# MANAGING WEANING DISTRESS

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The pig industry worldwide accepts levels of physical performance in the week to month following weaning, that are extremely poor. Excuses for this range from the 'fact' that such performance is inevitable and that even if the pigs perform poorly it doesn't matter as they will "catch up" later. The "inevitability syndrome" comes from the "fact" that farmers believe that piglets undergo such a severe physiological change after weaning i.e. shorter villi, reduced enzyme secretion and activation of the immune system, that better performance is an impossibility.

Before proceeding further, it is important to show that such "facts" need to be questioned. *Zijlstra, Whang, Easter and Odle (1996)* conducted a trial where piglets were (1) allowed to continue suckling (2) weaned onto dry feed or (3) fed milk replacer, together with dry feed in the period immediately after weaning. Their results showed that where feed intake was maintained after weaning, the pigs out performed those left on the sow. So the "fact" that piglets must perform badly after weaning is not a fact, at all. (Table 1)

Table 1: Effect of weaning regimen on daily gain of early weaned pigs in the early post weaning period.

| | | **TREATMENT** | |
|---|---|---|---|
| | **Suckled** | **Milk Replacer +** | **Starter Diet +** |
| Average Daily Gain (Day 18-25 ) g | | | |
| All Pigs | 288 | 471 *** | 123 *** |
| Large | 296 | 487 ** | 122 ** |
| Small | 280 | 455 ** | 125 ** |

+ Pigs weaned at 18 days of age
** Differed from suckled pigs (P20 – 01) (P<0.01)
*** Differed from suckled pigs (P20 – 001) (P<0.001)

*From Zijlstra et al (1996)*

**Weaning Distress**

So why do weaned pigs generally perform so poorly? To answer this question, we will consider features which make weaning a stressful event and what can be done to relieve these problems as much as possible.

The event of weaning has long been associated with the word – "Stress", which the late Prof. Moberg (2000) described as "the biological response elicited when an individual perceives a threat to its homeostasis". In addition, he suggested that, "When the stress response truly threatens the animal's well-being, then the animal experiences 'distress'".

In the field of pig production no one has a management system that endeavours to "stress" any animal or group of animals. However, performance results suggest that this may occur in the period immediately after weaning.

Using diagrammatic schemes (Figures 1 and 2), the late Prof. Moberg (2000) illustrated what happens to allow individual episodes of stress, either singularly or collectively, to become damaging to the physical performance of the animal.

*Figure 1* :

**Stress Response**

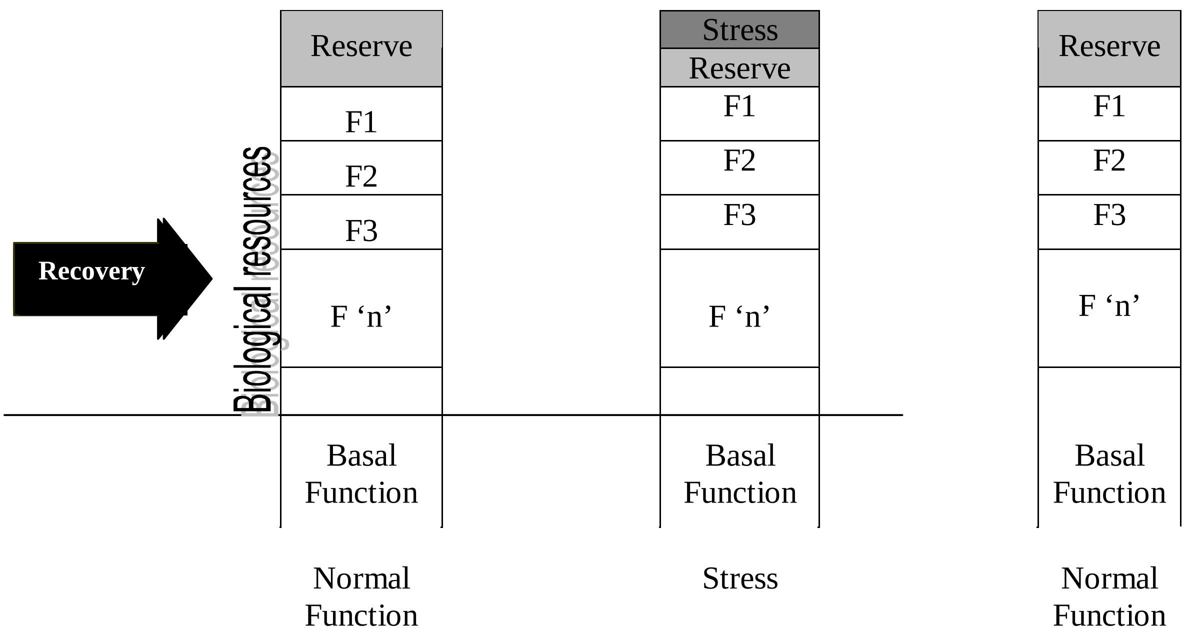



*Figure 1:* *A hypothetical scheme of how mild stress diverts biological resources. During mild stress, only reserve resources are used to cope with the stressor. The total stress response extends from the time biological resources are diverted until the reserves have been replenished.*

*From Moberg (2000)*

In the first of these schematic presentations (Figure 1), a single mild stress is shown to cause no problem to the performance of the animal as any nutrient needed to "cope" with the stress, can be withdrawn from reserves. After the "stress" disappears, these reserves are quickly replenished and there is no long-term impact on the animal. In the second case (Figure 2), an additional stressor results in such a diversion of reserves to counter the threat, that insufficient resources are available to maintain the usual level of biological function. Obviously, the stress level that causes an impact on biological function may be of one type at a very high intensity or multiple individual stressors, at moderate to low intensity, if they occur at the same time.

*Figure 2:*

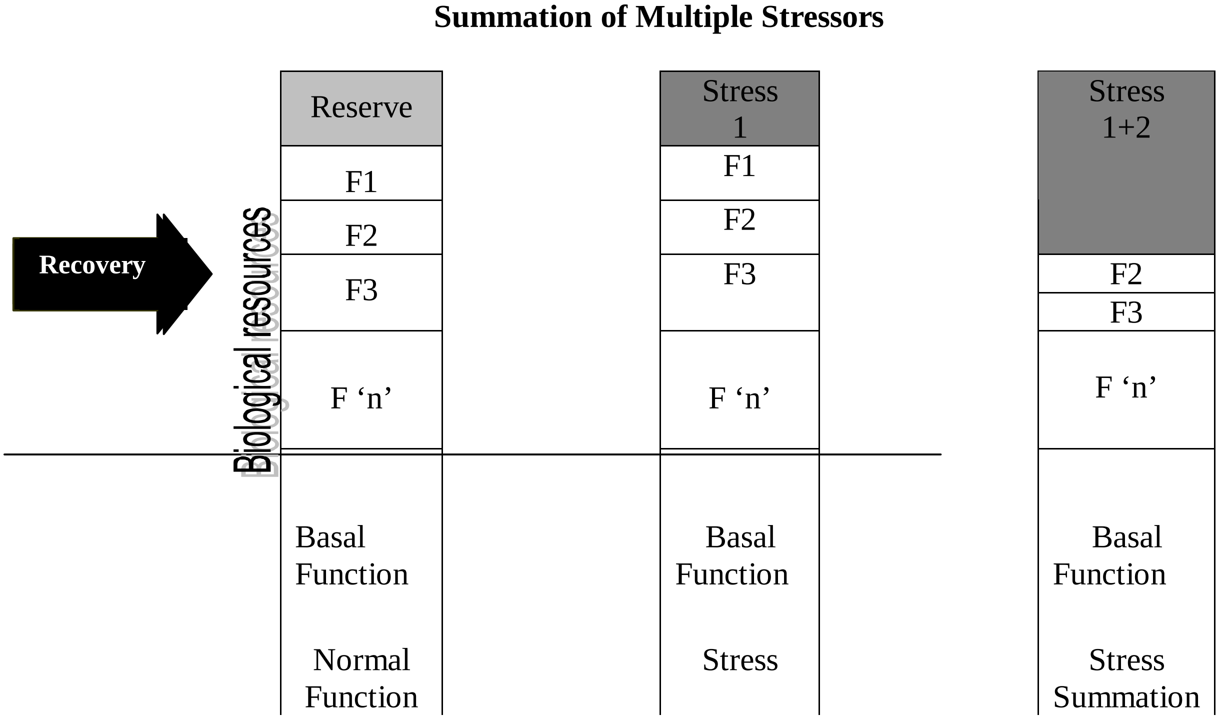



*Figure 2:* *A hypothetical scheme showing how the biological cost of two stressors can summate to impair normal function. As illustrated, exposure to only one stressor might not require the diversion of biological resources needed for other functions. If, however, two of these stressors occur simultaneously, the total cost may have a severe impact on other biological functions.*

*From Moberg (2000).*

Figure 2 illustrates the fact that the response shown to being subjected to a stressor or stressors will depend on their number, severity and/or duration. The impact of stress may be manifested as a reduction in growth rate, milk production or reproductive performance.

Professor Moberg's point is illustrated by the work of Hyan, Ellis and Johnson (1998) who compared the performance of pigs from 35 kgs over 28 days, when they were exposed to different levels of "stresses" – i.e. temperature, space and social environment. Their data showed (Table 2 ) that when the animals were exposed to one stress their performance fell, with the level of fall being dependent on the stressor. Exposure to two stressors simultaneously caused a further reduction in growth, with a third stress not reducing performance any further.

One feature which did show a consistent relationship to the imposition of one and two stressors was feed intake. One stress was shown to reduce intake by 10%, while 2 or three stressors resulted in a further 10% reduction when compared to the control animals.. Why the stressor reduced intake was unknown and how this effect was achieved was not defined.

Table 2: Treatment effects on pig performance over the 4 – week experiment

| Treatment | | | Performance | | |
|---|---|---|---|---|---|
| High temperature | Restricted space allowance | Regroup | ADG, g | ADFI, kg | Gain : feed |
| - | - | - | 876[b] | 2.18[b] | .40[b] |
| + | - | - | 792[bc] | 1.99[cd] | .40[b] |
| - | + | - | 734[cd] | 2.00[cd] | .37[bcd] |
| - | - | + | 777[bc] | 2.01[bc] | .39[bc] |
| + | + | - | 608[e] | 1.80[e] | .34[d] |
| + | - | + | 676[de] | 1.83[cde] | .37[bcd] |
| - | + | + | 657[de] | 1.88[cde] | .35[cd] |
| + | + | + | 606[e] | 1.85[cde] | .33[d] |
| Pooled SE | | | 34.8 | .059 | .015 |

[-] No stress was applied
\+ Stress applied
[b,c,d,e] Means within a column with different superscripts differ (P< .05).

*From Hyan et al (1998)*

The introduction has shown that if pig performance is to meet the highest standards, it is imperative that stress (es) do not reach a level where essential nutrients are diverted from tissue maintenance or tissue growth and that feed intake is not impaired. In the following section, factors that can contribute to the diversion of nutrients to fight stress will be considered.

**Weaning**

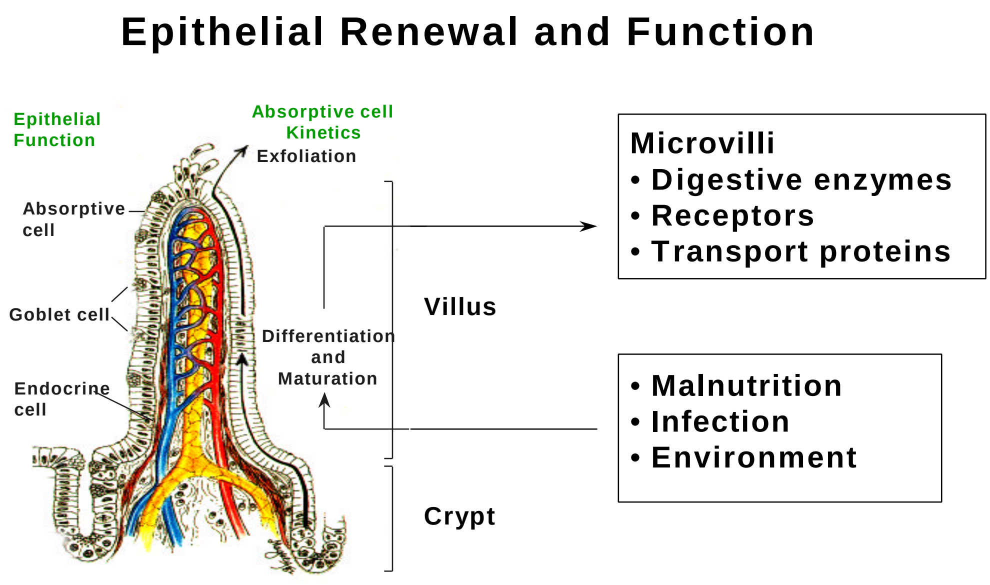
In pig production, one of the periods when the animal is most at risk of multiple/persistent stress, is in the initial days following weaning. Over this period there are a number of traumatic events taking place

- Removal from the physical presence of the mother
- Removal of the Immunoglobulin protection supplied by the milk of the sow
- Mixing with piglets from other litters
- Disruption of the social hierarchy
- A dramatic reduction in the level of nutrient intake
- A change from liquid milk to solid feed containing vegetable protein and carbohydrate
- Exposure to diseases/sanitary conditions that cause infection or subclinical disease
- Dramatic development of the immune system of the piglet from passive to active immunity.

Before considering the practical impact of weaning on performance, a brief consideration will be given to the structure of the gut and the physical changes which occur after weaning.

## Intestinal Structure

*Figure 3:*




*From: Tang et al (1999)*

The small intestine (duodenum, jejunum and ileum) consists of a series of projections (villi) that protrude towards the center (lumen) of the gut. On their outer surface (epithelium) these villi have a series of cells that form a barrier to gut content gaining immediate entry into the tissues of the intestine or beyond *(Figure 3*). In addition, some cells in the epithelium, known as Goblet cells, secrete mucus that acts as a further layer of defense *(Figures 4 and 6)* to prevent bacteria attaching to the surface or damaging it by toxic secretions. Other cells (endocrine cells) are capable of secreting hormones into the gut or systemic system.

*Figure 4:*

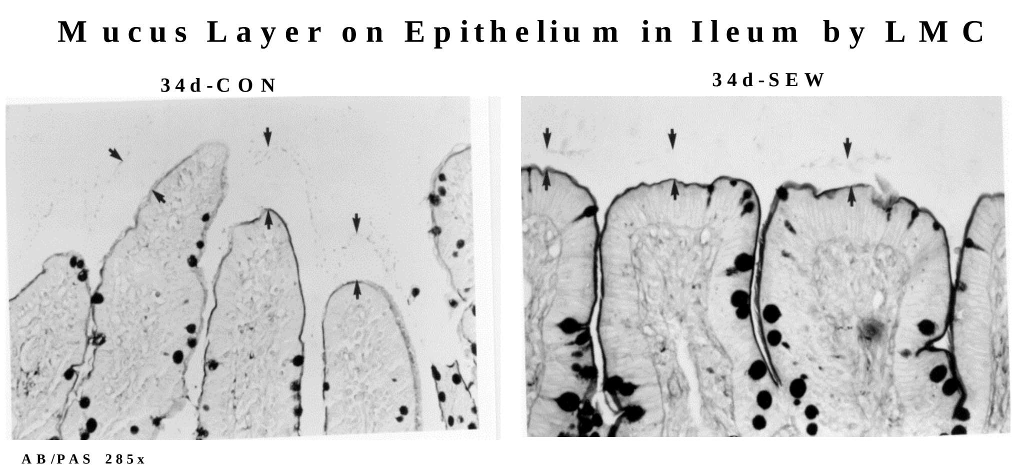



*Figure 4: Light micrographs of mucosal epithelial in ileum of a 34-d-old CON (A) and a SEW (B) pig. Thickness of mucus layer is indicated using arrows (AB/PAS x 285).*

*From Tang et al (1999)*

All these epithelial cells originate from a structure at the base of the villus, known as the “Crypt of Lieberkuhn” (Crypt) and migrate from there to the tip of the villus where they slough off. The older epithelial cells (located towards the tip of the villus) have either the greatest absorptive or greatest secretory capacity of all the cells on the villus surface. As the cells are generated at a constant rate the longer the villus is, the greater the absorptive capacity available to the animal. It has been suggested that comparing the crypt depth to the height of the villus can assess the absorptive capacity of the villus – with the greater figure indicating increased absorptive capacity.

At weaning villus length shortens and it was thought that this developmental change in intestinal structure was an inevitable consequence of weaning. However, Pluske, Williams and Aherne (1996) showed that a significant feature impacting on the structure of the intestine following weaning was the level of food (milk or solid) eaten by the piglet at this time. In their study piglets were either killed at weaning (1), or five days after weaning having been fed under the following treatments, dry starter feed ad libitum (2), Cows milk at maintenance (3), Cows’ milk at 2.5 times maintenance (4), or cows’ milk ad libitum (5) (Table 3).

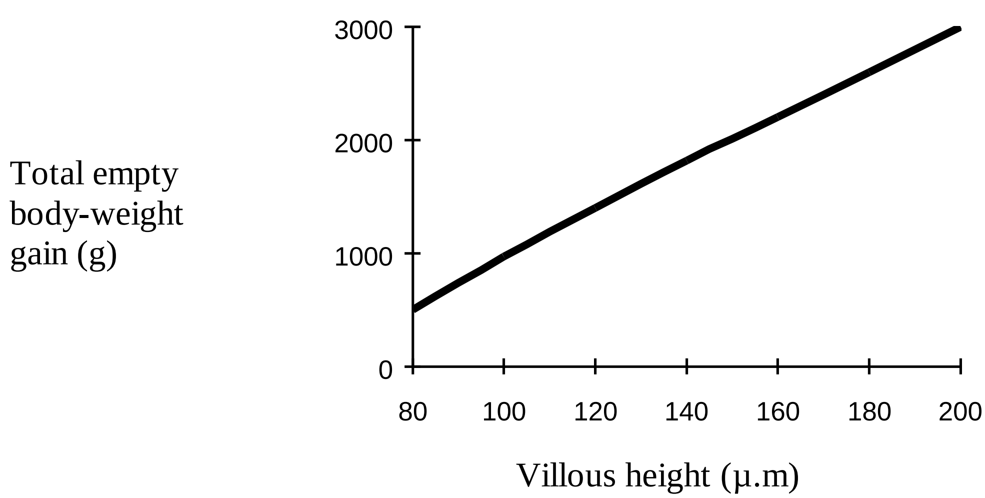
Table 3: Effect of feed intake on piglet performance and gut morphology post weaning.

| | **TREATMENT** | | | | | |
|---|---|---|---|---|---|---|
| | **1** | **2** | **3** | **4** | **5** | |
| Weaning Weight (Kg) | 8.9 | 9.0 | 9.1 | 9.2 | 9.2 | |
| Empty Body Weight Gain (g) | - | $231^{a}$ | $49^{b}$ | $253^{a}$ | $463^{c}$ | *** |
| Voluntary Daily Feed Intake (g) | - | $286^{a}$ | $102^{b}$ | $234^{a}$ | $400^{c}$ | *** |
| FCR | - | 1.0 | - | 1.1 | 0.9 | |
| Villus Height (um) | $449^{a}$ | $366^{b}$ | $330^{b}$ | $432^{a}$ | $499^{c}$ | *** |
| Crypt Depth (um) | 114 | $157^{c}$ | $119^{a}$ | $141^{b}$ | $151^{bc}$ | ** |

Figures with different superscripts differ significantly

*From Pluske et al (1996)*

Their results showed (Table 3) that feed intake was positively associated with daily liveweight gain, villus height and crypt depth. In addition there was a significant positive correlation between villus length, crypt depth and empty body weight gain. *(Figure 5)*



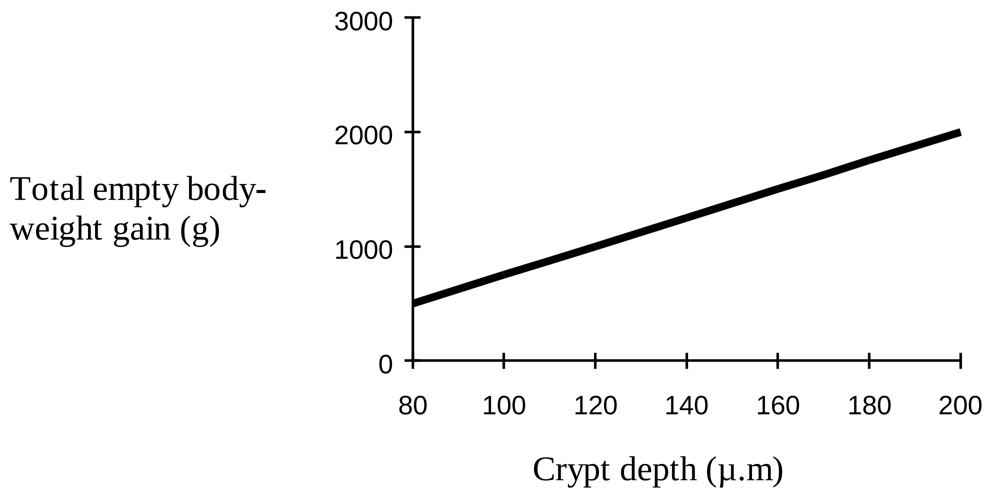



**Figure 5:** Relationship between (a) mean villous height and total empty body-weight gain ($y = -1788.3 + 7.24x$, $r = 0.68$, $P = 0.002$; no. = 22) and (b) mean crypt depth and total empty body-weight gain ($y = 919.3 + 15.86x$, $r = 0.45$, $P < 0.05$; no. = 22) for pigs receiving cows' liquid milk.

This finding was confirmed recently by McCracken, Spurlock, Roos, Zuchermann and Greskins (1999) who also found gut architecture significantly altered during the period of poor food intake immediately after weaning.

**Environmental Challenge**

A further feature impacting on the intestinal structure is the environment. The affect of a bacterial challenge to the structure of the small intestine is illustrated by the work of Tang, Laarveld, Van Kessel, Hamilton, Estrada and Patience (1999). Their research compared the intestinal structure of two groups of piglets that were weaned at 12 days of age, either into a conventional, (all in-all out) system (CON) or into a Segregated Early Weaning (SEW) environment.

The data showed (Table 4) that weaning resulted in a marked reduction in the length of the intestinal villi, in the duodenum, ileum and jejunum at 3 and 22 days after weaning, when compared to the situation before weaning. The ratio of the depth of the crypt to the length of the villus was significantly affected by treatment for the jejunum and numerically higher in the ileum 22 days after weaning. When germ-free pigs are compared to conventional animals this feature is also observed. Tang *et al*. (1999) suggested that the differences in the morphology in the intestine of these pigs at 22 days after weaning, meant that the CON pigs had more immature epithelial cells in the villus. This being due to the cells reaching the tip of the villus more quickly as it is shorter. This in turn would suggest that there was a reduction in the digestive and absorptive capacity of the intestinal tissue – following rearing in a CON environment.

Table 4: Effect of segregated early weaning (SEW) or on-site early weaning (CON) on small intestinal morphology in pigs

| **Region**[a] | **11-d pigs** | **15-d CON** | **15-d SEW** | **34-d CON** | **34-d SEW** |
|---|---|---|---|---|---|
| D | | | | | |
| Villus, *pm* | 777.4 ± 46.7$^{b}$ | 412.1 ± 14.6$^{c}$ | 438.7 ± 16.0$^{c}$ | 458.2 ± 13.3$^{cd}$ | 506.5 ± 12.6$^{d}$ |
| Crypt, *pm* | 171.7 ± 6.1$^{b}$ | 234.1 ± 11.5$^{c}$ | 242.1 ± 9.9$^{c}$ | 295.9 ± 11.8$^{d}$ | 294.9 ± 11.6$^{d}$ |
| J | | | | | |
| Villus, *pm* | 746.3 ± 44.3$^{b}$ | 405.4 ± 18.5$^{c}$ | 385.8 ± 12.1$^{c}$ | 473.1 ± 18.6$^{d}$ | 522.2 ± 12.6$^{d}$ |
| Crypt,*pm* | 181.3 ± 7.7$^{b}$ | 218.2 ± 11.1$^{c}$ | 213.3 ± 8.2$^{c}$ | 249.6 ± 12.9$^{d}$ | 210.1 ± 9.6$^{c}$ |
| I | | | | | |
| Villus, *pm* | 588.2 ± 22.8$^{b}$ | 374.6 ± 15.6$^{c}$ | 384.7 ± 13.2$^{c}$ | 400.6 ± 14.3$^{c}$ | 420.0 ± 10.1$^{c}$ |
| Crypt, *pm* | 154.7 ± 6.5$^{b}$ | 197.7 ± 9.4$^{c}$ | 221.8 ± 7.1$^{c}$ | 259.6 ± 11.4$^{d}$ | 204.4 ± 8.7$^{c}$ |
| V:C | | | | | |
| D, *pm/pm* | 4.5 ± .2$^{b}$ | 1.8 ± .8$^{c}$ | 1.8 ± .8$^{c}$ | 1.7 ± .6$^{c}$ | 1.9 ± .9$^{c}$ |
| J, *pm/pm* | 6.0 ± .3$^{b}$ | 1.9 ± .8$^{c}$ | 1.8 ± .6$^{c}$ | 1.5 ± .8$^{c}$ | 2.6 ± .1$^{d}$ |
| I, *pm/pm* | 3.9 ± .2$^{b}$ | 1.9 ± .7$^{c}$ | 1.7 ± .5$^{c}$ | 1.6 ± .7$^{d}$ | 2.2 ± .1$^{d}$ |

[a]D, duodenum; J, jejunum; I, ileum; V:C, villus height:crypt depth ratio.
[b,c,d] Mean ± SEM; within a row, means with a different superscript differ (9,<01).

*From Tang et al (1999)*

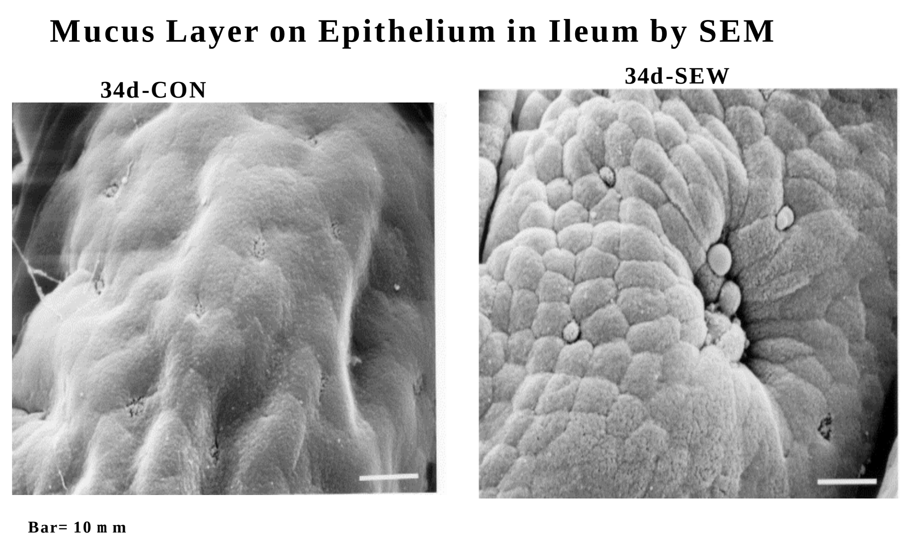



*Figure 6: Scanning electron micrographs of the ileal lumen for a representative CON (A) and SEW (B) pig showing variation in mucus covering.*

*From Tang et al (1999).*

Tang et al (1999) also recorded that a substantial amount of mucus (Figure 6) was secreted over the epithelial surface of the intestine of the CON pigs, relative to apparent absence of mucus in the intestine of the SEW pigs. The increased level of mucus in the CON environment was said to indicate the greater level of exposure that these animals have had to potential bacterial pathogens.

The function of the mucus is to protect the epithelial cells from the digestive enzymes secreted by the intestinal bacteria and provide a barrier to these potential pathogens gaining access to the intestinal epithelium. Unfortunately, the mucus may act as an impediment to nutrients being absorbed across the intestine wall as well.

Consequently, nutrient uptake may inhibited by both the mucus barrier and the reduced absorptive capacity of small intestine. This may contribute to the reduction in feed efficiency observed by many research teams when comparing CON and SEW pigs.

**Immune Activation**

While bacterial challenge may inhibit performance through direct inhibitor of nutrient intake, another cause of a reduction in post weaning performance is the activation of the piglets' immune system following bacterial infection.

One of the first teams to report observations in this area was led by Professor Tim Stahly at Iowa State University. Their work (Williams, Stahly and Zimmerman, 1993) which is illustrated in *Table 5*. This considered the affect on physical growth performance if a pig could be reared in an environment where it received little bacterial antigen challenge, rather than in one where the level of infection was significantly higher. In the research reported here and in other trials, this team showed that animals exposed to higher levels of bacterial challenge, grew less quickly and achieved this growth less efficiently than those reared in a "cleaner" environment.

Table 5 : Impact of level of chronic immune system (IS) activation on rate and efficiency of growth in pigs fed from 6 to 27 kilograms bodyweight.

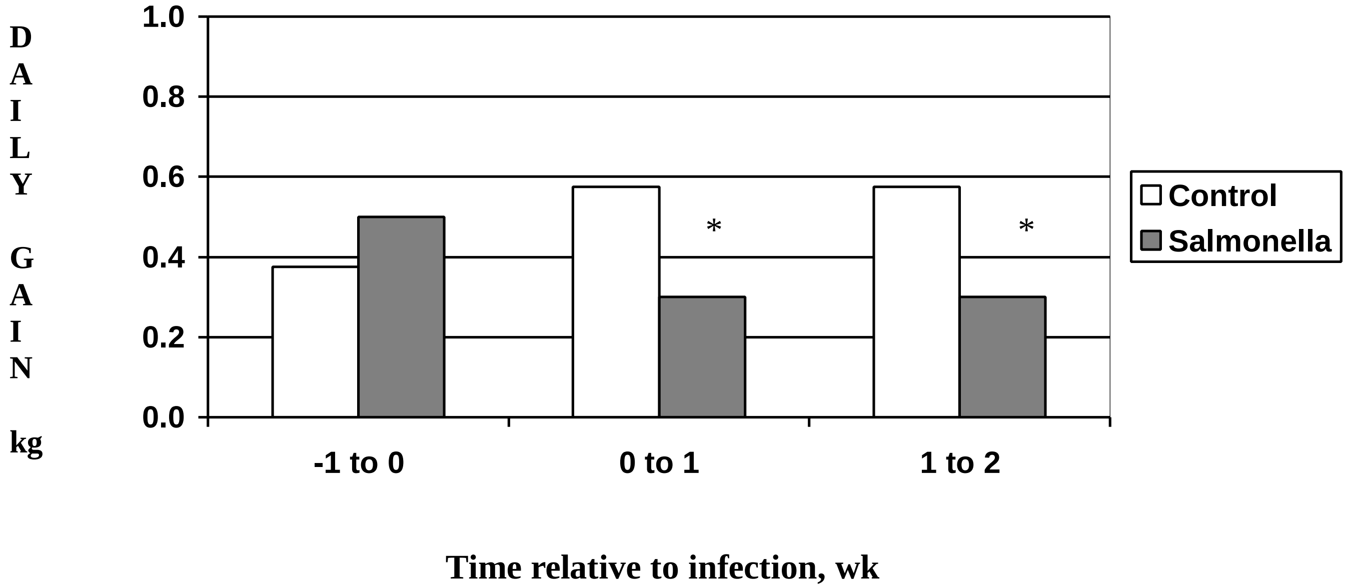
| **Item** | **IS activation** Low | **IS activation** High | **Unit Change** |
|---|---|---|---|
| **Pig body weight, kg** | | | |
| Initial | 6.4 | 5.9 | |
| Final | 27.2 | 25.9 | |
| **Growth and feed utilization** | | | |
| Daily feed, g | 973 | 863 | +110 |
| Daily gain, g | 676 | 477 | +199 |
| Feed/gain | 1.44 | 1.81 | -.37 |

*From Williams et al (1993).*

While other research groups have failed to replicate some of this work, the impact in practical terms has been enormous, with the widespread use of segregated early weaning and "all in all out" systems illustrating the point.

The effect has been reflected in other research where pigs have been directly infected with bacterial preparations. One such study, Balaji, Wright, Hill, Dritz, Knoppel and Minton, (2000) observed the affect of infecting pigs with *Salmonella typhimurium* on their growth rate after infection (Figure 7).

*Figure 7 :* *Daily body weight gain of pigs infected orally with $3x10^9$ cfu of S. typhimurium or given sterile broth. (* - P<0.001)*




*From Balaji et al (2000)*

Infected pigs showed a significant reduction in growth rate over the following three weeks when compared to the uninfected pigs. The feed intake of the treated pigs was only significantly less than that of the control animals for 120 hours after ingestion of the bacteria.

**Immune System Development**

Given the severity of the impact of the bacterial infection on animal performance reported above, one likely cause of the reduction in feed intake, Immune System Development, is considered below.

As a result of the placental structure of the sow, piglets enter the world with no immune antibodies. They achieve protection in the first hours of life by ingestion of maternal antibodies from the colostrum of their mother through their intestinal wall, which for a short period allows this transfer of intact, large proteins to occur. The limitation of this type of immune protection is that the mother must have been exposed to each specific bacterial species in the environment of the piglet, to create and transfer the appropriate protection to the young animal.

This systemic protection is augmented by the immunoglobulins present in the milk of the sow, which bathe the digestive system each time the piglet suckles. This “passive” immunity is gradually replaced after three to six weeks as the piglets begins to activate its own immune system. Active immunity occurs as a consequence of exposure of the individual pig to bacteria or feed/environmental antigens in their immediate environment.

An immune response can be caused by exposure of the host to antigens in the gut, the lungs, skin or through abrasions/cuts to any tissue. In this paper the organ that is discussed in relation to the immune reaction to bacterial challenge, is the small intestine. This is because it is the largest immune organ for all vertebrates, with one-quarter of the intestinal muscosal tissue comprised of lymphoid tissue (Gaskins, 1998). Furthermore, it is a major site of nutrient digestion and absorption so consequently is of extreme significance to a nutritionist.

When a pathogen (these may be referred to simply as an antigen in some publications) is ingested, some will attach to or be captured by cells referred to as "antigen presenting cells" (APC i.e. macrophages). These macrophages will transfer the antigen to T-lymphocytes that will stimulate either the secretion of compounds known as cytokines, the latter stimulate B-lymphocytes to change into antibody secreting cells (humoral immunity), or alternatively activate cellular immunity by causing the generation of cytotoxic T lymphocytes (CTL). (The latter is particularly relevant to the defense mechanism used by the body to fight viral infection.)

Acquired immunity is made more effective by cellular changes and the proliferation of memory cells, CTL and antibody secreting cells. These cells have unique receptors for the specific antigen which had been ingested, giving a much more rapid protection to the host if the antigen is ever encountered again.

The cyctokines (local or systemic hormones) secreted as a response to the identification of a particular bacterial antigen can have either a positive or a negative physiological impact (Gaskins, 1998). In general, treatment of humans with cytokines resulted in reduced food intake, an apparent lack of energy and the feeling that we all associate with conditions such as "influenza".

Gaskins (2000) detailed numerous cyctokines released in the mouse and human system, i.e. Interleukin (IL) 1 – alpha (IL-1a), IL-1ß, IL-6, IL-6, Il-8, Il-10 tumor necrosos factor – (TNF- a) transforming growth factors (TGF- a) and TGF- ß to mention but a few.

The Interleukin group was used by Roura, Homedes and Klasing (1992) to study the effect of antibiotic use on the level of immune response and subsequent growth of chicks. The birds were housed in a clean or dirty environment and, as might be expected, showed better performance in the clean situation (Table 6). In addition IL levels were significantly lower in the blood of birds receiving the antibiotics (100 mg/kg Streptomycin and 100 mg/kg Penicillin) when they were weaned in the dirty environment. Indeed circulating IL levels in the plasma of antibiotic fed birds raised in poor sanitation were similar to that of birds raised under very high sanitary conditions (Figure 8). Thus IL levels may act as a possible indicator of the immunological status of a particular herd or flock. This work showed that even when disease was not causing death or obvious illness, activation of the immune system caused a reduction in the growth potential of the animals.

Table 6: The influence of environment and antibiotic (AB) on weight gain and feed efficiency in chicks.

| **Treatment** | **Weight Gain (g) Chick - d** | **Feed Efficiency (g) gain / (g) feed** |
|---|---|---|
| Clean | 12.65[a] | 0.66[a] |
| Unsanitary | 12.10[b] | 0.54[b] |
| Clean + AB | 12.72[a] | 0.67[a] |
| Unsanitary + AB | 12.57[a] | 0.63[a] |

*From Roura et al (1992)*

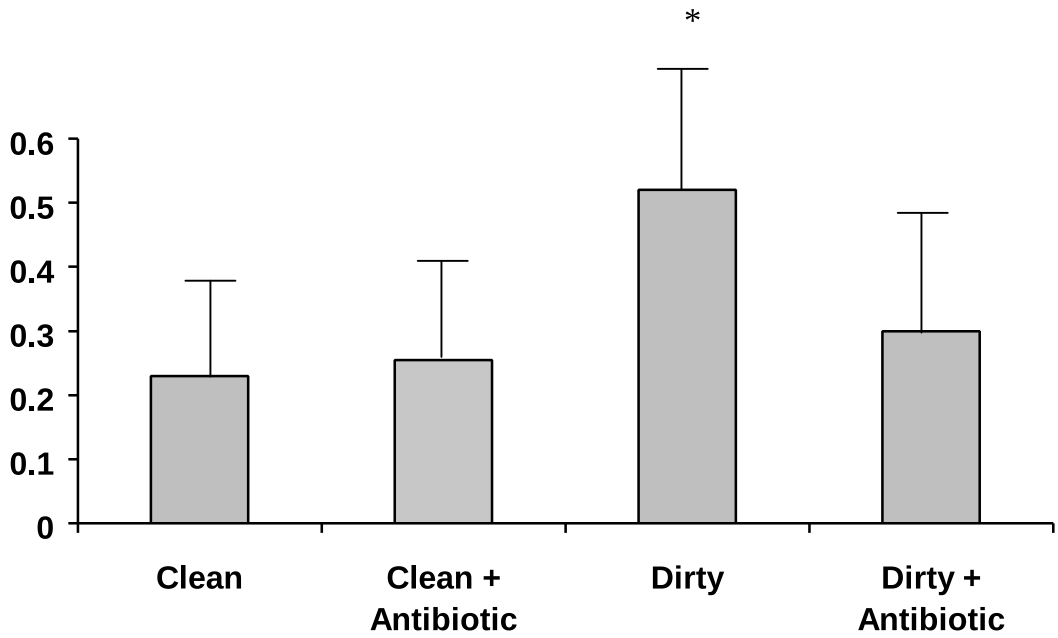



**Figure 8**: The influence of environment and antibiotics on plasma interleukin-1 (IL-1) of chicks. Each bar represents the mean ± SEM (*n* = 6) for each treatment. Asterisk indicates significant difference from the other means ($P < 0.05$).

From Roura et al (1992)

**Enzyme Production**

Previously, it was assumed that poor post weaning feed intake and subsequent performance was a reflection of a dramatic drop in enzyme production by the pig caused by the event of weaning. This idea was refuted by the work of Pluske *et al* (1996) which showed that if feed intake was maintained after weaning, enzyme output showed no significant reduction.

Table 7 shows that over a wide range of treatments, from feeding cows milk at maintenance to ad libitum, or ad libitum dry starter feeds, that the secretion of lactase and sucrase was not well related to piglet growth. As the authors explained, piglets given ad libitum cows' milk had 51% longer villi and grew 10 times faster than their contemporaries fed cows milk at maintenance levels, but expressed similar levels of enzyme secretion. There appeared to be little correlation between growth performance in the immediate post weaning period and enzyme activity.

Table 7 : Effect of post weaning diet and intake level on enzyme production.

| | | POST WEANING TREATMENT | | | |
|---|---|---|---|---|---|
| | **SUCKLING** | **Starter Diet** | **Maintenance** | **2.5M** | **Ad-Libitum** |
| Empty Body Growth Rate (gld) | - | 231 | 49 | 253 | 463 |
| Lactase Activity (umol/min/g protein) | 77$^{ab}$ | 105$^{a}$ | 80$^{ab}$ | 72$^{b}$ | 52$^{b}$ |
| Sucrase Activity (umol/min/g protein) | 65$^{ab}$ | 86b | 51$^{a}$ | 57$^{a}$ | 45$^{a}$ |
| Xylose absorption (mg/100 ml) | 22 | 16 | 20 | 18 | 16 |

## WHAT DOES ALL THIS MEAN TO PRACTICAL PIG MANAGEMENT

After considering the physiological aspects of the pig with regard as how they manage the change associated with weaning, brief consideration will be given to some practical steps that may be taken to minimize the “stress” associated with the period immediately after weaning.

### Segregated Early Weaning

A great deal has been written about the benefits of rearing pigs on more than one site. This data is exemplified by the report of Harris (1990). This data showed that where animals could be raised in an environment in which the disease challenge was reduced, this resulted in better physical performance Table 8 .

Table 8 : Average body weight (kg) of pigs procured via Isowean at 8-10 days of age from four different source farms.

| | Mean Weight | | | |
|---|---|---|---|---|
| **Age** | **65-74 (d)** | | **156-162 (d)** | |
| **Farm** | **I** | **C** | **I** | **C** |
| A | 25.48 | 23.31 | 92.42$^{d}$ | 85.78 |
| B | 23.70$^{d}$ | 17.68 | 92.51$^{d}$ | 80.53 |
| C | 24.03$^{c}$ | 21.94 | 92.46$^{a}$ | 82.69 |
| D | 20.88$^{d}$ | 12.52 | 91.73$^{b}$ | 86.07 |

*Isowean (I), controls (C), <0.01 ($^{a}$), <0.02 (sub), <0.05 ($^{c}$), <0.001 ($^{d}$) and standard deviation (*).*

*From Harris (1990)*

This effect has been demonstrated in a number of species, for example broilers, resulting in very strict hygiene and management regimes being employed on such farms. The concept of SEW is widely practiced and accepted, with refinements to the system making the idea easier to manage on farms independent of their size. The level of success achieved will be dependent on the disease(s) in the breeding herd and whether weaning pigs at a very young age will eliminate the disease transfer with the weaned animals.

## Human-Animal Interaction

One of the greatest sources of “stress” to the animals in a piggery are the people who look after them. The influence of the stock people on the growth and reproductive performance of pigs is well established. The effects are summarized in Table 9, taken from Hemsworth and Barnett (2000), where numerous studies were considered. The main features of the area of research has been to show that if the animal is afraid of the people looking after them, then the performance trait considered will show a significant reduction.

Table 9 : The effects of handling treatments on productivity and stress physiology of pigs in six studies.

| **Experiment and parameters** | **Positive Treatment** | **Minimal Treatment[1]** | **Negative Treatment** |
|---|---|---|---|
| Hemsworth et al. (1981a) | | | |
| Growth rate (11-22 weeks in g day$^{-1}$) | $709^{b}$ | - | $669^{a}$ |
| Cortisol concentrations (ng ml$^{-1}$)[2] | $2.1^{x}$ | - | $3.1^{y}$ |
| Gonyou et al. (1986) | | | |
| Growth rate (8-18 weeks, g day$^{-1}$) | $897^{b}$ | $881^{ab}$ | $837^{a}$ |
| Adrenal cortex (mm$^{2}$) | $23.2^{a}$ | $24.9^{ab}$ | $33.1^{b}$ |
| Hemsworth et al (1986) | | | |
| Pregnancy rate of gilts (%) | $88^{b}$ | $57^{ab}$ | $33^{a}$ |
| Cortisol concentrations (ng ml$^{-1}$)[2] | $1.7^{a}$ | $1.8^{ab}$ | $2.4^{b}$ |
| Hemsworth et al. (1987) | | | |
| Growth rate (7-13 weeks, g day$^{-1}$) | $455^{b}$ | $458^{b}$ | $404^{b}$ |
| Cortisol concentrations (ng ml$^{-1}$)[2] | $1.6^{x}$ | $1.7^{x}$ | $2.5^{y}$ |
| Hemsworth and Barnett (1991) | | | |
| Growth rate (from 15Kg for 10 weeks, g day$^{-1}$) | 656 | - | 641 |
| Cortisol concentrations (ng ml$^{-1}$)[2] | 1.5 | - | 1.1 |
| Hemsworth et al. (1996a) | | | |
| Growth rate (from 63Kg for 4 weeks, kg day$^{-1}$) | $0.97^{ab}$ | $1.05^{b}$ | $0.94^{b}$ |
| Adrenal weights (g) | $3.82^{x}$ | $4.03^{x}$ | $4.81^{y}$ |

*$^{a,b}$ and $^{x,y}$ denote significant differences at $P<0.05$ and $P < 0.0$, respectively.*
*[1]Treatment involving minimal human contact.*
*[2]Average of blood samples remotely collected at hourly intervals form 0800 to 1700 h.*

*From Hemsworth and Barnett (2000)*

This is achieved by hormonal influences on the hypothalamus-pituitary axis, mediated in part by compounds such as cortisol. Stressful situations have been shown to lead to rapid increases in circulating cortisol. However, it is likely that there needs to be a prolonged period of stress to reduce performance and that this results from the interaction of a number of hormones acting together.

The message from this is that harsh treatment of animals will result in a reduction in physical performance. Thus good staff, motivated to consider the well-being of the animal will repay any investment in training that they receive.

## DIET INGREDIENTS

### Cereal Processing

Diets of high digestibility have been shown to maintain a gut structure similar to that of unweaned piglets ( Lawlor, Flood, Fitzpatrick, Lynch, Caffrey and Brophy, 2000). This trial compared the gut morphology of pigs fed a complex diet including uncooked cereals (A), with those fed the same diet including cooked cereals (B), a simple diet (C) and unweaned pigs(D). The results showed that the depth of the crypts was similar between treatments B and D, but reduced for animals on treatments A and C. This effect suggested that the weaned pigs had had difficulty digesting the uncooked cereals and the raw materials in the simple diet, but that feeding diets containing cooked cereals overcame this problem. (Table 10)

Table 10 : Mean Crypt depth (µm) ± s.d. of weaned and un-weaned pigs

| | TREATMENT | | | | |
|---|---|---|---|---|---|
| | **A** | **B** | **C** | **D** | **F test** |
| Duodenum | $349.9^{a}$ | $277.8^{b}$ | $341.6^{a}$ | $285.3^{b}$ | P < 0.05 |
| Jejunum | 280.9 | 280.9 | 270.3 | 252.7 | NS |
| Ileum | $249.1^{a}$ | $270^{a}$ | $253.7^{a}$ | $210.6^{b}$ | P < 0.05 |

*From: Lawlor <u>et al</u> (2000)*

In addition, the statistical greater number of Argentaffin cells (which have a function in increasing intestinal motility through the secretion of 5-hydroxylryptamine) may increase the rate of digesta transport, or reflect a faster digestion of the diets from treatments B and D, thus requiring more digesta to be transported.(Table 11)

Table 11 : Mean Argentaffin cell numbers per $mm^2$ of Crypt epithelium.

| | TREATMENT | | | | |
|---|---|---|---|---|---|
| | **A** | **B** | **C** | **D** | **F test** |
| Duodenum | $5.11^{a}$ | $9.96^{b}$ | $5.86^{a}$ | $8.35^{b}$ | P < 0.05 |
| Jejunum | 3.78 | 4.01 | 2.53 | 3.08 | NS |
| Ileum | 1.14 | 1.31 | 1.23 | 0.74 | NS |

*From: Lawlor <u>et al</u> (2000)*

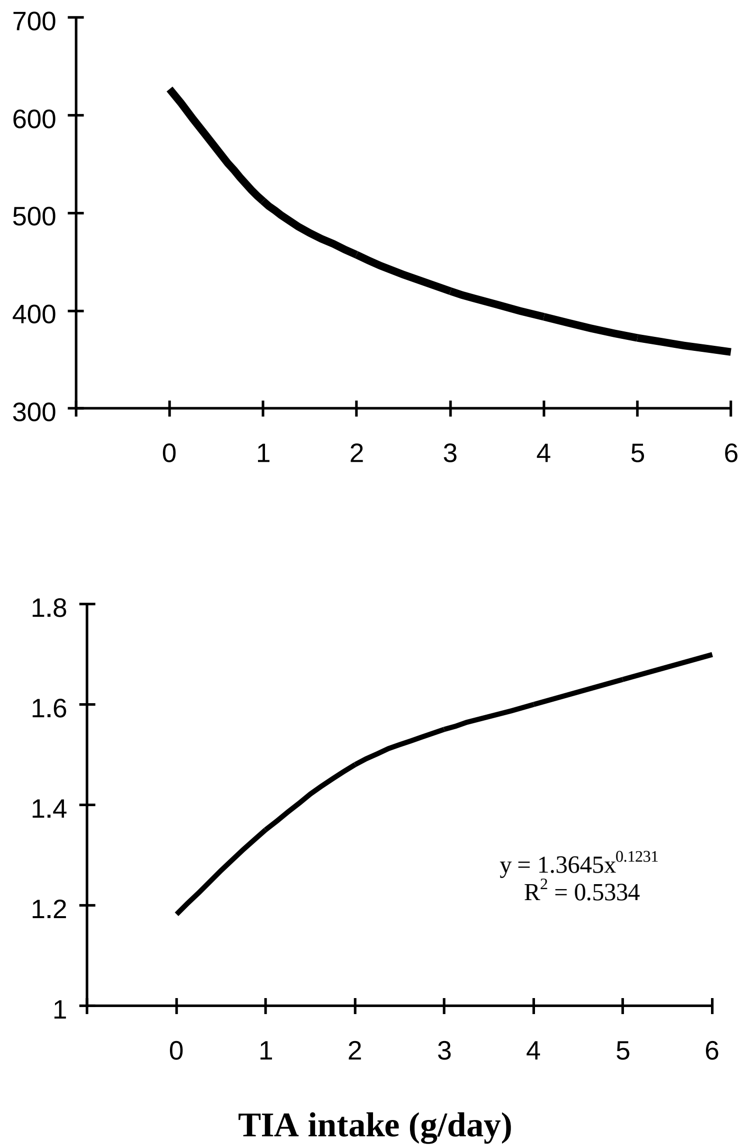
Simple modifications to the diet such as cooking the cereals is shown to impact on the digestive physiology of the piglet.

**Soya Beans**

Soya Beans contain an antigen, the level of which can be monitored by measuring the level of trypsin inhibitor activity (TIA) in any particular batch of the material. The TIA level is significantly influenced by the processing method used in the preparation of the beans.

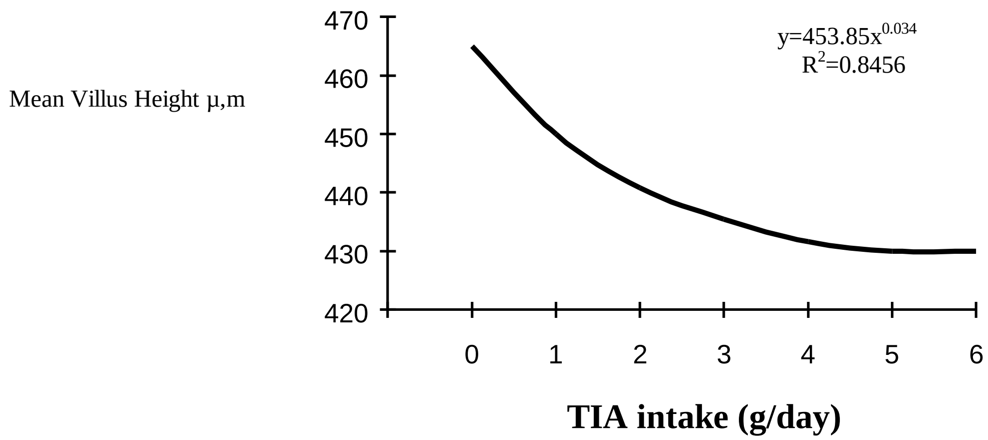
Zarkadas and Wiseman (2000a and b) reported research that studied the impact of full fat soya bean (FFSB) on the growth rate and gut morphology of weaned piglets. The results showed that to maintain optimum performance the TIA intake should remain low (i.e. between 0.5 to 1.5 g/day). Their results, in terms of both physical performance and villus height are illustrated in Figure 9 and show the inhibitory affects of poorly processed soya products on piglet growth.

**Figure 9: Means of growth rate and feed conversion ratio in relation to daily TIA intakes for both experiments with micronized (o) and extruded (x) FFSB diets**




From Zarkadas and Wiseman (2000 a)

**Mean Villus Height in relation to daily TIA intake from micronized (o) and extruded (x) FFSB diets**




From Zarkadas and Wiseman (2000 b)

**Liquid versus Dry Feed.**

The effect of weaning on feed intake has been illustrated by comparing the growth rate of pigs suckling, against those that are weaned. Results have shown that weaned pigs grow significantly more slowly after weaning, but their performance can be improved by giving the piglets access to a diet of liquid milk. (Table 1)

Feeding liquid milk has little application in commercial pig production, but considerable work has been conducted to investigate the impact of feeding liquid diets to weaned pigs based on conventional raw materials. This work, illustrated by research carried out at the Moorepark Research Centre in Ireland, has shown that wet feeding can achieve growth rates comparable to piglets fed dry feed post weaning, but with a considerable reduction in the feed conversion efficiency
(Table 12)

Table 12 : Effect of feeding fresh wet-feed and acidified wet-feed on pig performance.

| | **TREATMENT** | | | |
|---|---|---|---|---|
| | **Dry** | **Wet-Fresh** | **Wet-Acid** | **F-Test** |
| Number of pens/treatment | 8 | 8 | 8 | |
| Number of pigs/pen | 14 | 14 | 14 | |
| Weights (kg) | | | | |
| Initial | 7.7 | 7.7 | 7.7 | |
| Day 27 | 18.6 | 18.8 | 19.5 | NS |
| Day 62 | 43.8 | 43.7 | 43.9 | NS |
| ADFI (g/day) | | | | |
| Day 0-27 | $531^{b}$ | $622^{a}$ | $616^{a}$ | ** |
| Day 0-62 | $983^{b}$ | $1,030^{a}$ | $1,005^{ab}$ | * |
| ADG (g/day) | | | | |
| Day 0-27 | 408 | 416 | 433 | NS |
| Day 0-62 | 579 | 577 | 585 | NS |
| FCE (g/day) | | | | |
| Day 0-27 | $1.30^{b}$ | $1.50^{a}$ | $1.43^{a}$ | *** |
| Day 0-62 | $1.70^{b}$ | $1.79^{a}$ | $1.72^{b}$ | *** |

a,b Means in a row not sharing a common superscript differ significantly (P< 0.05)

Blanchard, Hiller, Perris and Toplis, (2000) reported that feeding a wet feed had a beneficial impact on gut integrity. The data showed longer villus length and more goblet cells on the villus. These effects would be expected to offer better nutrient absorption and protection of the gut from bacterial attack respectively. However, no physical data was presented to show whether the differences in gut integrity were reflected in the level of feed eaten, or what effect these differences had on growth performance.

In the United Kingdom, Professor Brooks at the University of Plymouth has pioneered the use of fermented feed to improve growth rates post weaning. Unfortunately, this success in the confines of the University has not been translated into improved performance in the field situation. Indeed, in Ireland, farms that have attempted to feed fermented diets have reported a reduction in growth performance and a dramatic increase in the quantity of feed required to achieve that gain. Obviously, improvements in the stability of the fermented mixture and feeder design may make this an area that deserves further investigation. However, in the short to medium term, liquid feeding does not appear to give any advantage in terms of piglet growth, over dry feeding post weaning.

**Feeding Programme**

After weaning the dietary programme that is selected can have a marked effect on the level of performance that is achieved. This was illustrated by two research projects undertaken in Ireland over recent years.

The first, completed at the Teagusc Research Center, Co. Cork and reported by Kavanagh (1995), considered the impact of feeding various quantities of high density baby piglet diets post weaning.

The piglets were fed according to the schedule shown in Table 13 with Diet 1 and 2 having the following chemical analysis respectively – Protein, 24 and 22.5; Lysine, 1.65 and 1.50% and Oil, 9.5 and 8.0%. The diets were made using milk products, cooked cereals, fish meal, soya products and oils.

This work showed that when the pigs ate more nutrient dense feeds (Treatment A), they grew more quickly and converted the food to tissue gain more efficiently. In addition, the data showed that the pigs did not compensate for the lower nutrient density of the diets in Treatment D, by increasing the level of consumption.

Table 13 :

**Effect of Level of Starter Diets on Piglet Performance after Weaning**

| | | TREATMENT | | | |
|---|---|---|---|---|---|
| | | **1** | **2** | **3** | **4** |
| **Starter 1** | **(Kg/Pig)** | 3.00 | 3.00 | 1.00 | 1.00 |
| **Starter 2** | **(Kg/Pig)** | 8.00 | 4.00 | 8.00 | 4.00 |
| **Weaner diet** | **(Kg/Pig)** | 1.32 | 4.62 | 2.98 | 6.84 |
| **TOTAL** | | **12.32** | **11.62** | **11.98** | **11.84** |
| **Start weight (kg)** | | 7.6 | 7.7 | 7.6 | 7.7 |
| **Weight at 26 days after weaning (kg)** | | 18.6 | 17.3 | 17.5 | 16.6 |
| **Average daily gain(g)** | | 422 | 371 | 381 | 341 |
| **Average feed intake (g)** | | 473 | 449 | 461 | 454 |
| **F.C.R>** | | 1.12 | 1.21 | 1.21 | 1.33 |

*From Kavanagh (1995)*

The second piece of research was conducted at the Agricultural Research Institute of Northern Ireland, Co. Down and was reported by Weatherup et al (1998). This work, compared the effect of two farm environments on the growth rate of pigs fed diets which differed in energy and protein (amino acid) content. The farm environments were a research station, where pigs were fed and managed individually and a commercial farm where pigs were held in groups of 20. The protein levels of the diets used in the trial did not impact on the pig performance data, so the latter was combined to show the effects of the energy levels in the diet on performance. Four levels of diet energy were used, with the major raw materials being maintained as far as possible.

Table 14 : The effect of energy level on intake and growth performance of individually housed pigs (Research Station).

| | Energy level (MJ/kg) | | | | |
|---|---|---|---|---|---|
| | **15.4** | **14.4** | **13.4** | **12.4** | **P** |
| ADG (g/d) | 865 | 882 | 831 | 846 | NS |
| DFI (kg/d) | $1.52^{a}$ | $1.59^{a}$ | $1.6^{ab}$ | $1.69^{b}$ | <0.001 |
| FCR | $175^{a}$ | $1.81^{a}$ | $1.9^{b}$ | $2.05^{b}$ | <0.001 |

Table 15 : The effect of energy level on intake and growth performance of group housed pigs

| | Commercial Farms Energy level (MJ/kg) | | | | |
|---|---|---|---|---|---|
| | **15.4** | **14.4** | **13.4** | **12.4** | **P** |
| ADG (g/d) | $642^{b}$ | $635^{b}$ | $594^{a}$ | $573^{a}$ | <0.001 |
| DFI (kg/d) | 1.12 | 1.12 | 1.16 | 1.16 | NS |
| FCR | $1.75^{a}$ | $1.77^{a}$ | $1.96^{b}$ | $2.03^{b}$ | <0.001 |

*From Weatherup et al (1998)*

The work (Table 14 and 15) showed two highly important effects

1. Individually housed and fed pigs on the research farm ate 40% more and grew 40% more quickly, than those housed in groups of 20 on the farm.
2. Pigs on the commercial farm were unable to increase the quantity of feed eaten, even though the energy density of the diets tested ranged from 12.4 to 15.4 MJ Digestible Energy/ Kg.

These two trials showed that in a commercial farm situation, where environment and social stresses may be high, animal responses to diets might not be in line with research / academic expectation. The main point is that the energy intake of these pigs was not maintained when the diet was diluted.

Most nutritionists have been taught that pigs will compensate for a reduction in diet density by eating more – this does not appear to happen in the commercial environment.

**Feeder Design**

One of the main causes for this poor post weaning performance is the fact that piglets do not eat enough feed to satisfy their requirements for maintenance and tissue growth over these initial two to three weeks.

Table 16: Effect of Feeder Design on Piglet Performance Post Weaning.

| | **FEEDER TYPE** | | | | |
|---|---|---|---|---|---|
| | **Dry Multispace** | **Wet And Dry Multispace** | **Maximat** | **Lean Machine** | **Verba** |
| **Food Intake (g)** | | | | | |
| Day 1 | 77 | 61 | 103 | 125 | 54 |
| Day 2 | 137 | 129 | 173 | 177 | 159 |
| Day 3 | 174 | 183 | 204 | 208 | 200 |
| Day 4 | 181 | 208 | 198 | 210 | 206 |
| Day 5 | 196 | 222 | 210 | 199 | 208 |
| Day 6 | 227 | 250 | 253 | 220 | 204 |
| Week 1 | 165 | 176 | 190 | 189 | 172 |
| Week 2 | 411 | 402 | 406 | 400 | 402 |
| Week 3 | 714 | 707 | 673 | 678 | 707 |
| Average Daily Gain(g) | | | | | |
| Week 1 | 161 | 123 | 163 | 104 | 107 |
| Week 2 | 378 | 420 | 360 | 413 | 397 |
| Week 3 | 530 | 496 | 522 | 508 | 556 |

*From Beattie (2000)*

Dr Violet Beattie and her team conducted the work presented in Table 16 , at the ARINI, Co. Down. They compared the feed intake achieved by piglets given access to different feeder types after weaning, while feeding identical diets. The data has shown that all piglets recorded very low feed intake levels in this immediate post weaning period. This is particularly apparent, if it is assumed that their intake of milk and solid food should have been in the order of 300 - 350 grams per piglet per day prior to weaning.

The second point that this work illustrates is that there is no magical piece of equipment that is going to replace the need for effort, when it comes to trying to get piglets to eat in the first few days after weaning. Commercially, it has been observed that supplying more round, plastic feeders in the first 5 to 7 days after weaning and feeding 3 to 5 times per days stimulates feed intake levels. The important features appear to be that the pigs can eat in groups, perhaps even family groups, and that they can observe their new pen mates while they eat.

Table 17:

**Comparison Of Feed Intakes Following Weaning**

| Day | Beattie (2000) | Pluske (1996) |
|---|---|---|
| 1 | 84 | 110 |
| 2 | 155 | 250 |
| 3 | 194 | 290 |
| 4 | 201 | 360 |
| 5 | 207 | 405 |

Finally comparison of the average feed intake figures achieved by Beattie (2000) compared to that of piglets on dry starter feeds from the experiment of Pluske etal(1996), shows the extent to which the feed intake of commercial piglets are compromised after weaning. (Table 17) This is particularly worrying as the management and welfare standards at the ARINI would be considered excellent relative to the best commercial farms.

**Conclusions**

Significant changes to the physiology of the piglet post weaning are associated with the fall in growth rate. However, great care must be made when trying to decide whether the change has been the cause of the performance deterioration or merely coincidental to it.

Activation of the immune system has been associated with poor growth rates, but attempts to reduce this with micro or macro nutrients has shown variable results.

One feature that appears to be of critical importance in the maintenance of post weaning growth is feed intake. Throughout the paper a reduction in feed intake has been shown to be associated with reduced physical performance. The reasons why intake has fallen in almost all of these cases may differ, but the result is always the same – reduced physical performance.

Feed formulation which minimizes digestive upset and antigenic reaction will help maintain performance. Even use of cooked cereals has been shown to influence post weaning gut morphology, so subtle change to the diet must be contemplated with great caution.

Under commercial environments the use of high density diets has led to improved physical performance. (Kavanagh 1995 and Weatherup et al 1998) It is important to remember that this is not just an academic exercise but a matter of significant financial importance. Understanding why feed intake falls and developing strategies to minimize this fall will, I feel reap very significant financial rewards.

It is unlikely that post weaning performance will achieve genetic potential until all aspects of the piglets' environment and nutrition are considered together. Spending more time with the young animals immediately after weaning, to encourage them to eat might be money very wisely invested.

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