

PIG
RESEARCH CENTRE

ANNUAL REPORT 2009



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The financial crisis stopped everything

Many pig producers were looking forward to increasing pig prices in 2009, but that changed in the autumn 2008 when the financial crisis kicked in.

The consumption of pork dropped as a result of the crisis, and though the production of pork dropped across Europe, it did not result in the price increases normally seen.

There is therefore still a long way to go for the pig producers before the economic gaps of the last years are closed.

At the same time, it has become increasingly difficult to borrow money for herd extensions, renovations and construction of new facilities, which means that investments have been considerably fewer than normally.

It was already difficult to obtain environmental approvals, and following the financial crisis, construction activities have almost come to a complete stop.

Export of weaners and breeding stock

The trends with declining production of finishers and increasing export of weaners continue.

Few people had expected the export of weaners to reach more than 7 million a year.

However, German finisher producers have accepted Danish genetics, and their scepticism against using Duroc as boar line rather than Pietrain is slowly but surely fading.

In 2008, DanBred was elected a clear winner of the impartial Waren test in which the various breeding systems that operate in Germany are compared. This further helped Danish breeding stock and weaners.

Environmental rules and revised Agricultural Act

The environmental standards have been revised and as a result one livestock unit now constitutes more animals. Thereby the pig industry got some recognition for the long-term efforts in reducing nutrient discharge. In fact, today the discharge from two finishers is the same as from one finisher in 1985, and the slaughter weight has increased significantly.

One of the problems related to environmental approvals is that they include a maximum limit for both nutrient discharge and for number of pigs produced per year. This makes it increasingly difficult for finisher producers to take advantage of the progress in productivity and operate with a full facility.

This makes no sense, and Pig Research Centre is exerting pressure to change this in connection with the Green Growth package.

Our wishes presented at the 2008 Annual Meeting have been partly fulfilled with the revision of the Agricultural Act.

The ownership requirement and the maximum limits for herd size are eliminated. This is an important step in the right direction, as the design of future production systems should be determined by the economy on the bottom line in combination with environmental approvals.

Improvement in animal welfare

It is a great pleasure to see that the results of the 5% welfare audits and the audits under DANISH Product Standard are generally moving in the right direction.

In particular the problems with shoulder ulcers are diminishing. In 2009, several trials demonstrated that evaluation of shoulder ulcers after an animal

is slaughtered is unfair compared with the producer's possibilities for evaluating the animal when it is alive.

Castration has been a hot topic in the animal welfare debate in Denmark and many other places in Europe. In Germany and in Denmark, agreements have been made in the industry on administration of pain relief during castration.

Naturally, the best solution for piglets and farmers would be to completely avoid castration, and extensive research is being put into this: sexing of semen, breeding, nutrition, vaccination against boar taint, sorting at the slaughterhouse etc.

We expect a breakthrough within a few years and we also expect politicians to give us time to work on a solution, and a common European solution.

Competitiveness

Danish pig producers must be leading internationally on efficiency to be able to maintain their competitiveness.

This is a huge challenge, but the effort is supported by the regional pig advisors, vets and the industry. Fortunately, productivity levels are significantly increasing, not least thanks to the many activities and results presented in this report.

New name

Please note that in the autumn last year Danish Pig Production changed its name to Danish Agriculture and Food Council, Pig Research Centre.

Thank you

Finally, thank you to all who have played a part in the work of Danish Agriculture and Food Council, Pig Research Centre over the last year.

Best regards
Danish Agriculture and Food Council,
Pig Research Centre

Lindhørdt B. Nielsen/Nicolaj Nørgaard

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In the spring 2009, the new industrial organisation Danish Agriculture and Food Council (DAFC) was established. Pig Research Centre fully integrated legally and financially in Danish Agriculture and Food Council at the merger.

The three basis organisations that previously formed the basis of Pig Research Centre, Danish Bacon & Meat Council, Danish Agriculture and the Danish Pig Producers' Association, made an affiliation agreement that safeguards the interests of Danish pig producers in the new organisation. The departments of Pig Research Centre employing approx. 145 people will continue as a research centre handling research and development tasks related to the live pig.

Tasks and activities in Pig Research Centre are decided by 12 pig producers representing the following parties:

- 3 from Danish Bacon & Meat Council
- 3 from the Danish Pig Producers' Association
- 3 from Danish Agriculture
- 3 from the regional pig production committees.

The aim of this forum is to optimise and safeguard interests of the primary pig production and the forum is responsible for:

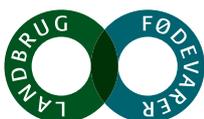
- Managing the joint funds of the pig producers that originate from gene fees, production fees and pig funds amounting to approx. DKK 110 million spent on tasks benefitting the pig industry.
- Prioritizing and implementing national research and development tasks.
- Opinions and decisions within DAFC concerning all matters relating to the live pig.

The chairman and director of Pig Research Centre are spokesmen professionally and politically on matters concerning the live pig. All statements are made in close co-operation with DAFC.

Pig Research Centre is responsible for communicating knowledge obtained through trials. This includes visible information activities with a clear profile to our base of support (pig producers, regional pig advisors, companies etc.) and the world in co-operation with the information activities of DAFC.

Pig Research Centre participates in the overall safeguarding of the political interests of DAFC to improve framework conditions and acceptance of the Danish pig production industry. This includes tasks such as:

- Professional participation in the political debate
- Participation in review processes and preparation of responses to hearing requests to Danish authorities and politicians, and EU authorities in matters relating to the pig producer.
- Representation in public committees concerning legislation and administration affecting the Danish pig production industry.



Landbrug & Fødevarer

The Danish Agriculture & Food Council represents the agricultural and food industry in Denmark and is the result of a merger between the Danish Agricultural Council, Danish Bacon and Meat Council, Pig Research Centre and Danish Agriculture.

The organisation also undertakes a range of key tasks for the Danish Dairy Board. Agriculture and Food are Denmark's largest industry and innovation grouping employing some 150,000 people and exporting agricultural products and equipment to a value of around €15 billion.

Programmes 2009/2010

A. Competitiveness

- Optimising organic production
- Managing the breeding system – selection, breeding data and breeder information
- Breeding for feed conversion (Bøgildgård)
- Genetic development
- AI research and development
- Improving feed conversion in finishers
- Cheaper feed
- 35 weaned pigs per sow per year
- Future production systems
- Information communication and technology and production management
- Data analysis and statistics

B. Environment

- Reducing odour emissions from pig houses
- Reducing N discharge and ammonia emissions
- Climate and ventilation
- Environmental impact of feed

C. Animal welfare

- Sow longevity
- Tail biting and ear necroses
- Farrowing pens for loose sows
- Enrichment and rooting materials

D. Inspection

- DANISH Product Standard
- Inspection of breeding material

E. Prevention of disease

- Optimising food safety – Salmonella surveillance and antibiotic resistance
- Health inspection
- Improving pig health

F. Advisory services

- Economy in pig production
- Implementation of know-how
- Veterinary development project
- Pig Research Centre management, contact to authorities and communication

G. EU programmes, Rural Development Programmes

- Demonstration of environmentally friendlier management in pig production - Rural Development
- Sow Life
- Shoulder ulcers – Rural Development (reduction of occurrence of shoulder ulcers)
- Better legs
- Farrowing pens for loose sows in commercial herds
- Alternatives to castration
- Improved feed conversion, Rural Development
- Improving finisher production.

International competitiveness

The production efficiency in the Danish pig production industry is among the best in the world when we benchmark ourselves with other countries. We manage to keep costs per kg carcass fairly low thanks to the high efficiency in pig production.

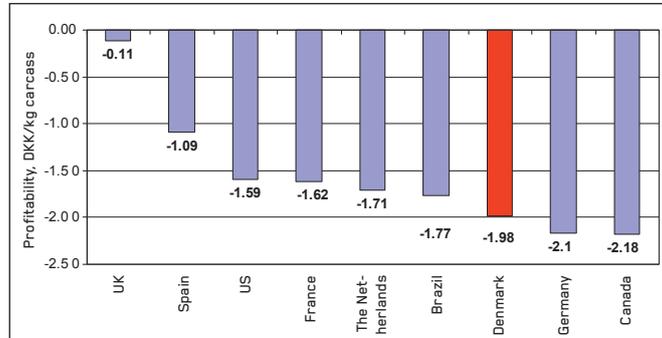
Economy of pig production

In 2007 and 2008, the pig production industry experienced two unfortunate circumstances that resulted in losses. In 2007, feed prices increased dramatically and in 2008 the financial crisis set in. There was no compensation for the high feed prices in the form increasing pig prices. As a consequence of the financial crisis, feed prices dropped, but the crisis also halted the increasing pork prices seen in the beginning of 2008.

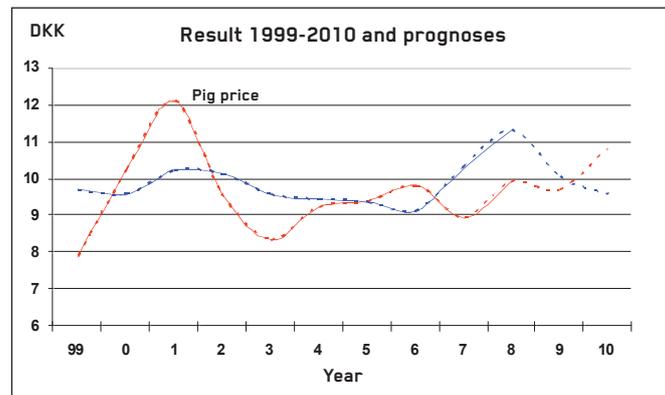
In 2009, the economy in the pig production industry is expected to improve significantly. Costs are expected to drop significantly because of the decreasing feed prices, and pig prices are expected to be higher than in 2008. As of the last half of 2009 and in 2010, a surplus is expected in the production of pigs.

Structural development

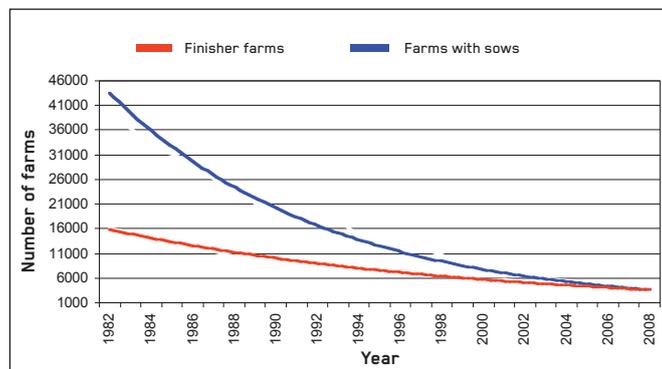
The trend is still moving towards fewer pig farms. In 2008, there were 5,513 pig farms in Denmark compared with 16,880 in 1998. In 2008, 62% of all sows were housed on farms with more than 500 sows per year. By 1998, this figure had dropped to 15%. Of totally 4,937 farms with finishers, 1,329 accounted for 62% of the overall finisher production. If these trends continue, in 2020 an average sow farm will house 1,000 sows and an average finisher farm will produce 11,000 pigs annually.



Profitability in the first half of 2009.



Development in pig price and costs per kg pork. Costs per kg pork are expected to normalise and settle at just below DKK 10 per kg pork. Pig prices are expected to fluctuate around this cost by +/- DKK 1.50 per kg.



Structural development in Danish pig production.

Productivity: sows

The development in sow productivity, measured as weaned pigs per sow per year, has now reached 27 pigs and the best 25% sow producers have 30 pigs per sow per year. The progress in productivity is triggered by an impressive increase in the number of liveborn pigs and increasing farrowing rates. In the large herds, more pigs are being weaned than in the small herds, but this effect decreases at approx. 800 sows.

Productivity: weaners

Over the last two years, weaner productivity has soared with progress for all parameters. Disease pressure is clearly tailing off resulting in lower mortality rates, increased daily gain and an improved feed conversion ratio.

Productivity: finishers

Positive trends are seen in finisher productivity. In 2007, the slaughter weight increased slightly as many pigs were culled for slaughter and the feed conversion increased. However, distinct progress was seen in 2008.

Increasing productivity

In 2000, the best 25% herds were at the same level of productivity as the average herds in 2008. In 8-10 years from now, it must therefore be expected that the average herds are at the same level of productivity as the best 25% today. Within ten years, the best 10% sow producers will be weaning approx. 30 pigs per sow per year.

	2006 All	2007 All	2008 All	2008 Bottom 25 %	2008 Top 25%
Sows/year	342	338	500	369	577
First parity litters, %	22.3	22.3	23.6	23.6	24
Liveborn/litter	13.3	13.6	14.0	13.6	14.5
Stillborn/litter	1.7	1.7	1.8	1.9	1.8
Weaned/litter	11.4	11.7	12.1	11.4	12.9
Days of lactation	31	32	32	33.2	30.2
Weaning weight, kg	7.3	7.3	7.3	7.4	7.1
Mortality until weaning	14.2	14.3	13.8	16.3	11.3
Non-productive days/litter	15.5	15.7	14.8	19.6	11.3
Days from weaning to first service	5.9	6	5.1	5.3	4.6
Returners, %	7.6	7.6	6.4	8.8	5.1
Farrowing rate	85	85	87	83	90
Weaned/sow/year	25.6	26	27.3	24.6	29.9
Litters/sow/year	2.24	2.23	2.25	2.17	2.32

Productivity, sows

Weaners	2006 All	2007 All	2008 All	2008 Bottom 25 %	2008 Top 25%
Daily gain, g	436	448	469	432	539
Feed conversion/kg gain, FUGp	2.04	2.02	1.97	2.15	1.83
Mortality	3.60	3.10	2.70	2.92	1.97
Weight at transfer to facility, kg	7.3	7.3	7.6	7.5	7.7
Weight per pig exited from facility, kg	31.4	31.7	32.8	33.1	34.0

Productivity, weaners

Finishers	2006 All	2007 All	2008 All	2008 Bottom 25 %	2008 Top 25%
Daily gain, g	859	879	904	812	994
Feed conversion/kg gain, FUGp	2.87	2.89	2.83	3.00	2.70
Weight at transfer to facility, kg	32.9	33.3	33.0	33.2	34.4
Av. slaughter weight, kg	80.4	82.8	82.3	81.3	83.4
Gain/produced pig, kg	72.4	75.2	74.9	73.4	74.9
Av. lean meat %	60.3	60.3	60.4	60.6	60.4
Dead and rejected, %	4.2	4.3	3.5	4.5	2.8

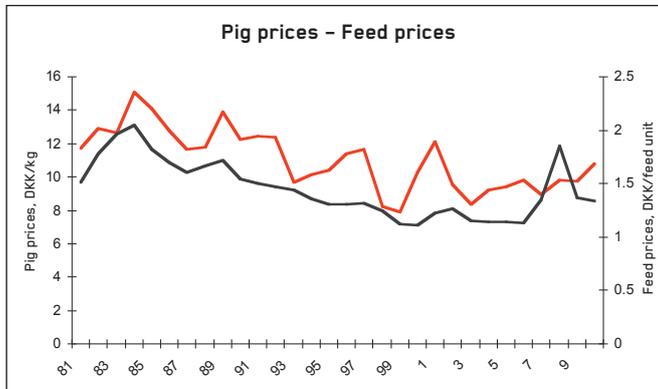
Productivity, finishers

Development in feed prices

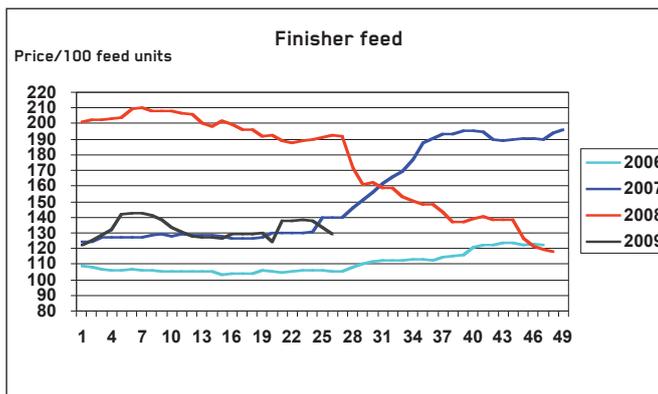
Before 2007, normal fluctuations in finisher feed were +/- DKK 0.10 per feed unit. However, since the 2007 harvest, fluctuations have been considerably greater, and as a result the risk of incurring significant losses has increased. 2009 feed prices have not yet reached 2006 levels despite the fact that grain prices have now reached 2006 levels. This lack of drop in prices is in particular attributed to significantly higher soya bean meal prices than in 2006.

Pig prices – feed prices

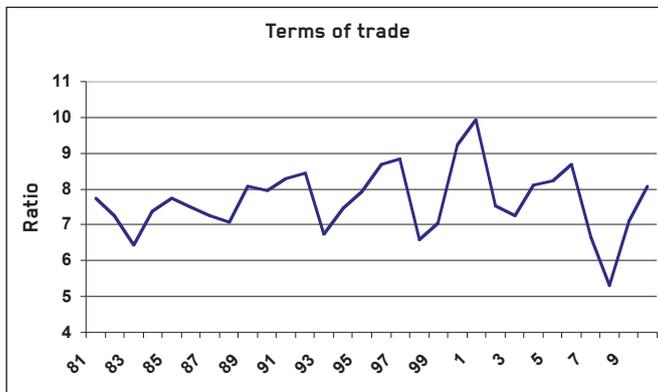
Unfortunately, increasing feed prices do not equal increasing pig prices. From 1985 to 2000, feed prices dropped gradually. From 2000 to 2006 prices were stable, and then leaped to land at almost the same level as before. Pig prices followed the pig cycles up and down while feed prices were stable. When feed prices changed dramatically in 2007, pig prices remained unaffected. No direct, short-term correlation can therefore be found between feed prices and pig prices. Pig prices adjust to feed prices when and only when a recession has resulted in adjustments in the pig production industry.



Correlation between feed prices and pig prices. There are no direct correlations between pig prices and feed prices.



Trends in feed prices. Feed prices increased dramatically in 2007 and dropped as dramatically in 2008. Feed prices may drop to 2006 levels if soya bean meal prices drop to the 2006 levels.



Terms of trade between pig prices and feed prices. Since 1981, the ratio between 1 kg pork and 1 feed unit of finisher feed has averaged 1:7.4. In 2007/08, this ratio was extremely unfavourable due to the high feed prices.

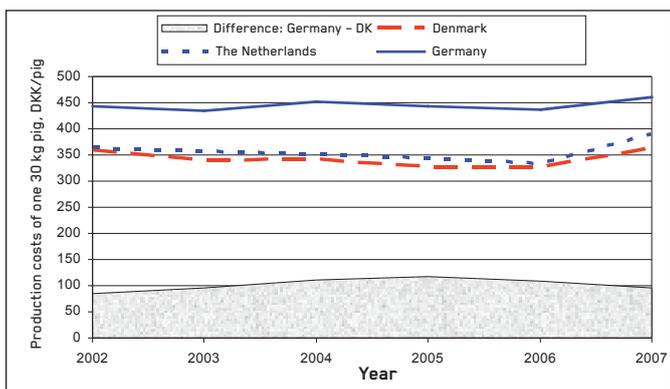
Export of weaners

In 2004, the number of slaughtered pigs in Denmark peaked with 23 million slaughterings, and dropped to 20.8 million in 2008. This drop, combined with an increase in sow productivity, resulted in an export of 5.3 million weaners in 2008; a figure expected to rise to more than 7 million in 2009. The increasing export is partly attributed to difficult framework conditions for Danish finisher producers and partly to high weaner prices in Germany.

Strict rules on ammonia and odour emissions and the harmony requirement make it difficult to establish large, profitable finisher herds in Denmark. The high weaner prices in Germany are partly attributed to the fact that the break-even price of a weaner is approx. DKK 80 higher than in Denmark, which reduces the supply of weaners, and partly that the Germany pig prices are higher than in Denmark, which increases the demand for weaners.

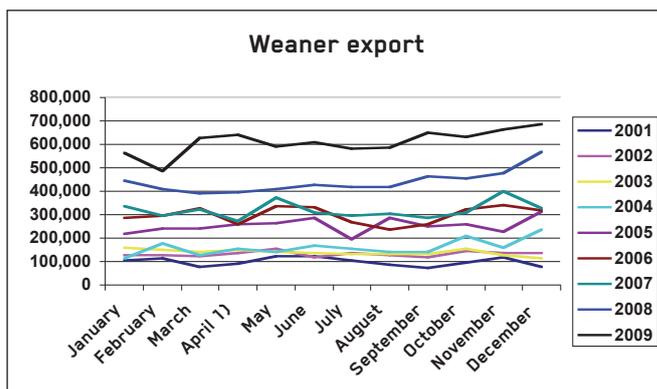
Export costs

Depending on the profit of sellers and agents, export costs of one weaner amount to approx. DKK 30-60. When exporting weaners, the price is averagely the same as in Denmark, if we disregard 2009 when the export price of weaners was higher than normally. Weaner prices fluctuate more in Germany than in Denmark, if seen over an entire year.



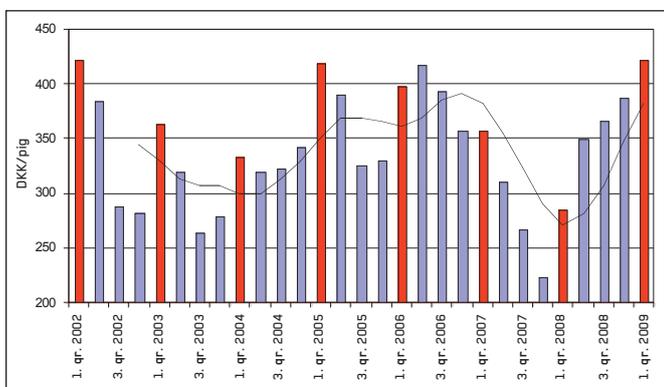
Break-even price of one weaner.

Danish and Dutch pig producers are far more efficient weaner producers than their German colleagues. We are able to produce 30 kg weaners at costs that are DKK 70-80 lower.



Export of weaners.

The export of weaners has increased since 2001, but the largest increases are seen within the last two years.



Seasonal variations in market prices for weaners.

The weaner market is controlled by supply and demand and prognoses for pig prices for the next 4 months. As higher pig prices are normally expected in the second and third quarters, market prices are normally highest in the first and second quarters.

	Costs, DKK/pig at full load (600 pigs)
Ear-tagging, incl. labour	5
Production fees	2.35*
Vet	2.50 - 5
Transport	20
Collecting facility	2.5-4**
Total	32.5-36
Administrative fee to seller	0-30 (estimate)
Total	32.5-66

Additional costs related to export of weaners

* this is not really an extra cost as the cost is included in the calculated pig price. However, if one wishes to compare the calculated price and the export price, the production fee must also be included here.

** Reloading typically DKK 2.5. Overnight an additional DKK 1.5 per pig. Transport to a collecting facility in Denmark is not included as it almost corresponds to the normal costs related to selling the pigs in Denmark.

Genetic progress

Table 1 provides an outline of the genetic progress of each of the breeds in the breeding programme over the last four years and an average for a D(LY) finisher for this period. There are significant differences in the genetic progress between the breeds: the female breeds – Landrace and Large White – still show great progress in litter size (on day 5). Longevity as a trait is negatively correlated with the production traits, and progress in these traits is not as great.

In the 2007 revision of the breeding objectives, the weighting of the trait feed conversion was increased which resulted in an improvement in progress – particularly for the female breeds.

The average progress for all breeds over the last four years amounts to DKK 11.7 per D(LY) finisher annually.

Production level

At Bøgildgård, 4,955 boars were performance-tested. Progress is still seen in all recorded production traits, and as shown in table 3, also Landrace has now reached 1000 g in daily gain. The progress in the production traits

is also clear from the figures from the nucleus herds, where it is important to notice that breeding for litter size is still paying off.

As shown in table 7, Landrace sows have 12.0 live pigs on day 5 after farrowing. For Large White the figure is 12.6. This corresponds to increases of 0.6 and 0.3 pigs, respectively, compared with 2008.

Sale of semen and boars

A total of 4,245,000 doses of Duroc semen were sold in Denmark. Foreign sales are still very low because Duroc boars could not be transferred to foreign AI stations until April 1, 2009. However, by August 2009, approx. 300 Duroc boars were housed at foreign AI stations. In Denmark, the sale of boars to herds (not AI) continues to drop and has reached an all time low with only a sale of 2000 boars. This is due to the fact that AI has gradually taken over an increasing part of the boar market in Denmark and is also expected to do so abroad.

AI boars

Landrace and Large White boars at the AI stations are in production for averagely six months before they are

overtaken by younger boars in terms of index and are replaced. That is one month less than last year. However, a Duroc boar's time in production has increased by one month, so now a Duroc boar produces semen for AI for 9.7 months (table 6). The index for all three breeds is largely unchanged.

Sale of breeding stock

This year's statistics are characterised by the sale of hybrid gilts, which amounted to 419,000. Added to this is the sale of purebred gilts that should not be disregarded just because the figure is much lower. Most breeding systems operate with a conversion factor that says that one purebred female pig corresponds to ten hybrids – which here corresponds to 250,000 hybrid gilts.

Sale of semen should also be included, and here the rule thumb is that one dose of LL or YY semen results in one hybrid female pig. In Denmark, this corresponds to 260,000 gilts and abroad, where the sale is increasing, it corresponds to 45,000 gilts. The total "sale" from DanBred thereby amounts to 974,000 gilts in 2009. This is sufficient to maintain a sow population of 1.95 million sows.

Breed	Year	Daily gain (30-100 kg), g/day	FCR, FUp/kg daily gain	Lean meat %	LP5	Conformation, points	Daily gain (0-30 kg), g/day	Killing-out %	Longevity, %
Duroc	05/06	15.8	-0.042	0.23	-	0.01	1.4	-0.04	-
	06/07	20.3	-0.039	0.13	-	0.05	3.7	0.03	-
	07/08	20.1	-0.040	0.17	-	0.03	4.0	0.02	-
	08/09	13.9	-0.051	0.21	-	0.02	0.5	-0.02	-
Average	4 years	17.5	-0.043	0.19	-	0.03	2.4	-0.003	-
Landrace	05/06	11.8	-0.036	0.02	0.45	0.04	1.1	-0.13	-0.059
	06/07	5.8	-0.013	-0.03	0.43	0.02	0.4	-0.02	-0.040
	07/08	-5.0	-0.004	-0.03	0.55	0.00	3.6	-0.02	-0.025
	08/09	15.1	-0.024	0.03	0.37	0.03	0.8	0.06	-0.013
Average	4 years	6.9	-0.019	-0.003	0.45	0.02	1.5	-0.03	-0.034
Large White	05/06	-3.0	-0.006	0.04	0.56	0.02	0.8	0.05	-0.008
	06/07	1.3	0.004	-0.01	0.40	0.05	-0.8	-0.11	0.003
	07/08	-5.3	-0.003	0.04	0.45	0.02	2.1	0.20	0.004
	08/09	9.9	-0.027	0.05	0.32	0.06	1.2	-0.01	0.016
Average	4 years	0.7	-0.008	0.03	0.43	0.04	0.8	-0.01	0.004
Aver. 3 breeds	4 years	10.7	-0.028	0.1	0.44	0.03	1.8	-0.01	-0.015

Table 1. Genetic progress 2005-2009.

Δ G: Genetic progress

	Female pigs				Boars			
	2007/08		2008/09		2007/08		2008/09	
	DK	Export	DK	Export	DK	Export	DK	Export
Landrace	8,632	1,900	5,667	5,880	87	357	80	510
Large White	6,329	3,269	5,573	5,777	112	419	58	534
Duroc	10	175	58	62	1,053	981	1,149	1,285
All 3 breeds	14,971	5,344	11,298	11,719	1,252	1,757	1,287	2,329
Purebred, total	20,315		23,017		3,009		3,616	
Hybrid*	313,400	81,000	284,555	134,435	1,409	147	712	58
Hybrid, total**	394,400		418,990		1,556		770	

Besides what is stated above, DanBred multiplication herds are run by exporters have sold approx. 25,000 hybrid gilts.

* Export incl. F2 females. ** Incl. export.

Table 2. Sale of breeding stock in 2007/2008 and 2008/2009.

Breed	Number	Daily gain (30-100 kg), g/day	FCR, FUp/kg gain	Lean meat %	Killing-out %	Scanning objective, mm
Duroc	2,083	1032	2.29	60.2	74.9	7.5
Landrace	1,437	1000	2.34	60.8	74.5	8.1
Large White	1,435	940	2.34	60.9	74.6	8.5
Total	4,955					

Table 3. Average production results from performance test station Bøgildgård, 2008-09.

Breed	Number	Daily gain, g*		Lean meat %	Conformation, points	Scanning objective, mm	Scanning weight, kg
		0-30 kg	30-100 kg				
Duroc	6,329	384	1,077	60.9	2.89	7.8	95.9
Landrace	20,559	377	1,014	62.3	2.94	8.3	94.1
Large White	14,281	359	942	61.6	3.06	8.5	93.0
Total	41,169						

* Note that daily gain 30-100 kg is calculated on the basis of weighing of live animals, which means that the calculation of gain at the performance test did not include differences in killing-out percentage between the breeds.

Table 4. Nucleus herds - average production results for boars, 2008-09.

Breed	Number	Daily gain, g*		Lean meat %	Conformation, points	Scanning objective, mm	Scanning weight, kg
		0-30 kg	30-100 kg				
Duroc	8,633	388	1,025	61.1	2.95	7.5	95.1
Landrace	24,878	381	947	62.5	3.03	8.1	93.0
Large White	16,843	361	905	61.6	3.11	8.7	92.9
Total	50,354						

* Note that daily gain 30-100 kg is calculated on the basis of weighing of live animals, which means that the calculation of gain at the performance test did not include differences in killing-out percentage between the breeds.

Table 5. Nucleus herds - average production results for young sows, 2007-08.

Breed	Boars transferred, 2008/09	Active boars, August 2009	Index level for active boars, August 2009	Months in production of boars departed in 2008/09
Landrace	676	326	120.6	6.1
Large White	762	368	122.4	6.1
Duroc	2,578	2,174	109.1	9.7

Table 6. Index level and time in production of AI boars.

Maternal breed	Litter size	LP5	Per cent gilt litters
Duroc	10.0	-	74.7
Landrace	15.0	12.0	60.5
Large White	15.5	12.6	62.4

Table 7. Nucleus herds - litter size of purebred litter, 2008.

Genomic selection

For nine years, Pig Research Centre has managed several, large-scale biotechnological projects. The projects have mainly dealt with identification and mapping of the pig genome to find a correlation between individual genes or gene sequences that can explain the physical and phenotypic traits of pigs.

Genomic selection is a brand new method that combines modern biotechnological techniques with advanced statistical models and estimation techniques. With this method, thousands of genetic markers (SNPs) are used to make considerably more accurately breeding values than today. Genomic selection marks a new research area for implementing biotechnological know-how in livestock breeding and genetics as the method is based on biotechnological analyses of the entire genome, which carries all genetic information. The use of genomic selection in pig breeding will create an entirely new basis for our genetic work.

The use of genomic selection will present entirely new possibilities for selecting animals with good health traits and prevent increases in the traditional production costs. This will improve the pig's genetic potential for health. It will reduce disease and treatment frequencies, which will benefit animal welfare and increase our possibilities for exporting Danish pork.

To investigate the possibilities of genomic selection in pig breeding, Pig Research Centre has received financial support to a project under the Innovation Act in co-operation with the Faculty of Agricultural Sciences, Aarhus University, aimed at demonstrating the use of genomic selection in pig breeding. This will create the basis of a more efficient selection programme for breeding stock with a high level of disease resistance and longevity. Today, it is difficult to select for these traits as records of many animals are required to obtain sufficiently accu-

rate information. The future development of methods for selecting breeding stock will also be ensured through this project; a development process that can be obtained through these sub-goals:

1. Development of methods for estimation of genomic selection models for traits in pig breeding based on 6,000 genetic markers.
2. Estimation and evaluation of the theoretic additional genetic progress resulting from genomic selection.
3. Development of a technology for simultaneous typing of 50,000 markers for future implementation of genomic selection.

In the past year, typing of markers has been performed on 996 Landrace boars in co-operation with the Faculty of Agricultural Sciences, Aarhus University. Preliminary results from analyses of lean meat percentage reveal a correlation between DNA typings of the boars and the breeding values for lean meat percentage for these boars. It shall be interesting to see whether future breeding can be based exclusively on breeding values calculated on the basis of DNA typings.

With practical use of genomic selection in mind, Pig Research Centre initiated a project of DNA typing of approx. 2,000 Duroc animals. The animals are selected from among the most significant breeding stock within the breed over the last ten years. The aim is to construct an index formula based on DNA that can be used in the future genetic work. Generally, genomic selection is expected increase progress, and, firstly, to improve the sub-index for feed conversion.

Selection for optimum contribution

The purpose of practical use of selection for optimum contribution is to implement the method in DanBred's breeding work. It will improve the genetic progress by 10% and reduce the



Genetic selection has the potential of significantly increasing progress for, for instance, fertility.

increase in inbreeding by approx. 50% without significant costs.

Today, breeding increases inbreeding as more animals are selected from the best families. Inbreeding is unfortunate as it results in fertility problems and disease resistance and as it reduces the future genetic progress.

Selection for optimum contribution is an advanced method that can be used for breeding better pigs and at the same time keep inbreeding under control. This is specifically done by deciding which breeding stock to use in the breeding work and how many matings be assigned to each animal. This will improve the breeding system as it will increase genetic progress and reduce inbreeding.

Pig Research Centre will implement selection for optimum contribution by establishing where to incorporate the selection method into DanBred's breeding system to maximise genetic progress, minimise inbreeding and at the same time keep the method applicable, ie. which gender and age to select for when selecting for optimum contribution. This is determined with computer simulations and subsequently the best method will be implemented.

DanBred will benefit from selection for optimum contribution as the three following criteria are met:

1. DanBred's current breeding system is well-managed, which will make it possible to use the method without changing the system significantly.
2. The software programme EVA that selects for optimum contribution is made by Aarhus University (Institute for Genetics and Biotechnology).
3. The simulation software programme ADAM for conducting the computer simulations is developed by Pig Research Centre and Aarhus University.

The project is a joint venture between Pig Research Centre and Aarhus University. Both are leading in breeding plans.

QTLs for osteochondrosis

Osteochondrosis is a disorder seen among weaners and finishers. The disorder is characterised by lesions in joints and bones; in mild cases changes are observed on the surface of the cartilage. Osteochondrosis lesions are fairly easy to record in slaughtered animals, and can also be recorded in live animals via x-rays, but this is far more timeconsuming. Recordings based exclusively on slaughtered animals make osteochondrosis a difficult disorder to breed against, and it will therefore be interesting to use biotechnological methods such as marker-based selection. With marker-based selection, a DNA analysis is made on individual pigs, and with selection it can be ensured that each individual carries a certain haplotype. This makes it unnecessary to measure that trait of the individual animal.

It is necessary to identify the genes that trigger osteochondrosis for marker-based selection against osteochondrosis to work. The first step is to identify the areas on the chromosomes that are correlated to osteochondrosis.

Chromosome	Variable	Position	Per cent	Chromosome	Variable	Position	Per cent
1	A	51 ([39;58])	3.8	7	A	61 ([54; 64])	2.8
1	B	53 ([44;60])	3.1	7	B	11 ([0; 26])	1.5
1	C	55 ([28;84])	2.7	7	C	63 ([51; 64])	1.3
1	D	49 ([34;60])	2.0	7	D	57 ([51; 64])	1.9
1	F	27 ([20;44])	3.6	7	E	29 ([18; 36])	1.7
2	A	11 ([0;24])	1.3	7	F	31 ([20; 36])	3.8
2	B	15 ([6;22])	1.7	8	B	45 ([22; 70])	1.2
3	A	27 ([6;36])	2.0	9	A	69 ([62; 82])	1.3
3	B	63 ([0;22]∪[54; 76])	1.5	10	A	81 ([62;100])	1.6
4	A	79 ([62;83])	2.9	10	B	59 ([34; 90])	1.4
4	B	75 ([65;88])	3.8	10	C	75 ([70; 86])	1.7
4	C	23 ([16;32]) 2, QTL	1.8	10	D	83 ([76; 100])	3.1
4	C	71 ([58;80])	2.7	13	A	81 ([75; 86])	1.1
4	D	69 ([53;90])	2.5	13	B	85 ([75; 92])	1.3
4	F	41 ([28;44])	2.4	13	F	93 ([82; 100])	1.7
5	A	27 ([18;48])	1.7	14	A	43 ([28; 96])	1.5
5	C	53 ([40;54])	1.6	14	D	55 ([40; 72])	1.1
5	D	23 ([18;42])	2.5	14	F	83 ([64; 96])	1.3
6	A	13 ([4;126])	0.9	15	A	55 ([46; 78])	1.2
6	B	37 ([20;54])	1.4	15	B	53 ([48; 78])	2.3
6	F	51 ([34;90])	1.4	15	F	83 ([66; 100])	1.6
6	F	119 ([110;144]) 2, QTL	2.6	16	B	37 ([14; 38])	1.4
7	A	5 ([0; 14]) 2, QTL	2.2	16	C	23 ([2; 38])	1.0

Chromosome: is the chromosome on which the trait is localised. Variable: is one of the six variables that constitute the osteochondrosis complex. Position: is the position of the QTL and its 95% confidence interval. Per cent: the percentage of the phenotypic variance explained by the QTL.

Table of QTLs

The aim of this project is therefore to identify QTLs that are related to osteochondrosis. A QTL is a longer piece of DNA with several genes that influence one or more traits.

A total of 7,172 finishers, that were all included in the project Breeding for Disease Resistance, were examined. All finishers were D(LY) hybrids and both castrates and female pigs were included from a total of 875 litters. The finishers were reared under normal, conventional Danish production conditions and were slaughtered when the first pig in the litter reached 110 kg. Tissue samples were collected from the tender loin and used for purification of DNA. 463 SNPs were identified from the DNA and with these

QTLs for osteochondrosis were determined.

Osteochondrosis is a complex disorder composed of several variables. This project comprises six variables:

- A. Irregular cartilage on the elbow joint of the humerus.
- B. Cartilage thickness on the elbow joint of the humerus.
- C. Lesions in bone tissue under the cartilage of the elbow joint of the humerus.
- D. Fissure between cartilage and bone on the elbow joint of the humerus.
- E. Irregularities in the trochlea of the humerus
- F. Deviant form in the articular surface of the radius.

All six variables are included in the overall evaluation of the disorder. The left elbow joint was examined on all the animals.

The results showed that 46 QTLs influence the six osteochondrosis variables and that with 95% certainty the QTLs lie within the intervals shown in table 8 in square brackets in the column "Position". This means that many QTLs influence osteochondrosis, which in turn means that many different genes affect the disorder. QTLs linked to lesions in the humerus explained with four variables (A, B, C and D) were in several cases found in the same position on the chromosome. The genetic factors that influence these variables are thus almost the same.

The QTLs linked to deviant forms in the articular surface of the radius (F) were found on the same chromosomes, but in different positions on these chromosomes.

The positions between the variables for lesions in the elbow joint of the humerus (E) and the variable for deviant form in the articular surface of the radius are so far apart that the genetic factors of the two disorders must be different. Consequently, the deviant form in the articular surface of the radius (F) must be considered a separate osteochondrosis variable and should therefore not be included in the complex of several variables describing the disorder.

F4 project

In 2003, a selection project was initiated to increase the resistance to post-weaning diarrhoea caused by *E. coli* 149 F4. F4 selection runs parallel with the regular index selection in Landrace, Large White and Duroc. The use of F4 resistant boars has been compulsory in nucleus herds for many years, and, as of April 1, 2007, this also applies to multiplier herds.

As shown in Figure 1, both Duroc and Large White populations are now almost 100% resistant. Among DLY offspring, 94% are resistant. However, for all breeds the current test strategy will be followed for some years to come. When the percentage of resistant breeding stock in a given population reaches 97-98%, it is planned to test the remaining animals of unknown F4 status. This will minimise the costs for F4 testing and the loss in genetic progress for other traits in the breeding objective.

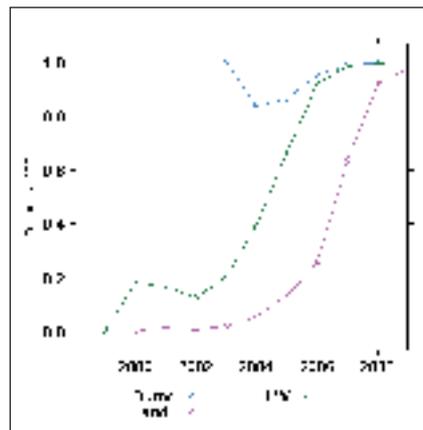


Figure 1. Development in F4 genotype distribution in the generation of young animals (basis of recruitment of AI boars).

Alternative breeds

There is an increasing interest among consumers in niche products of a high eating quality. To ensure a high price for these products, they must stand out from conventional products by having a considerably higher eating quality. Production of pigs in Denmark is based on the same nucleus of breeding stock. In production of pork today, it is mainly possible to vary elements such as slaughter weight, nutrition and maturation, which may affect eating quality, but not to an extent that makes the product stand out from standard products. It is therefore necessary to find new ways, and the use of foreign alternative breeds with extremely high eating quality is one of the most interesting ones.



Mangalitza (Hungarian wool pig) and Iberico pigs were selected after evaluating the eating quality of eight pig breeds and comparing the result with the Danish standard finisher D(LY). The evaluation was made by the Danish Meat and Research Institute (DMRI) and it revealed that in particular meat from Mangalitza and Iberico pigs was distinctly and positively different from that of the Danish breeds as the meat was more tender and had a more attractive taste.

Pig Research Centre is in charge of a trial production under Danish production conditions with Mangalitza and Iberico pig as boar lines. Sow lines are LY and Duroc. The hybrid offspring will be compared with D(LY). Meat will be produced from these hybrids:

- Iberico x LY
- Iberico x Duroc
- Mangalitza x LY
- Mangalitza x Duroc
- Duroc x LY (control)

The pigs are produced under traditional conditions and are given traditional feed. In total, approx. 300 pigs will be produced. The first pigs were born in August 2009.

When the pigs are slaughtered, the eating quality of different cuts of the fresh meat and of meat products will be evaluated. The quality will be evaluated by experts from the Danish meat industry and by chefs and other gastronomic opinion makers. This part of the project will be conducted by DMRI. The project is a joint venture between Pig Research Centre and DMRI.

Project Pigs and Health

The project has two aims: development of healthier pigs for meat production and development of model pigs for medical research in human diseases. The basis of the project is the knowledge on the pig genome acquired by Pig Research Centre and Danish scientists. It is a four-year-long project with an overall budget of DKK 50 million, of which the Danish National Advanced Technology Foundation funds half. Pig Research Centre is in charge of the project. "Pigs and Health" consists of two separate projects that only have the pig and its genome as common denominator. The project "Healthy Pigs" will identify genes that affect pigs' resistance to livestock diseases, primarily various types of pneumonia.

Parallel with the mapping of the pig genome, a comprehensive study was made in which more than 10,000 pigs were followed from birth to slaughter. The pigs were reared under identical conditions, and disease, gain and other traits were recorded. The genetic material from pigs that for instance fell ill was compared with corresponding pigs that had not fallen ill, and this resulted in identification of certain areas in pigs' DNA that is assumed to control resistance or particularly susceptibility to certain diseases.

Currently, four regions in the genetic mass have been identified for pneumonia in pigs that seem to influence resistance to this type of disease. The genetic mass will now be analysed in detail to find the genes that trigger this resistance.

If successful, it will be possible to test pigs for these genes, and, through selection, ensure that the trait is passed on to future generations of pigs. The preliminary mapping of the pig genome shows that it is possible to be even more determined in locating the genes that make the pigs resistant to certain diseases. This will result in healthier pigs, a lower consumption of medicine and a better economy for the pig producers.

The genes will be identified by scientists from Aarhus University, the Danish Technical University and Copenhagen University, while Pig Research Centre will conduct the practical testing of the effects in live pigs.

Model Pigs

The second project, "Model pigs", is aimed at improving human health. This project concerns development of special model pigs for use in the pharmaceutical industry. Pigs are actually much more suitable for pharmaceutical trials than traditional experimental animals such as dogs and rodents as the pig's organ development, physiology and metabolism have clear resemblances to those of humans. Model pigs are special mini pigs whose ancestors are Vietnamese pot bellied pigs.

Development and testing of new pharmaceutical products require time and resources, but hopefully the production of special model pigs will change this. Model pigs must be particularly predisposed to diseases that normally affect only humans.

Scientists from Humane Genetics at Aarhus University and the Faculty of Agricultural Sciences together with LEO Pharma are working on locating and, through cloning, introducing genes that make the pigs sensitive to certain human diseases. Ellegaard Göttingen Minpigs, who supplied mini pigs for the project, and Pixie-Gene AB, who is in charge of this part of the project, also participate in the project. In a supple-

mental part of the project, scientists at Copenhagen University are working on developing a new technique for future use of embryo stem cells in pigs.

The project began April 1, 2007, and involves eight parties and more than 50 scientists. The project is now halfway. In Model Pigs, several lines of transgene and cloned pigs are born; both pigs with Alzheimer's genes and pigs with genes causing arteriosclerosis. Psoriasis pigs are also underway.

Breeding for increased pH

Slaughter affects the pH (acidity) of the meat, which influences the quality of several products. The industry demands meat with a higher pH, not least in the production and processing of ham.

In the project "Genome scan for identification of genes affecting traits for health, product quality and production" (conducted by Pig Research Centre and the Faculty of Agricultural Sciences, Aarhus University) several promising gene markers have been identified that affect pH in the carcass. The markers need to be validated before they can be used in the breeding.

These markers are currently being tested in Danish pigs. In the first phase, 250 old, purebred D, L and Y boars will be analysed for these markers. For the boars to be selected, pH must be available of minimum 15 offspring. This will make it possible to confirm the effect of the QTL haplo-types on pH. In the second phase, 20 young Duroc boars will be selected for a more accurate determination of the effect of the markers. Approximately 1,000 three-way hybrids will be produced, and pH will be recorded at slaughter and their genotypes analysed. Phase 1 was initiated in the autumn 2008, and phase 2 is expected to be initiated in 2009-2010.

Effect of breeding for FCR

As opposed to, for instance, litter size, the genetic progress for feed

conversion ratio is difficult to measure and assess for the individual pig producer. There are several reasons for this; factors such as feed, feeding strategy, facilities and recordings must be identical over several years before it is possible to determine whether changes are attributed to the genetic progress or to other factors. On a year-to-year basis, only marginal progress can be achieved through breeding. This is one of the reasons why it is difficult to see the effect of breeding for feed conversion ratio in production herds, and that it is why the subject is still being discussed.

Genetic progress is ensured by measuring the feed conversion ratio of every single animal that is performance tested at Bøgilgård. The genetic correlation between feed conversion ratio and the traits gain and lean meat percentage is also utilised.

To be able to prove that breeding based on recordings of individual animals can be transferred to a production environment, the correlation between breeding value and the actual feed conversion in a production environment will be studied. The most efficient way to do this is by measuring the feed conversion ratio of purebred Landrace boars in a nucleus herd, as a fairly accurate breeding value is being estimated here through on-farm testing without the actual feed conversion directly affecting the breeding value. Furthermore, a large genetic variation is observed in Landrace, which means that a more certain result is available. It is not possible to make these measurements in production herds as that would require knowledge of the pedigree of the production animals and an extreme amount of data due to a considerably smaller variation in breeding values.

Compilation of data began at the end of 2007 in the investigation in which the breeding value for feed conversion and actual feed conversion in a production environment will be com-

pared. Landrace boars are weighed in the pens and feed consumption per feeder is weighed. Compilation of data will be completed by the end of 2009. Through statistical analysis, the correlation between breeding value for feed conversion and the actual feed conversion at group level will subsequently be determined, and the effect of the breeding work at group level will be clear.

Project for survival

Improvement in the survival rate of pigs will significantly benefit the economy of Danish pig production. With the breeding objective LP5, survival rate the first five days after farrowing will be improved. This contribution to improved survival is a trait in the sow breeds Landrace and Large White. To further strengthen the survival until slaughter, heritability of the trait "survival" is currently being investigated (definition of survival = an animal lives to slaughter). Data has now been compiled from a production herd. A total of 2,205 litters were produced from 924 sows and 203 boars over a two-year period, which resulted in 30,752 live-born and 4,175 stillborn hybrid piglets. All pigs had a known pedigree and all liveborn pigs were ear-tagged.

Currently, data is being analysed to establish heritability of survival, which may become part of the breeding objective for Duroc. This dataset will also provide the opportunity of investigating whether LP5 is effective in the production herds, as it is possible to say how many pigs were alive on day 5 in these 2,205 litters. This is compared with the sows' sub-index for LP5. In April 2005, LP5 replaced the total number of piglets born for Landrace and Large White. It is relevant to investigate whether the progress in LP5 is also found in the production herds in order to ensure that the genetic progress found in the purebred populations is also transferred to the users of the breeding material.

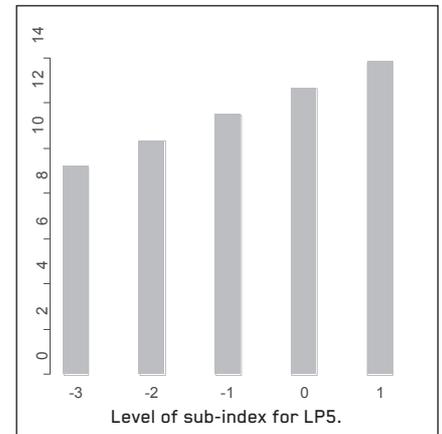


Figure 2. Sows with a high sub-index have more live piglets on average on day 5 after farrowing.

Analyses revealed a positive effect, which means that a sow with a high LP5 sub-index on average has more piglets on day 5 than a sow with a lower sub-index. The result is shown in figure 2, in which it is seen that the difference in litter size on day 5 may be as large as 4 piglets after farrowing between sows with a high and a low sub-index, respectively.

Sale of semen

In 2008/2009, DanBred's AI stations sold 5.3 million semen doses, which is a 3.8% increase compared with 2007/2008. This corresponds to 95% of all matings being made with semen from AI stations. The figures are based on an estimated population of sows and gilts in Denmark of 1,073,000. The sales figures are shown in figure 1.

Sexing of semen

With sexing of semen, it is possible to choose the gender of the offspring. In the cattle industry, sexing of bull semen is an established and well-tried method. However, this method cannot be used for sexing of boar semen, as the number of sperm in a dose of bull semen is a thousandth of that of a dose of boar semen. Furthermore, the method is too slow to be used for boar semen.

A method for sexing of boar semen is currently being developed in a project conducted in co-operation with DanBred's AI stations, Norsvin (Norway) and Ovasort Ltd. (Wales). The method is based on the assumption that sperm of different sexes also have different antigens on the sperm surface. Antibodies against such antigens have not yet been developed, but once they are, Pig Research Centre will investigate these antibodies in practice as a method for sexing of boar semen.

Sperm motility and fertility

The correlation between sperm motility and fertility of the sperm was investigated in a trial with sperm from Large White boars. Semen was analysed on day 3 with an instrument that measures the motility of 1,000 sperm in 30 seconds. Based on this analysis, the semen doses were divided into three quality categories with 1/3 of the boars in each: good, medium or poor. A clear correlation was found between fertility of the sperm and motility. The difference in litter size between good and poor-quality semen was one pig per litter. The method can be used for

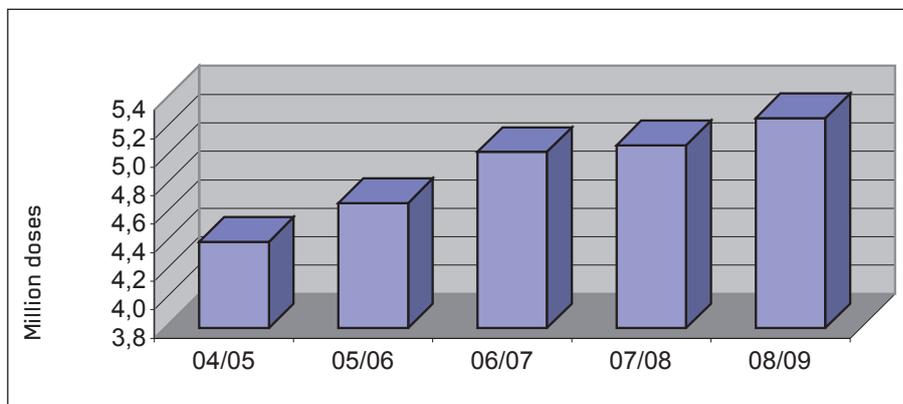


Figure 1. Sale of semen over the last 5 years.

monitoring sperm quality and for culling boars on the basis of a lower limit for acceptable semen quality and boar indices.

The method is also being used for studying whether ejaculates with sperm of lower motility affect fertility in doses with heterospermic semen. This study is not completed, and, so far, no significant reduction in fertility is observed when poor-quality semen was mixed with high-quality semen. The general quality of sperm will improve if the negative effects can be completely eliminated by mixing sperm.

Efficient service

Correct insemination of sows is the basis of making a profit in pig production. It is crucial to be efficient in the service facility is well spent in order to reduce piglet mortality and to avoid empty farrowing pens.

In a trial comprising two groups, it is currently being studied whether it is possible to be more efficient during insemination. In the control group, the sows are heat-detected according to the 5-point plan and subsequently inseminated while the inseminator is sitting on the back of the sow. In the trial group, the 5-point plan is also used for heat detection, but during insemination the inseminator does not sit on the sow's back (see picture below).

The aim is to establish the value of sitting on the back of the sow during the insemination. Thorough heat detection must therefore always be performed. Improving heat detection and stimulation of the sows will improve the ability to distinguish between heat detection and stimulation. The aim of heat detection is to locate the sows ready for insemination, whereas the aim of stimulation is to ensure a good transport of the sperm in the uterus. Once the exact importance of heat detection and stimulation is determined, it will be easier for the herd owner to decide on a management strategy.

The trial is now halfway, and we have yet to see an effect of stimulating the sow during insemination. Note, however, that all sows were subject to heat



The semen dose hangs in a chain during the insemination.

detection according to the 5-point plan for approx. 1 minute prior to insemination.

Reduction of boar variance

Boar variance is the varying influence of boars on litter size. This influence is unwanted as it interferes with calculations of sows' subindex for litter size. Boar variance is normally approx. 4%, but varies between breeds. Analyses have demonstrated that Large White have a larger boar variance than Landrace. It is assumed that boar variance is correlated with sperm quality for the breed or with the fragility of the sperm.

The project includes several different trials dealing with methods that might help semen of reduced quality. The trials include investigations of various extenders and more gentle production processes of semen doses at the AI stations.

Extenders

In 2008, nine different semen extenders were studied in a trial in which sperm was diluted with each of the nine extenders and subsequently subjected to an analysis of sperm motility after storage. Based on the results of these analyses, four extenders were picked that were investigated during artificial insemination. However, the investigations during artificial insemination did not show sufficiently promising results to be used as an evaluation of which extender is most gentle. Other methods for studying the most promising extenders are now being considered. The aim is to investigate if there are extenders more suitable than the ones we use today.

Temperature during dilution

The effect of cooling of boar semen was investigated by comparing different temperatures during pre-dilution and final dilution of sperm. The effect was evaluated on the basis of sperm motility (see the table).

Group	Temperature of extender during pre-dilution	Treatment of semen between pre- and final dilution	Temperature of extender during final dilution
A	30 °C	Immediate final dilution	20 °C
B	30 °C	Cooling to 22°	20 °C
C	20 °C	Immediate final dilution	20 °C

No differences in motility were observed between groups A and B. Today, at the AI stations the sperm is subject to pre-dilution with an extender that is 30° warm and final dilution with an extender that is 20° warm. The above results indicate that it is irrelevant whether sperm is subject to final dilution immediately or whether some time passes before final dilution. In group C sperm was pre-diluted with an extender that is 20° warm and immediately subject to final dilution with an extender that is 20° warm. In this group, a positive effect on motility was seen compared with groups A and B.

Quality control of AI stations

According to "The Guidelines for Breeding, Management and Biosecurity for AI stations", all AI stations are subject to routine audits for the number of sperm per dose. Besides a self-audit programme run by the AI stations, the audit also includes unannounced audits conducted by Pig Research Centre.

The self-audit programme of the AI stations includes, for instance, weekly submissions of randomly selected sperm doses to a trial lab in Ringsted where the concentration of the doses is determined. The result is analysed by Pig Research Centre.

On March 1 and 15, 2009, unannounced audits were conducted at Boar station Mors and Hatting KS, departments Horsens, Aalborg, Ringsted, Marup and Billund. Results from these audits showed that no semen doses were found with a content of less than 1.8 billion sperm for Landrace and Large White and 1.5 billion sperm for other breeds. All audited stations thereby complied with the guidelines at the

audit. Vets from Pig Research Centre participate in the audit programme, but are also available as technical and scientific advisors to the AI stations.

Blood plasma for weaners

Blood plasma for weaners was investigated in co-operation with DAKA in a trial in which starter diets with and without zinc and with and without blood plasma were compared (see table 1). Today, DAKA produces spray-dried blood plasma from the slaughterhouses. Only blood approved for human consumption can be used in feed. 5% blood plasma and/or 2500 ppm zinc prescribed by the vet (3 kg ZnO per tonne) were added to the trial feed that was given to the pigs the first ten days post-weaning. Subsequently, all pigs in the trial were given the same diet. Blood plasma replaced fishmeal, dried milk in part and soya protein concentrate.

The greatest effect of adding either blood plasma, 2500 ppm zinc or both to the starter diets was observed the first ten days, but an effect was also seen from weaning until approx. 30 kg. The addition of blood plasma resulted in a 3% increase in production value compared with the diets that did not include blood plasma. Daily gain increased by 44 g the first ten days and 34 g a day in the entire period (7-30 kg).

Group	1	2	3	4
Plasma, %	-	-	5	5
Zinc, ppm	-	2500	-	2500
First ten days (7.1-9.3 kg)				
G/day	137	231	190	266
FUgp/day	0.29	0.35	0.33	0.37
FUgp/kg	2.61	1.74	2.05	1.63
Entire period (7.1-30.5 kg)				
G/day	454	477	468	501
FUgp/day	0.80	0.83	0.82	0.87
FUgp/kg	1.68	1.66	1.66	1.64
DKK/pig, identical feed price	71.8	74.6	73.8	78.6
Index	100	104	103	109

Table 1. Productivity and index of production value

The inclusion of zinc improved the production value by 3.7 % compared with the two diets without zinc. The first

ten days, the effects were 85 g a day in gain; 0.6 FUgp/kg in improved feed conversion; and, for the entire growth period, an increase in daily gain of 43 g. The addition of DAKA Porcine Plasma increased the production value when calculated with identical feed prices, but this could not cover the excess feed price.



Ultrafiltration of blood plasma.

The addition of zinc or plasma did not affect mortality rates and culling rates. In the first ten days post-weaning, the pigs in the control group had significantly more treatments for diarrhoea than the pigs in the other groups. When analysed for the entire growth period, the frequency of treatments for diarrhoea did not differ between the groups (see trial report 846).

Chicory and benzoic acid

Chicory has demonstrated a positive effect on skatole, parasites and Lawsonia. Chicory was studied alone and in combination with benzoic acid to determine the effect on health and productivity of weaners.

Preliminary figures show that the addition of 7.5% chicory and 0.5% benzoic acid increased the production value by 18%; 15% chicory increased the production value by 14% compared with the control group. If only the current feed prices are used in the calculations, the production value is identical in the control group and trial group 4 (7.5% chicory and 0.5% benzoic acid) only if chicory costs DKK 3.50 per kg. Today,

the price of chicory ranges between DKK 6.50 and 7.50 per kg. In the other groups, the actual production value lies below that of the control group. At a chicory price of DKK 7.50 per kg, the production value will be 59% below the control group when 15% chicory is added.

Group	1	2	3	4
Chicory	0	7.5 %	15 %	7.5 %
Benzoic acid	0	0	0	0.5 %
G/day	422	429	457	473
FUgp/day	0.78	0.77	0.79	0.83
FUgp/kg	1.84	1.77	1.71	1.73
DKK/pig, identical feed price	64.3	68.3	73.6	75.5
Index	100	108	114	118
Index DKK 3.50/kg chicory	100	91	84	99
Index DKK 7.50/kg chicory	100	70	41	77

Table 2. Productivity and index of production value

No effect was found on mortality and treatments for diarrhoea. Half as many Lawsonia bacteria per gram manure were found in the pigs given 15% chicory compared with the pigs given control feed: 3.13×10^7 vs 6.88×10^7 . A change of this scale is not sufficient to conclude whether chicory is able to reduce Lawsonia diarrhoea. For more information, see trial report at Pig Research Centre's website.



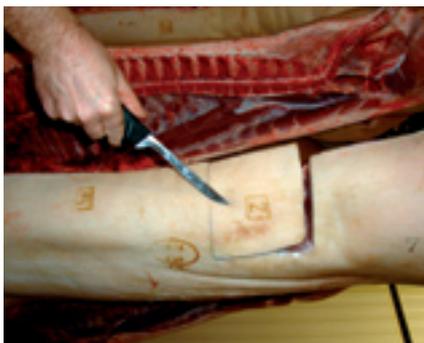
15% inclusion of chicory increased productivity, had no effect on health, but is far too expensive.

Corn and fat quality

Corn has a high content of unsaturated fat. Large amounts of unsaturated fat in pig feed may have a negative effect on the finished product by making it soft, flabby and yellow as opposed to firm and white as desired. Therefore, there is a maximum for the inclusion rate of corn in finisher feed.

The effect on fat quality of high inclusion rates of corn was investigated on a pig farm where the pigs were given liquid feed mixed on-farm with 40-50% inclusion of corn and no added dietary fat. The effect was also studied of adding up to 60% corn to pelleted feed in combination with 1.5% vegetable fat and 8% barley. According to the preliminary results, the iodine value in fat increases when the inclusion of corn increases.

A new model is being prepared that will provide a better prediction of a diet's effect on the iodine number in fat compared with the one currently used.



A satisfactory fat quality was obtained with up to 40% corn in feed without fat and up to 20% corn in feed with 1.5% fat.

Fermentation of corn

In a lab test, ground corn mixed in cold water and fermented at 5, 12 or 20°C for five weeks was studied. The results were compared with fermentation of barley and wheat at 12°C. The investigation was an attempt to copy the German system, Ligavator, for preserva-

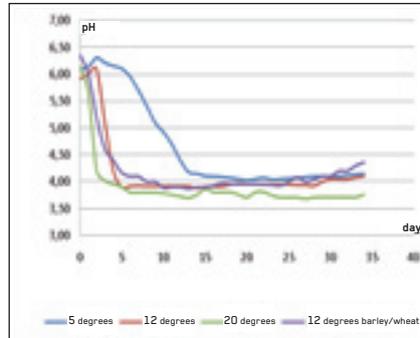


Figure 1. Development in pH during fermentation at different temperatures for five weeks.

tion and storage of corn. Furthermore, corn fermented in the Livagator system in Germany was subject to microbiological analyses. The analyses demonstrated that ground corn mixed with water to 50% dry matter spontaneously fermented at 5, 12 and 20°C as pH stabilised at approx. 4 within a few days (see Figure 1). As expected, fermentation depended on the temperature, ie. pH dropped faster as the temperature rose.

Fermentation at 12°C resulted in a loss of dry matter in corn of 8.8%, which is slightly more than what is seen in other studies. No effect was found of fermentation on the content Fusarium toxins.

It was concluded that fermentation of ground corn at 5-12°C, corresponding to Danish conditions in November/December, is possible and that the low temperature helps maintaining a good microbiological quality. However, there is a risk of a large loss of dry matter when storing fermented corn.

Amino acid standards for heavy pigs

There are no standards for amino acids for heavy pigs. The amino acid standard applying in the weight interval 65-110 kg also apply for finishers weighing 75-105 kg. However, this is not based on practical studies, and the requirement for amino acids in the last part of the growth period is poorly investigated.

Three different levels of amino acids were investigated in a herd where the pigs were housed according to gender from approx. 75 kg to 124 kg. The pigs were given a unity mix until av. 75 kg and subsequently switched to diets containing 7.7, 7.0 or 6.6 g dig. lysine, respectively, per feed unit. The standard is 7.4 g dig. lysine in the weight interval 30-105 kg.

Not surprisingly, the study demonstrated that female pigs had a higher production value than castrates, which was due to the fact that the female pigs had a better lean meat percentage than the castrates and that the castrates had the poorest feed conversion.

The castrates had a poorer feed conversion ratio at 6.6 g dig. lysine per feed unit, whereas the female pigs had a lower daily gain and a poorer feed conversion ratio at 7.0 g dig. lysine per feed unit (see trial report 852).

Ronozyme WX for finishers

The effect of adding the xylanase product Ronozyme WX to finisher feed was studied in one herd. 200 g Ronozyme WX was added per tonne ready-mixed feed corresponding to an enzyme activity of 200 FXU/g ready-mixed feed.

The diet was based on wheat and contained approx. 105 feed units per 100 kg. The addition of Ronozyme WX was compared with a control group without enzymes. The trial comprised 44 batches with 1.384 pigs per group. The pigs weighed 31 kg at the start of the trial and 105 kg upon delivery to the slaughterhouse.

Overall, the trial demonstrated no benefit of adding Ronozyme WX to finisher feed as the production value was identical for both groups in the trial (see trial report 848).

Energy value of fermented grain

In previous trials, an improved feed conversion, but also a poorer lean meat percentage, were demonstrated when grain was fermented (trial reports 547 and 844). This is probably because the energy value of the grain increases during fermentation. A diet containing fermented grain will therefore contain more feed units than a corresponding diet with non-fermented grain.

In a digestibility trial with fermented grain conducted in co-operation with the Faculty of Agricultural Sciences, Aarhus University, it was demonstrated that the energy value of barley and wheat increased during fermentation. The greatest effect was observed for barley. During fermentation, digestibility of barley increased by 9% and by 3% for wheat. The trial also showed that analyses of feed units (FUgp) do not demonstrate the increased energy value during fermentation of grain.

It is currently being investigated whether this increase in energy value of fermented grain can also be found in a production trial with finishers.

The results will form the basis of recommendations for the use of fermented grain including how to take account for the increased energy value of fermented grain when formulating diets.

Quality of liquid feed

Some pig producers experience problems with low feed intake when they use liquid feed. This may be due to substances produced by micro organisms that reduce the pigs' appetite. It is not known which substances in liquid feed have this effect and which micro organisms produce them, but the most dominant micro organisms in liquid feed are lactic acid bacteria and yeast.

The quality of liquid feed was investigated in 40 pig herds in a project made in co-operation with the Faculty of Agricultural Sciences, Aarhus University, and the Faculty of Life Sciences (LIFE), Copenhagen University.

In the 40 herds, weaner feed intake was correlated to the occurrence of different lactic acid bacteria and yeast species in the liquid feed.

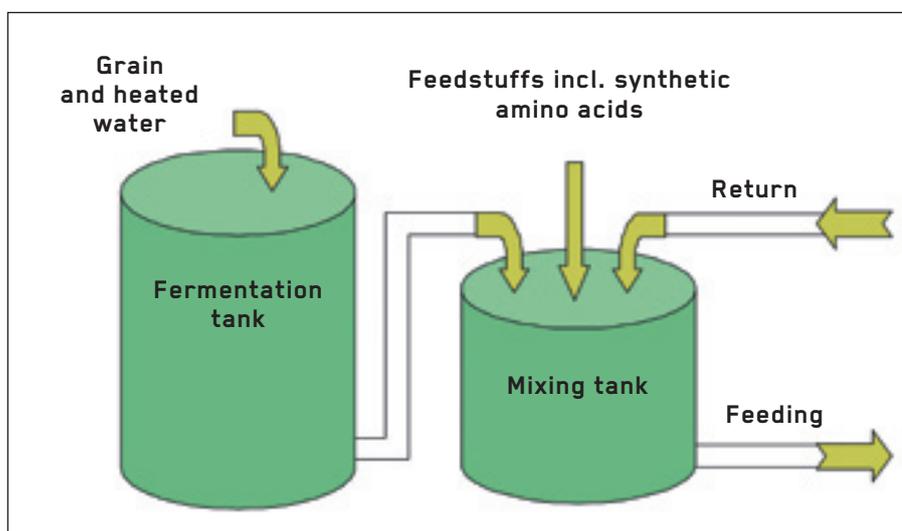
This preliminary study demonstrated a positive correlation between feed intake and the occurrence of two species of lactic acid bacteria (*Lactobacillus rosaie* and *Lactobacillus sanfranciscensis*) and one species of yeast (*Saccharomyces exiguous*).

At the Faculty of Agricultural Sciences, these species of bacteria and yeast were subsequently tested as inoculation cultures in liquid feed in a small-scale trial with fully fermented liquid feed for weaners. The trial demonstrated a positive correlation between feed intake and the addition of the inoculation cultures. The effect was greatest in the first weeks post-weaning.

The trial at the Faculty of Agricultural Sciences will be followed up by a production trial with weaners. EU approval is required before the inoculation cultures can be used in practice.



Some micro organisms in liquid feed have a positive effect on feed intake. This image shows yeast of the type *Saccharomyces exiguous*.



Energy value in grain increases during fermentation, and the effect is greatest during fermentation of barley.

Liquid feeding with no residue

The effect of changing a regular liquid feeding system into a liquid feeding system with no residue was studied in one sow herd (report 0905). The effect was measured on the microbiological quality and the nutrient content of the liquid feed.

The investigation was conducted as a "before and after" study, i.e. samples were taken before and after changing the system.

Before changing the liquid feeding system, there was a residue in the pipelines of up to 68%. More than two thirds of the feed given to the sows was "old feed" from previous feedings/days.

The investigation revealed that the composition of micro populations and biochemical characteristics of liquid feed change when a regular liquid feeding system is changed into a system with no residue. It is not yet possible to pinpoint which of these changes improve sow appetite and health as seen in some herds when changing to liquid feeding with no residue.

Analyses of the liquid feed's content of dry matter, crude protein, calcium and phosphorus demonstrated very large differences in nutrient content in the feed from different valves. This may be due to the fact that, at some valves, the feed was diluted with water or whey used as pushing medium in the pipelines.

Density when feeding with no residue

With liquid feeding with no residue it is essential to know the density of the feed (kg/litre) to ensure that the correct diet is fed from all valves without the inclusion of pushing medium.

In three herds, the density of the feed was determined with different methods (report 0906). It was determined in samples taken from the mixing tank and from valves. Furthermore, the density of the individual feedstuffs was determined by mixing them in water, and subsequently correlating a weighted average to the composition of the feed.

The study demonstrated no systematic difference between the various methods for determination of density. Therefore, it cannot be concluded which method is better for determining density of liquid feed.

Even small deviations in density may affect the feeding process so that only pushing medium, such as water or whey, is fed from some valves. If, for instance, the density is incorrectly entered by +/- 4%, approx. 22 kg pushing medium may be fed instead of feed at each feeding in a pipeline that is 200 m long and has a diameter of 63 mm,. If this happens in a farrowing facility where 10 kg is fed per valve, it would mean that two sows are not getting feed but only pushing medium (for instance water).

When using liquid feeding with no residue, it is essential to determine the density of the diet or feedstuff and enter this correctly in the computer. It is also recommended to mix slightly more feed than will be fed.

It should subsequently be checked that the correct diet is fed from all valves. This is done by taking samples from the first and last valves in a feeding sequence and checking that the sediment in per cent or dry matter percentage are identical.

Another method is to add a colouring agent to the pushing medium and then check whether coloured feed is poured into any troughs during feeding, which is an indication that pushing medium is being fed instead of feed.



Collecting feed samples from different valves and comparing the sediment is an easy and quick way for checking feeding in systems with no residue.



In systems with no residue, feeding can also be checked by adding a colouring agent to the pushing medium.

Dosing of liquid feed

Dosing accuracy was studied in three herds where lactating sows were given liquid feed (report 0808).

The liquid feeding systems were not adjusted before the study.

Allocation of small amounts of liquid feed (2-3 FUsow a day over three feedings) with a satisfactory accuracy was only possible in one of the three herds. In this herd, small deviations in the amounts fed were observed compared with the planned amounts, but in most cases they were constant and insignificant deviations that could be eliminated through management.

In the two other herds, the study clearly revealed unacceptable deviations in dosing accuracy from what was planned. It is not ideal for high-performing sows if they are not fed at the same time as the other sows in the farrowing section or if the overall amount of feed over three daily feedings is significantly below the amount planned, ie. deviates by more than 10%.

Optimum production

It is essential to ensure that the pigs get the nutrients they require for the pig producer to have maximum benefit from the production. Several factors may be involved if this is not the case.

Mineral diets

In continuation of previous investigations, Pig Research Centre investigated whether mineral diets segregate during transport from the supplier and during use on the farm. The investigation included mineral diets delivered in Big Bags or in bulk and the amount consumed via fibreglass silos.

Analyses of delivery and consumption from Big Bags are completed, while sampling is still taking place in herds using fibreglass silos. Samples were taken from the mineral diets during a regular feed consumption (mixing of finished feed). Samples were taken just as the Big Bag was taken into use, when it was half full and when it was almost empty.

Samples of the mineral diets were analysed for content of lysine, threonine, methionine, calcium, phosphorus, copper and zinc.

The analysis demonstrated that threonine and methionine segregate significantly when the mineral diet is being used. The differences amounted to 5-7% and are therefore not estimated to have any practical influence. Segregation of the other nutrients was not observed.

Segregation of liquid feed

Trials have shown that the risk of segregation increases when finishers are fed dry meal feed via tube feeders.

It was therefore investigated whether this is also the case for liquid feed. This was investigated in six herds with liquid feed made from either meal feed or pelleted feed. Liquid feed samples were taken when feeding began, when the mixing tank was half full and when

it was almost empty. The samples were taken during a normal round of feeding.

The investigation demonstrated that the liquid feed's content of dry matter and minerals segregated – some significantly – but this generally had no practical consequences (trial report 834). However, it cannot be ruled out that special conditions may cause one or more minerals to segregate during feeding, for instance because calcium is included which is not suitable for use in liquid feed.

Transport of meal feed

More and more pig producers transport meal feed mixed on-farm between premises. It is therefore necessary to investigate the degree of segregation during this transport and during handling of the feed in connection with unloading and offloading.

The investigation was not finished at the time of writing, but preliminary results do not indicate that nutrients segregate to an extent that affects the productivity of the pigs.

Various types of equipment are being studied: transport via truck with an auger or unloading of the feed into a pit followed by transport to the silo via an auger.

Control of laboratories

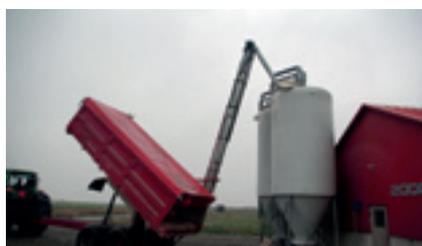
In the annual analyses of the grain harvest, Pig Research Centre has for the last five years used reference samples to have a guarantee against random variations in the content of, for instance, phosphorus, in the grain

due to variations in the levels found at the labs that were used. In this case, a reference sample is a main sample of for instance 40 kg purified grain that is correctly divided into small samples of approx. 300 g each and stored in a freezer. These samples are submitted as required for control of the levels at the labs.

If a lab that on average detects, for instance, eg. 6% more phosphorus than the average of all analyses made at that lab on small samples of the same main sample, a correction factor of 0.94 is calculated and used for phosphorus analyses from this lab for that particular year. On paper, uncorrected results would in this case lead to a phosphorus content in grain that is too high, and will in practice cause a phosphorus deficiency in pigs. Correction factors are published together with the annual grain analyses.

Over the last year, this task was also performed for pelleted finished feed to ensure that nutrients are accurately determined. As a result, attention on the labs' determination of phytase activity and phosphorus has increased.

It is an expression of high accuracy at a lab, if a low variation of a certain parameter is found on the submitted samples, ie. you can be certain that the results you get on, for instance, phosphorus content, are only subject to slight uncertainty. These results are included when Pig Research Centre decides which lab to use for analyses of trial feed and feed samples submitted from local pig advisors.



Transport of meal feed.



Consequence of Green Growth

The Danish government's vision for Green Growth signals more areas of nature and a continued reduction of environmental impact.

Water Framework Directive

Several measures in Green Growth are aimed at crop fields, where in particular the goals in the EU Water Framework Directive will have large consequences. In order to improve the ecological status of all Danish lakes, rivers and coastal waters, leaching to the aquatic environment will be reduced by 19,000 tonnes nitrogen (N) - see box on the right

A 10,000 tonnes reduction in the leaching of N to the aquatic environment is expected to be administrated in a system with nitrogen quotas. Currently, this corresponds to spreading of 70-75,000 tonnes N fertilizer, which is 20% of the current usage of N.

Ammonia

Requirements for reduction in ammonia must follow the technological development:

- As of 2011, the general requirement for reductions is increased to 30% compared with the best housing system.
- As of 2012, the general ammonia requirement is replaced by BAT standard conditions (livestock farms over 250 livestock units).

Vulnerable nature:

- **Natura 2000 nature:** Ammonia regulations will be changed to a requirement for a maximum total burden of 0.2-0.7 kg N/ha depending on the number of livestock in the proximity.
- **Other nature areas with buffer zone protection:** Ammonia regulation will be changed to a requirement for a maximum total burden of 1 kg N/ha.
- **Other nature areas without buffer zone protection:** State guidelines on maximum total burden of 1 kg N/ha.

As a consequence of increased ammonia requirements for Natura 2000 nature areas, some livestock farmers with

EXTENT OF DEDICATED MEASURES

- 50,000 ha: 10 m zone along all lakes/water courses: 7,300 km (compensation to farmers)
- 10,000 ha wetlands and 3,000 river valleys managed extensively (grants)
- 140,000 ha additional catch crops

NITROGEN EFFECT:

- ↓ 6,300 tonnes N as a consequence of 10 m buffer zone, wetland, river valleys and catch crops
- ↓ 2,000 tonnes N as a consequence of nature and town development, ban on soil cultivation for a period of time
- ↓ 10,000 tonnes N as a consequence of tradable nitrogen quotas or other regulation.

premises located in or close to Natura 2000 areas will not be able to obtain a new environmental approval.

Possibilities for growth

On July 1, 2010, an updated agricultural act comes into force that includes;

- No upper limits for number of live-stock units per farm.
- Abolition of ownership requirement, but unchanged harmonisation requirement.
- No upper limits for the maximum number of hectare ground a farmer can own.
- The farmer must own min. 10% of the capital and have decision-making power in the company.

It is crucial to find a solution to odour problems as livestock farms will continue to increase in size.

History has also taught us that new knowledge will be contingent on new, strict environmental requirements. It is therefore crucial that new technologies are cost-efficient and sufficiently reliable and applicable that they can be implemented in as many farms as possible.

Lower harmonisation requirements

The basis for calculating the number of pigs per livestock unit (LU) has been revised. Until recently, 32.5 finishers constituted one LU (in the interval 32-

107 kg); this has now increased to 36 finishers. As a result, the harmonisation requirement drops by approx. 10% for finishers (see the table).

For weaners, things look even better; until recently 162 weaners in the interval 7.3-32 kg constituted one LU, and this has now increased to 200. In practice, this means that if a pig producer only produces weaners, he can make do with 19% less land.

There are no changes for sows with pigs up to 7.3 kg. Most producers will be able to use the new calculations in relation to the harmonisation requirement. However, environmental approvals may include special conditions that can make it impossible to reduce the area for spreading. Such conditions could be phosphorus limits or conditions concerning catch crops in relation to nitrate categories.

Production in full facilities

If a finisher producer goes from, for instance, 250 LU to 226 LU in September, he will not automatically be able to have more pigs in the facilities.

According to the interpretation of the Danish Environmental Protection Agency, the number of pigs at the time of the approval, and not the discharge of nitrogen of the farm, must determine the extent of the production.

In close co-operation with the Environmental Protection Agency, a constructive solution is being sought to this problem.

	Before, number/LU	Today, number/LU	Land requirement compared with today
Finishers, 32-107 kg	32.5	36	÷ 9.7%
Weaners, 7.3-32 kg	162	200	÷ 19.0 %
Sows with pigs up to 7.3 kg	4.3	4.3	0 %

BAT standard conditions

For pig producers with herds bigger than 75 livestock units (LU) to be granted environmental approvals, BAT documentation must be presented for new facilities, ie. it must be documented that the best available technology is being used.

Applicants' BAT documentation is evaluated by the local authorities, and, in order to ensure a uniform review process, BAT standard conditions must be prepared for all animal categories and facilities from 75 to 950 LU.

In a pilot project expected to finish by October 2009, standard conditions are prepared for finisher herds of 75-250 LU. Nine technologies are described for feed, housing facilities, storage facilities and spreading of manure. All technologies are evaluated in terms of environmental improvements, reliability and economy in additional costs per pig and per kg reduction in ammonia emission. The economy is calculated for herds of different sizes.

In the autumn 2009, the Minister for Environment will evaluate the level of additional costs for BAT. It will then be possible to select the technologies that meet the financial criteria, ie. these technologies will form the standard for herds of a given size.

With the Green Growth package, it is planned that, as of 2012, BAT standard conditions will replace the general requirements for ammonia reductions in the current Environmental Approval Scheme for livestock farms larger than 75 LU.

Trial protocols

Through new environmental legislation, it is possible to extend production units located close to neighbours and nature areas. However, it requires continued dedicated development of environmental technologies.

It is essential to create export markets

for the technologies. If producers are unable to export their products, there will be no money for development of efficient, reliable and financially realistic environmental technologies to enable all Danish pig producers to keep extending their farms.

The Danish Environmental Protection Agency has therefore set up an international group consisting of members from Denmark, Germany and the Netherlands who have developed joint measurement protocols for test of environmental technologies in these areas:

- Cleaning of air
- Housing systems
- Cover of slurry containers
- Spreading of fertilizer
- Technologies for separation

The Danish and Dutch Ministries of the Environment support the new protocols and will require that they be used in the future. Currently, the Länder in Germany do not have the same protocols, but it is being attempted to make the leading Länder use them.

In a one-year-long test, odour, ammonia, energy consumption and reliability are being recorded.

The new, international test is called VERA, which is short for Environmental Technology Verification.

Operation of environmental technology

Pig Research Centre always investigates environmental technologies in newly established facilities. However, it is also important to investigate how the systems work after a number of years in use. Pig Research Centre has therefore initiated a study in 17 herds where environmental technologies have been implemented in the last 5 years. The herds were randomly picked among pig producers who have implemented environmental technologies.

In July, August and September, ten finisher herds with air cleaning and



Odour samples are taken in the project "Test of environmental technology under practical conditions".

seven finisher herds with acidification systems were inspected. Inspections were only arranged if the farmer believed the system to be running correctly. Twenty-eight finisher producers were contacted to set up 17 meetings.

At each inspection, ammonia, odour, hydrogen sulphide and temperature were recorded. The pig producer was also asked about reliability, time spent and costs for service and maintenance.

Preliminary analyses demonstrate that in 9 of 10 herds with air cleaning, ammonia concentration was reduced. Odour was reduced in 6 of 10 herds with air cleaning. In seven of the herds with acidification systems, the system ran reliably. In 4 of these, pH in the slurry was 5.5. In the other herds, pH was higher, which resulted in a drop in ammonia reduction.

The investigation demonstrates that it is necessary to pay more attention to the reliability of new environmental technologies. Also, many pig producers have ended up in the unfortunate situation that the company that supplied the technology has gone bankrupt.

Benzoic acid for finishers

In the EU, benzoic acid is approved as an additive to finisher feed in inclusion rates of 0.5-1%. In Denmark, benzoic acid is also approved for limiting ammonia emissions by 1% per g benzoic acid added per feed unit (FUgp). This corresponds to a reduction in ammonia of 9% if 1% benzoic acid is added to the feed.

This effect was also observed in a trial in climate chambers at Experimental Station Grønhøj.

Besides having an acidifying effect on urine, benzoic acid has an antimicrobial effect in the gastro-intestinal tract, which is expected to have a positive effect on daily gain and feed conversion.

The effect of benzoic acid on the production results of finishers was therefore investigated in a commercial production herd. The pigs were given feed mixed on-farm, and 1% benzoic acid was added to the trial feed via the mineral mix.

	Control	Trial + 1% benzoic acid
Av. daily gain	925	945
FUgp/kg gain	2.90	2.82
Lean meat %	59.9	59.7
Index	100	109

Table 1. Production results from the trial with benzoic acid.

The index included daily gain, feed conversion and lean meat percentage, and identical feed prices were used in both groups. If the current costs for benzoic acid were included in the production index, the index for the trial group was reduced to 91, ie. the cost for benzoic acid was higher than what could be covered by the improved production results. Benzoic acid currently costs DKK 12-13 per kg, and the production results barely covered DKK 7 per kg. The remaining DKK 5-6 per kg is therefore an "environmental" cost. Based on

these results, limiting ammonia emissions by 1 kg N with the addition of 1% benzoic acid will cost DKK 250-300.

Low-protein feed for finishers

A reduced protein level in feed limits ammonia emissions. However, a low protein level will in many cases result in decreasing production results. Pig Research Centre studied the effect on ammonia emissions of a diet with a level of digestible crude protein 6-7% below the minimum standard. Free amino acids were added to the diet to meet all amino acid standards.

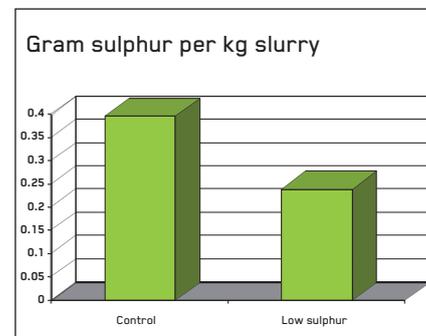
The effect of this diet on ammonia emissions was investigated in the climate chambers in pens with 1/3 drained floor and 2/3 slatted floor. Results from two trial rounds demonstrated that a reduction in crude protein of 15 g per FUgp limited ammonia emissions by 18%.

For more information on the economy and costs related to ammonia reductions, see the section on BAT.

Limiting odour through feed

A method has not yet been found for limiting odour emissions from finisher facilities with feed. Currently, Pig Research Centre is co-operating with the Faculty of Agricultural Sciences, Aarhus University, in a project called STOP in which a diet with a low content of sulphur is being investigated. Theoretically, a reduced content of sulphur in feed and thereby in slurry will result in falling emission of sulphurous odours. It is believed that the sulphurous substances hydrogen sulphide and methanethiol play a significant part in the impression of odour from pig houses.

However, the majority of sulphur in feed originates from the essential amino acids methionine and cystine. Often, synthetic methionine is also added to diets to meet the requirements for amino acids. It is therefore difficult to reduce the level of sulphur without significantly



Expected level of sulphur in slurry

compromising the standard requirements. In this project, the sulphur content of the feed is reduced by approx. 30%, which results in a reduction of approx. 40% in the content of sulphur in slurry as the pigs' deposit of sulphur will remain the same.

Results of this project are not yet available.

The above projects have obtained financial support from the EU and the Rural Development Programme under the Danish Ministry of Food, Agriculture and Fisheries.

BAT for protein and phosphorus

When expanding his production, a pig producer is required by the authorities to use the best available technology (BAT) in relation to environmental impact. It is also decided that "descriptions of technology" must be made for feed, and the plan is to convert these into actual BAT sheets.

For the moment, possibilities and costs related to reduction of protein and phosphorus are described for finisher herds with less than 250 livestock units. The final requirements have not yet been decided upon, as it requires deciding on the costs per pig and, for ammonia, also per kg ammonia reduction.

In 2010, BAT sheets will be published on requirements for phosphorus and protein for finishers, weaners and sows.

Preliminary descriptions for finishers include the levels of phosphorus and protein that can be obtained with phase feeding and the use of phytase and free amino acids, respectively.

Phosphorus requirements

A level of 4.3 g P per feed unit is described, which is the level of a typical ready-mixed diet with a 150% inclusion of phytase, ie. 50% more than the original standard dose. A level of 4.3 g per feed unit corresponds to the national average in feed in 2008 when the price of phosphorus and thereby the inclusion of phytase was unusually high. This results in approx. 25 kg phosphorus per ha when, according to the revised definition of livestock units, one ha covers 1.4 livestock units.

For many pig producers, a requirement for 4.3 g per feed unit will be almost cost-free, but will limit the inclusion of rape cake/meal and sunflower meal. In periods when soybean meal is expensive compared with these alternative protein sources, the feed price may rise as the requirement may make it impossible to use a high inclusion of in particular sunflower meal.

The requirement will also be an inconvenience to producers who use certain by-products with a high level of phosphorus such as brewer's yeast. These producers will therefore need to be exempt from the requirement.

Protein requirements

Three levels of protein are described: the average protein level obtained with phase-feeding according to minimum standards for digestible crude protein, and limiting the level of digestible crude protein by 5 and 10 g, respectively. Thus, three requirements are described: a level of total crude protein of 153, 147 or 141.5 g per feed unit.

It is possible to comply with the current amino acid standards with phase feeding with all three levels, but the lowest level has no safety margin for the

Table 2. Costs, DKK/pig, with reduction in protein depending on type of feed and with and without phase feeding, average savings.

Cr. protein	Dry feed		Liquid feed	
	Phase*	Unity	Phase*	Unity
157	0	0	0	0
153	0-1	0-2	0-1	1-2
147	1-2	2-4	2-3	4-5
141.5	4-5	6-7	6-7	8-9

* Assuming that a phase feeding system is already installed to avoid additional investments in such a system.

amino acids for which the requirement is determined less accurately.

Recent trials demonstrate that when the protein level drops, the lean meat percentage drops and the feed conversion ratio is marginally worsened. However, under normal price conditions the feed will be cheaper when the protein level drops, and the economy of a reduction in protein will vary depending on the price differences between grain and soybean meal.

The expected costs per pig and per kg reduction in ammonia N are shown in tables 2 and 3 and are based on the average feed prices of the last 3-4 years. The costs are higher in herds with liquid feed as extra amino acids are required to compensate for losses in the feed pipes. If calculated per kg ammonia N, the lowest costs are found in facilities with drained floor as this is where the highest ammonia emissions are found.

It is clear that phase feeding with 153 g crude protein is expected to be largely cost-free compared with the reference feed, which is a unity mix with 157 g crude protein, while the requirement for lower protein level will result in a loss that grows as the requirement for crude protein drops. However, with a unity mix a small loss can be expected already at 153 g protein.

The economy will vary though, and in 2009, when soybean meal was much more expensive than grain, it will pro-

bably be cost-free to drop to approx. 150 g total protein per FUGp – if, that is, the savings in feed prices benefit the pig producer.

Table 3. Marginal costs DKK per kg NH_3-N reduction, with phase feeding.

Cr. protein g/FUGp	25-50% solid floor		Drained floor	
	Dry feed	Liquid feed	Dry feed	Liquid feed
157	0	0	0	0
153	4	4	4	4
147	42*	65	35	53
141.5	107	139	87	113

* Example: Represents the cost of going from 153 to 147 g with dry feed.

Environmental activities

Pig Research Centre participates in development and testing of environmental technologies for reduction of ammonia and odour emissions from livestock production facilities. These technologies include cleaning of air, partial air cleaning, pit ventilation and slurry treatment. The work is conducted in close co-operation with production companies, research institutes and farmers, and the projects receive financial support from the Rural Development Programme and the Innovation Act under the Danish Food Industry Agency.

Partial air cleaning

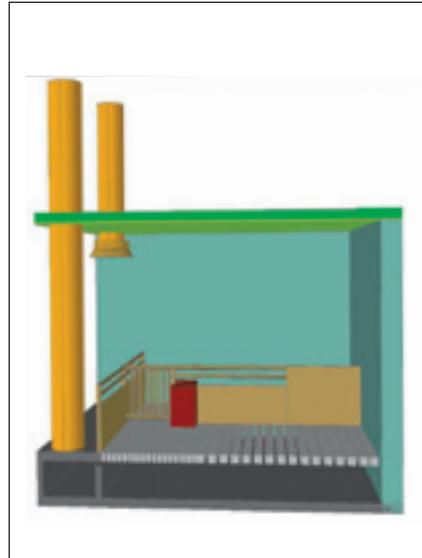
Partial air cleaning is interesting for reduction of ammonia and odour emissions from pig houses. For approx. 40% of the year, the ventilation system operates at less than 20% of the maximum ventilation capacity. Initial costs drop when part of the exhaust air is cleaned as a smaller air cleaning capacity is required in comparison with cleaning of all exhaust air. Today, partial air cleaning for reduction in ammonia emission is possible to use in practice when applying for an environmental approval. Calculations show that a purification efficiency of 95% results in a 70% ammonia reduction annually when cleaning only 25% of the maximum ventilation capacity.

Partial air cleaning and pit ventilation

A large part of the gasses in the ventilation air of a facility can be collected in the exhaust air in the pit ventilation. Partial air cleaning can be made more efficient in combination with pit ventilation in comparison with partial air cleaning and ceiling exhaust.

From September 2008 to mid-March 2009, pit ventilation was investigated in the climate chambers at Experimental Station Grønholm. Each chamber consisted of two traditional finisher pens with 32 finishers each.

10% and 20%, respectively, of the maxi-



The climate chambers at Grønholm are designed with a "specially designed drained floor" and pit ventilation. In a specially designed drained floor, the slurry pit covers the entire pen, but the slot width is reduced by approx. 40% compared with regular drained floors to increase the air speed through the slatted floor and thereby increase the effect of pit ventilation.

mum ventilation capacity was emitted via the pit ventilation. The investigation comprised two types of floor:

Group 1: 2/3 drained floor with a 40% reduction in slot width

Group 2: 2/3 drained floor

Ammonia concentration was recorded in both groups, whereas odour was measured in group 1 only. When 20% of the maximum ventilation capacity was emitted via the pit ventilation, 82% and 67% of the ammonia emission was collected in the pit ventilation in groups 1 and 2, respectively.

The results of odour measurements showed that when, during the winter, 10% and 20% of the maximum ventilation capacity was emitted via the pit ventilation, 50% and 75% of the odour emission was collected there. It is thereby possible to collect a large part of the gasses from the facility in the pit

ventilation air, and when the air is led out this way the working environment in the pig house also improves.

By combining pit ventilation with partial air cleaning, ammonia emissions may therefore be reduced considerably by cleaning the part of ventilation air that has the highest concentration. It is probably also possible to significantly reduce odour emission if the pit ventilation is equipped with an air cleaner that efficiently reduces odour. This is currently being investigated.

Biofilters with crushed roots

Previous studies have demonstrated reductions in odour emissions from pig houses with air cleaners with woodchips as filter material. It was therefore studied whether a larger reduction in odour was possible in the Farm AirClean BIO module from SKOV A/S when connecting it to a biofilter with filter material of crushed tree roots. However, results showed that such a biofilter did not significantly reduce odour and ammonia emissions further, and there was therefore no reason to continue studying biofilters from SKOV A/S based on crushed tree roots.

A chemical air cleaner from ScanAir-clean A/S that solely reduces ammonia was also investigated to determine if it was possible to reduce odour when combining chemical air cleaning with a biofilter with crushed roots. Measurements demonstrated that the ammonia concentration in the ventilation air was reduced to 0.9 ppm corresponding to a 91% reduction. On the first four days of the ten-day-trial period, an average reduction of 57% in odour concentration was observed. However, no statistical reduction was observed in odour concentration on the last six days of the trial period.

The reason for this stop in odour reduction may be that, a few days before, 15 kg concentrated sulphuric acid were accidentally added to the recirculation fluid for the first filter element.

As a result, the environment became extremely acidic which probably affected the microbiological conditions in the following biofilter. Due to insolvency of ScanAir-clean A/S, it was not possible to re-establish the filter material and further analyse odour reduction in the air cleaner. ScanAirclean A/S products are now being sold by MHJ Agroteknik A/S.

Biological air cleaner, VengSystem

VengSystem A/S has developed a biological air cleaner that consists of a plastic filter module fitted horizontally in the air cleaner. On top of the filter, nozzles moisten the filter element with water depending on the outdoor temperatures. The higher the temperature, the more the filter is moistened. Beneath the filter is a reservoir from which excess water is emptied to the slurry pits. Pig Research Centre measured reductions in odour and ammonia in the ventilation air from a weaner house in the summer period. The results showed a reduction in ammonia concentration of averagely 20%, and a 21% reduction in odour concentration. Ninety litres of water were used per produced weaner for moistening of the filter. Energy consumption was not recorded, but the pressure drop across the filter element averaged 4.3 Pa, which is very low compared with other air cleaning systems.

Biological air cleaner, SKIOLD A/S

SKIOLD A/S has developed a biological air cleaner that is built-in in a ventilation exhaust. This construction makes it possible to replace current exhausts with air cleaners. The ducts of the air cleaner are coated with fibreglass on which ammonia and odour are biologically decomposed. Seep hoses on top of the filter supply water to the filter. Measurements performed by Pig Research Centre in 2008 revealed a 44% ammonia reduction with this system. The reduction of odour was not significant, but a tendency to a 19% reduc-

tion of odour was observed. However, more measurements are required to establish the odour reduction efficiency of the system. In the test period, the system had an extremely high pressure drop of 200 Pa, which will result in a high consumption of energy and thereby high running costs. SKIOLD A/S has subsequently developed a ventilator to reduce the energy consumption, and, in the summer of 2009, Pig Research Centre recorded pressure drop and energy consumption in the air cleaner.



Biological air cleaner from SKIOLD A/S

Farm AirClean BIO for weaners

In previous trials, Pig Research Centre has documented that the biological air cleaning system Farm AirClean BIO from SKOV A/S reduces odour emissions from finisher and weaner houses by 30% under summer conditions. Measurements have also shown that the ammonia concentration is reduced to 1-2 ppm in the ventilation air from finisher facilities, and that costs for electricity and water for running the air cleaner amount to DKK 6 per produced finisher. In order to determine running costs and ammonia reduction when using the air cleaner in weaner houses, Pig Research Centre is currently compiling data for an entire year.

Chemical air cleaner, VengSystem

VengSystem has developed a chemical air cleaner consisting of a horizontal plastic filter element through which the ventilation air is emitted. Beneath the filter element, nozzles moisten the air with a sulphuric acid solution. The sulphuric acid solution is recirculated from a reservoir beneath the filter element. Pig Research Centre is currently measuring the ammonia reduction in the air cleaner as well as the annual consumption of water, acid and electricity. The air cleaner is installed in a sow facility with two sections: one section functioning as a control service section and the other as a gestation facility with one feeding/resting stall per sow. The VengSystem acid air cleaner is installed in the partition wall between the two sections. All ventilation air from the two sections is led through the air cleaner.

Chemical air cleaner, BioScent ApS

BioScent ApS has developed a two-step chemical air cleaner that cleans the air of both odour and ammonia. The system consists of two drums partly lowered in an acid and a basic aqueous solution, respectively. The drums are covered in a plastic net and rotate to keep the net moist. In step one, the water is kept acid with sulphuric acid and ammonia is eliminated from the housing air, and in step 2 the water is kept basic with sodium hydroxide and part of the odorants are eliminated from the air. The air cleaner is connected to a pit ventilation system from a multiplication facility with approx. 130 gilts. The air cleaner has a capacity of 1.800 m³/hour, corresponding to approx. 15% of the air from the pig house at maximum ventilation rates. In summer 2009, Pig Research Centre started recording data from the air cleaner and comparing these with the overall emissions of odour and ammonia from the facility in a section without pit ventilation and air cleaning. It is still too soon to make any conclusions, but both the air cleaner and the

combination of pit ventilation and partial air cleaning look promising.

Biological air cleaner, DORSET

The Dutch company Dorset Milieutechniek B.V. has developed a biological air cleaner that has shown positive results in trials in the Netherlands and Germany. In Denmark, the air cleaner is being sold by Rotor A/S. It has one layer of filter elements on which ammonia and odour are biologically decomposed. The air is led in through the bottom of the system and is sucked through the filter elements that are constantly sprinkled with water recirculated from a reservoir at the bottom of the system. The sprinkling water is drained from the system when a certain level of contamination is reached. This water is then transported to slurry pits or the manure storage tank. However, foreign studies showed that the water consumption and the production of discharge water were significantly higher than what is acceptable under Danish conditions, as the production of discharge water was larger than the animals' own slurry production. The operation of the system has therefore been further developed to significantly reduce the consumption of water and the production of discharge water. Pig Research Centre is testing the modified biological air cleaner in terms of efficiency against ammonia and odour under Danish conditions. The test is being performed at a finisher facility, and the nitrogen content of the discharge water is also recorded to determine its fertilizing value.

Slurry treatment, smellFIGHTER

In 2008, Pig Research Centre initiated a project with the company BioAqua on reduction of ammonia and odour emissions from finisher facilities. The project was supported by the Innovation Act, and was a continuation of a previous project conducted in the climate chambers at Experimental Station Grønhøj concerning reduction of odour through ozone treatment of slurry. Besides reduction of odour, the aim of the



Biological air cleaner from Dorset

new project was to significantly reduce ammonia emissions. Infarm A/S, owned by Grundfos, was therefore invited to participate in the project with their know-how on how to acidify slurry with sulphuric acid.

In spring 2008, an experimental set-up was established at Experimental Station Grønhøj in connection with the climate chambers as well as a full-scale system in a finisher production herd. During treatment, the slurry was separated once a week on a band-pass filter and the thin fraction was subsequently treated with ozone and polymer to reduce odour and with sulphuric acid to limit ammonia emission from the slurry.

The experimental set-up at Grønhøj had a capacity of approx. 1 m³/hour and was operated manually. When treatment was complete, 3.5 m³ was returned to the slurry pit, corresponding to a slurry height of approx. 15 cm in the section, while the rest was transferred to the storage tank. In two batches of pigs, from April to October, odour emissions were reduced by 40% from 570 to 340 OU_E/sec./1.000 kg animal and ammonia emissions were reduced by 30% from 0.29 to 0.20 NH₃-N/hour/animal. The

odour reduction lasted for minimum one week after treatment was complete.

Measurements in the production herd demonstrated that the smellFIGHTER is not yet ready for sale.

In the winter 2008/2009, extra climate chambers were established at Grønhøj as part of the project under the Innovation Act (Climate Lab 3), where it is currently being attempted to improve treatment and obtain a better and more lasting reduction in ammonia emission.

Frequent emptying of slurry pits

Based on experiences with treatment of slurry in the climate chambers at Grønhøj, Pig Research Centre initiated an investigation in the summer 2009 on reduction of odour from a finisher facility by changing the frequency of emptying the slurry pits. The first measurements made in a finisher house with four sections of 136 pigs and 68 pigs per slurry pit indicate that odour and ammonia can be reduced by emptying the pits once a week. However, it is still too soon to conclude on annual reductions and on whether significant amounts of dry matter will accumulate in the pits over time.

Ammonia and odour emissions can be reduced from finisher pens with solid floor provided that the pens are kept clean. Pig Research Centre therefore investigated various brands of supplemental air intake and the effect of floor cooling and cooling by high-pressure demisting of water. Various stocking densities were also investigated and a demonstration project was initiated on how to improve pen function in existing facilities.

The lying area is the pigs' main priority

The lying/resting area is the pigs' main priority, but as pigs use the pen for several activities, the lying area is affected by requirements other than those applying to resting. Pigs never defecate or urinate in the resting area, but prefer to do so in a dry, draught-free lying area without interruptions. They prefer to rest up against a solid wall where the temperature allows them to rest in a relaxed position, i.e. partial prone/lateral position. Preliminary results from the demonstration project show that it is possible to keep a solid floor clean if the solid floor is the pigs' main priority.

Pigs' temperature requirements in the lying area of their priority change throughout their growth. It is therefore necessary routinely to adjust the management parameters of the climate control according to observations made among the pigs when they rest and by the look of the pigs. Dirty pigs are an indication that the pen is too warm and that problems with mess are underway. Pigs are unable to perspire and compensate for this by wallowing to increase the heat loss from the body.

Solid floors often become dirty from wallowing and because the pigs choose another lying area than the one on the solid floor. Often, mess occurs because the pigs find the area on the solid floor less comfortable or attractive than the other areas of the pen. When the pigs, for instance, use the slatted

floor as their preferred lying area, the solid floor gets a lower priority and is changed to dunging/activity area, and this has created the expression "the pigs have turned the pen around". The pigs send several warnings or signals before this happens. The trick simply lies in using your observations to adjust the climate control to ensure that the lying area on the solid floor is always the pigs' first priority.



The temperature needs to be lowered if the pigs prefer to lie in the middle of the pen. Alternatively, increase sprinkling frequency or air speed in the lying area by opening the supplemental air intake if outdoor conditions allow this.

Management

When a herd owner wants to ensure that the pigs choose to lie on the solid floor, he has several management tools to choose from. The most important one is the desired temperature or "the set temperature". However, the value read on the control is less important as it may be affected by the location of the sensor in the facility. Instead, it is important to look at the pigs - the aim should always be for the pigs to lie on the solid floor in partial prone/lateral position.

Sprinkling time and intervals must be adjusted to match the requirements of the animals. To avoid humid pens, the sprinkling system should be used in the daytime when it is not possible to meet the pigs' requirements to climate by adjusting the desired temperature. This will typically be when the outdoor temperature reaches more than 10-14 °C.



The pigs' lying behaviour demonstrates that the immediate environment fulfils the pig's requirements in terms of climate.

The maximum cooling requirement is set to an outdoor temperature of 18-20 °C. The sprinkling system can also be used for "potty training", i.e. moistening of a slatted area that the producer wishes to be used for defecating or as an actual "go away" signal.

Air intake through ceiling inlets is used for increasing the air speed in the pen and for ensuring fresh air or better ventilation efficiency in the desired lying area. Preliminary results from the demonstration project show that pigs over 50 kg prefer lying areas under a supplemental air intake that leads outdoor air straight down to the lying area with an air speed of 1-2 m/sec. when the outdoor temperature reaches more than 19-20 °C.



The supplemental air intake is located directly above the lying area. To avoid draught, the valves automatically close when outdoor temperatures are below 18-20 °C.

Space for finishers

Different degrees of stocking density in finisher pens are being investigated in a trial. According to the preliminary results, no differences were observed between the groups in terms of daily gain, feed conversion and mortality. This confirms the results from a previous trial that also demonstrated that, provided the pigs have sufficient feeding points, the space of the pen is less important.

When the current space requirements for finishers were made, the slaughter weight was lower than today and there were no requirements for partially solid or drained floor in the pens. Due to environmental considerations it is important to keep the solid floor clean as ammonia and odour emissions will increase if the floors are dirty. This was the basis for the investigation in which the effect of pen space on daily gain, feed conversion and mess in finisher pens is being analysed.

The investigation is being conducted in two herds with solid floor in 1/3 of the pen area and liquid feeding in long troughs. The trial groups were established by moving the pen wall opposite the trough thereby enlarging the pen on one side and reducing it on the other side. As a result, it was possible to change the space available in the pen and at the same time maintain the group size. In both herds, each pen holds 14 pigs and troughs measure 4.8 m. The investigation comprises three groups: 0.67 m² per pig; 0.73 m² per pig; and 0.79 m² per pig. These figures denote the space available, ie. they do not include trough and equipment/walls.

Recordings of mess in the pens so far do not indicate differences between the groups in this area. However, recordings of the hygiene of the pigs do indicate that the pigs in the group with the lowest stocking density were cleaner than the pigs in the other groups.

Space per pig, m ²	0.67	0.73	0.79
Daily gain, g/day	892	900	892
Feed convers. ratio, FUgp/kg	2.86	2.84	2.85
Mortality	0.9	1.3	1.3

Preliminary production results in three trial groups with different stocking density.

Restrictive dry feeding

For many years, it was impossible to feed finishers dry feed in a long trough. However, this is now possible as a new feed wall has been developed.

The principle of the feed wall is a horizontal flexible auger placed in a pipe on top of the wall above the trough. This pipe fills with feed via the flexible auger and is fitted with a number of holes adjusted to the length of the trough (33 cm intervals) and can be turned by way of a servomotor. When filled with feed, the pipe turns 180 degrees until the holes point downwards. The flexible auger subsequently starts operating to enable the feed between two holes to pour out through the holes and via the downpipes into the trough. Electronic management of the servomotor operates both the flexible auger and turns the pipe when the system fills with feed and empties.

During the observation period, the system was developed from a prototype into a system ready for sale. As a result, the servomotor is now placed differently and it is possible to remove the top lid making it possible to wash the downpipes. The system is now functional and reliable.

The main challenge in the daily use of the system is finding a feed curve that matches the appetite and growth rate of the pigs. Now the feed curve is checked by inspecting the troughs after one of the three daily feedings. Generally, the feed strength is correct if the pigs have not eaten all the feed 15-20 minutes after feeding and weigh below 65 kg.

It seems that a feed curve where the feed strength increases rapidly and ends at 2.85 FUgp a day provides the basis of a high gain and a feed conversion ratio corresponding to or better than the feed conversion ratio when feeding ad lib.

Tube feeders for weaners

Good tube feeders provide access for weaners to fresh feed and result in minimum feed waste. The feed falls freely into the trough or onto the feed platform without the feed coming into contact with water, which may result in caking and perhaps growth of fungi and bacteria. It is easy for the pigs to use



Feeding of finishers in a long trough by the pen partition with a flexible auger at the top.

the feeders and they cannot get injured in the process. Furthermore, good feeders are easy to use for the staff, easy to clean and durable.

Pig Research Centre is currently testing 12 tube feeders for weaners. These feeders are being evaluated in terms of function, for instance feed wastage, adjustment options, caking, cleaning and how the pigs use the feeders. The following five feeders generally have a good function and will be studied until summer 2010 in terms of their production value:

Ergomat XXL with shoulder separation,
KJ Klimatechnik A/S
FunkMat, ACO-Funki A/S
Maximat Weaner, Skiold A/S
PigNic, Big Dutchman A/S
Tube-O-Mat VI+,

Jumbo, Egebjerg International A/S

The production value or the gross margin per pig will be calculated on the basis of daily gain and feed conversion for each feeder. Each feeder will be used for min. 28 batches of pigs before an average production value is calculated.

The investigation is conducted in a weaner facility built in 2007 where the pigs, in the weight interval 7-30 kg, are housed in double pens with 30-35 pigs per pen. The pigs are given meal feed ad lib. Phase-feeding is practiced and the pigs are given three different diets during the period in the weaner facility.

Straw for finishers

Straw meets the requirements for both rooting material and enrichment materials. The question is how much straw is required to comply with the statutory requirement for "a sufficient amount" in relation to the pigs' needs. Whether the requirement for straw is met can be assessed by observing the degree of straw-directed behaviour and of abnormal behaviour directed against pen mates.

Pig Research Centre has initiated various activities on straw as rooting and enrichment material in co-operation

with the Faculty of Agricultural Sciences, Aarhus University. Previous studies have shown that up to approx. 100 g straw a day per pig reduces abnormal behaviour compared with no straw in the pens.

As part of the activities, Pig Research Centre is investigating the effect of frequent supply of cut straw to finishers. The investigation comprises five groups:

1. 20 g straw per pig/day given once a day
2. 20 g straw per pig/day given five times a day
3. 50 g straw per pig/day given once a day
4. 50 g straw per pig/day given twice a day
5. 100 g per pig/day given once a day.

Compared with one daily allocation, frequent allocations of straw are expected to ensure that:

- The straw is available to pigs for a longer period of time
- The straw becomes less dirty
- A smaller amount of unexploited straw disappears into the slurry channel
- Pigs' behaviour directed towards straw increase.

In practice, up to five daily allocations of straw is unrealistic unless done

automatically. As part of the activities, Pig Research Centre is studying different methods for automatic supply of straw in finisher facilities.

Furthermore, the effect on pigs' behaviour of supplying 100 g long straw per pig vs 100 g cut straw per pig is being studied. Straw is supplied once a day, and the observations are made in 2-3 finisher herds in pens with 1/3-2/3 solid floor.

Researchers from the Faculty of Agricultural Sciences are also investigating how much straw is required to benefit finishers' requirement for rooting and enrichment material measured on the degree of abnormal behaviour. In this study, increasing amounts of the long wheat straw are allocated from 10 g to 1000 g per pig/day. Straw is supplied once a day on the floor in the lying area.

To be able to compare the investigations made by Pig Research Centre and the Faculty of Agricultural Sciences, the same behavioural recordings are made. Behaviour directed towards the straw and degree of abnormal behaviour are recorded. Furthermore, Pig Research Centre will contribute with recordings of the climate in the facility, pen function and handling of manure.



Preliminary results from a trial with 100 g straw per pig/day, corresponding to 1.4 kg straw/pen/day, show that the straw stays on top of the slots and hinders manure from passing through the slots.

Development of pens

Just as traditional pens are constantly being developed, so are pens for loose sows. This work includes both combi pens in which it is possible to use a crate, for instance around farrowing, and pens in which the sows are loose from transfer from the gestation unit and until weaning.

Lactation

Pig Research Centre has compared the duration of milk letdown, behaviour of sow and piglets, and piglet growth in pens with crates and in pens where the sows were loose from approx. 4 days after farrowing and until weaning.

The best results were obtained in farrowing pens for loose sows. In these pens, the following observations were made:

- Fewer fights among piglets over teats
- Fewer piglets did not get milk during nursing
- Milk letdown lasted longer and this was independent of litter size.

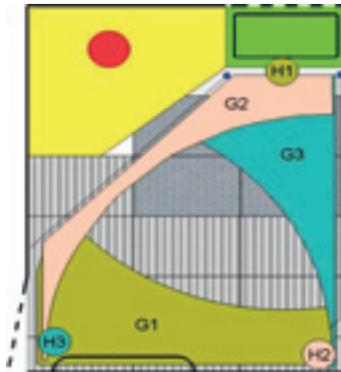
There was plenty of space by the udder, which may explain the positive effects.



Lactation in a combi pen where the sow is housed loose.

Hygiene in combi pens

Maintaining a high level of hygiene is a common problem in combi pens. Therefore, Pig Research Centre conducted a trial with the aim of gaining more knowledge on dunging behaviour and resting area in sow facilities. The gate



Drawing of the sows' position during dunging, where H1, H2 and H3 are the sow's head, and G1, G2 and G3 show where the sows defecate in each of the three positions.

of the pens was either a solid board or was equipped with bars. The pen side by the trough was open in all pens.

Covered or open sides in the gate did not, as expected, affect the dunging behaviour of the sows. Results showed that in more than half of the recorded cases, regardless of the type of gate, sows faced the gate when defecating. When resting, the sows were facing the trough in 75% of the recorded cases.

As a result of the dimensions of the combi pen, the sows defecated in the area by the trough (G2 and G3) if they were facing the pen gate or by the end wall (H3). In order to maintain a high level of hygiene in combi pens with solid floor, it must be possible to manage sows' dunging behaviour to an even greater extent than today.

In a pilot study made in co-operation with producers of equipment, Pig Research Centre is studying a new type of combi pens in terms of on hygiene in the periods when the sows are loose.

Increased piglet survival

It is interesting to investigate equipment or other design measures that reduce piglet mortality in farrowing pens for loose sows, as the effect of such measures is expected to depend less on the daily tending to the pigs.

Studies have shown that if the floor in pens for loose lactating sows has a slight incline, piglet mortality may drop.

In a production herd, two different pen designs with 10% incline in the expected resting area were studied. The aim was to study the effect of the floor on sows' rolling behaviour. When a sow rolls from lying sternal to lying ventral, there is a great risk of crushing the piglets. The greatest risk of this happening is seen in the first days post-farrowing when piglets often stay close to the sow.

The study demonstrated that the sow's rolling behaviour was the main cause for crushing of the piglets.

The results indicate that the design of the pen may restrict the sow's rolling behaviour and is thereby likely to reduce the number of crushed piglets.



A piglet is crushed as the sow rolls from lying sternal to lying ventral.

Further development

Besides the abovementioned activities, Pig Research Centre also participates in projects concerning farrowing pens for loose sows that are financially supported by the Danish National Advanced Technology Foundation and the Innovation Act, and projects that have obtained funds from the Rural Development Programme under the Danish Ministry of Food, Agriculture and Fisheries. These projects largely take place in co-operation with Aarhus University.

Streamlining and improvement

Pig Research Centre, Organic Denmark and the Danish Animal Welfare Society are co-operating on further development of farrowing huts and outdoor runs for growing pigs. This also includes the possibility for treating *Lawsonia* without medication.

Farrowing huts

The aim is to develop a new design of farrowing huts and establish whether an update of design and function of individual farrowing huts will increase efficiency and improve the working environment. The investigation focuses on annual piglet mortality rates, a sound climate in the hut and improved supervision of the piglets.

In traditional huts, the air flow is too slow. A design with a greater air flow will ensure that the hut is the coolest place in the summer so that farrowing in the field is avoided and will ensure that the sow stays more in the hut the first days post-farrowing. The lactation process is expected to be improved in the first weeks post-farrowing if the piglets do not leave the hut. As part of the study, temperature sensors are installed in a new type of huts and in eight different existing types/models. The first huts with a new design have been taken into use in two herds.

Preliminary experiences in these herds show that, as expected, the sow often



The bivouac provides shelter for the pigs and separates the solid floor from the slatted floor. Nipple drinkers placed strategically correct will help keep the slatted floor wet.

leans against vertical walls when she lies down. However, the survival rates for piglets remain unchanged compared with existing huts.

Facilities with outdoor runs

Organic production and production of outdoor pigs are subject to requirements for a specified outdoor run for pig facilities with growing pigs. The intention is that the outdoor runs function as a substitute if it is financially and environmentally unrealistic to establish outdoor production of finishers.

The aim of the project is to increase the actual value of the outdoor areas for facilities with growing pigs to ensure that the obligatory solid floor is kept clean of manure. The aim is:

- To keep the solid floor attractive to the pigs in the summer and winter for lying and eating/rooting activities.
- To have all manure deposited on the slatted floor.
- To increase the actual value of roughage.

Two models are established each with four pens of approx. 30 finishers each. Both models are generally intended to ensure that all manure is deposited on the slatted floor. Recent foreign studies have shown that pigs defecate immediately after they exit to the outdoor area. Therefore, the time spent on the slatted floor is increased with partition walls. The solid floor has also been made more attractive with a shelter and in two of these shelters, floor heating was installed.

Chicory and *Lawsonia*

Pig producers practising outdoor or organic production generally have a low consumption of medicine. In organic pig production, a pig loses its organic status after more than one treatment with antibiotics etc. *Lawsonia*, which is traditionally treated with antibiotics, is the main cause of treatments. The primary aim of the study is to establish which diseases are most significant in



This new, large hut has improved access combined with possibilities for increased ventilation. The walls are upright, which enables the sow to lean against them when she lies down.

outdoor and organic pig production. It will subsequently be studied if the addition of chicory to feed for weaners and finishers affects the number of pigs culled due to diarrhoea.

Chicory was selected because research has demonstrated that feeding with chicory root that contains inulin reduces the population of *Lawsonia* bacteria in the pigs' intestines by 50%. However, documentation obtained through controlled, large-scale studies in organic and outdoor herds is required before the method can be recommended in practice for producers of outdoor and organic pigs.

In a pilot study, manure samples were taken in ten large herds; five with outdoor production and five with organic production. Ten individual samples were taken from animals with diarrhoea in each herd. The samples were taken min. 14 days post-weaning to rule out post-weaning diarrhoea.

These samples were analysed for bacteria levels of PCV 2, *E.coli* F4 + F18, colitis and dysentery. Preliminary analysis results reveal *Lawsonia* to be an overrated cause for diarrhoea in growing pigs. The results are analysed in co-operation with *Lawsonia* experts from the Danish Technical University, the Veterinary Institute, and the conclusion of this work will form the basis of further investigations.

Welfare audits

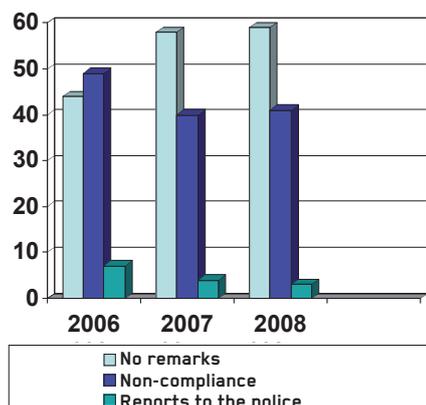
Welfare standards on Danish pig farms are still moving in the right direction according to reports of the 384 welfare inspections carried out in 2008 under the control of the Danish Veterinary and Food Administration.

In 2008, 59% of the producers demonstrated full compliance with the standards. The total of all non-compliances amounted to 429 distributed on 159 farms, and a total of 56 reports were made to the local police distributed on 12 farms.

The main reasons for non-compliance were insufficient records of medical treatment of sick animals, inadequate care or treatment of sick animals, design of hospital pens and inadequate use of rooting and enrichment material.

The number of reports made to the local police concerning shoulder ulcers observed at the slaughterhouses fell from 132 in 2007 to 39 in 2008. This demonstrates that negative trends can be reversed through a dedicated effort on the farms.

However, the number of reports concerning bruises increased from 2007 to 2008. These bruises were observed at the slaughterhouse, i.e. the pigs got the bruises before they were delivered



Results from the welfare audits under the Veterinary and Food Administration.



Of the 1,667 welfare audits made in 2008, 382 audits took place in finisher herds.

to the slaughterhouse. It is therefore recommended that inspection alleys and pick-up facilities be designed in a way that allows for calm and efficient transport of the pigs to the transport vehicle.

Self-auditing

Self-auditing procedures are now part of the Welfare agreement from 2008. Herd owners must prepare a self-auditing programme that is adjusted to that herd and that addresses the current conditions/problems that the owner wishes to improve. The self-auditing programme can be prepared on the basis of existing work plans or action plans for the herd or on the basis of guidelines and fact sheets published by Pig Research Centre. Implementation of self-auditing procedures in Danish herds will kick-off at the beginning of 2010 and full implementation is expected by January 1, 2011. The programme will be audited by practising vets.

DANISH Product Standard

Today, more than 4,000 pig producers have obtained a DANISH certification.

Results from the audits demonstrate that conditions in the herds are gene-

rally good. Overall, 70% of all pig producers demonstrate no or few non-compliances with the required standards – primarily statutory requirements. In approx. 27% of all audits, non-compliances were observed that required submission of documentation for the matters to be rectified. These non-compliances primarily concern administrative matters such as the correct recording pig supply contracts, correct recording of pigs bought and sold, etc. The remaining 2-3% have received a follow-up audit.

Very few non-compliances are triggered by inadequate animal welfare conditions. However, there is still room for improvements in a number of key areas. This particularly applies to the design of facilities for storage of dead pigs, the provision of rooting and enrichment materials, and the design of hospital pens. It is therefore essential that all areas of the production are inspected routinely to ensure that statutory requirements are being met. It is furthermore essential that all pig producers check that their data is recorded correctly in the CHR register in terms of production volume, pig supply contracts and movings of pigs.

Fewer dead sows

In the autumn 2007, Pig Research Centre initiated a comprehensive demonstration project aimed at reducing sow mortality in selected herds and showing the way to a 25% reduction in sow mortality in Denmark by 2013. The project is supported by funds from the Rural Development Programme under the Ministry of Food, Agriculture and Fisheries and the EU.

For most of the herds in the project, a dedicated advisory course run in co-operation between Pig Research Centre, the individual herd owner and his pig advisor and practising vet proved efficient. For each herd, a strategy was drawn up on how to reduce mortality.

The implementation of this strategy was monitored over 18 months through frequent visits from the pig advisor, and the result is clear. Gross margin increased by DKK 100-700 per sow/year as a consequence of reduced mortality rates. In one of the herds, mortality averaged 18.3% of 2,000 sows/year in 2007. As a result of a dedicated effort from staff and advisors, this dropped to 11.6% in 2008. Combined with other improvements in productivity in the sow unit, GM per sow/year increased from DKK 2,880 to DKK 3,586. The most distinct feature was an increase of 1.9 weaned pigs per sow/year and a decrease in the purchase of gilts.



Av. monthly mortality in 17 herds participating in Sow Life in the period January 07-July 09.

At www.soliv.dk, fact sheets can be downloaded on the measures that were effective in many of the herds.

EXAMPLES OF MEASURES

- Optimising production techniques
- Feed hygiene
- Improved training facilities for gilts
- Active selection of gilts
- Strategy for introducing sows to group-housing
- Management of body condition – feed curves
- Daily supervision
- Consistent use of hospital pens
- 3-5 daily feedings in farrowing facility
- Gastric examinations of slaughter sows
- Recording of culling

Demo days

Several of the herds functioned as demo herds. So-called demo days were arranged when other pig advisors and vets visited the herds and were presented with the results and experiences obtained in the project. The aim was to increase the awareness of these experiences and, through advisors, for these experiences to be shared with

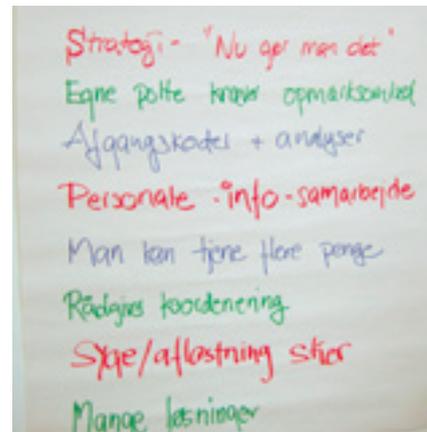


herd owners and advisors across the country.

A demo day was also arranged for herd managers employed in the herds that were part of Sow Life. The agenda for



This picture shows experiences obtained by herd managers during Sow Life.



this day concerned selection of gilts, management of body condition and evaluation of how many litters a sow can manage in her production cycle.

Follow-up in Sow Life II

Sow Life demonstrated that it is possible to reduce sow mortality through a dedicated effort from advisors, herd managers and staff. However, the project also illustrated problems related to co-operation and communication in large herds. Often new staff members are not given the introduction necessary, and herd owners must ensure that their managers are given the required training on staff management.

In-house communication in large herds is essential to the health of the sows and production results as the individual employee often performs specialised tasks and as such does not know what is going on in other sections. The herd manager is a regular in all sections of the herd, works up the overview necessary and he needs to be able to express himself clearly.

Sow Life II will include eight large herds (more than 1,500 sows/year) with more than six employees. A white paper will be prepared by the end of the project in 2011 containing instructions on staff management on pig farms.

Metabolic disorders

It is well-known that some sows suddenly stop eating and lactating in the farrowing facility. Some of these sows die, and often the cause of death cannot be determined. Sows today perform at an extremely high level, which puts body and productivity under great pressure. This investigation studied causes of mortality in the farrowing facility. Unlike other investigations, focus was on the metabolic disorders ketosis, hypocalcaemia and diabetes. Sows dying during the investigation were examined for anaemia and circulatory disorders.

Preventing mortality

Prevention is more important than cure. However, to be able to prevent, you need to know why the sows die in the farrowing facility. If it is possible before farrowing to pinpoint sows that may be in the group of risk, it will be possible to take precautions to reduce the pressure on these sows. Blood samples were taken from 1,825 sows one week before farrowing. The sows went through a normal lactation period and weaning. After weaning, the blood count of each dead sow was compared with the blood count of two surviving sows to test for any differences.

Analyses

Sows dying during farrowing or lactation were all subjected to post-mortem examination. After weaning, data was compiled from the sows that died and those that survived. Blood count and biochemical values (liver and kidney, and analysis for selected minerals) for all dead sows were compared with a number of surviving control sows. The results of the biochemical profile are not yet available.

Samples of liver, kidney, heart, uterus and tissue from the udder from the dead sows were submitted for thorough analysis at the Department of Veterinary Disease Biology at the Faculty of Life Sciences. Using histology of the submitted tissue samples, early

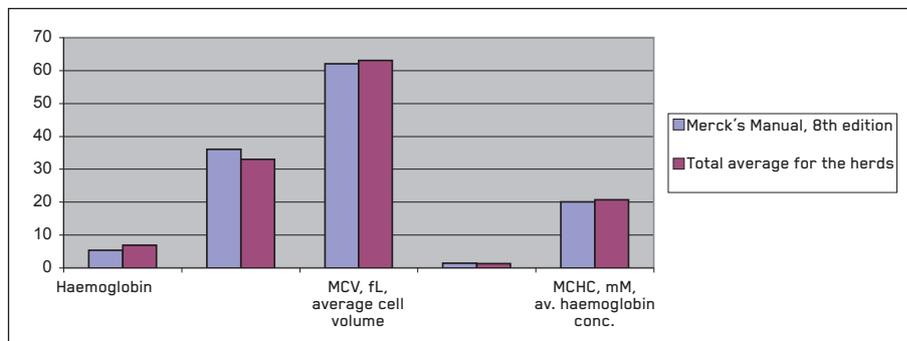


Figure 1. Blood count of 1,825 sows in 19 herds. The values are compared with reference values from The Merck Veterinary Manual, 8th edition.

stages of ketosis, M.M.A. and perhaps circulatory disorders may be diagnosed. The results are expected by the end of 2009.

Ketosis

Ketosis is a metabolic disorder that may occur when sows metabolise more energy than they achieve, for instance due to a high milk production. The majority of the 1,825 sows were tested for ketosis on the day of farrowing. A few drops of milk were expressed onto a paper stick. Presence of ketosis is diagnosed if the stick changes colours. In 5 of the 19 herds, sows with ketosis were found on the day of farrowing. Occurrence of ketosis during the entire lactation period is currently being investigated.

Blood counts

The average levels of haematocrit (haemoglobin percentage) and haemoglobin (oxygen-carrying blood pigment) are shown in Figure 1. The values are compared with reference values from The Merck Veterinary Manual, 8th edition.

The average values of Danish sows do not differ from the reference values and there are no indications of anaemia. However, it must be emphasised that these are preliminary assumptions.

The reference values are based on finishers that have a higher level of haematocrit than sows just before they farrow. This explains why the haematocrit level in sows is lower than the reference values.

Post-mortem findings

Forty-two of the 1,825 blood-sampled sows died in the farrowing facility. This corresponds to a mortality of 2.3% in the period from one week pre-farrow until weaning. Findings in the post-mortems are shown in Figure 2, which shows that ulcers continue to be a significant cause of death among Danish sows. A fairly high prevalence of prolapses was also seen- both uterus and rectal prolapses.

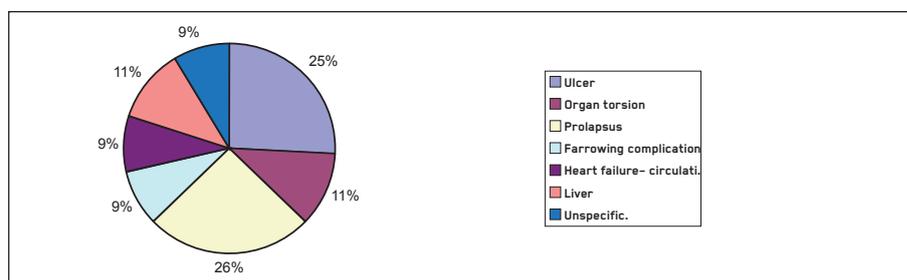


Figure 2. % distribution of post-mortem findings in 42 dead sows.

Fewer shoulder ulcers

The frequency of shoulder ulcers has dropped considerably over the last years as a result of the attention to the problem. The veterinary compromise of August 2008 included, among other things, a national action plan on shoulder ulcers, and as of 2010 shoulder ulcers must be included in the pig producers' self-inspection programme. A new scale is also being developed for evaluating shoulder ulcers.

The following projects have all received funds from the EU and the Rural Development Programme under the Ministry of Food, Agriculture and Fisheries. They demonstrate that if a pig producer makes a dedicated effort it is possible to reduce the occurrence – and the severity – of shoulder ulcers.

Project “Healthy shoulders”

The aim of this project was to reduce the frequency of shoulder ulcers in nine herds in which an effort had unsuccessfully been made to reduce the problem.

Nine pig producers followed an action plan against shoulder ulcers written specifically for each herd. The action plans were made by a team of specialists within housing, feeding, breeding and shoulder ulcers.

Overall, the problems were related to feeding and management of body condition; 45% of the measures recommended in the action plans concerned these two areas.

Generally, three issues related to feeding were observed:

1. The sows lost too much weight in the farrowing facility
2. Sows in an advanced stage of gestation were too thin, which is often caused by inaccurate evaluation of body condition
3. The body condition of sows in an advanced stage of gestation varied greatly.



Results from the project “Healthy shoulders” show that many pig producers evaluate sows’ body condition incorrectly. In a sow with correct body condition score, ribs and hipbones can be felt by pressing a hand across the bones.

As a result of frequent, inaccurate evaluations of body condition, a new set of instructions for evaluating body condition has been drawn up – for more details, see p. 39.

The action plans also emphasise handling of risk sows, correct use of rubber mats in farrowing pens and culling of old sows. Many producers benefited in particular from culling risk sows and sows with incipient shoulder ulcers directly from the farrowing facility. Lower average age and fewer non-productive days are important to the general efficiency. Several of the pig producers experienced increases in production during the project.

Each producer had six months to implement the recommended measures, but this period was often too short. An optimum effort against shoulder ulcers will therefore often need to run for one or two years.

A good action plan must include all risk factors for shoulder ulcers, but it is necessary to list the efforts to ensure efficiency and clarity. Experiences from this project demonstrate that correct

feeding is often the first place to start. Optimum feeding will not only reduce the occurrence of shoulder ulcers, it will also benefit productivity as such.

In most of the nine herds, the occurrence of shoulder ulcers was already fairly low before the action plans were implemented. Still, the pig producers succeeded in further reducing the occurrence. There was a large variation between the herds, but even in the herd with the lowest prevalence, improvements were achieved. The largest reduction was seen in the number sows with degree 2 shoulder ulcers, whereas it was more difficult to reduce the frequency of sows with degree 1 shoulder ulcers. No producers succeeded in completely eliminating shoulder ulcers, and periodic set-backs were observed – primarily during the summer. Mild, low-degree shoulder ulcers will always be seen to some extent in Danish sow herds.

Managing body condition

Correct management of body condition is acknowledged as one of the primary factors for a good longevity, a high level of productivity and a low feed consumption. It is important to manage body

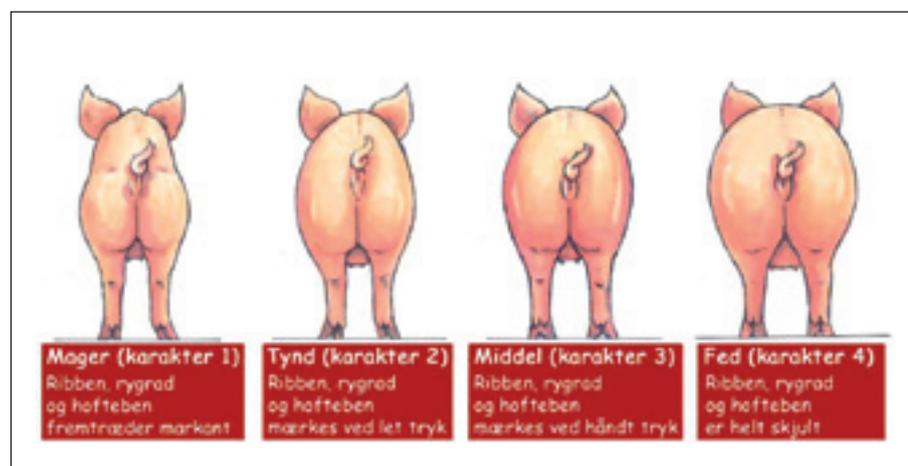
condition correctly and in due time as a good body condition is also one of the most important elements in preventing shoulder ulcers.

The effect of routine evaluation of body condition is being studied in three herds in which the sows are evaluated at farrowing, at weaning, at the first gestation check and approx. 70 days into the gestation period. At each evaluation, the feed dose was adjusted if necessary. The preliminary results indicate that the sows grow slightly bigger/heavier and more uniform at farrowing when their body condition is consistently evaluated. This is positive for the feed consumption and for the occurrence of shoulder ulcers.

Correct evaluation of body condition

Visual evaluation is a good method for evaluating body condition, but it is not enough. A pig producer must also feel (palpate) the sows. It is a good idea to evaluate body condition regularly together with, for instance, the advisor to adjust one's visual adjustment.

On www.soliv.dk, the website for this project, a video can be downloaded that illustrates how to make a correct evaluation of body condition.



Frequent mistakes when evaluating sows' body condition score have resulted in a new set of instructions that was taken into use in 2008. Visual evaluation is supplemented by feeling the sows' back, ribs and hipbones. Routine evaluation together with the herd advisor ensures correct evaluation of body condition.

Herd	1		2		3	
Daily feedings	3	5 → 8	3	5 → 8	3	5 → 8
Sows	407	391	456	413	456	443
Av. parity	3.8	3.6	2.3	2.4	3.9	3.8
% sows with shoulder ulcers	14	10	11*	3*	25*	16*

* Significant differences ($p < 0.05$) within herd. Source: trial report 847.

A study demonstrated that frequent feedings in the lactation period may reduce the occurrence of shoulder ulcers.

Frequent feeding

The effect of several feedings during lactation, correlated with the frequency shoulder ulcers, was investigated over an 18-month period in four herds. Compared with three daily feedings, the prevalence of shoulder ulcers dropped when the sows were fed five times a day when they were transferred to the farrowing facility increasing to eight feedings a day.

In one group, the sows were fed five times a day from transfer to the farrowing facility until Friday after farrowing. On the first Friday post-farrowing, one more feeding was added. On the following Monday, yet another was added, and on Wednesday one more. The feed dose per feeding remained the same in the period with additional feedings. From this point

onwards, the pigs were fed eight times a day (at 5:30 - 7:15 - 8:45 - 11:30 - 13:30 - 15:30 - 20:00 - 22:00) until weaning. The sows in the control group were fed three times a day (at 7:15 - 12:00 - 15:30). The investigation was conducted in three regular sow herds all with dry feed mixed on-farm.

The investigation also revealed that the sows' feed intake, piglet mortality and weaning weight were not affected negatively by increasing the number of feedings from 3 to 5 → 8. On the contrary, weaning weight was significantly higher in one of the herds.

Vitamin B12 for gestating sows

Vitamin B12 is essential to blood formation, and deficiency will result in anaemia, which is assumed to affect the sow's health and productivity and increase the risk of shoulder ulcers. An investigation demonstrated that injection with vitamin B12 resulted in a significantly higher level of vitamin B12 serum in the entire gestation period. However, this had no significant effect on farrowing rate, litter size or sow survival. Nor were there any significant differences in the frequency of treatment for MMA or occurrence of shoulder ulcers.

Bedding in farrowing pens

The floor of the farrowing pen also plays a part in preventing shoulder ulcers. It is documented that when a sow has developed a shoulder ulcer and needs treatment, a rubber mat is a better solution than fully slatted floors.

However, in terms of preventing shoulder ulcers in healthy sows, the effect of a soft bed under the sow remains to be investigated.

This is now being investigated in a study comprising three groups:

1. Regular, solid concrete floor
2. A traditional rubber mat (18 mm)
3. A "soft" mat (two layers with a soft core)

In groups 2 and 3, the mats stay in the farrowing pens as long as the sows to evaluate the effect of permanent, soft bedding in all farrowing pens. This is different from the normal recommendation stating that a risk sow or a sow with incipient shoulder ulcer (reddening on the shoulder) be given a soft bed.

Results are not yet available, but in group 3 there were problems with making the mat hold the pressure from sow and high-pressure cleaner.



Soft bedding is being studied in terms of preventive effect against shoulder ulcers in healthy sows.

Floor cooling

Lactating sows have a large production of heat and do not need the warm surroundings that piglets do. In a current study with floor cooling, the thermal environment of the sow is being improved to make it easier for the sow to "get rid of the heat". The aim is to reduce the occurrence of shoulder ulcers by avoiding, for instance, that the sow stops eating when the pig house heats up during the summer. The occurrence of shoulder ulcers in the trial is below 5% so far, which is very few. It is not

yet possible to observe any difference between the groups. Primarily sows with poor body condition upon transfer to the farrowing facility develop shoulder ulcers – regardless of group.

Breeding against shoulder ulcers

A comprehensive recording of animals in production herds is currently taking place to establish whether it is possible to prevent shoulder ulcers through breeding. The animals are of known pedigree, ie. their kinship can be traced back to parents and grandparents. Recordings began in autumn 2007 and are expected to finish in 2010.

The occurrence of shoulder ulcers in sows is being recorded. The sows are LY or YL hybrids of known pedigree, bought from multiplication herds. Recordings are coupled with information on origin from Pig Research Centre's database and with production data from the herds' efficiency control programmes.

Shoulder ulcers are recorded in eight production herds and these herds are visited once a week. The diameter of the shoulder ulcers and degree of reddening are recorded, and body condition is visually evaluated. Shoulder ulcers in the farrowing facility are recorded by a technician from the Department of Genetic Research and Development. Each sow is examined 4-5 times in each lactation period. Approx. 44,000 evaluations have been made by now from 8,500 farrowings of 6,000 sows.

Minimum 10,000 sows must be recorded to prove heredity. The material will be subject to statistical and genetic analyses. Genetic parameters for shoulder ulcers will be calculated as will the phenotypic correlation between shoulder ulcer, body condition, floor type, house and herd. If heredity is proved, it will be possible to increase the resistance to shoulder ulcers in Danish sows through selection in breeding.

New scale

With the upcoming self-inspection programme, which also includes recording of shoulder ulcers, the staff on the farms must be able to make fairly uniform evaluations of shoulder ulcers. As part of the veterinary compromise in 2008, a work group was set up to make a new scale for evaluating shoulder ulcers. The group consists of representatives from the Danish Agriculture and Food Council, Aarhus University (the Faculty of Agricultural Sciences), Copenhagen University (the Faculty of Life Sciences), the Danish Veterinary Association and the Danish Veterinary and Food Administration.

The scale will also help the pig producer wean sows with shoulder ulcers sufficiently early in the process that the ulcers do not develop into severe shoulder ulcers. Nationally, this will automatically reduce the number of severe shoulder ulcers and thereby also the number of reports of severe shoulder ulcers. The scale will be developed for use in the farrowing facility and must be used once the staff has received the necessary training from the herd vet.

The aim is to make the best descriptions of shoulder ulcers and divide them into three categories: No, mild or severe shoulder ulcer. A calibration tool will also be developed for checking that shoulder ulcers are always evaluated identically in all herds. The scale will be ready for use in the beginning of 2010.

The work group will also compile data to determine limiting values for mild and severe shoulder ulcers.

Legs that will last the sow's life

Pig Research Centre's demonstration programme "Stronger legs" has obtained financial support from the EU and the Rural Development Programme under the Danish Ministry of Food, Agriculture and Fisheries in 2009-2010. The aim of the programme is to analyse and implement know-how on housing and handling of young animals to avoid lameness. The first five projects under this programme are well underway. Preparation of a gilt manual was initiated by the end of 2009.

PROJECTS IN THE PROGRAMME "STRONGER LEGS"

1. Evaluation system
2. Causes of lameness
3. The good life
4. Socialisation and grouping
5. Floor quality and lameness
6. Gilt manual

Mobility is essential

A sow's mobility is essential. Severe lameness are the main reason for destruction of sows. Every year, 15% of the sows in the herds are destroyed, and more than half are destroyed due to fatal lameness. Lameness include hoof injuries, hoof abscesses, arthritis and injuries to joints, tendons and muscles. These are often painful injuries, and as a consequence the wellbeing of the animal is negatively affected. Even though it is often possible to treat and cure the sow, the best solution is to prevent the injuries.

Evaluation system

An evaluation system based on known principles has been made and this is now being used in the projects under the programme "Stronger legs". The aim is to enable pig producers to select the animals suitable for a long and healthy production life. In co-operation with national and foreign scientists, existing information on leg health was

evaluated and discussed. The individual elements in the evaluation was described and illustrated with photos and videos. An example of thorough evaluation of 29 gilts bred on-farm revealed that far from all animals are flawless. Four gilts suffered from slight lameness; eight had small inner hooves; and 11 had minor deficiencies in terms of leg position.

Causes of lameness

Lameness among sows is now being studied in detail in two production herds. The evaluation system is used for routine evaluation of sows. Possible correlations between reduced mobility and the sow's life and health are also being evaluated. Sows living under different conditions and with degrees of lameness are selected and destroyed for closer examination at a diagnostic lab. It is furthermore studied how the staff on the pig farms can prevent lameness by administering treatment and/or relief at an early stage.

The good life: Lactation

The foundation of a gilt's production life is laid already at birth. Approximately 1,700 female pigs are therefore being examined to determine the influence on production and longevity of piglet birth weight, number of piglets with the sow, whether the pig is reared by its own mother and weaning age. The first gilts in this study have now been delivered to

the buyer. Leg position was evaluated before delivery and over the next years, production data will be compiled from the buyers' herd records.

The good life: gilts

In two production herds, it is being investigated if optimum feeding of future breeding stock can be used to avoid lameness. The aim is to establish whether the growth rate influences leg health of the animals. Restrictive feeding (80% of the pigs' appetite) in the growth period is compared with approximate ad lib feeding up to 2.5 feed units a day. As a result, the gilts fed restrictively weigh less at service than gilts fed ad lib. The first farrowings in the study indicate that if gilts are flushed before service, there will be no difference in litter size at farrowing.

Socialisation and grouping

Young sows are overrepresented in the statistics of animals that are destroyed/die in production herd. One reason may be that young animals fail to form a hierarchy at an early stage in life in groups that also include elder sows. Young animals need to learn that it is pointless to fight with bigger/older animals as this will teach them to back off in future hierarchy fights and thereby avoid injuries. Young sows will find it easier to escape dominant sows if there is extra room and non-slippery floors in the pen where grouping takes place.



Moving a group of gilts.

Experiences with socialisation

In five production herds, Pig Research Centre analysed experiences with socialisation of gilts through interviews with the staff. Furthermore, in a period of four weeks after transfer to the gestation facility, recordings were made of hierarchy fights between gilts and older sows, gilts' lying behaviour and bites.



Conflict between sows.

Socialisation of gilts

In the gestation facilities in the trial the sows were housed in dynamic groups and were fed via had electronic sow feeding (ESF). The gilts were socialised either before or after they were trained in using the ESF stations. In one of the five herds, the gilts were socialised simultaneously with training. They were socialised in pens with training stations or ESF stations. It was possible for pigs to escape during hierarchy fights as there was plenty of space in the pen. One method for socialisation was to regroup the gilts several times whereby they were mixed with older gilts. Young sows were first mixed with older sows in the pen with training stations. The next mixing took place after training in ESF stations, which meant training took place under stable conditions, ie. without regrouping.

Fewer fights

Recordings demonstrated that 1-2 weeks after transfer to the gestation facility, gilts were resting side by side with the older sows. It is generally agreed that socialisation affects both

lying behaviour in the gestation facility where the animals are quicker to lie among with the older animals and it affects the frequency of hierarchy fights. According to the interviewees, an effect was observed of socialisation as leg problems were reduced in the gestation facility.

Floor quality and lameness

Lameness is by far the most common cause of destruction among group-housed gestating gilts and sows. The injuries probably arise during grouping on concrete slatted floor in the activity area. This type of floor is used primarily because the area with wet surfaces is smaller (less ammonia), and less labour is required for cleaning when handling manure.

Soft floors

Soft floors are known to reduce the degree of lameness in cows compared with cows housed on concrete floors, but it has not yet been demonstrated if it has the same effect in gestation facilities for sows. The rubber flooring used in cattle herds is mats that can subsequently be fitted on existing solid floors or on slatted floors. As opposed to cows, sows have a high degree of rooting behaviour which in many cases will result in destruction of loose objects or parts of the equipment.

Five types of rubber floor

In a pilot study in a production herd with five different types of rubber floor normally used in cattle herds it is being studied how easy the floors are to fit, their durability, non-skid properties, sows' lying behaviour and passage of manure in order to select one floor for testing in a production herd.

Sows like rubber floors

Preliminary results from the pilot study indicate that the sows largely use the rubber floor as intended; ie. they walk on it, but they also choose to defecate on it – probably because it has a higher degree non-skid properties. Manure passage is limited with the rubber floor

compared with the remaining concrete floor, and a great deal of development is still required.

Rubber floor in the activity area

An investigation is being planned in a production herd in which the selected rubber floor is fitted in the middle of the dunging/activity area where the sows mainly walk. It is thus only used in part of the slatted floor area, which means that it is still possible the sows to wear their hooves. The aim is to determine whether a soft floor in part of the activity area in gestation facilities with group-housed gilts and sows reduces the extent of lameness. The rubber floor is level with the remaining concrete slatted floor as the middle slats are lowered in order to prevent the sows from getting hold of the corners and thereby destroying the floors.



Pilot study with rubber floor.

Gilt manual

All the results obtained in the programme "Stronger legs" will be incorporated in a gilt manual. The manual is made by the advisors participating in Development Project Pigs. Work with the manual will begin in 2009. It will be finished in 2010 and will be aimed at the staff in the pig herds and their advisors.

Castration against boar taint

In Denmark and across Europe, the majority of all male pigs are castrated to prevent boar taint in the meat. Boar taint is caused primarily by the substances skatole and androstenone.

Castration of male pigs is a requirement from many international markets, and Danish consumers are also sceptical of meat from uncastrated pigs.

The development in Europe

Lately, the welfare implications of castration of pigs have been brought into focus in the EU, and in several European countries the issue has been heavily debated in the media.

In Denmark and Germany, the industry now require that pain relieving medicine be given in connection with castration. In the Netherlands, general anaesthesia is being used, and this is also considered in Switzerland. In Norway, castration without anaesthesia has been prohibited since 2002 and local anaesthesia is used. In the rest of Europe, pigs are not anaesthetised during castration.

Recent studies indicate that there are several drawbacks to local or general anaesthesia, and it is being discussed whether anaesthesia improves animal welfare. Consequently, Pig Research Centre does not consider anaesthesia to be a durable solution.

In the summer of 2009, a vaccine against boar taint was approved for use in the entire EU. However, the vaccine is not used in Denmark as we still need to clarify how the export markets will react to the use of the vaccine.

Alternatives wanted

Avoiding castration has several advantages including improved animal welfare and better production economy. Activities have been initiated to investigate various alternatives to surgical castration.

Introduction of pain relief

Since June 2009, Danish piglets have

been treated with pain relieving medicine when castrated. The Board of Pig Research Centre decided to introduce the requirement for pain relief partly due to demands from the German market and partly because the Danish Animal Protection Committee recommended the treatment.

So far, no pain relieving drugs are approved for treatment of castration pains in pigs. Therefore, the introduction of this treatment required approval from the Danish authorities and practising vets. Treatment guidelines were laid down in co-operation with the authorities and the Danish Veterinary Association.



Since June 2009, Danish piglets have received pain relief when castrated.

Abroad, the effect of pain relief during castration has been investigated. These studies show that treatment mainly affects pain after castration. This is indicated by the fact that the pigs' behaviour the first hours after castration is less affected when pain relief has been administered before castration. Pain relief also prevents the level of the stress hormone cortisol from increasing as much during castration as it would if pain relief were not administered.

Pig Research Centre will continue work to establish applicable methods for pain relief. This work is financially supported by the EU and by funds from the Rural Development Programme under

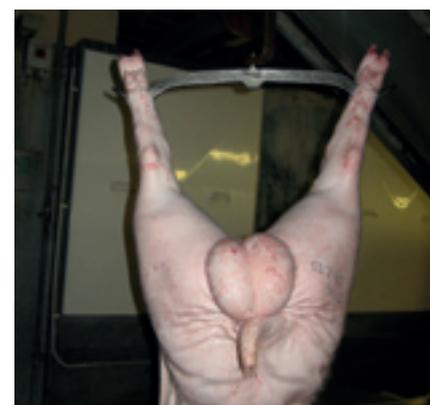
the Danish Ministry of Food, Agriculture and Fisheries.

The economy in male pig production

Cost-benefit calculations for male pig production were last made in 1993. In a new project, the production economy of female pigs, male pigs and castrates will be analysed to establish if there is still the same positive benefit of producing male pigs compared with castrates. The project will be conducted in two herds and is expected to be finished by the autumn of 2010. The project is financially supported by the EU and funds from the Rural Development Programme under the Ministry of Food, Agriculture and Fisheries.

Feeding against boar taint

Boar taint is caused primarily by the substances skatole and androstenone. Androstenone is an "aromatic" sex hormone produced in the testicles and excreted via the salivary glands in boars. Skatole, on the other hand, is produced in the large intestines from the amino acid tryptophan. It is therefore possible to restrict the production of skatole in the intestines by reducing the amount of bacteria that produce skatole or by reducing the content of tryptophan in the feed. However, tryptophan is an essential amino acid and reducing the level of tryptophan in feed would therefore have severe negative effects on the pigs' productivity.



New studies are carried out to establish the production economy of male pig production today.

A more promising solution would therefore be to reduce the production of skatole in the intestines by way of a fiber-rich diet.

Previously, small-scale studies have demonstrated that adding 15% chicory to the feed the last 14 days before slaughter reduced the skatole content in fat from male pigs. Adding 25% lupine to feed has been shown to have similar effects. In one herd, the effect of feeding with dried chicory root was studied and an effect on skatole was confirmed, but chicory was not found to have any effect on the level of androstenone in the fat. A taste panel concluded that "boar odour" was reduced in male pigs given chicory, but that the "boar taste" remained unchanged. The cost of adding 15% chicory to the feed is another drawback; at a price of approx. DKK 40 per male pig the product is far too expensive.

In the coming years, the effect of smaller quantities of chicory will be tested, possibly for a shorter period of time, as will other feedstuffs that may affect the production of skatole in the intestines. Feeding chicory and other fibres increases the amount of bacteria that ferment fibre in the intestines.

These bacteria "steal" tryptophan for their growth from the bacteria that produce skatole. An increased amount of the bacteria that ferment fibre will also leave less space for the bacteria that produce skatole. The project is financially supported by the EU and



Is it possible to eat the boar taint away?

funds from the Rural Development Programme under the Ministry of Food, Agriculture and Fisheries.

Sexing of semen

The need for castrating male pigs can be reduced considerably by sexing of semen. Pig Research Centre is supporting a development project under the Welsh company Ovasort Ltd. in which an immunological method for sorting of semen into "male sperm" and "female sperm" has been patented and is being further developed. Specific proteins on the surface of female sperm have been identified, and when antibodies are bound to these proteins, the sperm cells agglutinate (clot). By subsequent filtration of the sperm, male sperm can be separated from female sperm. After that, the female sperm will be released from the antibodies before being used.

The aim is for semen doses to have a sufficiently high concentration of female sperm so that minimum 70% of the pigs born will be female pigs. Whether the method is applicable under practical conditions will probably be clarified by 2014.

Vaccination against boar taint

Improvac, a vaccine against boar taint, is now approved for use in the EU, but is not yet marketed in Denmark. Studies carried out abroad have shown that it is possible to almost eliminate boar taint by vaccinating male pigs twice in the months before slaughter.

When pigs are vaccinated, they produce antibodies against a transmitter substance in the brain. This transmitter substance is necessary for the production of sex hormones. Once the signal substance is neutralised, the production of sex hormones ceases and boar taint is almost completely eliminated.

In co-operation with the pharmaceutical company Pfizer, the effect of Improvac is being studied in two Danish pig herds. It is investigated whether vaccinated pigs have a higher producti-



The Improvac vaccine is tested in two herds.

vity – including a better feed conversion ratio – than surgically castrated pigs. Results are expected in 2011.

Unfortunately, the vaccine also works on humans, though the effect is not seen until after two injections and is most probably temporary. Consequently, it is important to identify work routines that minimise the risk of self-injection. A safety injector has been developed by the producer of the vaccine.

It is not known how consumers and export markets will react to the use of the vaccine in Danish male pigs. This must be established before the vaccine can be taken into use in Denmark.



The first pigs vaccinated with Improvac were slaughtered in August 2009.

Departments

SPF (Specific Pathogen Free) Health Control and the Laboratory for Pig Diseases are service units in Pig Research Centre. This means that pricing must cover all costs and create a minor surplus for covering the capital tied in the activities.

SPF Health Control

The most significant task is SPF health control in Danish breeding and multiplier herds. On April 1, 2009, 243 CHR numbers were status "red SPF", which means that they will be inspected once a month. At the inspection, the herd is checked for clinical signs of SPF diseases and blood samples are taken as documentation of the health status.

In spring 2007, the Board of Pig Research Centre assigned the Health Control the task of consultancy and supervision of animal welfare in the herds with special attention to shoulder ulcers and tail bites. This task is performed in co-operation with the Department of Genetic Research and Development. Herd owners have reacted positively to this new effort, and the levels of animal welfare have increased significantly.

Several owners of red SPF herds have decided to let the Health Control handle the health advisory process.

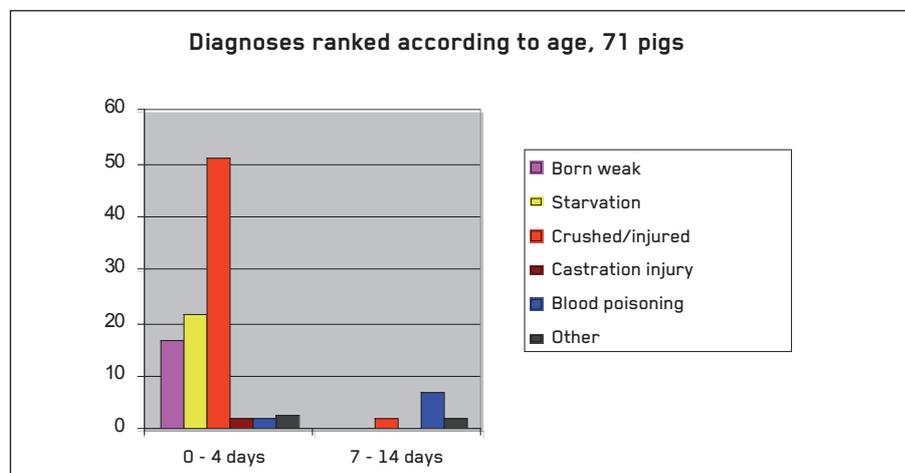
The Health Control functions as supervisory vets for Hatting AI, i.e. the vets are supervising entry and exit of boars at the AI stations.

The Health Control furthermore handles tasks related to Danish pig production, such as:

- Control of SPF transporters
- Consultancy in other countries in connection with export of breeding stock
- Participation in projects under Pig Research Centre

Laboratory for Pig Diseases

The Lab has two main areas of work. One is analysis of samples from red



SPF herds, which concerns serological examination for mycoplasma and pleuropneumonia types 2 and 6. The Lab also routinely monitors atrophic rhinitis. The other main area is the performance of post-mortems and microbiological analyses to establish causes of disease.

Extended and more specialised examinations are handled by the DTU Veterinary Institute.

Established in 1988, approx. 3,500 post-mortems are performed annually at the Lab; this number varies according to the pathological situation in the pig production.

Traditionally, a few pigs in a herd are subjected to a post-mortem examination including bacteriological analyses to establish the cause of disease and to establish which antibiotic is more efficient.

Lately, a new method for establishing causes of disease in farrowing facilities has proved successful. The method is called "USK gris" and is developed on the basis of a research project in the 1970s.

The method is based on examinations of a large number of pigs, often 40-50, over two weeks in the farrowing facility. The pigs are stored and shipped to the Lab in one load.

At the Lab, all pigs are subjected to a post-mortem, and, based on the dominant findings, material for further examination is selected.

The results of the post-mortem examination are collected in a report in which the vet and the herd manager are shown the findings accompanied by tables and graphs.

The findings will be organised for two periods: from birth to day 5 and from day 7 to day 14, as shown in the figure.

The report ends with a conclusion like this:

Conclusion:

Post-mortems of 71 pigs revealed the following:

- More than 80% of the pigs that died before day 5 were crushed
- The majority of the piglets have not had a sufficient milk intake
- Few pigs had sores caused by wear on the knees on their front legs
- The majority of the oldest pigs died from blood poisoning/arthritis
- Virtually none of the youngest pigs died from infections

The following pathogenic problems were detected:

- Blood poisoning triggered by non-haemolytic E.coli.

PMWS in Denmark

PMWS is still a problem in Denmark. Today it affects not only weaners, but also finishers, and therefore the name has been changed to Porcine Circovirus Diseases (PCVD). Besides increased mortality, low gain and non-uniform pigs are characteristics of the disease. Scientists have successfully isolated PCV2 virus from aborted pig fetuses, and it is therefore believed that PCV2 may also cause reproductive problems.

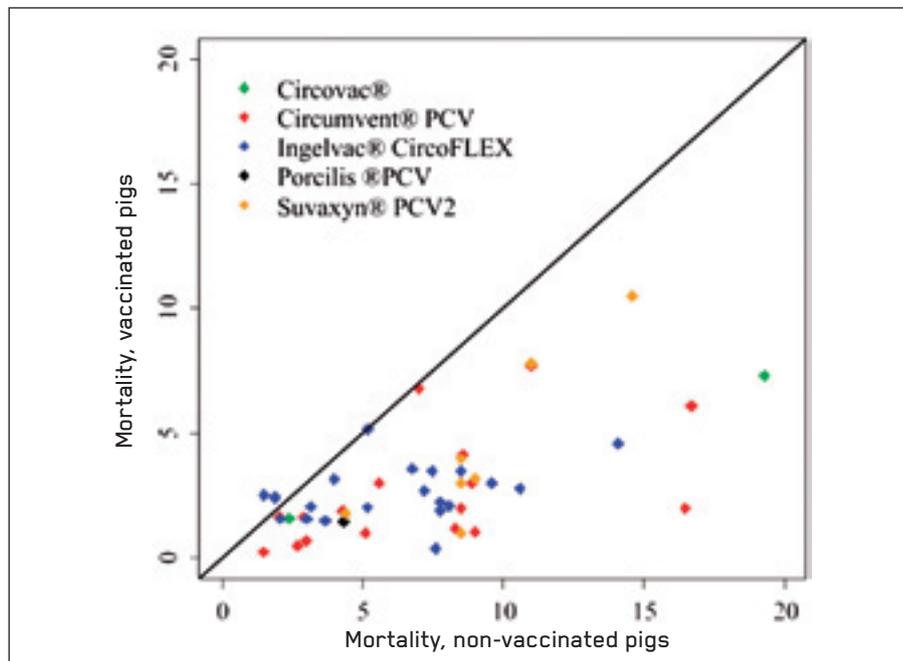
Previously, the disease was successfully controlled through management changes, but in recent years specific PCV2 vaccines have been developed.

Effect of PCV2 vaccines

Globally, there are currently five PCV2 vaccines; four for pigs (Ingelvac® CircoFLEX, Suvaxyn® PCV2, Porcilis® PCV, Circumvent® PCV) and one for sows (Circovac®). Circumvent® PCV is not available in Denmark.

The effect of the vaccines has been investigated in several Danish and foreign investigations. In many of these investigations, productivity in a period before vaccination is compared with productivity in a period when vaccination is applied, and an increase is always observed. It is difficult to conclude whether this increase is attributed to the vaccine, genetic progress or changes in management. A more correct way to evaluate the effect of vaccines is controlled clinical trials where half the pigs are vaccinated and the other half is not (control).

To obtain more knowledge of the effect of PCV2 vaccines, Pig Research Centre has completed two activities. In a meta-analysis, all existing investigations of PCV2 vaccines in the world were compiled. A critical evaluation of all investigations was performed followed by an analysis where the expected effect of the PCV2 vaccines and comparison of the vaccines were evaluated. Unfortunately, PCV2 vaccines for sows have



This figure shows paired results for mortality for non-vaccinated and vaccinated pigs from investigations included in the meta-analysis. Symbols under the black line mean that mortality of vaccinated pigs is lower than mortality for non-vaccinated pigs.

not been widely studied, and Pig Research Centre therefore investigated the effect of Circovac® in three herds.

Meta analysis

In total 107 publications were found of which 70 were excluded as they did not meet the inclusion criteria and 13 were excluded as they were double publications. The remaining 24 publications represented 66 clinical trials.

Unfortunately, too few investigations were performed with three of the vaccines to be included in the statistical analysis of average daily weight gain (ADWG). Therefore only Circumvent® PCV and Ingelvac® CircoFLEX were included. ADWG was increased significantly by approx. 30 g for both vaccines when vaccinated and non-vaccinated pigs were compared. Three vaccines were included in analyses of mortality; Suvaxyn® PCV2, Circumvent® PCV and Ingelvac® CircoFLEX. Analyses demonstrated that all three vaccines reduced mortality significantly by more

than 50% in the period from weaning to slaughter.

Circovac®

This vaccine was tested in three herds with PMWS and high mortality among weaners. Analysis of data is now finished in two herds. No side-effects were observed after vaccinating the sows. In the first herd, weaners after vaccinated sows had a significantly higher productivity compared with weaners after non-vaccinated sows. Mortality and treatments of individual animals decreased and ADWG increased. This tendency was not seen in the other herd. No differences in productivity among finishers were seen in the two herds. The results are available on Pig Research Centre's website.

Information

For more information on PMWS, see www.pcvd.org and www.vsp.lf.dk.

Lawsonia diarrhoea

The Lawsonia bacterium exists in almost all Danish pig herds, where it is the cause of diarrhoea and unthrifty pigs among both weaners and finishers.

In many herds, the disease is kept under control with antibiotics that may cause resistance. Therefore, Pig Research Centre initiated a study of the effect of the vaccine in co-operation with the company Boehringer Ingelheim, which is supported by the Rural Development Programme.

The study was designed as a blinded field study with parallel trial and control groups from weaning to 30 kg in two herds and from 30 to 100 kg in four herds. In all herds, Lawsonia was diagnosed as the cause of diarrhoea.

The study comprised approx. 6,000 weaners and approx. 5,500 finishers. Daily gain and feed conversion were recorded at pen level as was daily gain of 1,500 ear-tagged pigs.

Live vaccine

The vaccine from Boehringer Ingelheim is a live vaccine that must be administered approx. 6 weeks before antibodies against Lawsonia can be detected in the blood. Specific requirements apply to the handling of the vaccine.

- Pigs must not be treated with antibiotics 3 days before and after vaccination
- It must be applied within 4 hours after dissolution
- No contact with disinfectants.

Results

Observations among vaccinated pigs in the weaner period showed a significantly higher feed intake and fewer dead and culled pigs due to diarrhoea. In the finisher period, the vaccinated pigs tended ($p=0.10$) to have a higher daily gain.

Table 1. Effect of vaccination	Control	Vaccination	P value
Weaners: Daily gain, g/day	453	461	0.48
Feed intake, FUp/day	0.82	0.87	0.02
Dead and culled due to diarrhoea, %	1.0	0.7	0.02
Finishers: Daily gain, g/day	856	865	0.10

Overall, the ear-tagged pigs grew significantly faster from weaning to slaughter. The effect varied between the herds in the study. In the weaner period, daily gain of the vaccinated, ear-tagged pigs was 28 g higher. In the finisher period, this difference dropped to 2 g/day and was not significant. In herd 3, where the best effect was seen of the vaccine on ear-tagged pigs, a smaller spread in daily gain in the vaccinated group was seen.

Other studies

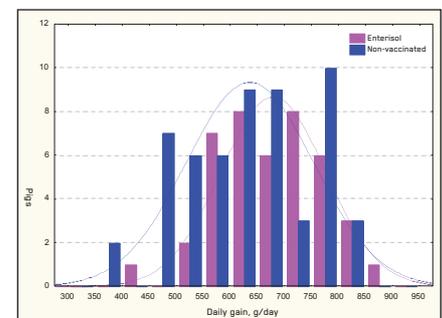
The Lawsonia vaccine has been tested in many other countries. Some studies are similar to the study of Pig Research Centre and others are 'before and after' comparisons. Most studies are made in the finisher period. As too few studies are made in the weaner period, these are not included in the analysis of average effects. The results from the selected herds are analysed as one in a statistical method called a meta analysis.

The number of pigs included in the individual study was used for weighting the different studies.

In 22 selected studies, the calculated average effect on daily gain of vaccinating the pigs was 40 g/day.

The effect found in the various studies ranged from -8 g/day to 76 g/day.

As shown in table 2, varying effects were found of vaccinating the ear-tagged pigs in the Danish study, as was the case in the other studies. The effect varied from -7 g/day to +53 g/day.



In the study made by Pig Research Centre, the average effect was lower than what was found in other studies. This may be due to a lower infection pressure in the herds the study.

Table 2. Effect of vaccination of ear-tagged pigs	Control	Vaccination	P value
Gain 7-30 kg, g/day	475	503	≤ 0.0001
Gain 30-100 kg, g/day	804	806	0.88
Gain 7-100 kg, g/day, herd 1	681	676	0.64
Gain 7-100 kg, g/day, herd 2	618	650	0.03
Gain 7-100 kg, g/day, herd 3	678	731	0.01

Antimicrobial resistance means resistance to antibiotics. Bacteria may develop resistance to certain types of antibiotics. This means that the antibiotics no longer have any effect on these bacteria

MRSA

Every fourth of Danes have staphylococci in their nose or on their skin. MRSA (Methacillin Resistant Staphylococcus Aureus) is a staphylococcus, that has become resistant to the medication normally used for treatment of staphylococci in humans. The Danish health care system has known MRSA for a long time. Healthy people will not normally become ill from MRSA. Humans may carry the bacterium on their skin or in their nose without showing signs of infection. If the bacterium causes disease, an immediate treatment with a special antibiotic is required. To ensure that the correct treatment is given right from the start, it is essential that the health care staff is informed about patients who may be carriers of MRSA.

MRSA CC398

MRSA has several subtypes, and one of these is MRSA CC398. It is found in pigs in particular, but has also been detected in other livestock. CC398 transmits between animals, but can also be transferred to humans. MRSA CC398 is found on the pig, in the dust and on surfaces in the pig house. Humans transmit the disease via direct contact or via objects they have touched, for instance door handles.



Hand wash

MRSA guidelines

The Danish National Board of Health has issued the following guidelines for people working on pig farms with MRSA infection:

- Shower and change clothes before leaving the stable.
- Wash hands frequently and thoroughly. Use disposable towels.
- In case of medical treatment, explain that you work in a herd positive for MRSA CC398. This ensures treatment with the correct antibiotic.

Carriers of MRSA can have completely normal social contact with other people (schools, visits etc.).

Screening for MRSA

All 1,945 participants at the annual conference for Danish pig producers in October 2008 were offered a voluntary, anonymous test for MRSA, in which a person's MRSA carrier status of the nasal cavity was clarified. A total of 769 people agreed to an examination paid by Pig Research Centre.

2.5% carried MRSA CC398

Results of the screening revealed that 2.5% of the sampled persons were tested positive for MRSA CC398 and 0.3% carried other MRSA types. In total, 3.1% of farmers working on a pig farm and 1.8 % of agricultural consultants were MRSA CC398 carriers. No veterinarians were diagnosed positive. Compared with reports from other countries, this is a fairly low prevalence. For instance, in Canadian and Dutch pig herds, 20% and 23% of the staff, respectively, were diagnosed MRSA positive.

The results indicate that if you stay in a pig herd on a weekly basis, you have an increased risk of being carrier of MRSA CC398 – particularly if you work fulltime on a pig farm. Working in sow units increased the risk of being an MRSA CC398 carrier. These observations correspond with Dutch experiences.



Swabbing of nostrils

Research and guidelines

Pig Research Centre co-operates with several organisations (including the National Health Board, DTU, and Statens Serum Institut) on optimising research and guidelines on resistant bacteria, which may pose a risk to the staff on a pig farm. These bacteria include MRSA, ESBL (cephalosporin resistance) and Clostridium difficile. Pig Research Centre is also involved in the updating of guidelines for veterinarians on the prudent use of antibiotics in the treatment of pigs.

PROTECT YOURSELF AGAINST ANTIMICROBIAL RESISTANCE

People handling antibiotics may develop antimicrobial resistance or allergies. Therefore, it is important to handle antibiotics with care:

- **Use gloves**, if you are in risk of having direct contact with antibiotics
- **Use respirators** (P2/P3) when you are at risk of inhaling antibiotics
- **Wash hands** often and use disposable towels

ICT

The use of information and communication technology (ICT) will have a great influence on pig production in the future. Key words such as management systems, surveillance, identification, productivity, optimisation, animal welfare, environment and traceability are all areas related to ICT. ICT is therefore one of the tools that will help Danish pig production stay in the lead on the internationally. Pig Research Centre is currently involved in a range of ICT-related activities.

Pigtracker

Pigtracker is a joint venture between Pig Research Centre and the Danish Meat Research Institute and two private companies; Printerlabels and Prodesign. The aim of the project, which is financially supported by the Innovation Act, is to develop a new electronic ear-tag. Today, electronic identification of livestock is based on the use of low frequency RFID technology (Low Frequency Radio Frequency Identification, ie. 125 KHz). Danish cattle producers are planning to implement electronic identification based on LF-RFID in 2009, and LF-RFID is also the standard in the EU. LF-RFID has a number of drawbacks: it has a very short reading distance (less than 10 cm), which makes it possible to read just one animal at a time, it has a low reading speed and it is expensive.

High frequency RFID technology (UHF-RFID, Ultra High Frequency, 867 MHz), which is used in the pigtracker project, has a long reading distance (5-6 m), reads many units at a time with great accuracy, has high speed data transfer speed and the technology is a lot cheaper than LF-RFID.

A new knowledge basis in pig production will be formed with individual identification and central data exchange, such as the latest network technology.

Many resources can be saved on locating pigs in the pig house, and with infor-

mation on the individual animal, much more accurate data on the influence of disease, feed and environmental impacts can be obtained compared with today. Individual identification in combination with recording of pigs' growth also makes it possible to market special products.



Handheld reading of pigs with UHF-RFID. Reading distance of 1.5-2 m.

The Intelligent Farrowing Pen

The Intelligent Farrowing Pen is a management and surveillance system that can adjust climate at pen level according to the current needs of the animals, and the pig producer is notified if critical situations occur among the animals. This improves animal welfare and piglet survival and increases the income of the pig producer. The farrowing pen is linked to an intelligent network that via data automatically compiled from sensors linked to each pen/sow at pen level regulates the climate to match the individual animal. The network also notifies the producer of farrowing problems, disease and inaccurate pen function. The project is a joint venture between Aarhus University, Skov and Engineering College of Aarhus.

New management system

Today, pig producers not only handle data from the individual pig; they also need to routinely assess data from feeding systems and climate controls to be able to monitor production. This requires efficient tools for compiling and analysing this information. Basically, a set of rules or standards is necessary to enable the various systems to "communicate" with each other. Pig Research Centre therefore participates in making these joint guidelines that will ensure that communication between the systems can take place the context of Danish Data Standard. Pig Research Centre is also involved in a joint venture with Copenhagen University and TNMIT that has received financial support from the Innovation Act. The aim is to develop an entirely new system for routine compilation and analysis of data from the production unit to enable the producer quickly and efficiently to supervise and adjust the production.

Phase 1

In close co-operation with a team of pig advisors, vets and pig producers, Pig Research Centre has now completed phase 1 of the demonstration project DKK +25 per finisher. The aim of the project was to implement all existing know-how on production of finishers. The project is financially supported by the EU and the Rural Development Programme under the Danish Ministry for Food, Agriculture and Fisheries. The name "DKK +25 per finisher" stresses that the aim is to increase the income of the individual pig producer.

The idea behind the project was to demonstrate where the production routines could be improved in the individual herd. The idea was also to ensure, through close follow-up by the herd advisors, that the efforts described in an action plan were in fact implemented. Possible improvements in production results and on the bottom line were estimated, and the results were analysed after a period of one year. The pig producers agreed to six visits from the pig advisor besides 12 annual visits from the vet.

The herds

The producers were nominated by the vets, and the only requirement for being nominated was an efficiency report showing the last year's production figures. Fifty-five pig producers participated in phase 1, and of these 35 were included in the final data analysis. There were several reasons for this reduction; some decided not to continue as part of the project, others stopped producing pigs, eradicated or sold their herd, and some were excluded because of insufficient/inaccurate data.

Productivity

The results varied greatly between the herds. Compared with the one-year before-period, most producers experienced improvements, but others experienced setbacks. On average, the 35 producers achieved the following improvements in productivity:

Daily gain:	+ 66 g
FUgp/kg gain:	- 0.08 FUgp
Mortality:	- 0.9 percentage unit

A gross margin (GM) per pig was calculated that did not include additional costs for operation of systems, investments and increased costs for advisory services. This figure solely expresses the value of changes in productivity. The calculations show that the 35 producers made averagely DKK +19 per pig.

All calculations of GM are based on a five-year price set, and changes in GM are thereby not an expression of current prices.

Bottom line

The measures in the action plans and increased advice in the individual herd resulted in increasing costs. The costs are converted to costs per pig, which means that for producers producing few pigs the costs per pig will be higher. All costs related to additional advice are included in year 1. In the 35 herds, total costs averaged DKK 7 per pig, which overall results in a gross margin of DKK 12 per pig.

DKK 12 was only half of what had been estimated in the action plans (DKK 24 per produced pig). A higher success rate was expected, but "the whole package" with action plan and follow-up was not implemented 100% in all herds. An essential part of the conclusion is therefore that it is difficult to maintain all producers in an advisory process. Seventeen of the 35 producers had more than four visits from their pig advisor. Only very few of the producers implemented the entire action plan. The project was conducted in a period when it was difficult to deliver pigs for slaughter at the desired time and thereby at the desired slaughter weight.

Success stories

Of the 35 producers, 12 achieved the magic DKK 25 in increased GM per pig.

Twelve producers achieved a higher GM than estimated in the action plan. The producers with the largest increase in GM also achieved the following changes:

Top 10	FUgp/kg	Gain, g	Mortality
1	- 0.10	+ 105	- 4.0
2	- 0.08	+160	- 4.8
3	- 0.40	+ 40	- 0.3
4	- 0.12	+ 56	- 0.2
5	- 0.37	+ 172	- 2.6
6	- 0.32	+ 89	- 1.2
7	- 0.17	+ 140	- 3.4
8	- 0.14	+ 117	- 2.6
9	- 0.31	+ 86	+ 0.3
10	- 0.08	+ 48	- 2.7

The results of this project demonstrate that interaction between several factors is required to obtain positive changes that also show on the bottom line: the producer and his staff must be motivated and the advisory team must focus on giving the right advice. This is a difficult task and huge challenge for all parties involved, but it is great when you succeed.



Says one of the producers: "We've succeeded in incorporating more systematism and better routines into our daily work. That has paid off on the bottom line. But you must be prepared to change your routines."

Implementing know-how

Danish pig producers are among the most competitive in the world. One of the reasons is that, together with their advisors, they are extremely efficient in implementing new know-how.

Competitiveness

There is still a great deal of know-how to implement before we can be sure to maintain our competitiveness. We cannot afford to sit back and relax as new knowledge constantly surfaces both nationally and internationally, and competition on efficiency increases. Production methods and society develop, and, as production costs need to be kept low, production units increase in size.

Fifth birthday

Fast and efficient implementation of know-how and new techniques is crucial to the survival of Danish pig production. With this in mind, the regional advisory offices and Pig Research Centre established Development Project Pigs in 2004. They agreed on a model of how to co-operate on implementing know-how in Danish pig herds.

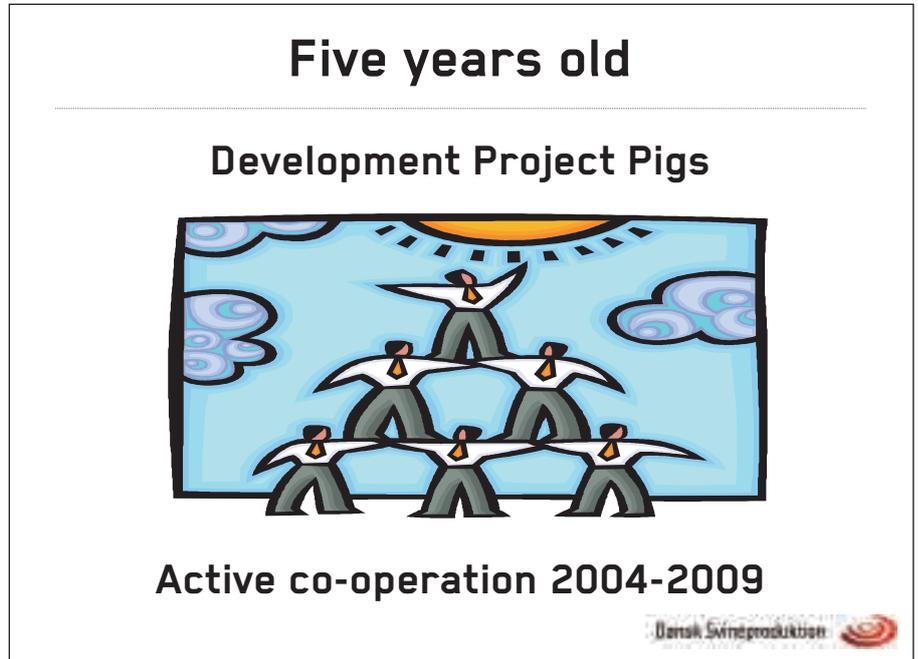
Specialisation

The central point of this work is specialisation, which in practice means that project groups manned by the most experienced advisors and experts develop models for implementing know-how in the daily work routines. The members of these project groups have many years of experience on each individual area. They work on developing management and advisory tools to facilitate immediate implementation of new know-how.

The groups are responsible for making pig advisors so familiar with these tools that the objectives set out for an advisory process be achieved every time.

Dedicated advisory process

Pig producers and advisors have now demonstrated how know-how can be implemented with a high degree of



accuracy and thereby benefit the bottom line result of the pig producer. A dedicated advisory process based on manuals and management concepts have brought the payoff of investments up for discussion. Improved production results are consistent as a consequence of dedicated advice. It not a question of whether the objectives are reached, but rather a question of when and, in some cases, of how many meetings with the pig advisor are required before the objectives are reached.

More liveborn

Danish weaner producers annually increase the number of liveborn piglets per sow/year by half a pig (see Figure 1).

In 2000, weaner producers produced 27 liveborn piglets per sow/year, and in 2008 this number had increased to 31, which is an increase of four liveborn piglets in eight years.

This presents great challenges to management methods.

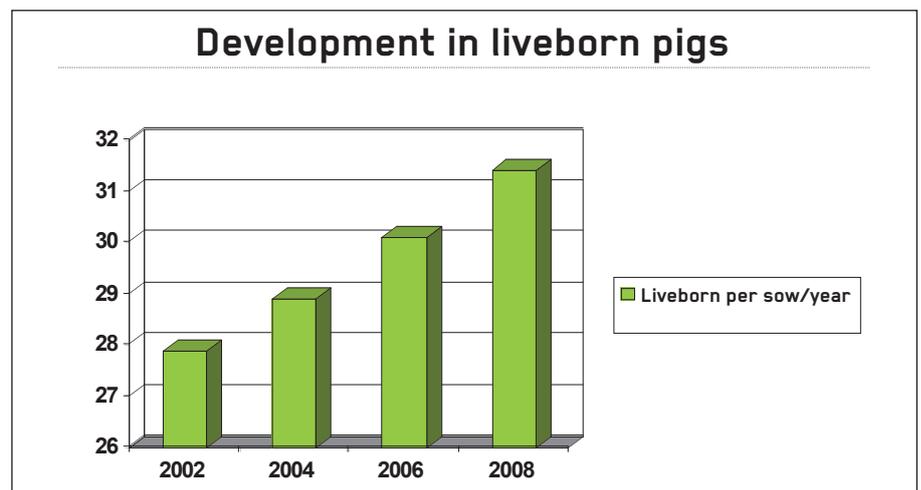


Figure 1. Average number of liveborn per sow/year increases by half a pig annually.

Trends

However, mortality rates for weaners and finishers have increased, and this is unfortunate. One third of the increase in liveborn piglets up to 2005 was lost again. At the same time, the genetic progress in feed efficiency was not really reflected in practice.

However, the trends have reversed. Figures 2, 3 and 4 clearly illustrate that piglet and finisher mortality rates and feed efficiency are now moving in the right direction.

Persistent drops

With a dedicated advisory process, attention and motivation are maintained when implementing know-how. Through skilled management and determined co-operation with advisors and vets, even the most efficient pig producers will be able to achieve a persistent drop in feed conversion and mortality.

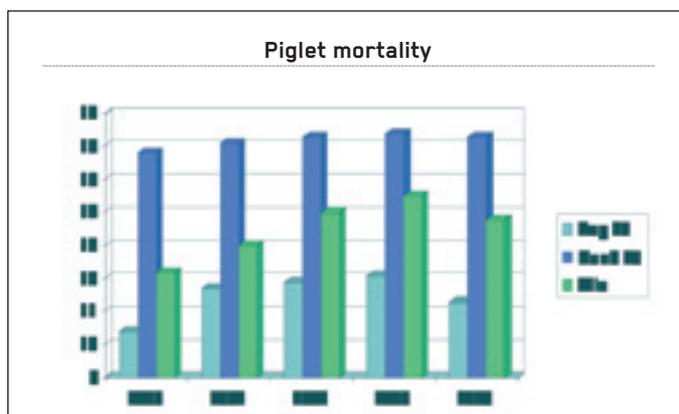


Figure 2. Piglet mortality is dropping in spite of the increasing number of piglets born. Note the spread between top and bottom.

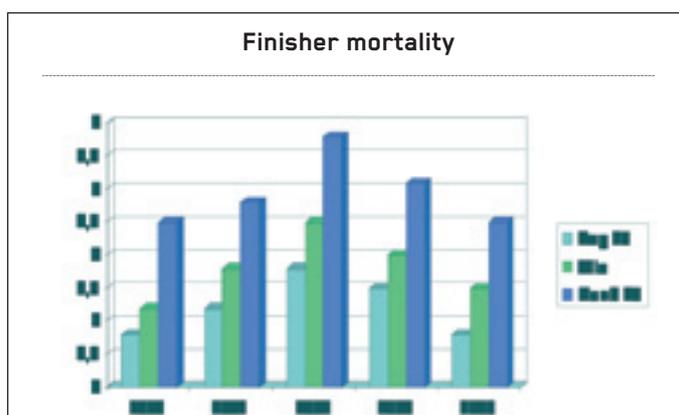


Figure 3. Since 2004, finisher mortality has dropped by 1%. Note the spread between top and bottom.

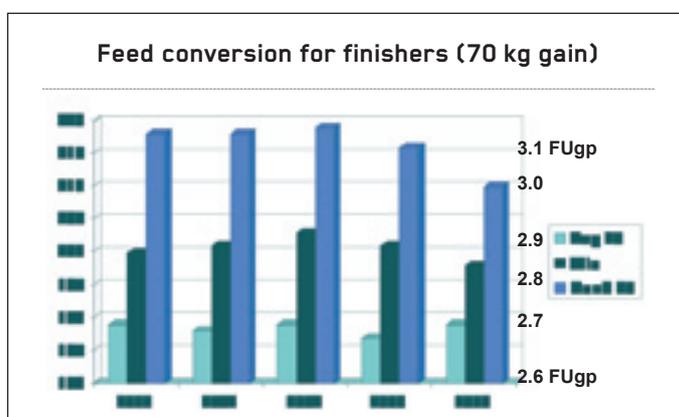


Figure 4. The average feed conversion ratio has dropped from 2.9 to approx. 2.8 feed units per kg gain since 2004 in spite of increasing slaughter weight.

New website

In October 2009, Pig Research Centre launched its new website.

In April 2009, it was decided that Pig Research Centre was to have a new website to replace the two existing sites www.vsp.lf.dk and www.infosvin.dk. However, transferring the content from the Infosvin website to the new website is a comprehensive task; the aim is to shut down www.infosvin.dk in October 2010 and by then to have all relevant information transferred to the new website.

Why a new website?

A user survey among pig producers, advisors and vets revealed a general satisfaction with our website, but also some elements of dissatisfaction. For instance, all three groups found it difficult to find what they are looking for. This will change with the new website.

Pig Research Centre wishes to communicate know-how to pig producers and their staff, and this is an impossible task if pig producers, advisors and vets cannot find the information they are looking for.

The user survey unequivocally concluded that in Pig Research Centre we need to express our opinions clearer both politically and scientifically. We must improve our way of communicating our opinions, not only to pig producers, advisor and vet, but also to the world. The aim of the new website is therefore to tell to the world what Pig Research Centre is, what we do, what we mean and what we represent. Pig Research Centre must be at the front when topics related to the pig industry are debated in the media. If we clearly communicate our opinions, recommendations and experiences, we will raise awareness and be visible.

User friendliness comes first

The current website and the Infosvin website contain incredible valuable information, but, as mentioned, it can be hard to find. Users often use Google instead to find the information they need. This must be changed, of course. It must be easy to find your way around the new website, and structurally all information related to one issue will be gathered logically.

Furthermore, the current website is based on a system that is incapable of handling the vast amount of information accumulated over the years. It is simply crashing. The new website will be based on a system that is built to handle the amount of information on the site, including future publications etc.



More videos

Videos are an excellent communication tool as opposed to texts. The survey also revealed that users would like to have more videos on our website. Videos will be produced for the new website, and it is one of the high priority areas. Publications will also be made easier to read as the lay-out will be revised. The reader will first be given a brief introduction to the publication, and can then subsequently choose whether to read the publication as html, PDF or livepaper.

Videos

At Pig Research Centre's website it is now possible to watch or download videos with Danish, English or Russian speak. These videos provide a good basis for incorporating practical routines in connection with selection of gilts, evaluation of body condition, destruction of animals etc. The videos can also be used in meetings in large or small groups as an introduction to renewed focus on essential problems.



Scientific videos are good tools for incorporating practical routines in the daily management.

Annual Meeting and Congress for pig producers

Every year in October, Pig Research Centre hosts the Annual Meeting followed by the Congress for pig producers in Herning with approx. 2,000 participants. At the Congress, pig producers, staff, advisors and vets are presented with the latest know-how and trial results.



In 2010, the Annual Meeting and the Congress will be held on October 26 and 27.

With more than 100 speakers and 65 presentations, the Congress is one of the largest pig events in the world. The Congress also provides an excellent opportunity for socialising and networking with other parties in the pig industry.

The Congress offers a highly varied programme with focus on the current situation in the pig industry, and the latest know-how is presented to producers of sows, weaners and finishers.

Topics include

1. The world around us
2. Management
3. Economy
4. Sow unit
5. Weaners/finishers
6. Nutrition
7. Welfare and health
8. Environment and pig housing

Speakers answer questions from pig producers, their staff and advisors concerning what to do to meet society's requirements and improve the bottom line results.

In 2010, the Annual Meeting and the Congress will be held on October 26 and 27.

Before the Congress, Pig Research Centre hosts a well-attended Annual Meeting where the progress obtained in the Danish pig industry is summarised and the future development is discussed. The political, economical and technical challenges in a world and an industry that is constantly developing are discussed.

Technical seminars and meetings

Pig Research Centre holds a series of annual meetings and seminars addressing specific technical problems. These events appeal to different target groups.

In 2010, the following meetings are planned:

- **Feeding Seminar** for employees in the feedstuff industry (open to all interested parties).
- **Firmamøde** for Danish producers of pig facilities and equipment

- **Fagligt Nyt** for pig advisors and vets.

For more information, visit Pig Research Centre's website.

Fact sheets in several languages

On our website, it is possible to download various instructions in the form of fact sheets with practical guidelines in Danish, English and Russian on a number of topical scientific subjects.

The fact sheets are A4 size, and can be printed and used in the daily work routines.

In co-operation with the technical magazine Svin, Pig Research Centre publishes a new fact sheet every month on good practical routines for a topical subject.



Fact sheets describing good production practices can be downloaded at www.vsp.lf.dk.

Reports

- No. 0803: Design and use of hospital pens for gestating sows
- No. 0804: Nutrients in grain harvested in 2008
- No. 0805: Rubber mats for farrowing pens
- No. 0806: Correlation between PMWS and Salmonella?
- No. 0807: Ammonia and odour reduction in the biological air cleaner "CleanTube" from Skiold A/S
- No. 0808: Dosing small amounts of liquid feed
- No. 0901: Surface treatment of concrete floors
- No. 0902: Farrowing pens with partially solid floor – with supplementary slatted floor in the pen side opposite the creep area
- No. 0903: Harvest and storage of corn
- No. 0904: Interventions against tail-biting – effect of penning, resources, climate and ventilation
- No. 0905: Liquid feeding of lactating sows - regular vs liquid feeding with no residue
- No. 0906: Volume of liquid feed
- No. 0907: Biofilter combined with a chemical air cleaner from ScanAirclean A/S
- No. 0908: Finishers in large pens with scales for sorting the pigs
- No. 0909: Gastric health of sows given industrial feed

Other reports

- No. 32: Management of the gilt's first heat
- No. 33: International competitiveness of Danish pig production
- No. 34: Mixing feed on-farm

Trial reports

- No. 824: Source separation with pit ventilation
- No. 825: Additional iron for lactating sows

- No. 826: Bergazym P in feed mixed on-farm
- No. 827: Finisher facility with biological air cleaning from Skov A/S – effect of filter area at maximum ventilation rate
- No. 828: CLA for finishers from approx. 4 weeks before slaughter
- No. 829: Nesting material in farrowing pens
- No. 830: Test of filter area and demonstration of Farm AirClean BIO module from Skov A/S in a weaner facility at maximum ventilation
- No. 831: Comparison of treatments for Lawsonia diarrhoea in two herds
- No. 832: Glycerol for weaners
- No. 833: Vaccination against post-weaning diarrhoea
- No. 834: Segregation of liquid feed
- No. 835: PCV2 dynamics
- No. 836: Voluntary examination of participants at Pig Research Centre's Congress in October 2008
- No. 837: Meal vs pellets for sows
- No. 838: Ammonia emission from a control service facility and a gestation facility with group-housing
- No. 839: Farrowing course in fertile, Danish sows
- No. 840: Effect of vaccinating with Porcine Circovirus type 2 – a meta-analysis of existing studies
- No. 841: Gestating sows' use of ESF and correlation between sows' deviant behaviour and heat/disease
- No. 842: Central air cleaner from ScanAirclean A/S in a combined weaner and gilt facility
- No. 843: Comparison of effect of three protein levels in finisher feed on ammonia and odour
- No. 844: Fermented grain for WTF pigs

- No. 845: Housing pigs according to gender - importance to tail-biting
- No. 846: DAKA Porcine Plasma and zinc for weaners
- No. 847: Several daily feedings in the lactation period reduce the risk of shoulder ulcers by 30%
- No. 848: Ronozyme WX for finishers

Other information material

- Statutory hospital pens
- Daily supervision of animals
- Ten point plan for handling of tail-biting
- Rooting and enrichment material
- Tail-bites – suitable for transport?
- Lameness – suitable for transport?
- Pain relief during castration
- 6 good pieces of advice for a successful DANISH audit
- Can the sow handle one more litter?

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