Animal & Grassland Research and Innovation Centre

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Conference Proceedings

Horse & Jockey Hotel, 21st October, 2014
Cavan Crystal Hotel, 22nd October, 2014

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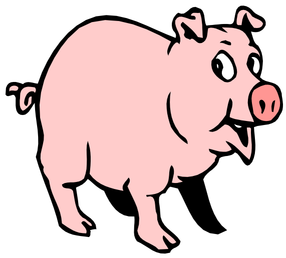

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Maintaining Growth in pigs weaned from Large Litters

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Introduction

Weaning is arguably the most stressful period in the pig's life. At weaning the pig is removed from the sow where it has had access to ~20 small feeds of sow's milk each day. It is removed to unfamiliar surroundings and mixed with strange pigs in pens where the only available food is predominantly vegetable in origin and generally fed in dry form. It is hardly surprising that with such social and nutritional stress the pig generally suffers a growth check in the immediate post-weaning period.

Irish sows now produce 1.7 more live born pigs per litter than they did 10 years ago and increases are likely to continue. However, large litters bring problems, with lighter piglets born and weaned, and greater within-litter variation in piglet birth and weaning weight. This is particularly important since birth weight has a huge influence on lifetime pig growth. We have always had a challenge to maintain pre-weaning growth rates in the early post-weaning period and this challenge is now even greater. Overcoming this post-weaning growth check will reduce mortality, increase lifetime growth and reduce the time needed to bring pigs to their target slaughter weight. Now is an opportune time to take stock of what we have learned about good post-weaning management and nutrition practices with this goal in mind.

1. Weaning age

Typically in Ireland pigs are weaned at ~26 days of age. Earlier weaning could increase sow productivity due to increased litters per sow per year. However, this can lead to greater health/mortality problems, and feed costs will increase as pigs are introduced to more expensive diets earlier. Leliveld et al. (2013) investigated the effect of weaning age (3, 4 and 5 weeks) on the growth performance of pigs up to 10 weeks of age. With each one week increase in weaning age, feed intake and growth rate increased and feed conversion improved in the first 2 weeks after weaning. When growth performance was measured to the same chronological age (10 weeks of age) feed intake and growth rate increased with each week increment in weaning age. Five week weaned pigs also had improved feed conversion efficiency compared to those weaned at 3 or 4 weeks (Table 1). Previously it was shown that each 1 day increase in weaning age contributes ~500 g of an increase in weight at 28 days post-weaning (Lawlor et al., 2003a). Older pigs adapt more rapidly to solid diets as their gastrointestinal tract is more developed.

Mortality between weaning and 10 weeks of age, and faecal E. coli counts at 10 days post-weaning were higher in 3 week weaned pigs compared to those weaned at 4 weeks (Leliveld et al., 2013). Higher amounts of undigested feed are found in the gastrointestinal tract of early weaned pigs compared to those weaned later leading to the proliferation of pathogenic bacteria in the intestine and diarrhoea.

2. Wean a heavy pig but "Birth weight is king!"

High feed intake and growth rate in the period immediately following weaning is essential if growth rates from weaning to sale are to be maximised. The key to achieving this is to wean heavier pigs. However, a heavy pig at weaning can originate because it was inherently heavier at birth or because, it received preferential management and nutrition during the suckling period. Increasing nutrition and management by creep feeding, offering milk replacer to suckling pigs and reducing litter size were effective in increasing weaning weight by 0.5kg per pig. However, boosting weaning weight in this manner did not influence post-weaning performance and the weight advantage created at weaning disappeared by 14 days post-weaning (Lawlor et al., 2002a; Table 2).

Table 1. Effect of weaning age on growth performance (Leliveld et al., 2013)

	Weaning age (wks)			
	3	**4**	**5**	**s.e.**[1]
Mortality (%)	14[a]	1[b]	4[ab]	
Weight at weaning (kg)	6.5[a]	7.8[b]	10.0[c]	0.34
Weight 2 weeks postweaning (kg)	9.5[a]	11.6[b]	15.5[c]	0.41
Weight at 10 weeks of age (kg)	24.4	24.7	26.7	1.01
Average Daily Gain (g)[2]	363[a]	402[b]	476[c]	17.6
Average Daily Feed Intake (g)[2]	560[a]	621[b]	680[c]	26.1
Feed Conversion Ratio[2]	1.57[a]	1.55[a]	1.43[b]	0.045

[1]s.e. = standard error. [a-c] Means within a row with different superscripts differ significantly.
[2]Performance data given for the period from weaning to 10 weeks of age.

Table 2. Effect of pre- and post-weaning nutrition on pig performance to 129 days post-weaning (Experiment 1; Lawlor et al., 2002a).

Creep and milk replacer	None	None	Yes	Yes	s.e. [1]	P value		
Dietary regimen	**HDR**	**LDR**	**HDR**	**LDR**		**Creep**	**Diet**	**Int.** [2]
Weight (kg) [2]								
Weaning	7.9	8.0	8.5	8.5	0.25	*		
Day 27	20.7	19.8	21.4	20.0	0.65		+	
Day 129	95.6	96.8	95.7	94.4	1.54			
Daily feed intake (g/day) [3]								
Day 0 to 27	582	576	562	541	26.8			
Day 0 to 129	1534	1559	1517	1508	28.2			
Average daily gain (g/day) [3]								
Day 0 to 27	462	428	474	417	21.5		*	
Day 0 to 129	681	697	684	667	14.9			
Feed conversion efficiency (g/g) [3]								
Day 0 to 27	1.26	1.38	1.23	1.30	0.036		*	
Day 0 to 129	2.27	2.26	2.23	2.28	0.039			

[1]s.e. = standard error determined using a sample size of 12 pairs of pigs.[2]Interaction effect, weight category x diet.[3]Day refers to number of days after weaning. + P <0.10, * P <0.05.

Conversely, pigs that were heavier at weaning because they were heavier at birth had higher intake and daily gain in the first 4 weeks post-weaning and their weight advantage had increased by 60 % at 26 days post-weaning (Table 3). The differential in weight between heavy and light pigs at weaning (1.3 kg) could be traced back to a 170 g difference in birth weight between the two groups. Similar results are reported extensively and the benefit from a heavy weaning weight is evident up to slaughter weight. This work highlights the importance of achieving heavy birth weights. Pre-weaning management, although important cannot correct for low birth weights. The importance of birth weight in this regard is most likely because lighter pigs at birth have fewer muscle fibres which results in lower lean gain deposition rates and poorer FCE (Dwyer, et al., 1993). It is also important to note that, unless a high nutrient density diet is fed post-weaning, the benefits that arise from having a heavy pig at birth are lost (Lawlor et al., 2002a).

Table 3. Effect of post-weaning diet on performance of heavy and light pigs from weaning to day 26 post-weaning (Experiment 2; Lawlor et al., 2002a)

Pig weight	**Heavy**	**Heavy**	**Light**	**Light**	**s.e.**	**P value**		
Diet density	**High**	**Low**	**High**	**Low**		**Weight**	**Diet**	**Int[1]**
Birth wt (g)	1586	1513	1343	1414	40	**		
Weaning wt (kg)	7.1	7.0	5.8	5.9	0.12	**		
Wt. Day 26 (kg)[2]	18.1	16.8	15.5	15.1	0.32	**	*	+
Growth Performance								
ADFI[3], day 0 to 26	448	431	390	402	11	**		
ADG[4], day 0 to 26	412	367	357	353	11	**	*	+
FCE[5], day 0 to 26	1.10	1.17	1.11	1.15	0.02		**	

[1]Interaction effect, weight category x diet. [2]Day refers to the number of days after weaning. [3]ADFI = average daily feed intake. [4]ADG = average daily gain. [5]FCE = feed conversion efficiency. + $P < 0.10$, * $P < 0.05$, ** $P < 0.01$

3. Water intake

It is vitally important to encourage piglets to maintain fluid intake post-weaning. It can take more than a week after weaning for the pig to restore its daily fluid intake to the equivalent of that on the day prior to weaning. According to Fowler and Gill (1989) a suckling pig has equivalent water consumption prior to weaning of ~680ml; however, water intake is only ~290ml in the first day post-weaning and averages ~442ml in the first week after weaning. It is only in the second week post-weaning that water intake averages ~770ml/pig. An adequate supply of fresh potable water is essential where the aim is to maximise post-weaning growth rates. Restricted water flow can reduce feed intake and consequently ADG by 15 %, respectively (Toplis and Tibble, 1994; Table 4). Drinker position is critical, as consumption can be inhibited if they are placed at the incorrect height, angle or position within the pen. Recommendations for the use of bite drinkers and bowls are shown in Table 5. Bowl drinkers are now more common because they waste 30 % less water and it is easier for pigs to find the water source. However, bowl drinkers should be cleaned at regular intervals to ensure a supply of clean water. Push type bowl drinkers have minimal water waste compared to nipple drinkers and float type bowls drinkers (Torrey et al., 2008). Whatever type of drinker is used for weaned pigs, it is important to use the same type also in the farrowing house.

Table 4. Effect of water flow rate on post-weaning pig performance (Toplis and Tibble, 1994).

	Water flow rate (ml/minute)			
	175	350	450	700
Time spent drinking (min)	4.46	2.97	2.93	2.32
Water intake (ml/day)	780	1040	1320	1630
Feed intake (g/day)	303	323	341	347
ADG (g/day)	210	235	250	247
FCE	1.48	1.39	1.37	1.42

Table 5. Recommendations on drinkers for weaner pigs (Pedersen, 1999)

Pig weight (kg)	**Drinker type**	**Height above floor (cm)**	**Flow rate (l/min)**
5	Bite	30	0.5-0.8
15	Bite	45	0.5-0.8
25	Bite	55	0.5-0.8
7-30	Bowl	5-10	1-2

4. Push energy intake early post-weaning

Daily gain during the first week post-weaning has a positive relationship with pig weight at day 56 post-weaning and particularly so for light weaned pigs (Tokach et al., 1992). There is huge variation in pre-weaning growth rates of pigs. Edwards and Rooke (1999) reported a between-farm variation in post-weaning growth rates of 34 % and within-farm variation of 165 %, attributing most of this variation to differences in feed intake.

In Moorepark, average pre-weaning growth rates (birth to weaning at 26 days) of ~260 g/day have been seen (Lawlor, 2000). Maintaining this growth rate in the early post-weaning period is problematic and in practice, intake in the first few days after weaning is normally insufficient to cover even the maintenance requirement, much less to support pre-weaning rates of gain (Lawlor et al., 2002). As a consequence of this, there is often catabolism of fat as the pig strives to balance its energy requirement for maintenance. Another consequence is a reduction in villous height seen after weaning which affects nutrient digestion, thus prolonging the post-weaning growth lag and affecting performance to slaughter.

Table 6 explores the average daily feed intake necessary for a range of weaning weights and a range of diets of differing energy density to maintain pre-weaning energy intake levels in the early post-weaning period. It is evident that, on a high health pig unit with good pre-weaning performance, if a starter diet of 16.5 MJDE/kg is provided then pigs would need to consume 420 to 464 g/day before pre-weaning energy intakes from milk are matched. This table also demonstrates that the necessary feed intake per pig is reduced when the energy density of the diet provided is increased.

Table 6. Calculation of feed intake required post-weaning to match pre-weaning energy intake

DE of Diet			14.5	15.5	16.5	17.5
Weaning age	26	days				
Birth weight	1.5	kg				
Weaning weight	ADG	MJ DE	g/day	g/day	g/day	g/day
6.7	200	5.6	384	359	338	318
7.4	225	6.3	432	404	380	358
8.0	250	7.0	480	449	422	398
8.7	275	7.7	528	494	**464**	438
9.3	300	8.4	576	539	506	478
10.0	325	9.1	624	584	549	517
10.6	350	9.8	672	629	591	557

5. Post-weaning diet

5.1. Level of milk products

Dairy products, though expensive, are very important constituents of diets for pigs in the early post-weaning period due to their effectiveness in improving growth rate and feed efficiency at this time (Lawlor et al., 2005a). The time taken to reach target slaughter weight (~97kg) was reduced by 5 days by feeding a high dairy product starter and link in the post-weaning period compared with a low dairy product starter (Table 8; Lawlor et al., 2003b). In addition to this, mortality, incidence of scour and veterinary interventions are all likely to be reduced while management is made easier when a high dairy product post-weaning diet is offered. However, economics (diet cost and pig price) will dictate the degree of complexity of the diet and its duration of feeding in the commercial situation (Lawlor et al., 2003b).

Including lactose as a carbohydrate source in the diet at levels even as high as 320 to 470 g/kg, increases post-weaning daily gain in weaned pigs. Dried whey contains 650 to 750 g/kg lactose and so it is the most widely used lactose source in starter diets. Crystalline lactose or de-proteinised whey can be used as lactose sources as long as they are of good quality. Skim milk powder is also commonly used in post-weaning diets but is not as critical in the diet as lactose and there is little benefit from substituting casein for soy protein sources for more than 2 weeks after weaning.

5.2. Cooking cereals

When cereals are included in diets for newly weaned pigs they have often been subjected to some form of heat processing. This is generally done to make the carbohydrate fraction of the cereal more available for enzyme digestion in the gut. This is particularly important in newly weaned pigs because of their initially low levels of starch-degrading enzymes. Increased starch availability is normally measured in the laboratory as an increase in the gelatinised starch content in a sample (Table 7).

Steam flaking is a relatively gentle heating process when compared with extrusion, expansion or micronization and is less likely to have negative consequences (formation of enzyme resistant starch and maillard reaction products, heat damage to amino acids). Steam flaking maize and wheat effectively increased the level of gelatinized starch in both maize and wheat (Table 7) but did not benefit post-weaning or lifetime pig performance. The response to inclusion of steam flaked maize and wheat in the post-weaning diet was not influenced by weaning age, weaning weight , level of dairy products in the diet (Lawlor et al., 2003a ;Table 8) or the sequence of feeding raw or uncooked cereals during the post-weaning period (Lawlor et al., 2003b). It is therefore difficult to justify the increased food cost associated with the process. Although we did not investigate the inclusion of barley in post-weaning diets, others found a 14% increase in average daily gain when the barley component of a post-weaning diet was extruded. This is most likely due to the higher fibre content in the barley.

Table 7. Starch and gelatinised starch values for wheat and maize used in experimental diets (Lawlor et al. 2003b)

	Wheat	Steam flaked wheat	Maize	Steam flaked maize
Starch (g/kg)	609	624	654	644
Gelatinised starch [1]	0.215	0.781	0.265	0.840

[1]As a proportion of total starch.

Table 8. The effect of cooking maize and wheat (un-cooked or cooked) and level of dairy product (high or low) on pig performance from weaning to slaughter (Lawlor et al., 2003b)

					s.e.	Significance		
Process	**Un-cooked**	**Cooked**	**Un-cooked**	**Cooked**		**C**†	**DP**‡	**CxDP**§
Level of dairy product	**High**	**High**	**Low**	**Low**				
Pig Weight (kg)								
Weaning	7.4	7.5	7.4	7.5	0.1			
Day‖ 26	19.1	20.0	18.5	18.5	0.5			
Day‖ 125	96.5	97.1	96.0	95.7	1.6			
Growth performance								
ADFI, Day‖ 0 to 26	571	583	576	578	16.9			
ADG, Day‖ 0 to 26	439	468	419	410	19.0		*	
FCE, Day‖ 0 to 26	1.36	1.27	1.39	1.43	0.06		+	

†The effect of cooking. ‡The effect of level of dairy product. §The interaction effect of cooking and level of dairy product. ‖Day refers to number of days after weaning. +P<0.10. *P<0.05.

Cereals are frequently thoroughly screened and cleaned in advance of any cooking process and these processes alone are beneficial in terms of reducing their microbial load and improving growth performance. Responses to cooking maize and wheat, in particular, are very variable in the literature and it is possible that where responses are seen that it may be due at least in part to a decontamination effect. Therefore, if raw cereals are to be used in post-weaning diets then quality well screened grains with a low microbial load should always be used.

5.3. Diet Acidification

Early weaned pigs produce insufficient levels of gastric acid which can result in a high stomach pH. As a result, the digestion of nutrients, especially protein is reduced. Moreover, high pH is favourable for the proliferation of diarrhoea-causing micro-organisms in the weaned pig. The use of organic acids has been suggested as a means of lowering gastric acidity in weaned pigs and has been reported to improve growth performance. The benefits that arise from feeding organic acids include an inhibitory effect on pathogenic bacteria, increased amino acid and energy digestibility and an increase in nitrogen retention. The response to organic acids was previously found to be greatest in diets with low levels of dairy products. Dairy products contain lactose which can be fermented to lactic acid thus reducing gut pH. In addition, milk proteins are much more easily digested than vegetable proteins in the immature gut. The response to diet acidification might be expected to be reduced when provided in post-weaning diets to pigs that were provided with creep feed prior to weaning as creep feeding of suckling pigs is thought to benefit post-weaning pig performance by stimulating gastric acid production and enzyme secretion.

Unexpectedly, Lawlor et al. (2005a) found that the response to a dietary acid was not influenced by the level of dairy product in the diet or whether pigs had or had not been creep fed while suckling the sow. Feed intake in one experiment was increased by ~32% in week 1 and by 11% over the first 3 weeks after weaning due to the dietary addition of fumaric acid. This increase in feed intake translated into a ~20% increase in growth rate in the first 3 weeks post-weaning. However, the response to diet acidification was not always consistent between experiments with a response to fumaric acid seen in 2 of the 3 experiments reported and the magnitude of the response varied greatly between the two experiments where a positive response was found. Similar results were found in later work (Lawlor et al., 2006). It was thought that microbial challenge during the post-weaning period has a major influence on the response to fumaric acid supplementation.

Table 9. Effect of pre-weaning creep feeding on response of weaned pigs to dietary fumaric acid (Lawlor et al 2005a)

					s.e.d.	F-test
Creep	**No**	**No**	**Yes**	**Yes**		**FA**
Fumaric acid (FA; g/kg)	**0**	**20**	**0**	**20**		
Pig weight (kg)						
Weaning	6.1	6.1	6.2	6.0	0.31	
Final	12.1	12.9	11.9	13.6	0.67	**
Feed intake (g/day)						
Week 1	194	233	180	260	19.0	***
Week 2	528	550	533	623	46.0	
Week 3	658	696	667	711	43.7	
Overall	466	500	466	535	30.3	*
Daily gain (g/day)						
Overall	289	320	273	358	23.6	**

There was no significant effect of C and no C x FA interaction.

An alternative approach to diet acidification, which can yield similar benefits, is to formulate post-weaning diets to have a low acid binding capacity. Acid binding capacity can be defined as the amount of acid in milliequivalents (meq) of Hydrochloric acid required to lower the pH of 1kg of feed sample to (a) pH 4.0 (ABC-4) and (b) pH 3.0 (ABC-3) (Lawlor et al 2005b). The lower the acid-binding capacity of the feed, the lower the amount of gastric acid that is required to lower its pH and create an acidic environment in the stomach, which is beneficial to pig health and digestion. Lawlor et al. (2005b) published a data set of acid-binding capacity values for a wide range of feed ingredients. There is great variation between ingredients with regard to acid-binding capacity values. For this reason, complete post-weaning diets can be formulated to have a low acid-binding capacity by selection of ingredients from this dataset with low acid-binding capacity and by using the acid-binding capacity value for each ingredient in the diet formulation matrix. Such diets can be used when a high gastric pH is likely to be a problem (e.g., at weaning) and as an effective alternative to diet acidification. When such diets were formulated by reducing calcium and phosphorus content in the diet formulation, feed intake in the first week after weaning was increased by 17% (Lawlor et al., 2006). This is the time where we need to increase feed intake as it has such an influence on subsequent growth performance.

5.4. Probiotics

Probiotics are 'live microorganisms which when administered in adequate amounts confer a health benefit on the host' (FAO/WHO, 2001). They offer potential as an alternative to antibiotics for pigs, both as a means of controlling enteric pathogens and improving growth performance. Their possible modes of action include modulation of the immune system, competitive exclusion of pathogens in the gut and antimicrobial production. Prieto et al. (2014) evaluated the safety and efficacy of a marine-derived *Bacillus pumilus* strain for use as an in-feed probiotic in newly weaned pigs. The *B. pumilus* used was pre-screened and selected for its ability to inhibit porcine pathogenic *E. coli* (Prieto et al., 2013). The *Bacillus* strain was administered to weaned pigs fed a non-medicated diet and compared to a negative control treatment without antibiotic or pharmacological levels of zinc oxide (non-medicated treatment) and a positive control treatment containing apramycin and pharmacological levels of zinc oxide (medicated treatment). The study herd was at the time experiencing oedema disease during the post-weaning period. The *B. pumilus* strain decreased ileal *E. coli* counts in a manner similar to the medicated treatment but without the reduction in growth performance (Table 10) and possible liver toxicity found with the medicated treatment (Prieto et al., 2014).

Table 10. Effect of feeding non-medicated, medicated or *B. pumilus* treatments for 22 days on post-weaning pig growth performance[1,2] (Prieto et al., 2014)

	Non-medicated	**Medicated**	***B. pumilus***	**s.e.**	**P value**
Day 0 BW[3] (kg)	8.7	8.6	8.8	0.26	0.38
Day 22 BW (kg)	18.1	17.6	18.7	0.35	0.07
ADFI[4] (g/d)	471	458	475	12.6	0.53
ADG[5] (g/d)	427	405	455	15.7	0.07
FCR[6]	1.11[ab]	1.14[a]	1.05[b]	0.023	0.04

[1]Mean values with their standard errors. [2]Within a row, values without a common superscript are significantly different ($P < 0.05$). [3]BW = body weight. [4]ADFI = average daily feed intake, weaning to day 22 post-weaning.[5]ADG = average daily gain, weaning to day 22 post-weaning. [6]FCR = feed conversion ratio (ADFI/ADG), weaning to day 22 post-weaning.

Casey et al. (2007) investigated the effects of oral treatment of pigs with a mixture of five lactic acid bacteria probiotic strains, on both clinical and microbiological signs of *Salmonella* Typhimurium infection. Following probiotic administration for 6 days, animals were challenged orally with *S.* Typhimurium and monitored for 23 days post-infection. Animals treated with probiotic showed reduced incidence, severity, and duration of diarrhea, gained weight at a faster rate than control pigs, and had reduced fecal shedding of *Salmonella*.

5.6. Prebiotics

Prebiotics, like probiotics, are used as a strategy to influence the composition of the gastro-intestinal microflora towards a more favorable balance, by reducing the amount of harmful/pathogenic species and promoting the growth of species thought to have beneficial effects on host health (O'Sullivan et al., 2010). A prebiotic is "a selectively fermented ingredient that allows specific changes, both in the composition and/or activity of the gastrointestinal microflora that confers benefits upon the host wellbeing and health". Prebiotics are resistant to digestion in the upper gut (i.e. resistant to acid and enzymes), a selective substrate for the growth of beneficial bacteria and able to induce luminal or systemic effects that are beneficial to host health. To date only inulin, oligofructose, galactooligosaccharides and lactulose are considered true prebiotics; however, other potential sources of prebiotics such as seaweed-derived compounds are currently being explored (O'Sullivan et al., 2010).

6. Quantity of starter and link to feed/feed budget

There is no disputing the necessity to feed nutrient-dense, milk product-rich diets in the post-weaning period to ensure fast and efficient lifetime pig growth (Lawlor et al., 2002a; 2003b; 2005a). However, these diets are expensive and their overuse must be avoided. Feeding small quantities of these diets post-weaning may not maximize post-weaning performance but may be sufficient to optimize lifetime performance. Kavanagh (1995) found that pigs given 1 kg starter diet and 4 kg link diet were 2 kg lighter at 28 days post-weaning than pigs given 3 kg of starter and 8 kg link diet. However, by day 40 post-weaning this 2-kg weight advantage had been reduced to a 1-kg weight advantage and as pigs were not followed through to slaughter weight it is not known if full compensatory growth would have occurred by this time. Likewise, Lawlor et al. (2002a) compared two post-weaning dietary regimes: 1. 10kg starter followed by link to 27 days post-weaning and 2. 3kg starter followed by 10kg link followed by weaner diet to 27 days. In this experiment pig weight at day 27 was increased by 1.2kg and feed conversion efficiency was improved between weaning and day 27 post-weaning when the higher levels of starter and link were fed. However, the weight advantage was lost by day 50 post-weaning and pigs from both treatments reached target slaughter weight at the same age and had similar FCE from weaning to slaughter. This work also found that the benefit from feeding starter diet elapsed after day 10 post-weaning (Lawlor et al., 2002a).

In a more recent study Leliveld et al. (2013) fed four different allocation levels of starter and link diet (Table 11), and found that the allocation levels of starter and link diets immediately post-weaning had little influence on post-weaning growth performance. Moreover, Leliveld et al. (2013) found that weaning age (3, 4 or 5 weeks) did not affect the response to the level of starter and link diets fed. If growth performance was looked at alone this would suggest that there was no benefit from feeding more than 1kg starter and 3kg link diet. However, this should be treated with caution as mortality was higher in this study when low levels of starter and link were fed.

Bearing the above in mind it might be possible to feed allocations of starter and link as low as 1 and 3kg respectively to heavy weaned pigs in a high health situation. However, lighter weaned pigs, which are more likely in large litters, will likely benefit from a higher allocation of starter and link. In addition, if there are health problems on a unit then pigs will also likely benefit from a higher allocation of starter and link.

Table 11. Effect of allocation of starter and link diets on growth performance (Leliveld et al., 2013)

Starter diet (kg)	**1**	**2**	**3**	**4**	**s.e.**
Link diet (kg)	**3**	**6**	**9**	**12**	
Mortality (%)	10	10	4	2	
Weight (kg)					
Weaning	8.1	7.7	8.5	8.1	0.29
2 weeks post-weaning	12.2	11.6	12.8	12.2	0.35
10 weeks of age	25.4	24.9	26.3	24.4	0.85
Performance data					
Weaning to 2 weeks post-weaning					
Average Daily Gain (g)	291	276	306	298	11.5
Average Daily Feed Intake (g)	342	328	357	334	13.1
Feed Conversion Ratio	1.18^{ab}	1.22^{a}	1.16^{b}	1.13^{b}	0.033
Weaning to 10 weeks of age					
Average Daily Gain (g)	416	411	432	395	14.8
Average Daily Feed Intake (g)	620	610	653	596	21.8
Feed Conversion Ratio	1.51	1.52	1.52	1.52	0.038

s.e. = standard error. $^{a-c}$ Means within a row with different superscripts differ significantly

7. Liquid feeding

Liquid feeding reportedly stimulates post-weaning feed intake and growth rate in pigs. A series of four experiments to examine the effect of liquid feeding of weaned pigs on post-weaning growth performance and residual effects up to slaughter were conducted at Moorepark (Lawlor et al. 2002b). Table 12 summarises the results from one of these experiments. Surprisingly, feeding liquid feed to weaned pigs did not increase pig growth rate and in fact, in other experiments decreased it. It was also quite wasteful, leading to unacceptable feed efficiency. With fermented liquid feed, uncontrolled fermentation of the feed is highly unpredictable and the growth of undesirable bacteria, yeasts and moulds can cause problems. A starter culture was deliberately added to produce fermented liquid feed in this study; however, DM gain/feed was still decreased. It is concluded that there is no benefit from liquid feeding weaned pigs whether in fresh, acidified or fermented form.

Table 12. Effect of liquid feeding on pig performance[a] (LSM[b] ± SEM; Lawlor et al. 2002b)

Treatment[c]	DPF	ALF	FLF	SEM
Weight (kg)				
Weaning	8.0	8.0	8.0	
Day 27	17.7	18.5	17.3	0.35
Live BW at harvest	101.0	99.8	98.4	0.8
DMI (g/d)[d]				
Day 0 to 27	407[f]	518[e]	473[e]	14.9
Day 0 to harvest	1376	1358	1337	13.1
ADG (g/d)				
Day 0 to 27	361	389	347	13.2
Day 0 to harvest	684	695	683	8.1
DM Gain/feed (g/kg)[g]				
Day 0 to 27	888[f]	749[e]	733[e]	15.8
Day 0 to harvest	498	513	511	6.7

[a] Values are means of 8 pens of 14 pigs each. [b] LSM = Least squares mean. [c] DPF = dry pelleted feed; ALF = acidified liquid feed; FLF = fermented liquid feed. [d] Average daily feed intake was calculated on a dry matter intake (DMI) basis. [e,f] Within a row and experiment, means without a common superscript letter differ ($P < 0.05$). [g] Dry matter gain/feed was calculated as ADG divided by DMI.

8. Feeding milk replacer post-weaning

Feeding milk replacer in the immediate post-weaning period could be an effective strategy to increase feed intake and daily gain in the critical few days after weaning. Feeding a milk replacer plus starter diet for 4 days after weaning increased daily gain by 20-30% in the first week after weaning when compared with feeding the starter diet alone. The pigs also contained more protein and fat in their carcasses and had longer intestinal villi than pigs that were left on the sow, or pigs that were weaned directly onto starter diet (Zijlstra et al., 1996).
Low post-weaning intakes are responsible for the reduction in villous height seen after weaning. This villous shortening accentuates the low growth rates normally observed in the first week after weaning. However, offering liquid milk diets at regular intervals during this period could help maintain gut integrity, and thereby help overcome the growth lag at this time (Pluske et al., 1995).
Feeding liquid milk post-weaning is not widely practiced due to economic and labour considerations. However, this is a strategy that could benefit immediate post-weaning feed intake and growth of, in particular, light weaned pigs. Extreme caution would be advised regarding hygiene for the system used to both deliver and feed the milk replacer to avoid associated health problems.

9. Summary

Larger litters are resulting in lighter and more variable birth and weaning weights in pigs which will make it even more difficult than before to achieve high intake and growth immediately post-weaning. To overcome the "growth lag" normally experienced at weaning, intake of feed and water should be targeted at levels achieved prior to weaning. Increasing weaning age particularly above 3 weeks will increase growth performance and improve piglet health and targeting increased piglet birth weight will increase post-weaning growth and lifetime performance. Post-weaning diets should contain milk by-products, the most important of which is dried whey, as a source of lactose. It is not necessary to cook cereals for inclusion in post-weaning diets but cereals should be well screened and clean. Acids, prebiotics and probiotics can be effective alternatives to antibiotics in weaned pig diets but the response from their use may not be as predictable as that from conventional antibiotic use. Good quality starter and link diets are necessary for weaned pigs; however, the levels used should be geared towards pig weaning weight, health and the optimization of lifetime growth. We have not found liquid feeding of weaned pigs to increase growth rate but rather to increase feed wastage and reduce piglet growth. However, feeding milk replacer for a short period after weaning can greatly increase piglet growth and gastrointestinal health.

References available on request from the authors.

Benefits of Net Energy utilization for pig diet formulation

Edgar Garcia Manzanilla, Teagasc

When feeding any livestock species, our aim is to combine different **ingredients** available (e.g. cereals, soy bean meal, oil) into a diet that covers the **nutrient requirements** of the animal, as accurately as possible. The main nutrients present in the ingredients normally used in pig diets are:

-**Carbohydrates** and **fats**, normally used as sources of **energy**.
-**Proteins** and their forming units, the **amino acids** (e.g. lysine), as building blocks for muscle growth or milk/piglet production.
-**Vitamins** and **minerals** as key elements in all the reactions that take place in an organism.

The system of units we use in order to combine the different ingredients to obtain the final balanced diet is called a **feed formulation system**. These systems differ mainly in the way they express the values for energy and protein. The feed formulation system we use has very important effects on the profitability of our business as feed is the most important cost in any pig farm (more than 70% of the production cost). At the same time, energy represents a major part of the cost of any pig diet. Thus, it is very important to pay attention to how energy is considered when formulating pig diets.

The amount of energy provided to the animal in the diet can be considered in different ways. Figure 1 shows the different ways that energy in the diet can be expressed.

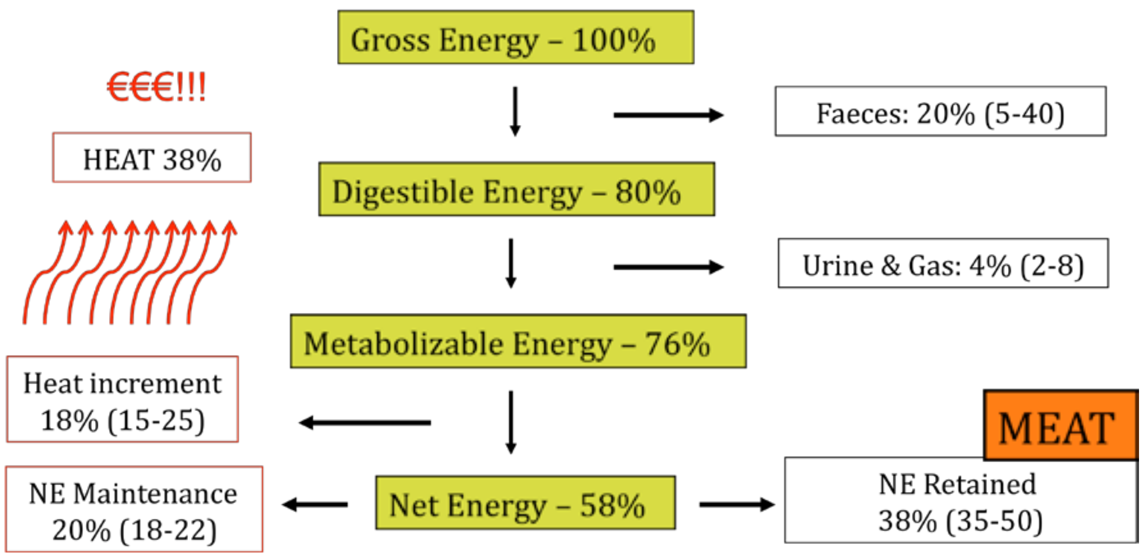

Figure 1. Different options to express energy level in pig diets. The figure also shows the different steps where the energy present in feeds gets lost and cannot be used by the animal for maintenance or growth.

The total amount of energy in the feed is called **Gross Energy**. It is measured by burning a sample of feed and measuring the amount of energy (heat) obtained. That is what the animal actually does with a major part of the feed; it "burns" it to obtain energy. However the animal is not able to use all the energy present in feeds and there are several losses when the nutrients are digested, absorbed and metabolised.

If we remove the energy lost in faeces we will have the **Digestible Energy** and if then we remove the energy lost in urine and gas we will be talking about the **Metabolizable Energy.** In pigs digestible and metabolizable energy are very similar and are around 75-80% of the gross energy initially found in the diet. This percentage varies depending on the composition of the feed. Diets can be formulated based on the metabolizable or digestible energy of the ingredients as it is still done in many cases. However, the animal will not be able to use all that energy and we may be formulating a diet that is not balanced for the requirements of the pig. In other words, we could be giving the animal less energy than it requires or we could be providing the animal with energy that it actually does not need.

Other than faeces, urine and gas, there is also an important part of the energy from the feed that is lost as heat, and it can account for between 15 to 25 % of the energy present in the food. Once we subtract that additional loss of energy from the energy of the diet we are talking about **Net Energy;** the real amount of energy that the pig will use to maintain itself and to grow, produce meat, or milk and piglets in the case of the sows. Thus net energy is the only energy system that accounts for the real requirements of the animal.

The differences in the energy content of different ingredients depending on the units used to measure energy are shown in figure 2.

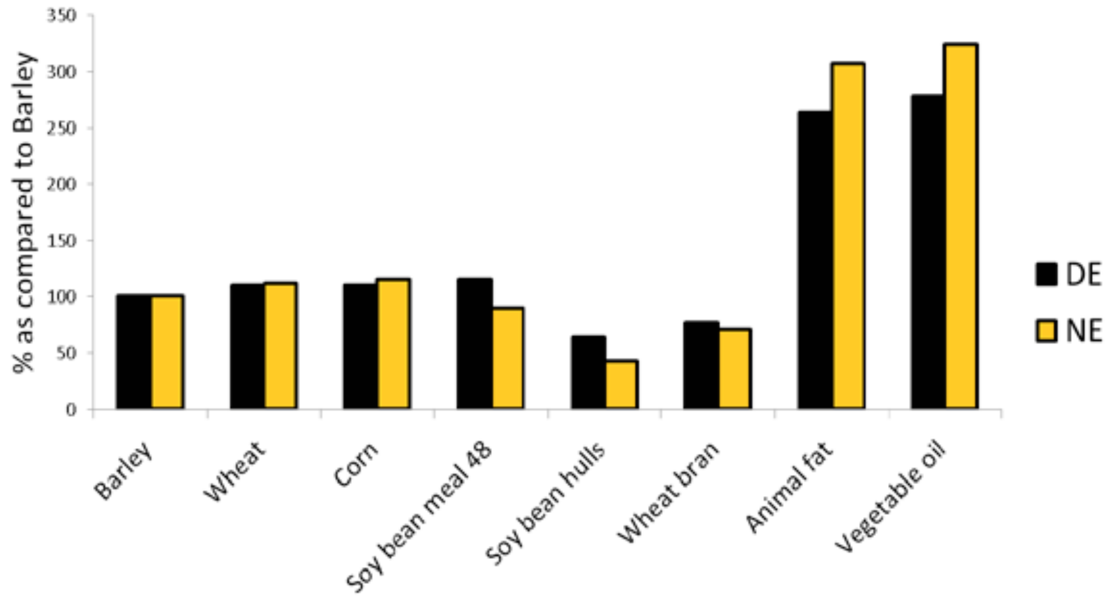

Figure 2. Digestible (DE) and net energy (NE) in different ingredients commonly used in Irish diets expressed using Barley as a reference value 100% (NRC, 2012).

Taking into account that net energy is the real energy value of the ingredients, it can be easily seen in the figure that digestible energy overvalues the energy content of fibrous feedstuffs (like hulls or bran) or high-protein feedstuffs (like soya bean meal). Thus, when we use a digestible or metabolizable energy system to formulate diets including these ingredients we are providing an animal with an energy level that is not real and is actually lower than expected. On the other hand, we can also see in figure 2 that fat and oil energy levels are under estimated by digestible energy systems.

Let’s illustrate what the problem could be when formulating a diet using digestible energy instead of net energy. We will consider a very simple diet only using barley, wheat, soya bean meal and soya oil. If we formulate a balanced diet based on digestible energy as shown in figure 3 we will need 67.6 % of cereals and 23.8 % of soya bean meal. If we then look at the net energy of the diet we will see that we are not meeting the real energy requirement of the pig. In this situation, the pig will have to consume more feed than expected in order to have all the energy it needs. However it will be eating an extra amount of the whole diet in order to just get the energy. The rest of the diet will be wasted.

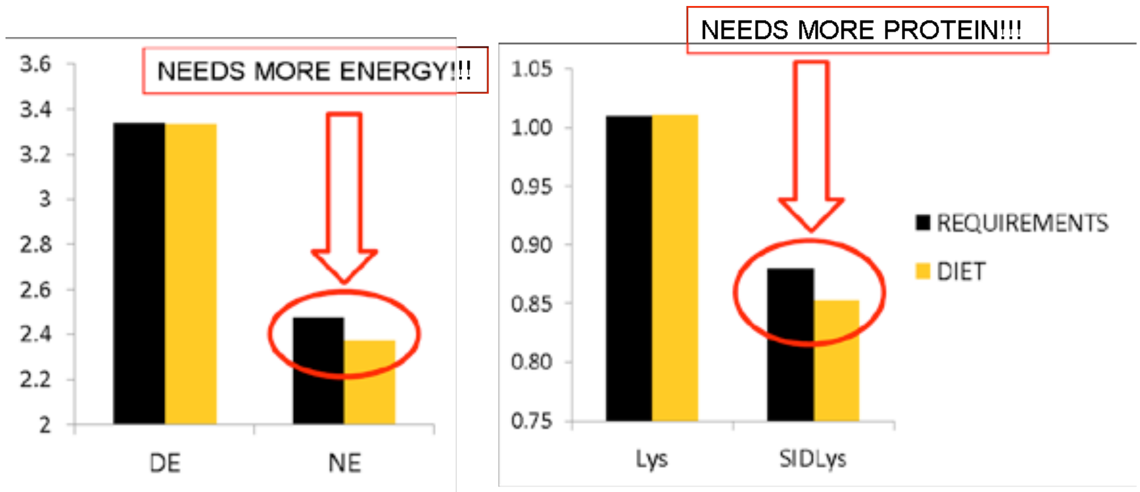

Figure 3. Composition of a corn/soya bean meal diet formulated based on digestible energy (DE; Mcal/kg) and total lysine (%).

If we formulate the diet based on net energy, we would actually need 72.0 % of cereals and 23.3 % of soya bean meal. If we calculate the price of this two ingredients in such diets with the current (September 2014) prices we would see that in table 1:

Table 1. Calculation of the price of a finishing diet based on digestible energy (DE) or net energy (NE).

Ingredient	**Price €/tonne**	**Diet based on DE* Kg/tonne**	**Diet based on NE* Kg/tonne**
Barley	167	256	256
Wheat	168	420	464
Soya bean meal 47	365	238	233
Soya oil	585	25	25
COST		214.81	220.37

*the sum of all ingredients does not add up to 1000 because the diet is not totally balanced yet for all nutrients.

Apparently the diet based on digestible energy may seem cheaper. However, we should remember that the pig will be consuming more feed in order to reach its real energy requirement. In this case the animal will eat 5% more of this diet than the one based on net energy and the real price of the diet per pig would be:

Diet based on ME: 214.81 x 1.05 =225.55 €/tonne (i.e. 5.17€/tonne more)

The low energy will not be the only problem for the diet represented in figure 3. It is also very important to consider the balance between energy and protein, in particular lysine as part of the protein. Lysine is another important nutrient in determining the price of the diet. If we go back to figure 3 we will see that lysine, as energy, can be expressed in different ways. Figure 3 shows the values of total lysine and digestible lysine (normally referred as SID = standardized ileal digestibility). As in the case of gross energy, total lysine in the diet is not a good measure of the lysine available for the pig for growth because there are several losses before lysine is used for muscle growth. Digestible lysine is a better guide of its nutrient value.

In figure 3 the diet is formulated using total lysine and we can also see how digestible lysine in the diet is not enough to cover the requirements of the pig. This problem will not be solved by the use of the net energy system. To solve it we could increase the amount of soya bean meal in the diet in order to raise the amount of lysine in it. However, we would be wasting everything else that is not lysine in the soy. Instead, the use of synthetic amino acids will allow us a more precise diet formulation with cheaper final prices despite the high cost of the synthetic amino acids.

Synthetic amino acids can be used even if net energy system is not used. However, net energy formulation places a higher value on synthetic amino acids than when formulating on a digestible energy basis. Soya bean meal is not a good energy source and the DE system gives soya bean meal an inflated energy value. Net energy gives a more realistic measure of the energy available in soya. Thus reducing soya bean meal and using synthetic amino acids with a higher level of cereal will be a better option.

A question that immediately comes to mind is why are not all companies/countries using net energy and sinthetic lysine when formulating their diets?

The reason is basically the initial effort that it requires in order to adjust the system to a particular situation compared to the potential benefit. Using the net energy system requires some work in order to obtain the real net energy values of the ingredients and how they related to the final composition of the carcass. For this matter two main options are available, the French system (INRA) and the Dutch system (CVB). There are differences between the Dutch and the French systems, but these are modest. The most important disagreement between the two is in estimated energy value of fat sources. Countries like France, Denmark and the Netherlands adopted net energy systems as soon as they saw the benefits. It took a little bit more time in the USA because the benefits are less when diets are based on corn and soya at cheap prices.

In summary, the net energy system allows for more elaborated diets with an increased use of by-product feeds, such as distiller's grains and with substantial use of synthetic amino acids resulting in lowering of dietary crude protein. With these diets, the net energy system comes into its own and offers substantial benefits to the producer. However it will offer potential benefits of €1-2/pig by just using it for the ingredients currently used in Ireland.

Farming Through a Company

James McDonnell / Kevin Connolly
Financial Management Specialists
Teagasc Rural Economy and Development Programme (REDP)

October 2014

Teagasc – The Irish Agriculture and Food Development Authority

Setting up a farming company

- Flavour of the month at the moment
- Selected reasons given for company setup…

I think there ar… my pension so… any income fro…

Everyone else seems to be doing it…

- Teagasc advise early discussion with accountant & solicitor

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Company Tax Rates

Two rates of tax apply to companies

- Basic corporation tax rate – 12.5%
  - Applies to trading profits
- Passive tax rate – 25%
  - Applies to passive income – investment and rental income
  - This income can't be allowed build up in the company indefinitely – 20% surcharge applies if not distributed with 18 months

    - ie the income on retained earnings (DIRT type of tax)
- VAT – company can remain unregistered and claim 5.0% flat rate addition

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The company route..

Worth looking at???

- High personal tax rates – 55% for > €100k
- Capital allowances exhausted
- Planned further expansion investment
  No Capital allowances / high borrowings needed
- Further restrictions on scope for tax relief on personal pension contributions
- Large debt – unable to make sufficient principal repayments due to tax
- No land transfer planned in the near future

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A company is..

….a separate legal entity

- You are not the farmer – the company is!
- Business profits belong to the company first!
- Company will have its own bank account
- All business expenses invoiced to the company

You become a shareholder / director

- Director duties

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Key questions

- Are you paying the top rate of tax?
  - Are you maximising all available reliefs and allowances.
- How much of your annual business profit do you need to withdraw as personal drawings?
  - Is there off-farm income which reduces demand on farm cash for personal use?
  - If you need substantial drawings from the business you will be paying top rate tax on this anyway – lessens the tax advantage of a company
  - Future farm profits & personal drawings
    Higher or Lower?? – Greater volatility in future farm prices and profits

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Key questions

- Are you looking at sustained (& increasing) high business profits?
  - A short period of high profits may not justify forming a company
  - These short term rises can be smoothed out with income averaging & still remain a sole trader
- Are you planning business expansion?
  - High company retained earnings (after paying corp. tax of 12.5%) can be used to fund this
  - There is a large benefit if you intend purchasing land and leaving it in the company

Repaying Debt

Sole Trader	Company
Pay 41% tax + PRSI + USC before capital repayment	Pay 12.5% tax before capital repayment
To repay €20,000 principle requires €41,666 profit (if at top rate)	To repay €20,000 principle requires €22,857 profit

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Life Cycle of the business

- Don't change over if owner is retiring in the foreseeable future
- Loss of retirement relief from CGT on land rented out to the company
- No stamp duty relief if the young farmer puts it straight into the company (declaration on intention to farm the land for 5 years). Could form a company in a number of years.
- CAT – grey area – is the company an agricultural asset to satisfy the 80% rule

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Other Issues

- Landlord may not be able to get income tax relief on money from a long term lease received from a company – grey area
- 'Double chop' – company sells land and pays 33% CGT – owner sells / transfers company and pays 33% CGT
- Keep appreciating assets that you may wish to dispose of in the future out of a company

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Single Farm Payment

- This can be transferred to the company in two ways

By Sale

- CGT
- VAT

By Lease

- Lease in owned entitlements, one entitlement per eligible hectare
- Income from the leased land and leased entitlements are taxable at individuals private tax rate as income
- Some accountants are putting nominal values on this – this may be looked at in the future by revenue, should be priced at market values
- May push the farmer into the top rate of tax
- Leases with 3rd parties cannot claim income tax relief

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Making the switch

- New company has a separate legal status
  - Ceasing as a sole trader &
  - Commencing as a company
- Implications
  - Revision of tax bill for previous year due to ceasing sole trader business
  - Implications for farmers on income averaging
  - If stock value in the books in low there may be a large once off tax bill, might offset this with pension payment

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Sole Trader V Company Taxation

Farm Net Profit	€70,000	
Drawings	€35,000	
Spouse Income	€35,000	
	Sole Trader	Company
Tax Payable - Personal Tax - Corp. Tax	€23,181	€8,981 €4,375
Tax Saving		**€9,825**

Getting money out

Annual salary

- Subject to PAYE, PRSI & USC

Company repaying directors loans

- Loans are created when director transfers assets to the company for no payment
- These loans can be withdrawn tax free at any time

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Loans & Security

Can existing loans be transferred to the company?

- Yes but the underlying asset may also have to be transferred (Stamp Duty & CGT??)
- Bank will want to renegotiate the interest rate given in the past – generally means an interest rate increase

Loans kept outside the company

- Repayments will have to be made out of company transfers/ payments to the owner
- These transfers will be subject to personal tax rates
- Repayments will have to be covered from after-tax cash – benefits of low company tax will be lost

- Interest on non-company loans connected with land & buildings can be offset against money received from the company for the use of these assets

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Pension Payments

- Company can make contributions to directors pension
  - Small Self Administered Pension
  - Less restrictions on maximum amounts
- Pension contributions made are generally fully deductible against company profits

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Company Paperwork

- Reduction in paper work promised in new legislation
- Register company name with Companies Registration Office
- Register with Revenue
- Clearance with DAFF
  - Transfer of herd number
  - Transfer / lease of Single Farm Payment entitlement
  - Transfer of other schemes – change name

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Company Paperwork

- Annual accounts to be prepared
  - Usually higher accountancy cost
- Accounts filed with Companies Registration Office
  - Form B1 – accounts summary attached
- Annual Tax Returns
  - Corporation Tax Return CT1
  - Directors must file a separate return Form 11

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Delivery of a Veterinary Surveillance Strategy for the Irish Pig Sector

John Moriarty, Head Pathology, Central Veterinary Research Laboratory, DAFM

Increased global trade and movement of animals and animal products is good for Ireland agrifood, but it must be balanced by increased vigilance.

Current world trade and the movement of people, animal and products facilitate rapid movement of disease agents globally and thus increase the potential for disease incursion into naïve animal populations. Disease incursion is further facilitated by animal intensification and more centralisation of farm and production systems. These together with extended distribution systems help rapid spread of both known and newly emerging disease agents which are potentially catastrophic to farms, animal industries and the national economy.

Equally costly to individual farms and the economy are the so called production diseases. These are the simmering and apparently low level endemic diseases occurring in the majority of herds that sap resources and profitability through poor growth, extra feed costs, subclinical disease and excess antibiotic usage. The cost of endemic conditions, such as respiratory disease, to an enterprise is always greatly underestimated and is often addressed as a balance sheet cost item where an apparently low level disease occurrence stays within so called acceptable limits.

"The total economic damage caused by production diseases in livestock is larger than the damage caused by notifiable diseases such as Foot & Mouth." - Henk Hogeveen, Associate Professor, Business Economics of Wageningen University & the Department of Farm Animal Health, Faculty of Veterinary Medicine of Utrecht University.

Constantly changing and evolving production systems provide continuous opportunity for a change in behaviour of a known disease agent or the emergence of new agents. The fear of ASF penetrating Europe, the emergence of PEDv causing devastating piglet mortality in America, the change of behaviour of klebsiella, which is now causing many outbreaks of septicaemia and death in free range pigs in the UK, an apparent change in oedema disease discussed by veterinary pathologists at a European patho-surveillance meeting recently, all point to risk and change as being the norm and the ability to identify and respond to these risks and changes as being the prerequisite.

Viral circulation is on the rise and ASF is now established beyond Africa, in the Caucasus, the Russian Federation and Eastern Europe. Any country with a pig sector is at an imminent risk from an ASF introduction. The informal movement of infected pork products has allowed the virus to jump across the globe thousands of kilometers from its source.

The sudden emergence of porcine epidemic diarrhoea virus (PEDv) for the first time in the United States caused significant economic concerns. Since its recognition and diagnosis in May 2013 by veterinary pathologists and virologists in the National Animal Health Laboratory on being alerted by specialist pig veterinarians, PEDV has spread rapidly across the United States, resulting in high mortality in piglets in more than 30 States. The economic cost of PEDv at farm level is between $216 to $338 per sow space with the loss of up to 10 million piglets in the USA alone last year.

Defra funded surveillance carried out by the VLA raised 160 alerts of possible new animal disease between 2005 and 2008, which on further investigation led to the identification of 26 emerging (or re-emerging) animal diseases or syndromes.

When foot and mouth disease struck the United Kingdom in 2001, 57 farms were infected before the disease was first reported.

Timely detection and understanding of disease is required to facilitate efficient and effective response and thus reduce impact on farms and the economy.

Credible animal health information can only be produced by credible surveillance involving the appropriate diagnostic expertise and capability, surveillance footprint and communication. This not only serves to improve animal health generally by guiding timely veterinary intervention but also helps protect the industry from trade limiting disease, thus providing competitive advantage where absence of these diseases is demonstrable.

This may appear straight forward because the basic components of surveillance are

1. Detection
2. Response
3. Information & Communication

Unfortunately it is not that simple, although it should be; surveillance is invariably broken down to sub categories often engendering differing supporting architectures

- Passive surveillance (or scanning surveillance)
- Active surveillance
- Targeted surveillance
- Sentinal surveillance
- Syndromic surveillance
- Abbatoir surveillance
- Regulatory disease surveillance
- Exotic disease surveillance
- Surveys

However underpinning all the subcategories of surveillance and health schemes is the requirement to have expertise and capacity in veterinary laboratory diagnostics (veterinary pathology, virology, bacteriology and toxicology) that provide the specialist diagnostic capability and information required to determine disease trends and response needs. These disciplines need a critical mass of experts and case throughput to maintain that expertise in the various veterinary laboratory diagnostic disciplines so as to service the needs of the pig industry. To do this they need to gain and maintain the confidence of specialist pig veterinarians and herdowners; confidence that is hard earned and easily lost.
Unfortunately internationally these fundamental disciplines are depleted, substantially due to rationalisation and dilution of efforts, and this has resulted in a loss of critical mass and expertise.

The AHVLA network of diagnostic laboratories covering England, Wales and Scotland offers diagnostic and consultancy services to producers through their veterinarians. These are similar to the Irish Veterinary Laboratory Service and its regional distribution of laboratories and are staffed by veterinary diagnostic specialists such as pathologists and virologists and are the key component of animal health surveillance in Great Britain. They provide in-depth diagnostics and information on health problems and new syndromes of all species including pigs. The AHVLA is currently undergoing uncompromising rationalisation.

Also in Great Britain, health schemes have become an important tool available to farmers and their veterinarians for monitoring and tackling important health problems affecting efficiency of production and/ or animal welfare. Two initiatives have been implemented by the pig industry there: Wholesome Pigs Scotland (WPS) and the BPEX Pig Health Scheme (BPHS). These schemes record the presence of a range of lesions associated with a reduction in performance traits or are indicators of animal welfare problems. The combined results from both schemes provide a powerful tool for prevalence estimations on endemic diseases in the British finishing pig herd. However a particular weakness is that lesions associated with challenges early in the life of the pigs will not be detectable in the abattoir and cannot be monitored by the schemes. Deaths on farms are also not accounted for. It is therefore important that the results of the health inspections in the abattoir are carefully interpreted within the context of the current and historical information available on the specific batch of pigs and the farm in general.

Similarly a network of sentinel pig veterinary practices with clients in all pig-producing areas collate surveillance information from practice activities. The clients for whom the information is recorded remain anonymous.

In Ireland the Veterinary Laboratory Service (VLS) is composed of the Central Veterinary Research Laboratory (CVRL) and five Regional Veterinary Laboratories (RVL) strategically located throughout Ireland to ensure effective geographic footprint of surveillance activities.

Within the CVRL there are three divisions dedicated to veterinary pathology, bacteriology and virology. All these divisions contain accredited national reference laboratories manned by veterinary diagnostic specialists, specialist techniques, and high containment facilities for handling high risk pathogens (such as ASF & CSF).

The VLS is a critical infrastructure to safeguard animal health in Ireland.
The ever increasing complexity of the animal health environment and the needs arising thereof must be seen in the context of the current economic climate, depleted funds and workforce. This climate, not unique to Ireland, has resulted in detrimental rationalisation of national animal health laboratories throughout Europe and further afield. The convergence of increasing threats and consequences of exotic and endemic animal disease, the need to have critical mass in diagnostics commensurate with addressing these threats and the reality of depleted resources has created a focused dialogue for cooperation amongst stakeholders in Ireland and across Europe.

Recognising that early detection of infectious disease is critical to a nations ability to access international markets for live exports and meat, the VLS has redoubled efforts to build critical mass and alliances nationally and internationally with sister organisations and concerned stakeholders.

There are ten accredited national reference laboratories within virology division's high containment facilities, including for ASF, CSF, aujeskys and for all intents FMD. Virology Division has repeatedly demonstrated ability to have tests in place and validated within weeks of newly emergent viruses, most recently Schmallemberg virus, PEDv and Deltacorona virus. It collaborates with many national reference laboratories for high risk viruses and high containment facilities across the world. It is currently developing capacity for next generation sequencing for novel pathogens.
Pathology Division similarly have accredited national reference laboratories and in the last year has refocused efforts in developing and maintaining pig pathology expertise for the Irish pig sector. In response to a need identified by the industry itself. Because Pig pathology expertise is a diminished resource across Europe, membership of the European Pathosurveillance and European veterinary surveillance networks have greatly enhanced the objective of improving and creating concrete links with pig pathologists, thus creating valuable connections and diagnostic collaboration.

The VLS employs one of the two accredited pig pathologist in Ireland (FRCPaths) and she has commenced mentoring RVL colleagues in pig pathology so that scope and quality assurance of the service can be extended across the country with the main axis being Dublin and Cork.

Continued development of pig pathology expertise is only possible because of the positive engagement with Irish consultant pig veterinarians who have supported and guided the direction of development in accordance with animal health needs at farm level. Through them the VLS is currently completing a pilot pig pathology project which aimed to create the necessary throughput for development and the collaboration required to characterise and define diseases on some large pig farms. This has evolved now to a more targeted investigation pilot project. The benefits of this has been immense not only in developing trust and collaboration with pig health specialists but also in identifying diagnostic and pathology needs for the industry and determining how value can be delivered to the farmer through his consultant pig practitioner.

Pathology division has also linked with experts in Teagasc, UCD and CIT in studies on pig health in a determined effort to develop another 'accredited' pig pathologist and new diagnostic technologies within the government and academic laboratories, in essence to deep root the resource for the industry.

Balancing increased global trade and movement of animals and animal products with increased vigilance and disease alert systems to protect both Irish farms themselves and their continued access to markets is GOOD for agribusiness. The time for such systems investment is BEFORE and not after the event.

I have outlined only the first tentative steps by the VLS towards redressing the diagnostic and surveillance needs of the pig industry. No doubt, should these initial endeavours be successful, there is great potential for a plexus of skills and collaborations across the country to intersect in a common effort to protect and enhance the animal health objectives of the Irish pig industry and indeed Ireland inc.

Benchmarking Irish sow performance based on average farm output

Keelin O'Driscoll and Peadar Lawlor, Teagasc

Increasing output per sow has been identified as a main research area by the IFA. In order to increase output per sow, it is important to categorise current sow output with regard to average performance in Ireland, as well as the performance of the top producing farms. This task is included in as part of the Optipig project that is currently underway in Moorepark. The results will inform both the research team, and stakeholders in Irish pig production, of the current status and how output has changed over time. Comparison of average Irish data with that of the top 10% and 25% of producers will shed light on production parameters that are driving improvements in the number of pigs produced per sow per year. As well as comparisons between top producing and average producing farms in Ireland, Irish data has been compared with data from other European countries.

Sow output in Ireland since 2003

Year	No farms	Avg Size	Top 10%	10% size	Top 25%	25% size
2003	110	435	11	544	28	504
2004	109	488	11	531	27	582
2005	88	538	9	410	22	551
2006	76	566	8	611	19	523
2007	96	549	10	649	24	694
2008	92	558	9	634	23	729
2009	79	606	8	713	20	620
2010	91	706	9	629	23	680
2011	93	706	9	745	23	680
2012	84	756	8	548	21	621
2013	103	723	10	395	26	724

In order to identify ways in which sow output could be increased, it is useful to investigate historical data. This allows us to see how sow output has changed nationally over time, and to investigate which aspects of production performance drove this change. Performance data from 2003 to 2013 were obtained from the PigSys database. The data within each year was ranked by the number of pigs produced per sow per year, as this was our main measure of interest. The number of farms used in analysis for each year is shown in Table 1. Data were averaged across farms, and not weighted by the number of sows per farm. This is because we were interested in averages based on overall farm records, rather than averages based on individual animal records.

As well as pigs produced per sow per year, the following parameters were used in analysis:, litters per year, pigs born alive, mortality rates days empty per litter, and conception rates. Within each year extreme outlying datapoints were eliminated from the dataset. Average figures from all farms, and the top 10% and 25% with regard to pigs produced per sow per year were calculated and displayed graphically.

Table 1. The total number of farms, number in the top 10% and number in the top 25%, with regard to pigs produced per sow per year used in analysis

On average, the annual output per sow in Ireland increased from 21.6 to 24.5 pigs produced per sow per year between 2003 and 2013. The average produced on farm for farms in the top 10% increased from 25.4 to 28.2. Further examination of the data aimed to identify which stages of production resulted in differences between average and top producing farms.

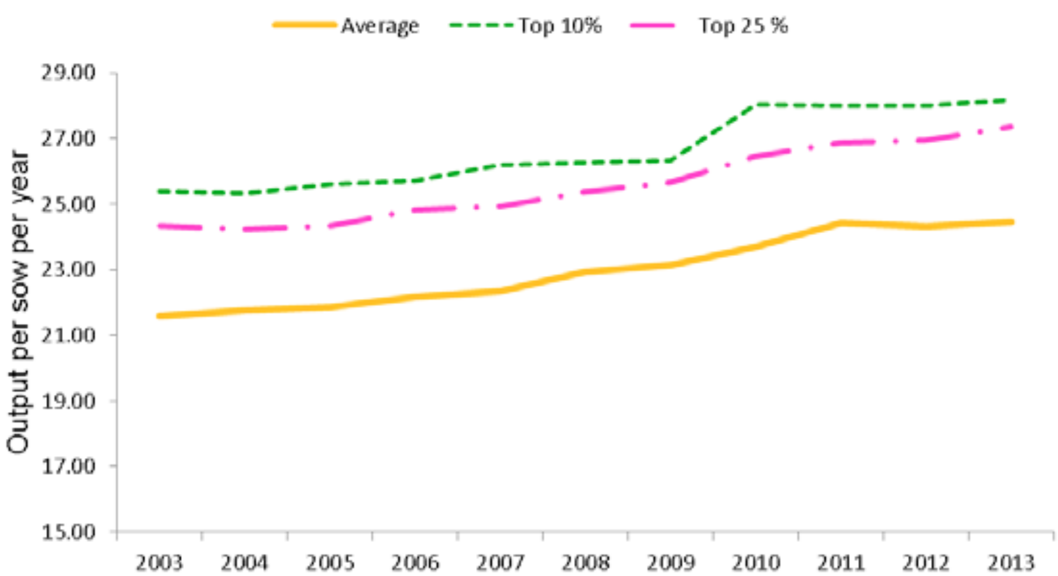
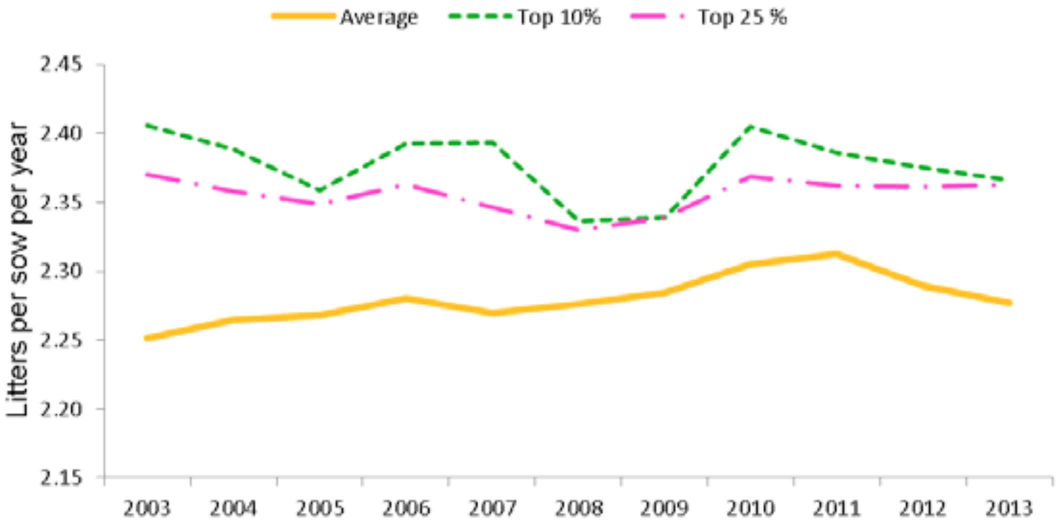


Figure 1. Pigs produced per sow per year between 2003 and 2013

Figure 2 demonstrates that the increases in production during this 11 year period were obtained primarily through an increase in the number of pigs born alive, rather than the number of litters per year, which has stayed relatively stable. However, for both measures, farms in the top 10% and 25% had higher values than average, indicating that the difference between these farms and average is due to both factors.



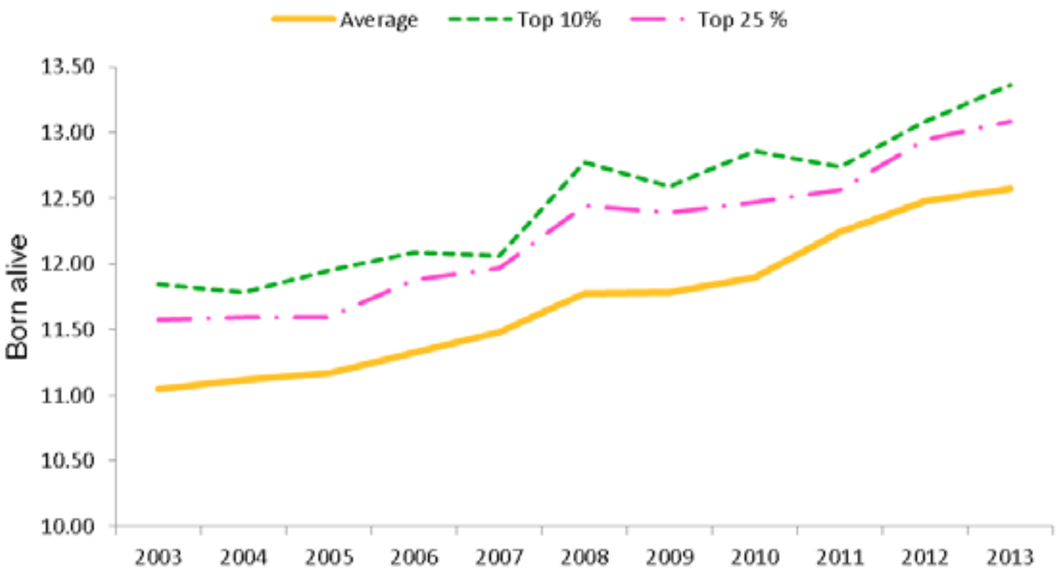


Figure 2. The average number of litters per sow per year, and numbers born alive, for all farms, and the top 10% and 25% with regard to pigs produced per sow per year.

Figure 3. Mortality figures during the production cycle for the average of all farms, and the top 10% and 25% of farms with regard to pigs produced per sow per year.

The most productive farms also had lower pre-weaning, weaner and finishing pig mortality figures than average. Thus even though these farms had higher numbers born alive, this did not necessarily correspond to a greater percentage of pre-weaning mortality (Figure 3). In fact overall there was a very low correlation between number born alive and pre-weaning mortality (0.165)

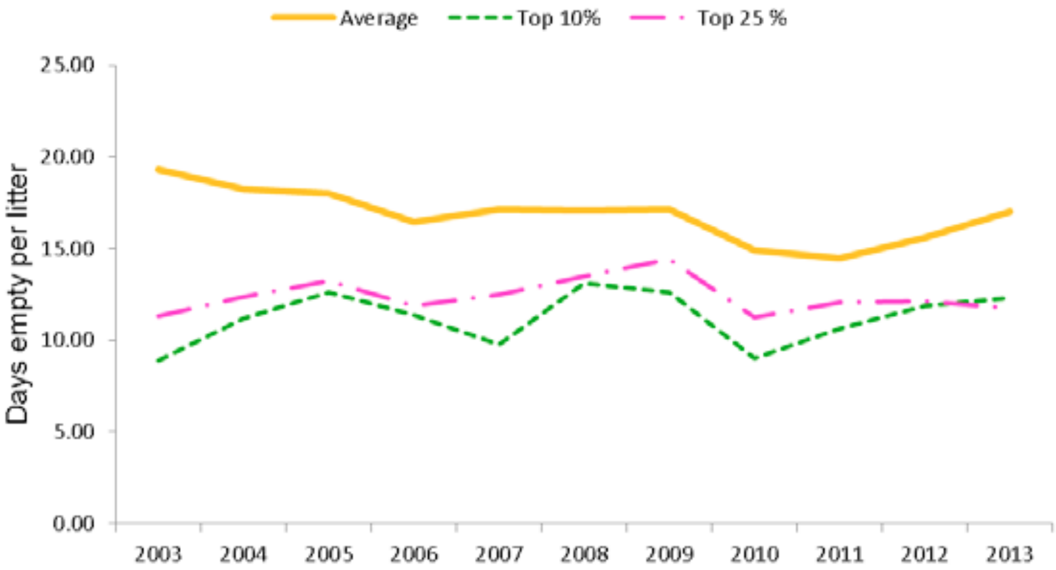


Figure 4. Days empty per litter for all farms (average), and the top 10% and 25% of farms with regard to pigs produced per sow per year.

With regard to sow parameters, there was a different pattern between the top producing farms and average. For days empty per litter there was no consistent pattern of change over time. However, the difference between the top 10% of farms, and the average farm value, has reduced from about 10.5 days in 2003 to about 4.75 days in 2013 (Figure 4). Likewise, although there's been no significant overall decrease over time, the difference in conception rate between the top 10% of farms, and average, has reduced from a difference of about 4.1% to approx. 1.2%. This probably means that while sow management practices have remained consistent in the top producing farms, there have likely been improvements in lower producing farms (Figure 4).

International comparison

As well as investigating national trends, it is useful to compare data with our European competitors. Interpig data from Denmark, The Netherlands and France were compared with Irish data for the years between 2002 and 2013. In 2002 there was little difference in the numbers of pigs sold per sow per year in each country. However the number in Denmark and The Netherlands increased significantly more than in Ireland and France during that period (Figure 5).

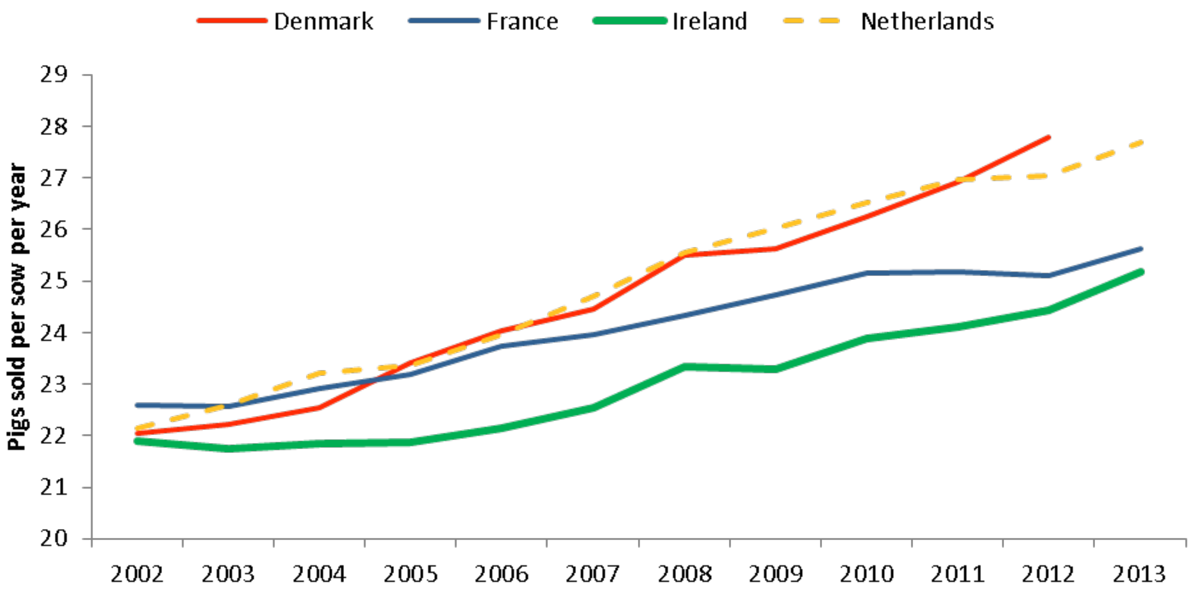


Figure 5. Pigs sold per sow per year in Denmark, The Netherlands, France and Ireland

This rise has been driven by a significant increase in the numbers of pigs born alive in these countries (Figure 6). However, the countries with the highest born alive also have the highest pre-weaning mortality rates (Figure 7). Although Ireland has yet the lowest pre-weaning mortality of the four countries examined, the percentage is increasing year on year, whereas it is stable in Denmark and The Netherlands. A continued increase in numbers born alive could pose a risk for higher pre-weaning mortality rates here in Ireland.

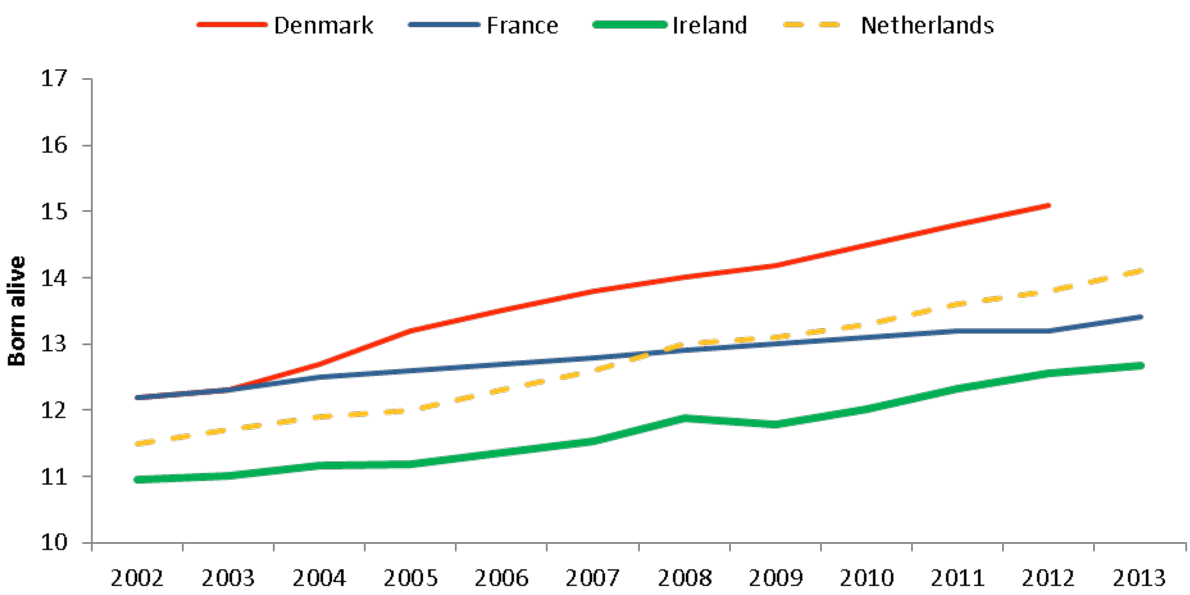


Figure 6. Pigs born alive in Denmark, The Netherlands, France and Ireland

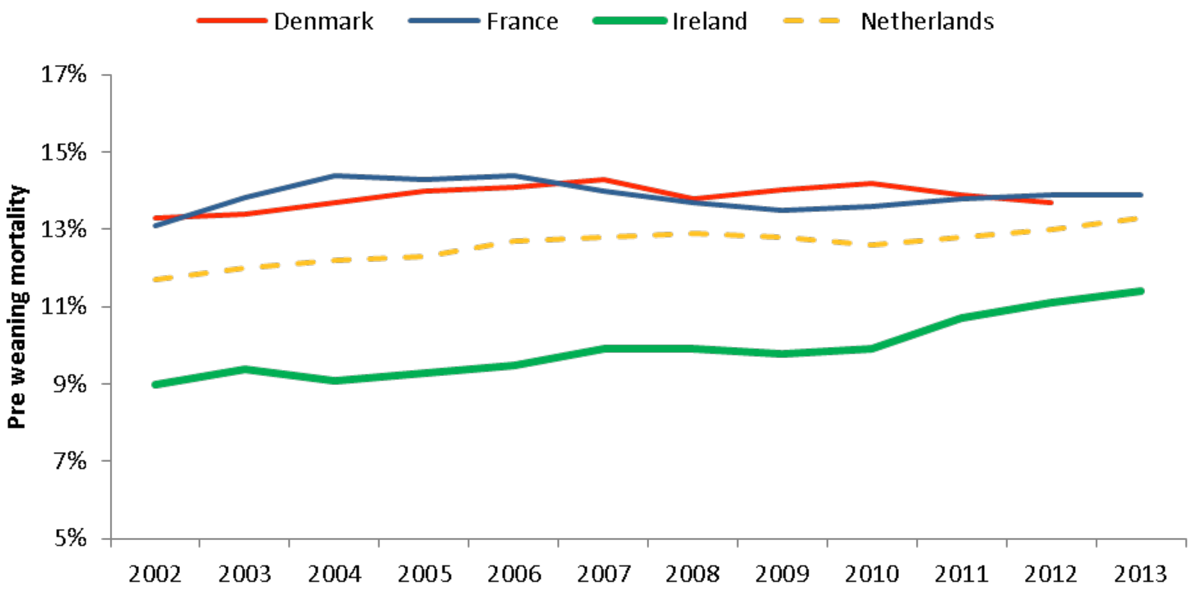


Figure 7. Pre-weaning mortality in Denmark, The Netherlands, France and Ireland

Conclusion

These data provide interesting exploratory analysis of sow production performance during the past 11 years. The number of pigs produced per year has increased at a similar rate across all farms, and in the top producing farms. This increase is driven by increases in the numbers of pigs born alive. Across all stages of production the top producing farms had lower levels of mortality, even though they also had greater numbers born alive than average. Thus farms with larger litters do not necessarily experience greater pre-weaning mortality at current Irish production levels. Ireland also has much lower pre-weaning mortality levels than our European competitors. However, every effort should be made to maintain or reduce current mortality levels, as further increases in born alive could cause the recent increase to become a continuing trend. Further studies are planned as part of the Optipig project to help prevent this. We will investigate pre-natal nutrition for the sow that will promote piglet viability as well as increasing the numbers born alive, and management of small and weak piglets.

Perspectives of stakeholders in the pig industry on the potential use of ante and post mortem meat inspection as a pig health and welfare diagnostic tool.

Laura Boyle and Dayane Teixeira (Teagasc); Catherine Devitt and Alison Hanlon (UCD); Niamh O'Connell (QUB); Mark Hawe, (CAFRE)

Introduction

In the European Union, meat inspection (MI) incorporates measures to conduct animal health surveillance, protect public health and ensure meat quality. In reality the focus of MI in many EU countries is primarily on lesions which pose a risk to human health. Such lesions result in pig carcasses being condemned at ante or post mortem MI. Currently, there is considerable interest in developing the MI process to incorporate lesions with relevance to pig health and welfare not only to ensure compliance with welfare legislation and food safety but also to ensure transparency along the food chain. At farm level such information could be used by producers and their Private Veterinary Practitioner (PVP) to inform herd health and welfare plans (Harley et al., 2012a). This could result in changes to management, feeding or housing practices which will improve pig health, welfare and performance thereby leading to economic benefits. For example, the Danish Pig Health Scheme launched in 1978, identifies farms that exhibit high carcass condemnation rates and in turn, offers the assistance of veterinary expertise (Willeberg et al., 1984; Nielsen, 2011). PIGIS (Pig Grading Information System) is an industry-led initiative in Northern Ireland (NI) which provides information on grading and weight, and levels of total condemnation to registered producers in order to reduce losses associated with carcass condemnation. Similarly a Carcass Inspection and Analysis (CIA) software package is under development which will provide producers with real time access to the meat inspection outcome for their pigs. In the UK, the Wholesome Pigs Scotland and the BPEX Pig Health Scheme records the presence of disease lesions from abattoir inspections, after which producers and their veterinarian are informed (Sanchez-Vazquez et al., 2011).

PIGWELFIND is a three year project led by Teagasc and funded by DAFM under the Research Stimulus Fund which aims to develop ante and post mortem inspection as a welfare (including health) diagnostic tool. A major focus of this work is on tail lesions. These are the main lesion related to pig welfare which can be observed on the carcass. None of the aforementioned schemes record different levels of tail lesion severity; they only document severely damaged tails. However, research for PIGWELFIND showed that even mild to moderate tail lesions are associated with significant reductions in carcass weight as well as being associated with an increased risk of carcass condemnation (Harley et al., 2014). Moreover, recent work revealed an association between mild to moderate tail lesions and the risk of the lungs being condemned for lesions related to pleurisy and pneumonia. Hence, documenting and importantly communicating changes in the severity of tail lesions to producers via the MI process could be a useful early warning system for averting pig health and welfare problems on the farm. Over time producers with the help of their PVP, could potentially identify and therefore take action to remedy risk factors for increases in the proportion of pigs affected by mild to moderate tail lesions. Such actions could even avert outbreaks of more severe tail biting. The potential benefits of developing MI as described are contingent on having a system that meets the needs of all stakeholders.

Important issues for the wider context of meat inspection data provision

Trust between the various sections of the supply chain is crucial to the development of a MI process that incorporates measures of pig health and welfare. Indeed transparency and fairness are crucial to the effective exchange and utilisation of any information. In preparing a development plan for the Irish pig industry, the Teagasc Pig Department reported that high levels of distrust existed in the industry, linked to inadequate feedback between producers and processing plants (Teagasc, 2008). Distrust was reported by producers concerning the perceived accuracy of the carcass grading system, with some producers claiming inconsistencies in reporting between processor plants. Similar issues are recorded in other European countries. For example, German pig producers are also concerned with the credibility of processors; they harbour doubts about the reliability of the carcass grading processes, and the lack of price transparency (Spiller et al., 2005). However, there are several other potential practical, political and social constraints to the development of MI as a health and welfare diagnostic tool.

Social science research with stakeholders in the pig industry

As part of one of the tasks in PIGWELFIND we applied qualitative research techniques to explore and understand stakeholder's perceptions as to the strengths, weaknesses and barriers to the development and implementation of MI as a health and welfare diagnostic tool. Semi-structured telephone interviews were conducted with 14 pig producers from the Republic of Ireland (ROI) and four from Northern Ireland (NI) which formed one distinct group of stakeholders. The second distinct group of stakeholders included a range of people involved in meat and farm animal inspection, personnel involved in policy formation and those involved in the slaughter and processing of pigs (these are referred to as 'other stakeholders' in the forthcoming sections). Two focus group discussions were held, one with DAFM veterinary inspectors (VI) involved in meat inspection and farm animal welfare inspections in ROI and another with senior/meat inspectors in NI. Five telephone interviews were conducted with ROI pigmeat processors and three with processors in NI. Finally, four interviews were conducted with personnel involved in policy in both ROI and NI (Bord Bia, FVO, DAFM and DARD) and one with an official from the European Food Safety Authority (EFSA).

All stakeholders were asked questions regarding the development of the current MI process to include measures with relevance to pig health and welfare. They were asked about their perceptions on the potential for an improved system of MI to be used to inform herd health and welfare plans, and what they thought were the main barriers to this development taking place. Producers were also asked questions on the pig health and welfare related problems they encounter on their farm, their levels of satisfaction with the current information received from the abattoir, and the usefulness of this information.

Main findings from producer interviews

Three key themes emerged from the interviews with pig producers. The first had to do with **producer identity** –this refers to producers description of their role in pig production, what is important in this role and their motivation for being involved in pig production. For some this centred on the health and welfare of their pigs, while for others it centred on producing a high standard of pig meat and for others on commercial objectives. In social science the term 'agency' concerns the capacity of individuals to act independently and to make their own free choices. Producer agency was clear, and involved approaching the pigmeat plant for information, and actively working with their PVP. Indeed most producers reported positive relationships with their PVP.

The second theme was concerned with **producers beliefs and expectations**. This covered their level of satisfaction with current feedback provision from the plant, and their expectations of the veterinary and meat inspectors. Of the 18 pig producers who participated, 11 expressed dissatisfaction with the feedback information they received. They reported that the information they received currently centred on minimal explanations of the reasons for condemnation, and in some cases, the information was described as illegible. Five reported not believing the reasons provided for condemnation based on previous experience with inconsistencies between reports. There were mixed perceptions towards the pigmeat factory. The NI producers who were all involved in the CIA development program reported greater levels of satisfaction, citing the benefit of being able to identify over a period of time, where key problems are. The majority of ROI producers had unfavourable perceptions of the VI with the issue of inconsistencies being attributed to their role in MI. Nevertheless producers felt that it should not be the VI's responsibility to record more detailed information at MI.

The third theme was concerned with **producers aspirations**. All producers agreed with the potential use of ante and post MI data to inform herd health and welfare plans. Yet they expressed uncertainty on how best this could be achieved, given the perceived inconsistencies in reporting on reasons for condemnation. They also expressed concern about potential conflict for the VI (and meat inspectors in NI) in their responsibility towards contributing to pig welfare and health and the perceived objectives of the factory. Ultimately producers expressed a desire for feedback of information that is centred on the producer and farm, is of practical use and that is provided for their benefit rather than against them. Nevertheless, less than half of the producers interviewed were willing to pay for improved feedback on pig health and welfare issues from the factory.

Producers were prompted to discuss their opinions on tail biting. There were varying opinions as to the cause of tail-biting, and regarding levels of acceptability as a health and welfare issue. Seven producers stated that tail docking is an unavoidable solution to tail biting. For most, tail biting was framed as less of a priority compared to other health issues because of what is described as its irregular nature and causes being outside of the producer's control. Indeed tail biting was described by some as being an inherent part of pig production, and not a cause of concern if occurring at low levels. This same level of tolerance on other welfare related issues, such as lameness was alluded to by several producers.

Main findings from interviews with the other stakeholders

Producer identity was also a key theme coming from interviews with the other stakeholders who described producers as being 'closed'. They believe that this contributes to problems in terms of awareness and perception of pig welfare problems amongst pig producers. DAFM animal welfare inspectors called for improved communication between vets in the factory (VI) and those involved on the farm (PVP) to try and address some of the welfare problems for pigs on farms.

Other barriers and weaknesses included difficulties in relationships and communication between those involved in pig meat processing and pig producers. Indeed, the findings from interviews with the other stakeholders in the pig industry mirrored those of the pig producers in terms of the undoubted distrust between both groups. The 'other stakeholder' group confirmed the existence of a general feeling of *'them versus us'* which often made communication difficult.

Communication difficulties were also reported in the context of pigs from ROI being slaughtered/processed in factories in NI. NI stakeholders reported that animal health and welfare issues which were identified in pigs from ROI at NI factories were reported to the appropriate ROI authorities.

In the factory, recording health and welfare information ante-mortem was considered achievable because of the relative absence of time constraints and easy visibility of the pigs. However, the key challenges are post–mortem where line speed and resulting time limitations are the main issue. Additionally there are difficulties with recording issues such as severity of tail-biting because of the lack of well-defined scoring systems, and the absence of a means of ensuring that consistent terminology is used between VIs.

Pigmeat processors were in favour of a health and welfare diagnostic tool but certainly those in the ROI placed the responsibility for the development of such a tool with DAFM. Concerns were expressed however, by policy stakeholders that the current role of pig meat inspection in ROI relates to ensuring that pig meat is fit for human consumption. They also felt that there were many difficult practical implications in trying to comprehensively gather and record data from post-mortem inspections in the factory.

Conclusions

Pig producers clearly recognise the potential benefit of the development and utilisation of meat inspection data as an animal health and welfare diagnostic tool. This acknowledgment, however, is undermined for some by dissatisfaction with the current system of feedback, issues relating to trust and fairness and concerns about data utilisation. Producer perceptions about animal health and welfare issues also influence the perceived usefulness of pig health and welfare data collected at MI. For example, acceptability of tail biting and the beliefs about this welfare problem undermine the potential value of recording information on tail lesions at MI. Nevertheless there were key strengths associated with producers which centred on their strong sense of identity and motivation as well as their level of agency and the positive relationship with their PVP.

In addition to practical and technological issues identified in the factory, the issue of trust is also echoed in comments from the other stakeholders. Similar findings were recorded in research from other countries, where it was shown that distrust presents obstacles as to how information is received and acted upon at the farm level, as well as the willingness for producers to participate in animal welfare schemes. In progressing the development of a diagnostic tool for pig health and welfare based on data collected at MI a unified approach will be critical.

Considering the challenges identified the development and utilisation of MI data as a health and welfare diagnostic tool could be supported by the implementation of a communication strategy that will help build trust and positive relations between all stakeholders in the pig industry. Such a strategy will also better inform producers on the consequences of certain pig health and welfare problems, and enable and empower them to see the producer-centred benefits of better data on pig health and welfare.

Reference list available on request from the authors

The Link Between Feed and Salmonella

Anne Marie Burns, Teagasc, Geraldine Duffy, Teagasc, Gillian E. Gardiner' Waterford Institute of Technology *and Peadar G. Lawlor, Teagasc*

Background

The link between feed, farm and food is well recognized and studies have demonstrated that *Salmonella* strains isolated from the feed mill or the finished feed can later be isolated from the farm, abattoir, and meat (Shirota et al., 2001; Österberg et al., 2006; Molla et al., 2010). An EU baseline study found that the prevalence of intestinal *Salmonella* in slaughter pigs within the EU was 10.3%, whereas the observed prevalence within Ireland was above this average at 16.1% (EFSA, 2008). Furthermore, Ireland had the highest *Salmonella* contamination rate (20%) on pre-chill carcasses in the same study.

In countries with a low on-farm prevalence of *Salmonella* (e.g. Denmark, Sweden, Norway and Finland), human infection linked to pork consumption has been traced back to *Salmonella*-contaminated feedstuffs (Hald et al., 2006; Wierup et al., 2010; Crump *et* al., 2002). As other EU countries (e.g. Ireland) reduce their on-farm *Salmonella* seroprevalence, they must become more vigilant in terms of producing *Salmonella*-free pig feed. Our aim should be to ensure that, in the first instance, purchased/home milled feed is "*Salmonella*-free" (i.e. feed that contains insufficient numbers of viable *Salmonella* to pose an infective risk to animals consuming it). Nonetheless, feed on the farm, even if *Salmonella* free when first introduced onto the farm, is an important vector for on-farm *Salmonella* spread (Wong et al., 2002).

The principle source of *Salmonella* contamination in pig feed is specific feed ingredients that are combined into compound feed at feed mills (Coma, 2003). Protein-rich feed ingredients used in pig diets in Ireland are almost exclusively imported. A recent study showed that *Salmonella* was frequently isolated from imported consignments of soybean meal and rape seed meal (Wierup and Haggblom, 2010). Relatively small quantities of animal protein (e.g. fishmeal and milk powders) are also used for formulating post-weaning diets and these ingredients may also be a source of *Salmonella*. In addition, ~70% of Irish pigs are liquid-fed using computerised feeding systems and liquid co-products/by-products, which might also be a risk, are sometimes fed as part of the liquid feed mix. Even minor *Salmonella* contamination during feed production has the potential to affect many herds. Maciorowski et al. (2006) has shown that *Salmonella* can enter animal feeds at several points throughout the feed production process, including the primary production of feed ingredients, milling, mixing, and/or storage.

A revised National Pig *Salmonella* Control Programme was implemented in Ireland in January 2010, with monitoring based on determining the *Salmonella* status of pig herds by serological testing of meat juice at slaughter. At present 17% of Irish pig herds presented for slaughter have high seroprevalence (>50% prevalence) (DAFM, personal communication). In a 'Farm to Fork' food safety concept, safe feed is the first step in ensuring safe food. Therefore, the aim of our research was firstly, to carry out an in-depth study on 10 high *Salmonella* seroprevalence pig farms to identify which production stages are the principal harbours of *Salmonella* infection and to assess the occurrence of *Salmonella* in feed throughout the different production stages.. The second aim was to assess the occurrence of *Salmonella* and *Enterobacteriaceae* (indicator bacteria) in a range of feed ingredients and compound feed sampled from the five commercial feed mills and one home compounder supplying the 10 high seroprevalent pig farms.

Overview of the research

Farm Survey

The 10 farms identified for sampling were selected from those with a history of high (>50%) *Salmonella* seroprevalence in the Department of Agriculture, Food and the Marine Irish Pig *Salmonella* Control Programme. Each farm (coded A to J) was sampled on one occasion between March and August 2012 and again between December 2012 and June 2013. On each farm, a number of composite faecal samples (from at least 3 pigs) were collected at random from each production stage. Where insufficient faecal samples were obtained, sterile gauze socks were used to swab the pen. Pen environmental samples were also taken i.e. 500ml water samples were collected into sterile bottles directly from the nipple drinkers and swabs were taken from the troughs and water drinkers. Feed samples (50-100g) which included liquid and dry feed (meal and pellets), depending on the farm and production stage, were taken from troughs, hoppers and storage areas (e.g. feed bins, feed tanks) on the farms. All samples were immediately transported on ice to the laboratory, where they were stored at 4°C until analysis (within 24 h).

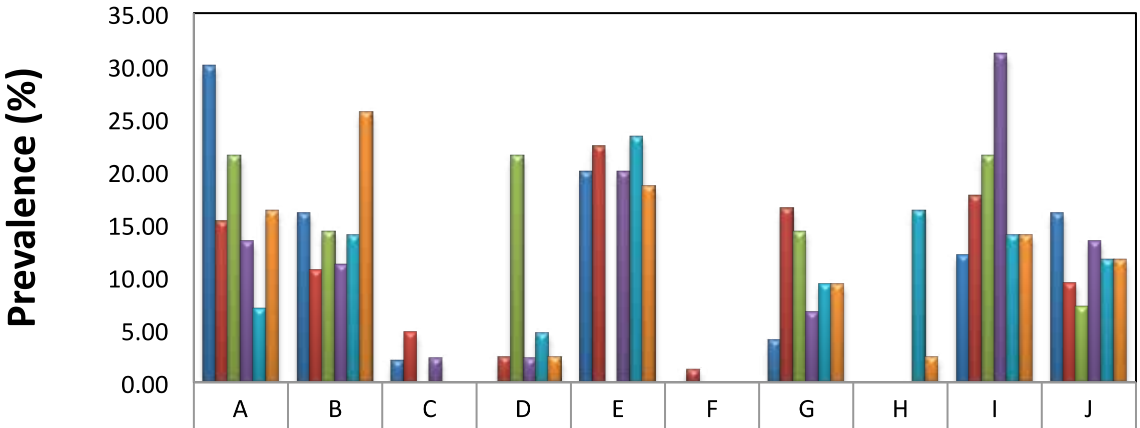
Mill Survey

A range of raw ingredients (n=338) and finished feeds (n=317) were obtained from feed mills supplying each of our 10 selected pig farms on a monthly basis for a 6-9 month period between November 2012 and September 2013. One was a home compounder and the others were commercial mills. Feed ingredients were sampled at the point of entry (ports), at mill intakes and from grain merchant storage bins and finished feeds were sampled from every finished feed batch. All samples were taken by mill personnel in accordance with Commission Regulation (EC) No 152/2009 and submitted to the laboratory on a monthly basis where they were tested for *Salmonella* and *Enterobacteriaceae*.

Results and Discussion

Farm Survey

A total of 2985 samples consisting of faecal/pen (n=926), feed (n=585) and environmental (n=1474) samples were taken across all production stages and analysed for the presence of *Salmonella*. *Salmonella* was detected in pigs on 9 out of the 10 commercial farms. Almost 15% of faecal/pen samples and 8% of environmental samples were positive for *Salmonella* (Figure 1).



	A	B	C	D	E	F	G	H	I	J
Faecal	30.00	16.00	2.00	0.00	20.00	0.00	4.00	0.00	12.00	16.00
Pen	15.29	10.59	4.71	2.35	22.35	1.18	16.47	0.00	17.65	9.41
Feed	21.43	14.29	0.00	21.43	0.00	0.00	14.29	0.00	21.43	7.14
Trough	13.33	11.12	2.22	2.22	20.00	0.00	6.67	0.00	31.11	13.33
Water	6.98	13.95	0.00	4.65	23.26	0.00	9.30	16.28	13.95	11.63
Water Drinker	16.28	25.58	0.00	2.33	18.60	0.00	9.30	2.33	13.95	11.63

Figure 1: Mean *Salmonella* prevalence on farms (A-J) for each sample type

This was to be expected, as all 10 farms were selected due to their history of high *Salmonella* seroprevalence. Eleven different serotypes were recovered, with a monophasic variant of Typhimurium (4,[5],12:i:-) predominating, accounting for 42% of all isolates recovered. The other serotypes recovered were Derby (27%), Typhimurium (13%), London (6%), Infantis (4%), Typhimurium Copenhagen (2.7%), Dublin (1.7%), Tennessee (1.4%), Anatum (0.69%), Orion (0.35%), and Stanley (0.35%), each from one herd. Fourteen different antibiotic resistance patterns were observed among the *Salmonella* isolates obtained from the farms, with isolates resistant from between one to eight antibiotics. There was no consistent pattern of infection found on the farms; however, large numbers of positive animals were detected within finishers (29.7%), 1st (16.7%) and 2nd stage weaners (22.5%) and gilts (18.8%). Two farms (A and E) had notably higher *Salmonella* prevalence than the other farms (45 and 42% respectively). Only 2.4% of all feed samples taken across all production stages were *Salmonella*-positive. These *Salmonella*-positive feed samples were found on six farms and the

Salmonella serotypes isolated were 4,12:i:-, Derby, Typhimurium, Typhimurium Copenhagen, and Tennessee. Molecular analysis is on-going to establish if the strains found in the feed were the same as those recovered from pigs on the same farms. Six (43%) of the positive feed samples originated on farms using liquid feed (farms A, B and J). The *Salmonella*-positive feed samples were generally recovered at only one stage of production on each farm, although on farm D they were found in two stages (dry sows and gilts). Feed sampled from dry sows had the highest *Salmonella* prevalence (35.7% of all samples positive).

Mill Survey

Salmonella was recovered from two ingredients (wheat and soya) sampled from one feed mill and one home compounder and in three compound feeds (dry sow and finisher) sampled from two commercial feed mills, resulting in contamination rates of 0.59% and 0.95% for ingredients and finished feed, respectively. The proportion of meal samples contaminated with *Salmonella* was ~1.6%, whereas 0.54% of pelleted feed samples were contaminated. All of the *Salmonella* isolated were monophasic variants of *Salmonella* Typhimurium (4,[5],12:i:-) and were antibiotic resistant (resistant to between 2 to 7 antimicrobials). Molecular fingerprinting methods were used to compare the 4,[5],12:i:- strains isolated from the mills with those found on the farms during the farm survey. Our data showed that there were two distinct profiles common to both feed mills and farms. A visual representation of these findings is given in Figure 2. In this diagram, each circle represents one type of *Salmonella*, with the most central circle representing the ancestral type from which the others have been derived. The length of the "branches" represents the evolutionary distance between profiles. The mill strains (highlighted in green boxes) show strong correlations with strains isolated from farms A, G and J. Strains highlighted by black arrows indicate a correlation between *Salmonella* strains recovered from feed samples taken on-farm and the *Salmonella* strains being shed by the pigs on those farms (farms A, B, D and G). This finding, combined with the results of other analysis techniques strongly suggest that the strains isolated on these farms are closely related to those found in the mills and may have originated from contaminated compound feed.

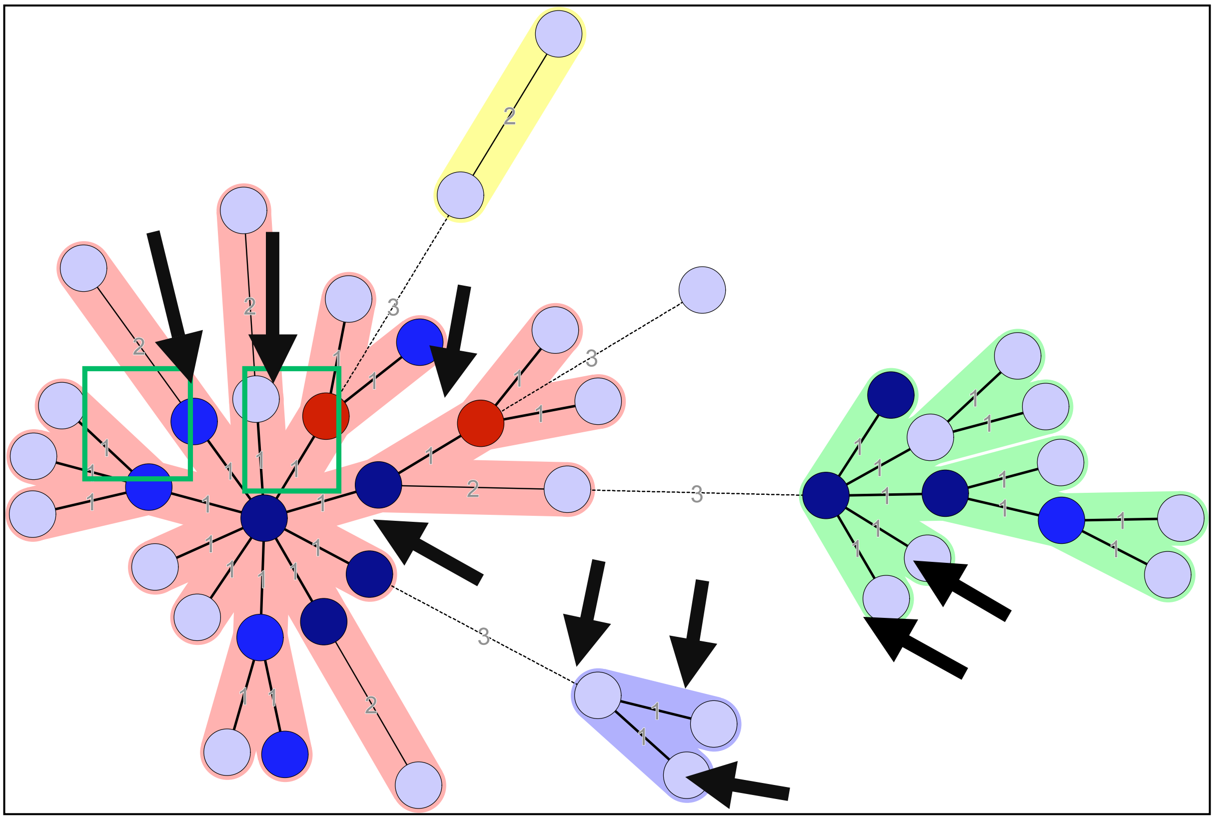


Figure 2: Minimum-spanning tree of multilocus variable number tandem repeat analysis (MLVA) of *Salmonella enterica* serotype 1,4,[5],12:– strains isolated from farms and mills. Each MLVA profile is indicated by one node or branch tip, displayed as circles that are connected by branches on a minimum-spanning tree. The length and the colour of the branches represent genetic distances (changes in loci) between two neighboring types. The sizes of the different colour circles depend on their population size.

In addition, data from this study indicated that a large proportion of the ingredients used for animal feed manufacture are contaminated with considerable levels (>10^4 CFU/g) of *Enterobacteriaceae,* which are an indicators of faecal contamination. *Enterobacteriaceae* were detected in 91.6% of meal samples, whereas only 28.7% of pelleted feed harboured *Enterobacteriaceae*, most likely as a result of the high temperatures involved in the pelleting process.

Conclusion

In order to reduce the prevalence of *Salmonella* in pigs, knowledge of the risk factors associated with subclinical infection is essential. In our study, *Salmonella* was detected in either the feed or pig faecal samples on 9/10 high seroprevalence pig farms. The incidence of *Salmonella* in compound feed was low at <1%. However, it is important to note that the strain of *Salmonella* found in compound pig feed at feed mills was also detected on pig farms, indicating a possible link between *Salmonella*-contaminated feed and the occurrence of *Salmonella* in pigs. This study highlights the need to ensure that feed is free of *Salmonella* contamination as safe feed is the first step in ensuring safe pork. Contamination of raw materials should be viewed as a critical control point for the entry of pathogenic bacteria into the feed and food chains. Even minor *Salmonella* contamination in feed has the potential to affect many herds, potentially leading to human infection via consumption of contaminated pork.

Another key finding from this study is confirmation of the occurrence of monophasic *Salmonella* Typhimurium on Irish pig farms and the indication of its role in the transmission of *Salmonella* from contaminated feed to pigs. Reasons for the dramatic increase in the number of reported cases of antibiotic resistant monophasic *Salmonella* Typhimurium in recent years remains unknown, but this trend has also been seen other European countries. This serotype was previously isolated from humans, as well as a wide range of animals and foods of animal origin, with pigs/pig meat appearing to be a common reservoir of infection.

Note: References available from authors on request.

Salmonella reduction in pig herds and pork – The Danish Experience

Jan Dahl, DVM, Chief adviser, Danish Agriculture & Food Council

Results of the Danish Salmonella programme for pigs and pork

The Danish Salmonella program for pigs and pork started in the late 1990's. A large research programme was initiated from the beginning, and research has continued until today. Over that long period many things have changed, and new knowledge has been incorporated.

Overall the results have been good. The number of human cases attributable to Danish pork has dropped from 22 out of 100,000 Danes to 2 out of 100,000 annually, a reduction of 90 % (figure 1.1)

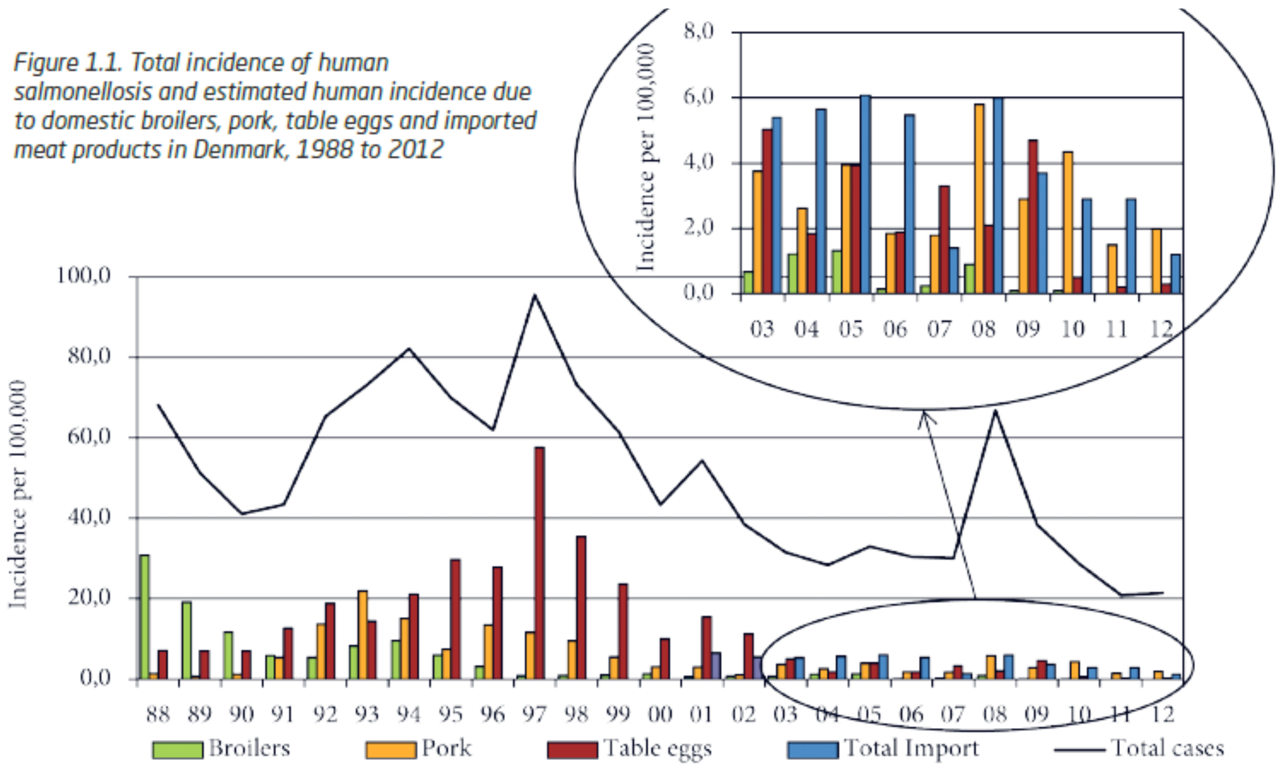


Figure 1.1. Total incidence of human salmonellosis and estimated human incidence due to domestic broilers, pork, table eggs and imported meat products in Denmark, 1988 to 2012

Source: Danish Zoonosis Centre, National Food Institute

So overall the programme has been effective.

However, a programme like this is made up of many parts, and not all parts have been equally successful. Salmonella surveillance is ongoing in nucleus herds, gilt producing herds, sow herds, finisher herds and at the slaughterhouse.

Going backwards from the slaughterhouse, the proportion of salmonella-positive carcasses has been reduced from 1.7 % in 2001 to less than 1 % in the first half of 2014. But probably more important, the most problematic salmonella-type, Typhimurium, has been reduced even more.
But epidemiological analyses showed that although the number of high prevalence herds (level 2 and 3 herds in the Danish programme) has been relatively constant between 2 and 3 percent in level 2 and 1 to 2 percent in level 3, the number of herds with a few positive samples has gone up. So the conclusion is that the number of positive herds has increased from approximately 30 % in 1998 to 60 % in 2011. In conclusion: Although the majority of the herds continue to have a low prevalence despite our efforts Salmonella has been spreading between herds. .
Improved hygiene in the slaughterhouse has been able to counterbalance the increase in primary production. But it is not possible to point out one particular intervention in the slaughterhouse as the most important factor.

The role of buying-in pigs or gilts

Realizing the continued spread of salmonella between herds prompted research into understanding the transfer of Salmonella from nucleus herd to sow herds and from sow herds to finisher herds. From the start of the programme, the general belief was, that buying gilts from a nucleus herds with a high prevalence was more problematic for a sow herd than buying from a low prevalence nucleus herd. But epidemiological evidence showed that even low prevalence nucleus herds could infect sow herds, when the sow herd brought in gilts.
The same relationship was found between sow herds and finisher herds. A low prevalence, but positive sow herd – especially if it was positive for Salmonella Typhimurium - constituted the same risk for the finisher herd as a high prevalence sow herd.
Based on this a new declaration system was initiated. Nucleus herds and sow herds that are positive for Typhimurium, Derby and Infantis are declared as Category C herds at risk of transferring Salmonella to sow herds or finisher herds. Herds infected with other serotypes of less significance are declared as Category B herds, with a lower probability of causing problems for the buyer. A herds are herds without any indication of Salmonella being present.
Approximately 35 % of nucleus herds and sow herds are Category C herds, and a few percent are Category B herds. The declaration can be found on a homepage, open to the public, so buyers have easy access to all information on the salmonella status of the herd.

Risk factors for salmonella in primary production

Recent studies have shown that risk factors for salmonella in pig herds should be divided up into risk factors for introduction and risk factors for high salmonella-prevalence in positive herds. Buying in pigs, contaminated feed, rodents, birds and other vectors can introduce salmonella, but other factors will determine whether it becomes a high prevalence herd.

Physical form of finisher feed: Pellets vs. mash/meal, crude vs. Fine

Epidemiological investigations showed that herds using pelleted, purchased feed on average had a three times higher % positive samples, compared to herds that used home-mixed meal.
This result was somewhat surprising since pelleted feed is salmonella controlled, and regular investigations from the Danish Plant Directorate show that the level of salmonella in Danish pelleted feed is very low, and the few positive samples are almost all serotypes, that are rarely found in Danish pig herds. Home-mixed meal in contrast is often based on non-heat treated material (soya), where salmonella is found regularly.
The results on pelleted feed and meal were confirmed and further investigated in several clinical trials. Feeding non-heat treated, non-pelleted feed to finishers had a protective effect compared to feeding pelleted, heat-treated feed in a herd infected with *S.* Typhimurium but pigs fed non-pelleted feed had a lower daily growth rate and reduced feed efficiency by approximately 5 %.
Home-mixed feed and coarse ground feed protected against salmonella compared to pelleted feed and fine ground feed.
In an intervention study it was shown, that herds using pelleted feed and having a high salmonella seroprevalence could reduce the prevalence by mixing 25 % of non-heat treated, non-pelleted wheat or barley to the diet, compared to herds only using hygiene and management as interventions.
The mechanism has been investigated. Salmonella reducing feeding principles will increase the number of lactobacilli in the gut, reduce coliforms, including Salmonella, and increase bacterial production of organic acids.

Barley/wheat for finishers

Increasing the amount of barley has a protective effect, compared to wheat-based diets. Growth and feed efficiency were only moderately affected, showing a tendency towards better results with wheat-based diets.

Organic acids for finishers

The use of 0.4 percent organic acids in dry, pelleted feed could reduce the seroprevalence in finishers. Other clinical trials showed that 0.8 percent formic acid or lactic acid could reduce the salmonella prevalence in finishers and that the same effect could be obtained by mixing organic acids in drinking water.

Other organic acids have not been investigated thoroughly, but could also have a potential.

Liquid feed for finishers

The epidemiological investigations showed that herds using liquid feed had a three times lower seroprevalence compared to herds using dry feed.

The fermentation process in many liquid feed systems will reduce the pH and increase the content of organic acids, thereby limiting salmonella in the feed.

The organic acids will probably also increase the pig's resistance to salmonella infection. Herds using liquid feed for finishers rarely have high salmonella seroprevalences. The author has visited several herds with a high seroprevalence and liquid feed. These herds all had a pH in the liquid feed above 5.5. Although it has not been scientifically validated, it is recommended to try to start a fermentation process in the liquid feed in these herds, or to add formic acid to the feed. Generally we recommend achieving a pH below 4.5 in the liquid feed.

Effect of feed factors in sows and weaners

Use of pelleted feed for sows and weaners was a risk factor for isolating salmonella from pen faecal samples from weaners. Use of organic acids in sow diets changed the gut flora in a direction similar to what happens in finishers.

Unfortunately the effect in weaners and sows has been less pronounced than in finishers, and it has not been possible to reduce the level to near zero.

Overall it has been concluded, that sow herds positive for *S.* Typhimurium stay positive.

The role of management and hygiene

Early research showed that it was possible to remove pigs at weaning from sow herds positive for *Salmonella* typhimurium, keep the pigs under commercial, but highly controlled conditions until slaughter, without any salmonella infection.

However, epidemiological studies have not proven that all in-all out alone could reduce the level effectively, and experience from Denmark showed, that although very strict all in-all out could produce batches of pigs without salmonella in infected herds, the results were unreliable, and often high prevalence batches would be produced alternating with low prevalence batches from the same production system, without any clear explanation.

Sufficient and reliable reduction could only be achieved if hygiene and change of management was combined with feed related interventions changing the gut flora.

Lessons learnt

- Pigs and pork as a source of human salmonellosis can be reduced by implementing salmonella reducing strategies
- Salmonella reduction in high prevalence herds can be achieved
- Feed interventions are essential in reducing the salmonella prevalence in high prevalence herds
- Improved hygiene in pig herd is not effective as the only intervention – but no excuse for bad hygiene
- Eradicating salmonella from a herd is difficult without depopulation of the herd
- Negative herds should not buy pigs or gilts from positive herds
- The success of the Danish programme is more due to improved slaughter hygiene than to reductions in primary production – although more Salmonella in herds makes it more difficult for the slaughter house
- Cost-benefit analysis has shown that slaughterhouse interventions are more cost-effective than on-farm interventions

Live Records for Benchmarking

Gerard McCutcheon and Kaitlynn Glover, Teagasc

The Teagasc PigSys record system was upgraded in 2013 and is now part of the Teagasc eProfit Monitor (ePM) System used by other farming enterprises. The transfer of the historic PigSys data onto the Teagasc ePM has progessed well in 2014, such that records are now kept exclusively on the ePM database. This is a project that has taken a great deal of time and work in the background.
The main benefits of the live ePM system are:

- More prompt collection of data from all herds merged on-line to monitor the performance trends in the "national" herd
- Benchmarking your herd against the Top 10% and Top 25% of herds in Ireland
- Benchmarking the Irish herd performance against international pig producers via the Interpig Group

The Teagasc ePM system is a web based system. Every pig producer may access their records on the Teagasc ePM once the farm has been appropriately registered. To log on to the system, the producer must know the allocated PPS number and password, assigned by the Teagasc Adviser. This database format allows producers to view and download individual Input Data (uploaded by the Teagasc Adviser), Pig Detailed Reports and the Benchmark Report. Performance figures are private, and as such producers will only have access to the records associated with the login details, but uploaded production records are immediately available on the system.

New Reports

All farms enrolled in PigSys or Teagasc ePM should now be receiving their results in the new format. While several reports are generated through the new system, the Pig Detailed Report is the report that is produced and returned to the farm owner/manager when quarterly records are submitted.

A number of new items are included in the Pig Detailed Report to more accurately address farm activity. The first new parameter in this report measures "kg of pig meat /sow /year". This is calculated in the report by multiplying the number of pigs produced /sow /year by the average dead weight, and again by the percentage (%) finishers sold (at bottom of Page 4 of Report). Obviously this figure is comparable for integrated units selling all pigs as finishers, but will be less representative for farms that sell a percentage of pigs produced as weaners.

The second new item in the Pig Detailed Report is the "tonnes of feed /sow /year", calculated by adding the total tonnes of all feed used in the data set and dividing it by the average herd size and extrapolating the figure to represent one year. The combination of these two new items allows units see assess their performance against the target production of the "Two from Seven" (2 tonnes of pigmeat produced from 7 tonnes of feed) which is useful when comparing individual production against domestic and international standards.

Domestic Benchmarking

"Nothing is good or bad but by comparison" – this is a quote from a statistics book published some years ago. Comparing individual herd performance figures allows producers to determine whether their unit is achieving good or poor results relative to national performance. This is why the Benchmark Report in ePM was developed (Appendix 1). The report compares a farms' most recent data with the most recent compiled data set for the entire "national pig herd".

The data in the "national pig herd" comprises the data from farms that currently have records within the ePM system; 49% of the Irish national sow herd, or 74,000 sows are represented within the system at the moment. The "national herd" performance is closely screened to ensure that any "outlier" results are excluded to prevent individual performance from distorting the average figures. For example, every effort is made to ensure the "weaning to sale" figures do not include herds that are selling more than 5% of their pigs as weaners as this could distort the feed conversion efficiency (FCE) figures.

Ultimately, the Benchmark Report shows how individual herd performance compares to the Average, Top 25% and Top 10% of herds within the "national herd". Table 1 below shows the Average, Top 25% and Top 10% for the number of pigs produced per sow per year on Irish herds keeping records on Teagasc ePM during the 2013 production year.

Table 1: Pigs Produced per sow per year from 2013 data

	AVERAGE	TOP 25%	TOP 10%
Litters/sow/year	2.36	2.39	2.37
Born Alive/Litter	12.67	13.11	13.28
Piglet Mortality %	11.4	10.5	8.8
Weaner Mortality %	2.54	2.32	1.64
Finisher Mortality %	2.44	2.64	1.52
Pigs Produced/Sow/Year	**25.2**	**26.7**	**27.8**

(Source: Teagasc ePM)

Below, Table 2 shows the performance based upon feed conversion of pigs from weaning (at 7 kg in all cases) to sale. There is a difference of 0.1 in the feed conversion between the "average" and the Top 25% of producers, which equates to 9.9 kg of more feed per pig on the "average" herds which carries a significant cost. Based on a finisher feed price of €290 per tonne, this amounts to a cost of €2.86 per pig. In reality, weaner diets would be used from weaning to sale – so a rounded extra cost of €3 per pig is justifiable.

Table 2: FCE Weaning to Sale

	AVERAGE	TOP 25%	TOP 10%
Liveweight at sale (kg)	105.5	106.8	111.4
Deadweight at sale (kg)	80.6	81.6	85.9
ADG (g)	644	708	764
Feed Conversion Efficiency	**2.46**	**2.36**	**2.33**

(Source: Teagasc ePM)

The reason for the better FCE from weaning to sale is not explained in these figures. It may be associated with a better herd health, less feed wastage and perhaps better housing conditions of the better performing herds. The list of factors associated with improved feed conversion efficiency is long – but it is important to see that the Top 25% of farms can achieve an FCE from weaning to sale of 2.36.

The combined benefit of getting better pigs produced and FCE from weaning to sale is shown in Table 3 below. The Top 25% of herds use 3.48 kg of feed to produce each kg of carcase compared to 3.66 kg in the "average" herds. The average or "composite" pig feed cost in 2013 was €356 per tonne. Therefore the average feed cost per kg of pigmeat is €1.29 (ie 3.62 by €356/1000) versus €1.24 (for the Top 25%). This difference, when applied to the above production figures, amounts to an extra feed cost of €102 per sow achieving the "average" performance (ie €0.05 by 2031kg of pigmeat per sow).

Table 3: Pigmeat produced and FCE Weaning to Sale

	AVERAGE	TOP 25%	TOP 10%
Carcase weight sold per sow per year (kg)*	**2031**	**2186**	**2388**
Total feed per sow(kg)	7356	7612	8092
Kg feed per kg of Carcase	**3.62**	**3.48**	**3.39**

**This is the Pigs produced /sow/year multiplied by the average deadweight at sale*.

International Benchmarking

In an increasingly globalised market, comparison with production sources with which the Irish market competes is a valuable tool. As such, the representative parameter "kg of pig meat /sow /year" is worth comparing among a number of countries. On balance, Irish production lags behind its European counterparts in a number of areas, as shown in Table 4 below.

Table 4 : Feed required to produce carcase gain

	Denmark	France	Germany	Netherlands	Ireland
Pig meat/sow/year kg	2322	2345	2452	2575	2031
Feed/sow/year kg	8402	8483	8916	8701	7356
kg Feed /kg of Carcase	**3.62**	**3.62**	**3.64**	**3.38**	**3.62**

(Source: 2013 Interpig Report)

The measurement of "kg of feed (used) /kg of carcase" shows the Netherlands with the best overall FCE (3.38) which was reflected in other figures that revealed Dutch pig farmers had an average feed cost of €1.09 per kg deadweight during the year in question.

There are individual pig units in Ireland that are competitive with figures from other European countries, but our average figures show there is still room to improve.

All farms need to measure their own performance and should not be afraid to benchmark their results against other producers. The pig industry operates largely as a cohesive unit, and internal comparison is to the benefit of all those who wish to increase the productive efficiency of their unit. Likewise, international comparison helps to ensure that Irish production remains competitive in the world market, ensuring that domestic production stays strong and profitable.

This Teagasc ePM Recording system is available to all Irish pig producers as part of the Teagasc/IFA Pig Joint Programme.

APPENDIX 1: EXAMPLE OF BENCHMARK REPORT:

PIG HERD PEFORMANCE AND PRODUCTION COSTS

YEAR **2014** **CODE NO** 1234567

YOUR HERD ENDING

1. SOW PRODUCTIVITY

	NATIONAL AVERAGE	TOP 25% **	TOP 10%**	MY HERD
AVERAGE HERD SIZE	706	793	607	540
LITTERS PER SOW PER YEAR	2.36	2.39	2.37	2.35
EMPTY DAYS PER LITTER	15	11	11	16
AVERAGE WEANING AGE	28	28	29	29
BORN ALIVE PER LITTER	12.67	13.11	13.28	12.8
BORN DEAD PER LITTER	0.87	0.78	0.72	0.91
PRE-WEANING MORTALITY %	11.4	10.5	8.8	9.8
WEANER MORTALITY %	2.54	2.32	1.34	2.43
FINISHER MORTALITY %	2.44	2.64	1.52	2.61
NO. PIGS PRODUCED PER SOW PER YEAR	25.2	26.8	27.8	25.6
SOW CULLING RATE %	48.9	50.9	49	48
SOW MORTALITY %	5.2	4.5	4.2	6.5

PIG MEAT PER SOW PER YEAR	2031	2186	2388	2012
TOTAL FEED PER SOW PER YEAR Tonne	7.356	7.612	8.092	7.245

2 GROWING PIG PERFORMANCE

	NATIONAL			MY
		TOP	TOP	
	AVERAGE	25% **	10%**	HERD
AVERAGE WEANING WEIGHT KG	7	7	7	7
AVERAGE FINISHER LIVEWEIGHT KG	105.5	106.8	111.4	105.9
AVERAGE DEADWEIGHT KG	80.6	81.6	85.9	81
KILL OUT %	76.4	76.4	77.1	76.5
WEANING TO SALE				
DAILY FEED INTAKE g	1633	1671	1780	1579
AVERAGE DAILY GAIN g	664	708	764	672
FEED CONVERSION	2.46	2.36	2.33	2.35
AVERAGE FEED PRICE PER TONNE €	345	354	345	347

* Selected on the number of pigs produced per sow per year

** Selected on Feed Conversion Weaning to Sale

3. WEANER PERFORMANCE

	NATIONAL			MY
		TOP	TOP	
	AVERAGE	25% **	10%**	HERD
WEANER WEIGHT AT SALE/TRANSFER	36.7	36.6	38.5	37.0
CREEP FEED PER WEANER KG	3	3	3.2	3.5
LINK FEED PER WEANER KG	6.9	8.3	6.9	6
WEANER FEED PER WEANER KG	44.6	41	44.4	44
FEED PER WEANER KG	54.5	52.3	54.5	53.5
DAILY FEED INTAKE g	834	857	888	849
AVERAGE DAILY GAIN g	457	492	527	477
FEED CONVERSION	1.83	1.74	1.69	1.78

4. FINISHER PERFORMANCE

	NATIONAL			
	AVERAGE	TOP 25% **	TOP 10%**	
WEIGHT WEANER TRANSFERRED	36.7	36.6	38.5	37.0
AVERAGE FINISHER LIVEWEIGHT KG	105.5	106.8	111.4	105.9
AVERAGE DEADWEIGHT KG	80.6	81.6	85.9	81
KILL OUT %	76.4	76.4	77.1	76.5
DAILY FEED INTAKE g	2262	2239	2525	2125
AVERAGE DAILY GAIN g	817	855	964	820
FEED CONVERSION	2.77	2.62	2.62	2.59

Composting Dead Pigs

Amy Quinn & Ciaran Carroll, Teagasc

Currently within the European Union the composting of dead pigs is not permitted. The cost of dead pig disposal however has risen to a level where it is now a significant cost for all pig producers (€200-300 per tonne). Therefore it may be the time to consider composting as an alternative strategy for disposing of pig carcasses. The use of composting as a carcass disposal method is widely used outside of the EU. Other EU member states have investigated the potential of composting and the future legislative changes required. Research to date has identified that there is no evidence that the product of composting pig and poultry carcasses poses any greater public threat than general food waste.

What are the Benefits?

Composting of pigs as opposed to rendering is a relatively low cost method of carcass disposal and could result in substantial savings. While switching to composting would require and initial investment in facilities the subsequent maintenance/ labour cost of these facilities is low. In cases where a bulking agent (dry organic material, e.g dry straw, sawdust, wood shavinga and manure) is not freely available there is an additional cost of purchasing it. It is estimated that the initial facilities cost would be paid off in a year and a half. In the US and Canada the final composted product can be used as a valuable soil amendment or organic fertilizer. The European Food Safety Authority however currently consider the composted product to still be an animal by-product and thus must be disposed of through incineration due to the perceived risk to the food chain due to pathogen survival during composting. Additionally composting on farm would eliminate the bio-security risk posed by collection trucks and may reduce the storage time of dead pigs on farm before disposal/collection. In addition if diseased pigs are present on a unit, on site composting will aid the prevention of disease spreading.

How does it work?

Composting is a natural biological process whereby microorganisms breakdown/ decompose organic materials by aerobic (requires oxygen) decomposition. This process can be used to break down animal carcasses by controlling the environmental conditions required. Carcass composting uses organic by-products, such as dead pigs, straw or sawdust, and converts them into odourless, inoffensive, generally pathogen-free product that can be used as a soil amendment or organic fertilizer or alternatively may be incinerated, depending on governing legislation. It is very similar to composting garden waste. Microorganisms consume Oxygen and feed on the organic substrates to produce carbon dioxide, water, heat, and a stabilized organic matter called humus. The speed and efficiency of this aerobic process depends on the temperature, nutrients, moisture, oxygen availability and particle size.

Temperature:

A temperature of 55°C is optimum for both the composting process and for destroying pathogens and should be regularly monitored throughout the composting phases as it acts as an indicator that the composting is progressing well. In North Carolina, research compost piles reaching temperatures of over 55°C, killed off most of the Salmonella and all of the Erysipelas in the compost pile.

Nutrients:

Carbon and nitrogen are the most important nutrients required for composting. Common carbon sources could include dry sawdust, wood shavings manure and straw. The primary nitrogen source is the pig carcasses themselves. A carbon:nitrogen ratio between 25:1 and 30:1 is optimal. Phosphorus, sulphur, calcium and trace amounts of other nutrients are also required however usually adequate amounts are found in the carcasses and carbon source.

Moisture:

A moisture content of 40 to 60% is optimal. Too much (>60%) or too little (<40%) moisture hampers microbe activity. If too dry water or liquid manure will need to be added and if too wet the source of water entry needs to be eliminated.

Oxygen:

Decomposition occurs fastest in fully aerobic conditions (oxygen present). However, over time aerobic conditions probably exist only at the periphery of the compost piles commonly constructed. Therefore, operators must mechanically aerate the piles periodically by turning the pile.

Particle Size:

The smaller the particle sizes of the carcass, the greater the surface area available on which micro-organisms can work. However, in practice, pig carcasses need not be cut into smaller pieces; larger carcases will however take longer to breakdown.

Facilities:

The facilities required vary but are generally basic in structure. The structures are required to be water and rodent proof. Often a bin system is used which is similar to a silage pit type structure with several bays enclosed within a shed, protected from wildlife and rain. The capacity of the facilities should contain a buffer so that it can handle a rise in mortalities as a result of disease outbreak for example. The composting occurs within the bays, where layers of bulking agents (carbon source) and carcases are held. Firstly there is an initial layer of a dry organic material bulking agent (Aprox. 24 inches). Next, on top of this layer, leaving a two foot margin at the edge of the pile, the carcases are positioned. Following this another two foot layer of bulking agent is positioned on top of the carcass layer and this pattern repeats until the bay is appropriately full. Once the layers are complete the pile is sealed off with sawdust or previously composted material to prevent odours and rodents. A crucial step in composting is monitoring the temperature to see how the composting process is progressing. In practice, the piles are turned 2 to 3 days after temperature peaks and again after 2-4 months if composting is not complete as turning the pile will provide air to complete the process and cover it with a bulking agent to allow the process to finish. Turning aerates the piles and restarts the decomposition process.

Although this process is not permitted in the EU at present, with current disposal costs running so high, perhaps this low cost option should be further investigated with a view to making it acceptable in the EU.

Rodent Control

Michael Mc Keon, Teagasc

Rodent control is unfortunately a necessity in the pig industry due to the abundance of feed material used. In Ireland the two principle rodents of concern are *Rattus Norvegicus* (Brown rat) and *Mus domesticus* (House mouse). While all pig units implement rodent control measures their effectiveness varies considerably from unit to unit. This paper aims to outline some of the key issues concerning this area.

Why is control necessary?

If rodents (rats and mice) are not controlled then they may inflict considerable damage on a pig units' productivity and efficiency. Meehan (1984) estimated that the annual cost from rodent damage in the UK exceeded £50 million and they were responsible for causing 20% of all fires due to electrical faults. In addition to inflicting structural damage (electrical, insulation) they also cause considerable food wastage due to spoilage. It is estimated that the volume of food spoilage in Asia would feed 200 million people annually. Malaysia estimated that the annual loss to their palm oil production exceeded $88 million. From a pig producers viewpoint the structural damage and food spoilage is further acerbated by the risk of disease spread. An infestation of 100 rats will produce one tonne of droppings and 500 litres of urine, which will cause food spoilage but may also transmit disease.

The table below shows the relevant pig diseases that are spread by rodents. While some of these have minor financial implications others such as Salmonella or Leptospirosis may be more costly. Hungry rats have been observed to travel 2 km at night which further increases the disease risk between pig units in areas of high pig density.

Table 1: Pig diseases spread by rodents

Disease	Agent	Host / Carrier
Bordetellosis	bacteria	rats
Encephalomyocarditis	virus	rats & mice
Leptospirosis	bacteria	rats & mice
Aujeszky's	virus	rats
Salmonellosis	bacteria	rats & mice
Swine Dysentery	bacteria	rats
Swine Erysipelas	bacteria	rats
Toxoplasmosis	protozoan	various rodents
Trichinosis	nematode	rats

Behaviour and control

In order to install an effective control programme it is important to first understand the behaviour and traits of rats and mice. The two are very different and therefore will be described separately.

Rats:

Rats have very poor eyesight, are colour blind and have only an ability to distinguish rough outlines though a 'haze'. They make up for these difficulties by utilising their whiskers, flank hairs and a strong sense of smell. As a result they stay close to walls when moving and avoid open spaces. They also utilise kinesthesis (muscle memory) to follow similar movement patterns. These traits result in rats been 'creatures of habit' who don't like change. This can be observed by the entry and exit trails that rats make over a period of time. This indicates that rat bait points / traps should be placed along trails or along the edge of building.

Mice:

Mice also have poor eyesight and can't distinguish the colour red. They can only focus on an item within 0.5 metres but the location of their eyes on the side of their head allow them to track surrounding movement up to 12 metres away. Unlike rats mice are inquisitive but cautious. They never travel the same route twice, varying their movements to minimise the risk. This results in them using a zig-zag movement across rooms rather than along the boundary wall. Likewise they don't eat all their feed at a single point instead preferring to sample from a number of different feeding points to reduce the risk of poisoning. This often results in mice spoiling more foodstuffs than rats. The ideal location for mice bait points is along internal divisions in pig houses rather than along the exterior.

Type of Bait

The type of bait commonly in use in Ireland has an –anti-coagulant as its active ingredient. Originally first generation anti-coagulants like Warfarin or Difenacoum were used but these required multiple feeds over a number of days for a lethal dose. More effective second generation anti-coagulants have now been developed which require much lower intakes to constitute a lethal dose – see Table 2. A single feed can now be lethal for rats (2 grams) and mice (1 gram) although they may continue to feed for a few days after the initial lethal dose.

Table 2: Effectiveness of active ingredients.

		1st Generation			2nd Generation		
Species	Bodyweight	Warfarin	Difenacoum	Bromadiolone	Brodifacoum	Flocoumafen	Difethiolone
	g	0.025	0.005	0.005	0.005	0.005	0.0025
Rat	250	5.6 - 58	9	6.5 - 8	2.1	1.25 – 1.9	5.6 - 6
Mouse	25	37.4	0.4	0.9	0.2	0.3 – 0.6	1.4
Pig	50	200.0	80,000.0	3,000.0	500.0	60,000.0	5,000.0
Dog	5	400.0	1,000.0	1,000.0	25.0	7.5	2,360.0
Cat	2	80.0	4,000.0	1,000.0	1,000.0	400.0	1,280.0
Chicken	1	4,000.0	1,000.0	1,000.0	90.0	150.0	36.0

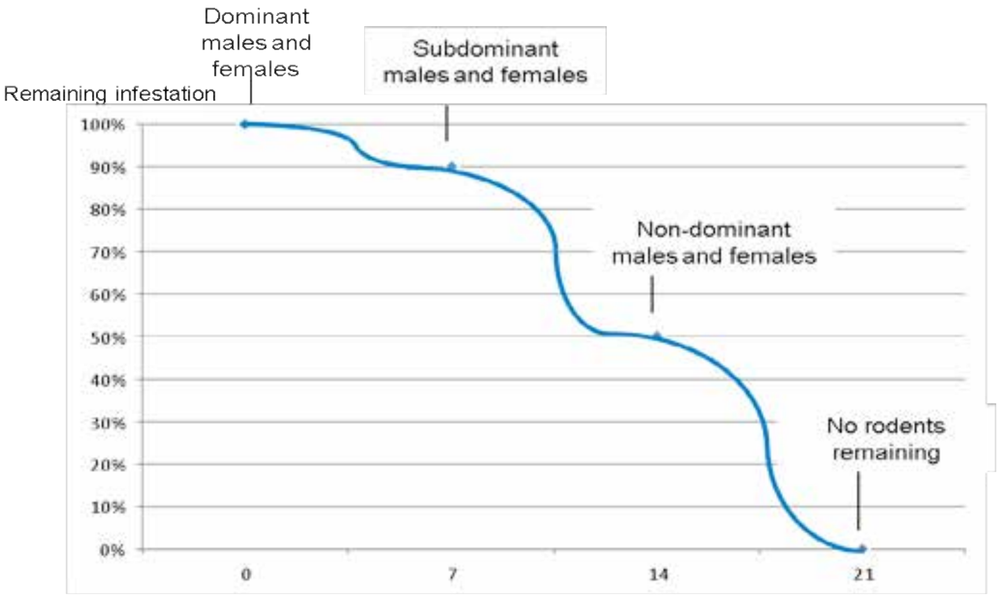
Rats and mice generally prefer bait that is moist therefore using wax blocks or a paraffin coating on the bait helps to ensure that it stays fresh and moist for longer. In pig units it also differentiates the bait from the surrounding dry grain feed sources - some companies now use a fat based product content rather than grain based for further attractiveness.

Bait Timing

The active rodenticide (poison) ingredient will dictate the timing of the bait allocation. If first generation anti-coagulants are being used then it will require a number of consecutive feeds for the intake to be high enough to reach a lethal dose. The bait must therefore be continually replenished to ensure that it doesn't run-out until the population is eliminated. The bait point must be checked at a minimum every three days but if the bait supply is fully eaten during 24 hours then double the supply until intakes reduce.

If second generation anti-coagulants are being used then only a single feed is required to be lethal. This means that the bait should be used on a pulse system and should only require 21 days to eliminate the rodent population – see Figure 1.

Figure 1: Bait timing for 2nd generation anti-coagulants



Days After Initial Baiting

After 21 days bait intake should have stopped allowing the refilling of the bait points to cease. Bait supply should only recommence if activity is again observed. This results in less bait been required (compared to 1st generation anti-coagulants) thereby saving money and reducing the risk of non-target animals being accidently poisoned eg shrews.

Bait Containers

Bait containers should ensure that the bait cannot be carried away by rats or other non-target animals. It should be clearly identifiable for humans and inaccessible to pigs. The bait box should ideally be composed of materials from the surrounding environment to ensure that the rats and mice can readily identify with it and therefore will freely enter it. Ideally it should be of sufficient size to accommodate a number of rodents at the same time with a seperate entrance and exit.

The container should be located as near as possible to the rodents shelter/nest. For mice the bait points should be closer together (3m) but rats travel further so may be 15-20 metres apart.

Figure 2: Bait point

Responsible Usage of Anti-Coagulants

Over the last decade a number of studies have highlighted the rodenticide toxicity levels in the owl population in Ireland and the UK. While rodenticides have not been definitively linked to a reduction in the owl population, it is definitely a contributory factor in their decline.
In a recent vote in the European parliament second generation anti-coagulants missed being banned by a very narrow margin. The issue will be revisited in the next few years and the industry and farmers must be able to show that they are using these products in a more sustainable and responsible manner i.e. the risk of non-target animal poisoning is reduced. If this cannot be clearly demonstrated then there is a high chance that these will be banned next time around which will severely comprise our ability to control rodents.

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