Salmonella* mix ELISA test results in pigs receiving a diet containing meal and whey with that of pigs receiving a diet of meal and water.

### RESULTS

It was established that the prevalence of *Salmonella* antibodies in pigs at slaughter which were fed a diet containing whey was less than one third that of pigs fed a liquid diet without whey (Tables 55 and 56). Due to the range of sero-positive test results in whey-free pigs , from 0 to 95%, the results recorded were not statistically significant. Statistical analysis, conducted on a generalised linear model with a binomial response distribution , indicated no significant difference ($P>0.05$) between the proportion of seropositives in whey and water. The multi-factorial nature of *Salmonella* exposure in pig farms is highlighted by the results of a separate study in which a high level of infection with *Ascaris suum* was recorded in pigs on one farm on a meal and water diet, (over 50% of livers contained “milk spots”) which was Category 3 *Salmonella* status. Following the introduction of an *Ascaris suum* control programme the level of *Salmonella* sero-positives reduced from over 50% to 7% in a six-month period (Kavanagh, 2003). The relative risk of *Salmonella* sero-positives is 2.7 times

higher when finishers are fed dry pelleted feed in contrast to fermented wet feed (Dahl and Wingstrand, 1997, Bager, 1994). This may be associated with an altered gut fermentation process due to the feeding of fermented wet feeds or feeds of larger particle size providing an unsuitable environment for *Salmonella* proliferation in the gut. A pH of >4 favours *Salmonella* survival. In most wet feeding systems, where the product is allowed to ferment, a natural fermentation process results in the growth of lactic acid-producing bacteria and yeast which lower the pH. The protective effect of feeding fermented wet feed may be underestimated. Van der Wolf (2000b) reported that feeding fermented liquid feed had a strong protective effect against *Salmonella*, such that it was the most important result of his thesis on the feasibility of *Salmonella* free pig production.

The Danish results, to date, would suggest that more specific research should be carried out on the influence of particle size and fermented wet feed on *Salmonella* sero-positives in finishers. The influence of yeast, enzymes, organic acids, mannan oligosacharides and dietary raw materials on the *Salmonella* carrier rate deserves further research. The results of the above study are broadly in line with those of the Danish and Dutch studies which demonstrate that fermented wet feed has a protective effect against *Salmonellae* in pigs.

**TABLE 55: The prevalence of positive meat juice *Salmonella* ELISA test results in pigs fed a diet containing whey.**

| Farm | No. Positive | % positive | Herd size | No. of samples tested |
|---|---|---|---|---|
| A | 42 | 39 | 430 sow unit [1] | 108 |
| B | 12 | 8 | 1500 sow unit [1] | 144 |
| C | 6 | 7 | 600 sow unit [1] | 84 |
| D | 9 | 12 | 1100 sow unit [1] | 79 |
| E | 1 | 2 | 6500 finisher | 30 |
| F | 0 | 0 | 750 sow unit [1] | 60 |
| G | 14 | 11 | 7000 finisher | 123 |
| Mean | 84 | 13.4 | | 628 |

[1] Integrated breeding herd, selling Finishers.

**TABLE 56: The prevalence of positive meat juice *Salmonella* ELISA test results in pigs fed a wet feed without whey.**

| Farm | No. Positive | % positive | Herd size | No. of samples tested |
|---|---|---|---|---|
| H | 4 | 9 | 400 sow unit[1] | 48 |
| I | 86 | 95 | 5000 finishers | 90 |
| J | 25 | 42 | 4200 finishers | 60 |
| K | 11 | 21 | 2700 finishers | 53 |
| L | 0 | 0 | 1400 sow unit[1] | 54 |
| M | 20 | 41 | 450 sow unit[1] | 48 |
| Total | 146 | 41.4 | | 353 |

[1] Integrated breeding herd, selling finishers.

## 4.4 ANTIBIOTIC RESISTANCE PATTERNS OF *SALMONELLA* ISOLATES FROM PIGS IN IRELAND

### INTRODUCTION.

Resistance to antibiotics existed even before antibiotics were used throughout the world. However, this intrinsic form of resistance is not of major concern for human and animal health. The vast majority of antibiotic resistant organisms have emerged as a result of genetic changes which were acquired through mutation or transfer of genetic material during the life of the micro organisms, and subsequent selection processes (Anon, 2001b).
Mutational resistance develops as a result of spontaneous mutation in an area on the microbial chromosome that controls susceptibility to a given antibiotic.
The presence of the antibiotic serves as a selecting mechanism to suppress susceptible micro organisms and promote the growth of resistant mutants.
Resistance can also develop as a result of transfer of genetic material between bacteria. Plasmids, which are small extra-chromosal DNA molecules, can be transmitted both vertically and horizontally and can code for multi resistance. It is estimated that the major part of acquired resistance is plasmid- mediated.

Resistance depends on different mechanisms and more than one mechanism may operate for the same antibiotic. Micro organisms which are resistant to a certain antibiotic may also be resistant to other antibiotics that share a mechanism of action or attachment. Micro organisms may also be resistant to several unrelated antibiotics. Use of one such antibiotic may therefore also select for resistance to the other antibiotics (Anon, 2001b).

Anti-microbial resistance is a source of major concern in the case of zoonotic pathogens such as *Salmonella*. During the period of this study the most common *Salmonella* serovars isolated were *Salmonella typhimurium, derby* and *choleraesuis.* The objective of this study was to determine the anti-microbial resistance patterns of a range of *Salmonella* cultures which were isolated from pigs in Ireland between 1995 and 1997.

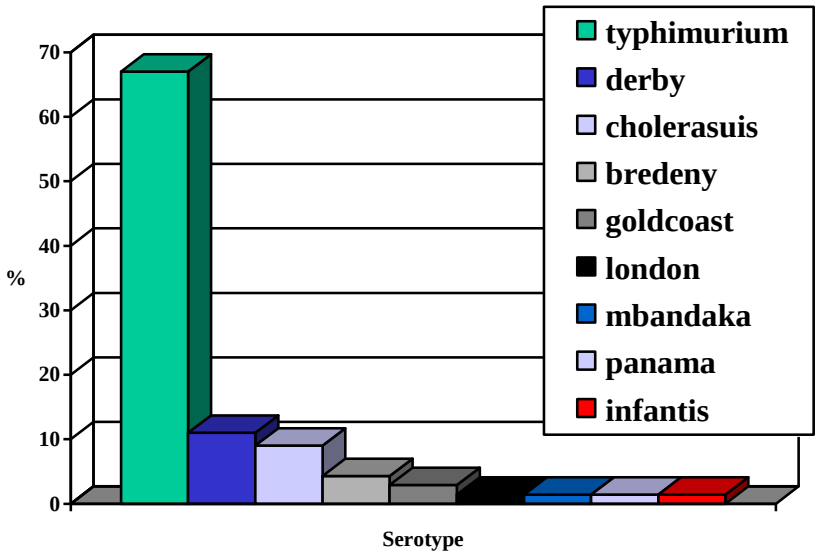
### MATERIALS AND METHODS.

The majority of isolates were derived from routine screening of pigs in the slaughterhouse for the presence of *Salmonella* by caecal swabbing, and the balance from clinical cases. *Salmonella* isolates were tested against a total of 16 anti-microbial substances. A total of 70 isolates were included in the study. The inoculum of each *Salmonella* culture was prepared by the technique described by NCCLS. The resistance patterns of the bacterial cultures were interpreted using the Stokes method described by Reeves and Wood (1991), which compares all zone of inhibition sizes to those achieved using a reference culture NCTC 10418 which was included in the test as a positive control. Isolates were classified as multi-resistant if resistance to ampicillin, chloramphenicol and tetracylines was demonstrated.

**RESULTS.**

Approximately two thirds of the isolates were *Salmonella typhimurium* (Fig. 15) and the balance made up of *Salmonella derby, cholerae-suis, bredeny, goldcoast, london, mbandaka, panama*, and *infantis*. (Table 57)

**Fig. 15: THE ISOLATION RATE OF *SALMONELLA TYPHIMURIUM* FROM IRISH PIGS (1995-1997)**




These findings are broadly similar to those reported from Great Britain where *Salmonella typhimurium* and *derby* are ranked one and two. However *choleraesuis* is more prevalent in Ireland, making up 9% of isolates compared with 2.5% in GB.

**TABLE 57: The types of *Salmonella* isolates from pigs in Ireland (1995 - 1997)**

| | **No.** | **%** |
|---|---|---|
| *Salmonella typhimurium* | 47 | 67.14 |
| *Salmonella derby* | 8 | 11.42 |
| *Salmonella choleraesuis* | 6 | 8.57 |
| *Salmonella bredeny* | 3 | 4.29 |
| *Salmonella goldcoast* | 2 | 2.86 |
| *Salmonella london* | 1 | 1.43 |
| *Salmonella mbandaka* | 1 | 1.43 |
| *Salmonella panama* | 1 | 1.43 |
| *Salmonella infantis* | 1 | 1.43 |
| **Total** | 70 | 100 |

Resistance to tetracycline, spectinomycin, sulphonamide and streptomycin was common, whilst most isolates were classified as intermediate or sensitive to amoxycillin/clavulanic acid, apramycin, cephalosporins, colistin, enrofloxacin, neomycin and framycetin. 44.6% of *Salmonella typhimurium* isolates were classified as multi-resistant. In Britain approximately 95% of *Salmonella* DT104 isolates were multi-resistant in 1996 (Threlfall *et al*, 1997).

None of the remaining *Salmonella* serovars demonstrated multi-resistance (Table 58).

**TABLE 58: Multi-antibiotic resistance patterns of *Salmonella* isolates from pigs in Ireland (1995-1997)**

| | No. | No. resistant | % Multi resistant |
|---|---|---|---|
| *S. typhimurium* | 47 | 21 | 44.6 |
| *S. derby* | 8 | 0 | 0 |
| *S. choleraesuis* | 6 | 0 | 0 |
| *S. bredeny* | 3 | 0 | 0 |
| *S. goldcoast* | 2 | 0 | 0 |
| *S. london* | 1 | 0 | 0 |
| *S. mbandaka* | 1 | 0 | 0 |
| *S. panama* | 1 | 0 | 0 |
| *S. infantis* | 1 | 0 | 0 |

Amoxycillin and ampicillin demonstrated identical resistance patterns for the isolates under test, with 38.6% of isolates being resistant in contrast to 1.4% resistant to amoxycillin/clavulanic acid combination. Multiple resistance was confined to *Salmonella typhimurium*, since all of the isolates, with the exception of *typhimurium*, were sensitive to most of the antibiotics under test. Only 2.9% of the isolates demonstrated resistance to apramycin and 30% to trimethoprim/sulphadiazine, whilst over 80% were resistant to spectinomycin and tetracyline (Table 59).

**TABLE 59: Anti microbial resistance patterns of *Salmonella* isolates from pigs in Ireland (1995-1997)**

| Anti microbial (ug) | No. | % resistant |
|---|---|---|
| Amoxycillin (10) | 27 | 38.6 |
| Amoxycillin/ clavulanic acid (30) | 1 | 1.4 |
| Ampicillin (15) | 27 | 38.6 |
| Apramycin (15) | 2 | 2.9 |
| Cephalexin (30) | 0 | 0 |
| Chloramphenicol (10) | 22 | 31.0 |
| Colistin (25) | 0 | 0 |
| Enrofloxacin (5) | 1 | 1.4 |
| Framycetin (100) | 0 | 0 |
| Gentamicin (15) | 2 | 2.9 |
| Neomycin (10) | 2 | 2.9 |
| Spectinomycin (25) | 57 | 87.4 |
| Streptomycin (25) | 44 | 62.9 |
| Sulphonamide (300) | 44 | 62.9 |
| Sulpha trimethoprim (25) | 21 | 30 |
| Tetracycline (10) | 58 | 82.9 |
| **Total** | 70 | |

## 4.5 A COMPARISON OF THREE *SALMONELLA* ELISA KITS FOR MONITORING *SALMONELLA* ANTIBODIES IN PIG SERUM OR MEAT JUICE

### INTRODUCTION.

Within the last 10 years, serology has been developed to determine the prevalence of *Salmonella* on pig farms and has been adopted by several countries. International control programmes have been designed to reduce the occurrence of *Salmonella* in pigs on the farm and on pig carcasses.

Serology is an attractive alternative to bacteriological methods, which have a lower sensitivity and are expensive to perform in the laboratory. At its present level of sensitivity and specificity, the *Salmonella* ELISA kits operate under field conditions as a herd test and evaluate the responses of individual animals which have been exposed to *Salmonella* and as a result developed antibodies. The cut off point at which optical density (OD) a sample is deemed positive was arbritrarily set by Denmark at 40% initially, with the objective of categorising a workable proportion of the national herd into category 3.

Category 3 herds are classified as high risk herds and it is on these herds that the main focus of the *Salmonella* control programme is directed. A number of commercial ELISA kits are calibrated against the Danish mix ELISA test which was the original serological test for monitoring herd *Salmonella* status. The test is conducted on serum samples collected from live animals on the farm or on meat juice which is collected when a meat sample from the carcass is frozen and then thawed. Using this method of identifying high risk herds, the prevalence of *Salmonella* in Danish pork is reported to have declined from 3.5% in 1993 to 0.7% in 2000 (Nielson, 2002).

Several commercial companies now offer Salmonella ELISA kits for use on pig serum or meat juice. Three companies supplied commercial kits which were used in this study. The objective of this study was to compare the results of the three commercial kits in order to establish if one or more of them could be incorporated into the Irish *Salmonella* control programme.

A total of 62 blood samples were tested and these consisted of approximately 50% positive and 50% negative or inconclusive on the ELISA test.

### MATERIALS AND METHODS.

Three ELISA kits were evaluated: A- Vetsign, B- HerdChek and C- Salmotype. Blood samples were collected from pigs in the slaughterhouse from herds that were known to have a positive *Salmonella* sero prevalence of between 40 and 60%. Sixty two blood samples were selected for testing and each sample was subjected to three ELISA tests, one from each kit being evaluated. In each case the test procedures followed in the Laboratory where in accordance with the recommendations of the manufacturer. A total of 62 samples were included in the study. The blood samples were collected at slaughter from pigs derived from two herds which were classified as Category 3 on meat juice assays by the Danish Mix ELISA. The assays for herd categorisation were conducted

by the DAF as part of the Irish *Salmonella* control programme. The samples selected for the study contained approximately 50% sero-positives. The test kit manufacturers claim good overall correlation with the Danish Mix ELISA test in terms of the percentage giving a sero-positive result but advised that variations could occur in the result of individual samples when kits are compared. Also, due to variations in the systems of calculating and interpreting results in the three ELISA's, a comparison of the ELISA reader print-out for each test would not provide a basis for the comparison of test results. This is due to variations in the design of the individual ELISA test kits.

**RESULTS AND DISCUSSION.**

The objective of monitoring finishing herd *Salmonella* sero-prevalence is for the purpose of categorising herds as high, medium or low *Salmonella* risk. Using this system, herds with a high exposure rate and as a result high sero-prevalence, are identified and subjected to intensive veterinary investigations, accompanied by the introduction of a *Salmonella* control programme. The original Danish Mix ELISA test was developed as a herd *Salmonella* monitor and was not intended as a test for classifying the *Salmonella* status of individual animals. The test cut-off point used in Ireland is aimed at identifying high risk herds. The higher cut-off is used to create a workable number of herds that require intensive *Salmonella* control and is not designed to indicate *Salmonella* freedom in pig samples that give a negative result at 40% OD cut off or its equivalent in other commercial ELISA kits. In Ireland, a sample cut-off value of 40% OD is used. The sample cut-off value is the demarcation between a positive and a negative test result. A sample cut off value of 10% most accurately reflects the demarcation between a positive and a negative test result. However, the higher cut-off value of 40% OD was used in Denmark (Mousing *et al* 1997) in order to achieve a workable number of herds undergoing compulsory intervention. As the programme of *Salmonella* control in Ireland progresses and the percentage of herds in category 3 falls, the cut-off value may be reduced in order to bring more herds into compulsory *Salmonella* control.

The results are presented in Table 60. Since the method of assigning an inconclusive result varied between ELISAs a comparison of them would have been meaningless. Also, herd categorisation is based on sero-positive prevalence only. The results in all three ELISAs were quite similar at approximately 50% sero-positive. Variations in the results of individual samples were recorded between kits , however, the overall correlation between the results was good. Of the three kits, the highest sero-positive level was recorded by ELISA test B (HerdChek, IDEXX Laboratories, Netherlands), at 56% and the lowest by ELISA test A (Porcine *Salmonella* test kit, Vetsign, Guildhay Ltd, UK), at 47%, whilst ELISA test C (Salmotype Pig LPS ELISA test kit, Labor Diagnostik, Leipzig, Germany ) recorded 48% as sero-positive. On statistical analysis the results were classified as similar by the chi square test ($P< 0.001$). The range of results was less than the random variations that could occur in the results of herd monitoring in the Irish *Salmonella* control programme, in which 72 samples are tested per annum. Due to sample size the repeatability of the results is limited to an accuracy of +/-10%, with 90% confidence (Cannon and Roe, 1982).

**Table: 60 A comparison of the *Salmonella* ELISA test results between three commercial test kits in 2003**

| Sample No. | ELISA A | ELISA B | ELISA C |
|---|---|---|---|
| 1 | + | + | + |
| 2 | + | + | + |
| 3 | + | + | + |
| 4 | + | + | + |
| 5 | + | + | + |
| 6 | + | + | + |
| 7 | + | + | + |
| 8 | + | + | + |
| 9 | + | + | + |
| 10 | + | + | + |
| 11 | + | + | + |
| 12 | + | + | + |
| 13 | + | + | + |
| 14 | + | + | - |
| 15 | + | + | + |
| 16 | + | + | + |
| 17 | + | + | + |
| 18 | + | + | + |
| 19 | + | + | + |
| 20 | + | + | + |
| 21 | + | + | + |
| 22 | + | + | + |
| 23 | + | + | + |
| 24 | + | + | + |
| 25 | + | + | + |
| 26 | + | + | + |
| 27 | + | + | + |
| 28 | + | + | + |
| 29 | - | + | + |
| 30 | - | - | - |
| 31 | - | - | - |
| 32 | - | - | - |
| 33 | - | - | - |
| 34 | - | - | - |
| 35 | - | - | - |
| 36 | - | - | - |
| 37 | - | - | - |
| 38 | - | - | - |
| 39 | - | - | - |
| 40 | - | - | - |
| 41 | - | - | - |
| 42 | - | - | - |
| 43 | - | - | - |
| 44 | - | - | - |
| 45 | - | - | - |

| | | | |
|---|---|---|---|
| 46 | - | - | - |
| 47 | - | - | - |
| 48 | - | - | - |
| 49 | - | - | - |
| 50 | - | - | - |
| 51 | - | - | - |
| 52 | - | - | - |
| 53 | - | - | - |
| 54 | - | - | - |
| 55 | - | - | - |
| 56 | - | - | - |
| 57 | - | - | - |
| 58 | - | - | - |
| 59 | + | + | + |
| 60 | - | + | + |
| 61 | - | + | - |
| 62 | - | - | - |
| **% +ve** | **47** | **56** | **48** |

+= Positive, -= Negative or inconclusive, ELISA A = Vetsign, ELISA B = HerdChek, ELISA C = Salmotype.

The Vetsign ELISA Kit , manufactured by Guildhay Ltd, presents the results as an S/P ratio. The data sheet states that the results are calculated by converting the percent OD of a sample, to a sample to positive ratio (S/P). This conversion is stated to minimises the effect of variables associated with temperature or operator. The formula applied to convert the OD values for controls and samples to an S/P ratio is is as follows:

$$\frac{\text{Sample OD - Negative Kit Control OD}}{\text{Positive Kit Control OD - Negative Kit Control OD}}$$

The Vetsign *Salmonella* ELISA Test Kit is set so that an S/P ratio of 0.25 is equivalent to a 40% OD value on the Danish Mix ELISA Test. The data sheet reports that a 96% assay sensitivity was established by comparing the results of the Vetsign assay with the Danish Mix ELISA on 75 pig serum samples.

The data sheet of the Salmotype ELISA Test Kit, manufactured by Labor Diagnostik, states that it was calibrated against the Danish Mix Elisa Test, so a 40% OD on this kit correlates with a 40% OD on the Danish Mix ELISA Test. The Salmotype ELISA Kit expresses the result as percent OD.

In the HerdChek *Salmonella* ELISA Kit, manufactured by IDEXX, the presence or absence of antibody to *Salmonella* in the sample is determined by calculating the S/P Ratio. However, in many countries the results are presented as percent OD by referring to a set of standard Danish Mix Elisa sera, so, to obtain a result comparable to the Danish mix ELISA a correlation factor of 2.5 was built into the calculation of results. The HerdChek ELISA test results are presented as percent OD which correlates with that of the Danish Mix ELISA test.

Operator input into sample and reagent preparation was similar in the Vetsign and HerdChek Kits, but took longer in the Salmotype due to variations in the methods of preparation of materials and reagents between tests.

The period of incubation was shorter in the Vetsign and longest in the Salmotype, so the test duration from start to completion was longest in the Salmotype test.

Calculation of test results involved one calculation in the Vetsign test, since results are presented as an S/P ratio. It involved two calculations in the HerdChek test, which initially calculates an S/P ratio. A percent OD is then calculated from the S/P ratio. Calculation of results in the Salmotype ELISA Kit involved one calculation and the setting up of a graph. The calculation of results in all three tests was relatively straightforward and can be facilitated, in house, by setting up simple ELISA Kit specific spreadsheets for calculation of results. The current cost of the test kits, per test, based on a purchase quantity of three to five plates was compared. Each plate is capable of testing approximately 90 samples. The cost of ELISA A- Vetsign and B- HerdChek were similar, at approximately € 1, whilst ELISA C- Salmotype was more expensive (Table 61).

**Table 61 : A comparison of operator convenience and cost of three *Salmonella* ELISA Kits**

| | **ELISA A** | **ELISA B** | **ELISA C** |
|---|---|---|---|
| Sample/Reagent preparation, time ratio | 1:1 | 1:1 | 1.2:1 |
| Length of incubation | 1:1 | 1.2:1 | 1.8:1 |
| Test duration | 1:1 | 1:1 | 1.4:1 |
| No. of calculations on results | 1 | 2 | 1 + 1 Graph |
| Format of results | S/P Ratio | OD% | OD% |
| Cost per sample(€) | 0.95-1.05 | 0.95-1.05 | 1.90-2.10 |

S/P = Sample to positive ratio, OD% = Percent optical density, ELISA A = Vetsign, ELISA B = HerdChek, ELISA C = Salmotype.

A 40% OD cut off value is currently used in Ireland, however in Denmark, as *Salmonella* control has progressed, the percent OD cut off between positive and negative results has been reduced below 40%.
The results of this study confirm that ELISA kits, Vetsign, HerdChek, and Salmotype satisfy the study objectives and therefore could be incorporated into the Irish *Salmonella* control programme as methods for monitoring herd *Salmonella* sero-prevalence, as alternatives to the in-house Danish Mix ELISA test currently used by the DAF.

## 4.6 DISCUSSION OF SECTION IV

It is important that pig veterinarians have a sound working knowledge of pig zoonoses such that the relatively rare and exotic ones be identified, so they focus on the important ones such as *Salmonella* and in particular multi-antibiotic resistant phage types of *Salmonella typhimurium.*

Medical and veterinary opinions are unanimous in identifying *Salmonella*e as the most important pig zoonosis in Ireland. The reasons are two-fold. Not only are *Salmonellae* associated with food poisoning in humans, but multi-antibiotic resistant strains of *Salmonella*, such as *Salmonella typhimurium* DT104 are refractory to treatment with many antibiotics. *Salmonella* control must commence at farm level, with a view to reducing the exposure rate of pigs to *Salmonella* on the farm. This should be supported by sound butchering, transporter and lairage hygiene procedures in order to prevent pig exposure to *Salmonella* at slaughter and contamination of carcasses during the butchering process. The importance of good hygiene and cooking procedures in the kitchen cannot be over emphasised, since *Salmonella* can be killed by exposure to a temperature of 71.5$^{o}$ C for a period of only 15 seconds. As *Salmonella* control progresses, it is important that an intensive control programme be introduced in those herds containing multi-antibiotic resistant *Salmonellae*.

The level of exposure to *Salmonella* contaminated faeces is influenced by the system of housing, management and the quality of the hygiene programmes operated. The epidemiology of *Salmonella* is complex so control programmes (Appendix 7) should be designed around current research data.

Davies *et al* (1997) reported that the prevalence of *Salmonella* in faecal samples was lowest in pigs housed on fully-slatted floors, compared with all other floor types and was highest in pigs raised on dirt lots. Birds can act as a source of *Salmonella*. Seagulls, sparrows and pigeons can contaminate feed mills and pig farms with *Salmonella typhimurium* (Wray and Davies, 1996). The results of recent investigations have indicated that following oral exposure of pigs to *Salmonella typhimurium*, the bacterium may be isolated from caecal contents within 4 - 6 hours (Fedorka-Cray *et al*, 1995). Consequently, pigs could become carriers as a result of exposure to dirty loading ramps, dirty transporters and contaminated lairages. A survey carried out in the USA revealed that the percent of farms with at least one *Salmonella* positive sample increased as herd size increased, from 32% of farms selling <2,000 pigs annually to 57% selling >10,000 pigs (Bush and Fedorka-Cray, 1997). This trend has been observed in Ireland by Kavanagh (1997) where the mean size of herds from which *Salmonella typhimurium* was isolated was 910 sows, compared with a mean size of practice pig herds of 410 sows. A similar trend was observed in Denmark (Baggesen *et al*, 1996). In the Danish studies *Salmonella typhimurium* was isolated in 23.1% of large herds (producing > 2,600 pigs per year) compared with 14.7% of small herds (annual production 500-550 slaughter pigs per year). Carstensen and Christensen (1998) reported that whilst herd size was positively associated with the seroprevalence of *Salmonella enteritica*, it was of little significance because the within herd and between herd variations were relatively larger in comparison. Meyer *et al* (1993)

reported that *Salmonella* vaccines reduced the rate of shedding of *Salmonella* and therefore could make a positive contribution to a *Salmonella* control programme.

The use of *Salmonella* vaccines in growers and finishers is currently undesirable since the antibodies induced by vaccination cause a high incidence of sero-positives on the *Salmonella* mix ELISA test. Vaccination of sows with *Salmonella* vaccines could however make a positive contribution to the efficiency of a *Salmonella* control programme by reducing the rate of shedding in sows and providing maternal antibodies to protect piglets in the first few weeks of life. Early weaning has been practised in the US to produce *Salmonella*-free pigs in conjunction with multisite production systems. A survey was carried out on nine such farms by Fedorka-Cray *et al* (1994). They found that all pigs, with the exception of one, when tested at 142 days following weaning were negative on culture for *Salmonella*. With multisite production systems each unit is operated on an all in/all out production system. This highlights the importance of all in/all out production. In order to maintain their *Salmonella* free status through the grower and finisher stages of the production cycle the management system should incorporate good hygiene procedures, all in / all out production, efficient rodent and bird control and elimination of cross contamination. Lynch *et al* (2001), in an Irish study reported that pigs in 1st-stage weaner houses in *Salmonella* category 1 herds were more likely to be *Salmonella* positive than those from category 3 herds, based on faecal cultures. This suggests that early exposure could trigger sero-conversion and that antibody levels could subsequently fall so they are sero-negative when they reach slaughter weight. Herds are categorised on the results of the ELISA test.

Van der Wolf (2000b) reported that feeding fermented liquid feed had a strong protective effect against *Salmonella,* such that it was the most important result of his thesis on the feasibility of *Salmonella* free pig production.

Heijden (2001) reported on an International ring trial of ELISAs for Salmonella. He recorded that the specificity of most of the ELISAs was satisfactory, however there were large differences in the sensitivities of the tests examined. Camitz *et al* (2001) compared the HerdChek (IDEXX) ELISA with a competitors kit and found a clear difference in detection levels between the kits. In the study reported in this thesis the results in all three ELISAs were quite similar at approximately 50% sero-positive. Variations in the results of individual samples were recorded, however, the overall correlation between the results was good. On statistical analysis the results were classified as similar by the chi square test ($P< 0.001$). Of the three kits, the highest sero-positive level was recorded by ELISA test B (HerdChek, IDEXX Laboratories, Netherlands), at 56% and the lowest by ELISA test A (Porcine *Salmonella* test kit, Vetsign, Guildhay Ltd, UK), at 47%, whilst ELISA test C (Salmotype Pig LPS ELISA test kit, Labor Diagnostik, Leipzig, Germany ) recorded 48% as sero-positive. The current cost of the test kits, per test, based on a purchase quantity of three to five plates was compared. Each plate is capable of testing approximately 90 samples. The cost of ELISA A- Vetsign and B- HerdChek were similar, at approximately € 1, whilst ELISA C- Salmotype was more expensive.

The long-term success of farm-based programmes designed to improve food safety will be dependent, to a great extent, on the design of pig housing and the quality of management. The successful operation of such programmes, which must satisfy the criteria laid down by Kavanagh (1997), may favour the fully or semi-slatted

systems which minimise pig contact with contaminated faeces, water or feed. Great difficulty will be experienced in satisfying the above basic guidelines in the case of semi-intensive or extensive systems based on straw bedding, continuous throughput and inefficient effluent control. Due to current planning restrictions there is little potential for the development of multi-site pig production systems in Ireland which would allow all in/all out production of pigs by site. The system of sow housing could also influence the prevalence of foodborne pathogens in sows at slaughter. It has been demonstrated that outdoor sows can have a significantly higher carrier rate of *Toxoplasma gondii* than sows housed indoors (Assadi-Rad *et al*, 1995). As efficient *Salmonella* control progresses at farm level, the sow may assume a role of greater importance than at present, where the transfer of *Salmonella* from the sow to her piglets may need to be maintained at a low level by adopting housing systems which minimise the sow's contact with contaminated faeces. This would apply particularly where piglets are being weaned at more than four weeks of age, due to the loss of maternal antibody protection. As food safety issues assume a role of greater importance in pig production, more research will be required in order to establish the influence of house type and management on the prevalence of foodborne pathogens in pigs at slaughter, under Irish conditions. With the exception of *Toxoplasma* there is little reference in the literature to a comparison of the prevalence of pig foodborne pathogens such as *Yersinia, Campylobacter, Salmonella* and *Arcobacter* in pigs kept in different types of production systems. There is a requirement for research programmes to target such topics in the future. The ultimate objective should be to develop systems and procedures which enhance food safety and satisfy the welfare requirements of the pig without compromising the economics of pig production.

Food safety will occupy a prime position in the eyes of the consumer over the next 10 years and programmes designed to improve food safety will require close liaison among veterinarians, government agencies, producers, meat processors, supermarket chains, consumer associations, transporters and pharmaceutical companies. As the food safety directorate in the EU is now responsible for agriculture-related decisions and is controlled by the Commissioner for consumer affairs, the commission may be even more influenced than previously by political rather than scientific considerations.

# SUMMARY

This thesis, initially, presents an overview of global pig production in which over 50% of the world pig population can be found in Asia. The EU pig industry, with higher feed costs than the USA produces pigs at a significant economic disadvantage which will be exacerbated in the future as a result of the recent banning of the use of six in-feed growth enhancers in the EU. Indeed, further expansion of the EU pig industry seems unlikely due to stringent environmental regulations and economic factors. Within the past five years, the USA has become a net exporter of pig meat, and with lower production costs, less stringent environmental regulations and the availability of in-feed growth enhancers, it is ideally situated to expand and become a major exporter of pig meat world-wide. With EU policy being primarily based on political initiatives rather than being scientifically driven, it is possible that the future may see a further contraction in the availability of antibiotics for inclusion in animal feedstuffs. Should this occur, even more emphasis will have to be placed on alternative methods of maintaining and improving pig health and production efficiency.

The bulk of this thesis is devoted to methods of improving pig health and production efficiency, based on sound economic principles. The onset of the "BSE crisis" created an acute awareness of the importance of food safety and current indications are that food safety issues will occupy a prime position in the pig veterinarian's schedule in the foreseeable future. This is particularly so in the case of the Republic of Ireland which exports approximately 60% of pig-meat produced and so its ability to capture and retain an export market is likely to be influenced by the quality and food safety standards of the end-product.

The ability of a pig to reach its genetic potential is influenced by its health status. There will be a requirement to reduce the quantity of routine antibiotics administered to pigs on farms in order to satisfy quality assurance and residue avoidance standards, so the emphasis on improving herd health status will increase with the objective of maximising the economic efficiency of pig production whilst satisfying food safety standards.

The positive isolation of toxigenic *Pasteurella multocida* type D in a herd of pigs does not provide conclusive evidence that the herd is positive for AR since the organism did not produce clinical signs or lesions of AR in the M.D. herd from which it was isolated. Declarations of freedom from AR should not depend solely on the results of laboratory tests on nasal or tonsil swabs. For a given herd, the results of such tests are best interpreted in conjunction with the results of regular clinical and abattoir inspections of stock.

In a slaughterhouse survey, 44% of pigs had Mycoplasma-type lesions. Almost 9% of lung volume (pigs with lesions) was affected with EP type lesions which is similar to that recorded in 1994 by Kavanagh (1995). Mange scores were low, suggesting that current control procedures are quite effective. Liver ascaris lesions were confined to pigs from less than 20% of herds. There was little evidence of gastric ulceration; perhaps wet meal feeding was beneficial, since, with the exception of three herds, all of the finishing pigs were fed wet meal by pipeline. Pleurisy lesions were detected in 25% of lungs examined from EP positive herds, which is higher than

that recorded by Done and Penny (1998). In their investigations in the UK 18% of lungs had pleurisy lesions and, most interestingly, the lesions were more common in the right caudal lobe than the left. They suggested that, in the case of haematogenous spread of bacteria, this might be due to the fact that the right caudal lobar pulmonary artery is larger than the left one, so the blood supply is greater to the right caudal lobe than the left. If the above results are extrapolated to the Irish Pig Industry, based on the correlation between lung lesions and FCR (Pointon *et al*, 1987), it is estimated that complicated EP costs the Industry approximately € 3 million annually.

Multi-source finishing units, particularly those that purchase pigs from a large number of small suppliers, have great difficulty in achieving target performance. A marked improvement in performance can be achieved by terminating supplies of pigs from problem suppliers, or by depopulating and repopulating with M.D stock. Total depopulation of a diseased herd, followed by cleaning and disinfection of the premises, and repopulation with MD stock is quite commonly carried out. However, it is very expensive, so other methods of eradicating disease without depopulation should be carefully considered before reaching a decision. A simple "rule of thumb" system for estimating the cost of a depopulation and restocking programme is based on a cost of € 13,000 to € 19,000 per 1,000 sow herd size per week of "no sale" period under Irish conditions. Improvements in herd health status could be achieved by age segregated weaning, segregated early weaning, vaccination, all-in / all-out systems of pig production, and improved environment and management**.**

Swine dysentery was eradicated from a 150 sow herd , without depopulation, by pulse medication. Progressive atrophic rhinitis, *Streptococcus suis* type 2, EP, AP, SD and sarcoptic mange were eradicated from a herd by M.E.W.

Blood-sampling sows, for the purpose of monitoring herd AD status is tedious. By comparing piglet serology with that of their dams it was established that herd AD status could be ascertained by taking one piglet sample per litter and that the results closely matched that of samples taken from their dams. The DAF, in recognition of the above research which achieved a 100% correlation between the results of piglet serology to that of sow serology as a method of establishing the AD status of pig herds, authorised sampling of one piglet per litter instead of blood sampling the sow in the current Irish AD eradication programme. With this system, in herds of 300 sows or greater, the majority of breeding stock samples are collected from piglets in the farrowing area and the balance from random sows and replacement gilts of greater than six months of age in the dry sow and gilt areas.

A modified AD ELISA test was developed for use on meat juice which gave comparable results to that of serum samples, thus creating a cheap and efficient method of monitoring for the presence of circulating AD virus in pig herds throughout Ireland, without having to resort to on farm investigations and sampling. This system facilitates the testing of samples for AD in conjunction with the National *Salmonella* control programme in which meat juice samples are routinely collected at slaughter for the purpose of monitoring for the presence of *Salmonella* antibodies. A low cost eradication programme designed to eradicate AD from the state is outlined.

The projected cost to pig farmers of a three year programme varied from € 1.3 million to € 21.5 million depending on the design of the programme.

In a 1992 survey of 85 herds representing 28,000 sows, 10.6% of samples gave a positive result to the G1 antibody ELISA test for AD and 29% of herds contained sero-positive animals. Sero-positive animals were identified in six herds which were not vaccinating and therefore at risk of a major AD outbreak. Aujeszky's disease spread occurred primarily in association with the purchase of breeding stock of unknown health status. The disease was eradicated from seven herds by twice-yearly vaccination but failed in 13 herds, suggesting that twice-yearly vaccination with inactivated AD vaccine controlled the clinical signs of AD but failed to eradicate the virus from the farms. Inactivated AD vaccine was used until 1994 when it was replaced by live vaccine. Subsequent experience would suggest that the live vaccines stimulate a stronger immune response and therefore are more capable of eliminating virus-shedding than the inactivated vaccines.

A further AD survey of practice breeding herds was conducted in 2003 as part of the National AD eradication programme. Aujeszky's disease eradication was actively pursued between 1992 and 2003 in the herds which were identified as positive in 1992. The programme was successful since the 2003 survey established that AD was eradicated from all 22 AD positive herds in the period 1992-2003. As a result all herds in the authors practice were AD free in 2003.
Aujeszky's disease was eradicated from a multiple herd enterprise, which consisted of 23 weaner-producing herds and one finishing herd, by a combination of vaccination and culling of sero-positives over a two and a half-year period. The disease was eradicated from the 12,000 place finishing unit over a period of four months by vaccinating weaners derived from herds with circulating virus twice and all others once only, on arrival at the farm. The cost of AD was calculated at € 0.013 per kg bodyweight gain or € 0.58 per pig, by comparing similar nine-month periods of production, before and after eradication. The total cost of AD to the unit was calculated at approximately € 32,000 per annum.

A pig *Salmonella* control programme was introduced in Ireland, based on an ELISA test of meat juice samples taken in the slaughterhouse, which is capable of establishing the exposure rate of pigs to a range of *Salmonella* serovars on the farm of origin. Herds are categorised according to the prevalence of ELISA-positive test results in meat juice samples. The Irish *Salmonella* control programme is geared, initially, to reducing the prevalence of *Salmonella* antibodies in slaughtered pigs and subsequently to focus on herds which are positive for *Salmonella typhimurium*, and particularly multi antibiotic-resistant strains of this organism. Since complete eradication is unrealistic, the National pig *Salmonella* control programme is designed to reduce the pig exposure rate to a level that is no longer a major threat to human health.

Multi-antibiotic resistant strains of *Salmonella typhimurium*, most commonly DT104, are very prevalent in pigs world-wide. *Salmonella* species occupy a prime position as foodborne pathogens, followed by *Yersinia* and *Campylobacter*. *Salmonella typhimurium* is the most common serovar isolated from pig herds in Ireland,

representing over half of all isolates. Also, in addition to being pathogenic to humans, approximately 40% of *typhimurium* isolates demonstrate multiple resistance to antibiotics (Kavanagh, 1998b).

The *Salmonella* sero-prevalence of pigs fed on a diet containing wet fermented meal or whey and meal is approximately one third that of pigs receiving a pelleted diet. Van der Wolf (2000b) reported that feeding fermented liquid feed had a strong protective effect against *Salmonella,* such that it was the most important result of his thesis. Whilst the importance of conducting cost benefit studies is highlighted in this thesis, *Salmonella* control is perhaps one area where cost benefit studies may not play such an important role, since the availability of an export market for pig meat in the future could be influenced by issues such as food safety, meat hygiene and freedom from multi-antibiotic resistant strains of *Salmonella*. Since there is a risk that the availability of antibiotics for inclusion in animal feedstuffs may be further restricted in the future, the programmes described, which are aimed at improving health status by depopulation and restocking with MD stock, disease eradication by vaccination and culling of sero-positives, MEW, medication-hygiene and partial depopulation., may become even more critical to the success of pig production enterprises. Biosecurity, which is currently a very important issue because depopulation and restocking programmes are very expensive, will become even more critical if more antibiotics are banned. Currently, diseases such as SD and proliferative enteropathy are regularly controlled by the inclusion of antibiotics in the feed. If the inclusion of phenoxymethyl penicillin was banned in feed, since it is also used in human medicine, difficulties could be experienced with successful treatment of Streptococcal meningitis. Current trends point towards a future requirement for more vaccines.

Three *Salmonella* ELISA kits (A-C) were evaluated. Serum samples were collected from pigs in the slaughterhouse from herds that were known to have a positive *Salmonella* sero prevalence of between 40 and 60%. Sixty-two samples were selected for testing and each sample was subjected to four ELISA tests, one from each kit being evaluated. Since the method of assigning an inconclusive result varied between kits a comparison of inclusives would have been meaningless. Also, herd *Salmonella* categorisation, in Ireland, is based on sero-positive prevalence only. In Ireland, a sample cut-off value of 40% OD is used. The sample cut-off value is the demarcation between a positive and a negative test result. The higher cut-off is used to create a workable number of herds that require intensive *Salmonella* control and is not designed to indicate *Salmonella* freedom in pig samples that give a negative result at 40% cut off or its equivalent in other commercial ELISA kits. A sample cut off value of 10% most accurately reflects the demarcation between a positive and a negative test result. However, the higher cut-off value of 40% was used in Denmark (Mousing *et al* 1997) in order to achieve a workable number of herds undergoing compulsory intervention. As the programme of *Salmonella* control in Ireland progresses and the percentage of herds in category 3 falls, the cut-off value may be reduced in order to bring more herds into compulsory *Salmonella* control.

The results in all three ELISAs were quite similar at approximately 50% sero-positive. Variations in the results of individual samples were recorded, however, the overall correlation between the results was good. On statistical analysis the results were classified as similar by the chi square test ($P< 0.001$). Of the three kits, the highest sero-positive level was recorded by ELISA test B (HerdChek, IDEXX Laboratories, Netherlands), at

56% and the lowest by ELISA test A (Porcine *Salmonella* test kit, Vetsign, Guildhay Ltd, UK), at 47%, whilst ELISA test C (Salmotype Pig LPS ELISA test kit, Labor Diagnostik, Leipzig, Germany ) recorded 48% as sero-positive. The range of results was less than the variations that could occur in the results of herd monitoring in the Irish *Salmonella* control programme, in which 72 samples are tested per annum. Due to sample size the repeatability of the results is limited to an accuracy of +/-10%, with 90% confidence (Cannon and Roe, 1982). The results of the study confirm that the Vetsign, HerdChek and Salmotype ELISA test kits could be incorporated into the Irish *Salmonella* control programme as a method of monitoring herd *Salmonella* sero-prevalence, in place of the in-house Danish Mix ELISA currently used by the DAF. The current cost of the test kits, per test, based on a purchase quantity of three to five plates was compared. Each plate is capable of testing approximately 90 samples. The cost of ELISA A- Vetsign and B- HerdChek were similar, at approximately € 1, whilst ELISA C- Salmotype was more expensive (Table 61).

As the supermarket multiples became more involved in pig production they influenced trends in the design of pig housing. However, the trend from fully-slatted floors, towards solid floors, and particularly straw-bedded floors, may have a negative impact on food safety. This applies particularly in the case of pig exposure to *Salmonella* which is closely related to the exposure rate of the pig to faeces and other carrier pigs. In the circumstances, the pig veterinarian will play a key role in developing and advising about alternative systems of housing that satisfy welfare standards under commercial conditions, food safety standards and also allow pork to be produced profitably. The global pig industry of today requires specialists in pig medicine who are familiar with the technical, practical management, financial, and food industry aspects of modern pig production systems. To achieve this standard, species specific training may be required at undergraduate level in the future (Penny, 1998). The results of a recent RCVS manpower survey (Anon, 2003b), confirm that between 1998 and 2003 small animal activities increased from 66 to 73.5% while work with farm animals decreased from 20 to 9.2%.

Separate clinical courses for farm animals and companion animals would seem to be the sensible way of handling the situation outlined above, while keeping the length of veterinary degree courses within limits (Penny 1998). Such a change would permit graduates who had taken the farm animal option and so had a deeper knowledge of their chosen species, to progress more readily to a postgraduate specialist course in pigs, such as those available at the universities of Minnesota and Illinois in the USA, or the Diploma in Pig Medicine (DPM) of the RCVS.

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## ABBREVIATIONS

| | |
|---|---|
| AD | Aujeszky's disease |
| ADF | Aujeszky's disease freedom |
| AP | Actinobacillus pleuropneumoniae |
| AR | Progressive atrophic rhinitis |
| BF | Breeding unit selling finishers |
| BSE | Bovine spongiform encephalopathy |
| BW | Breeding unit selling weaners |
| Cv+ve | Circulating virus positive |
| CV-ve | Circulating virus negative |
| CPA | Clinical pathology accreditation |
| DAF | Department of Agriculture and Food |
| DLG | Daily liveweight gain |
| EBL | Embryonic bovine lung |
| ELISA | Enzyme linked immunosorbent assay |
| EP | Enzootic pneumonia |
| EU | European Union |
| FCD | Food consumption per day |
| FCR | Food conversion ratio |
| FDA | Federal Drugs Administration |
| GATT | Global Agricultural Trade Tariff |
| GLP | Good laboratory practice |
| GNB | Gram negative bacillus |
| G1 | Glycoprotein 1 |
| HACCP | Hazard analysis critical control point |
| ISO | International standards organisation |
| LPS | Lipopolysaccharide |
| MD | Minimal disease |
| MEW | Medicated early weaning |
| NAMAS | National measurement accreditation service |
| NCTC | National collection of typed cultures |
| NIP | Not in pig |
| NT | Not tested |
| OADF | Official aujeszky's disease freedom |
| PCR | Polymerase chain reaction |
| PHCA | Pig health control association |
| PRCV | Porcine respiratory corona virus |

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|---|---|
| PRRS | Porcine reproductive and respiratory disease syndrome |
| REPS | Rural environment protection scheme |
| SCAN | Scientific committee of animal nutrition |
| SD | Swine dysentery |
| SPF | Specific pathogen free |
| TGE | Transmissible gastro-enteritis |
| TPM | Toxigenic Pasteurella multocida |
| WTO | World Trade Organisation |

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# APPENDIX 1: BIOSECURITY AUDIT

# APPENDIX 2: HERD HEALTH DECLARATION FORM

# APPENDIX 3: A COMPARISON OF THE RESULTS OF THE AUJESZKY'S DISEASE ELISA TEST ON PAIRED SAMPLES OF SERUM AND MEAT JUICE

# APPENDIX 4: COMPUTERISED CASH-FLOW

# APPENDIX 5: DEPOPULATION REPOPULATION SCHEDULE

# APPENDIX 6: “WHIF” VETERINARY AUDIT

# APPENDIX 7: GUIDELINES FOR ON-FARM CONTROL OF FOOD-BORNE PATHOGENS