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Guidelines for Fostering
Getting the "One per centers" right

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Farrowing Management-Fostering Know How

Making sure that every pig is well looked after in a farrowing shed can take a special kind of dedication as well as specialised management. Why is that? Because you have different groups of pigs that have different requirements and it's not only the differences in requirements that you would expect between adults and their offspring - the ages of piglets in the farrowing area can vary from newborn to 4 weeks plus and the needs of a piglet change as they grow. Pre-weaning mortality is the major cause of production loss in the farrowing area and it can vary greatly from farm-to-farm. Around 80% of piglet losses occur in the first 72 hours of a piglet's life and mortality also increases with increasing litter size. Good farrowing stockpeople look after large and varying populations of pigs while still managing to see and treat each pig as an individual. Getting the "one per centers" right and showing careful attention to detail is what is needed to care for all ages of pigs in the farrowing accommodation. This sets up the health of the herd and safeguards the robustness of replacement breeders. In the farrowing shed one of the most important tasks is fostering piglets. Successful fostering results from the careful management of many different animal care procedures for not only piglets but for the entire herd. The information in this manual is to assist farrowing stockpeople in the everyday tasks that impact on fostering success, especially the "one per centers".

1. Piglet and Sow requirements

Having the same animal at two very different stages of a life cycle can present a few problems as the needs for both differ dramatically. But if you do meet the requirements of both the sow and her litter, it can greatly simplify work in the farrowing sheds.

1.1 Sow Requirements

Basic needs for sows in the farrowing shed that you as a animal attendant can have an impact on are:

Correct temperature: Sows require an ambient temperature of about 18-20°C. At this temperature, sows eat well and stretch out at rest. Below this temperature, sows will eat more and tend to "hunch" their bodies in an attempt to reduce heat loss. Above this temperature, sow appetite and feed intake is reduced, and they can become heat-stressed, all of which can interfere with milk production. Heat stressed sows are also more likely to have stillborn pigs.

Correct feed (type and amount): Sow feed is formulated according to the needs of the sow at the different stages of production. Different genetic companies may have different pre-farrowing feeding recommendations for the sows they produce. Namely:

- Some may recommend that sows are fed to a restricted level before they farrow with feed levels increasing after farrowing and when it becomes obvious the sow's appetite is increasing.
- Other pre-farrowing feeding programs recommend placing the sows on ad-lib feed at day 114 of gestation. Generally the next day, the sow's appetite is a bit reduced but it will usually return within a day. On the day of farrowing, sow appetite will probably also be less than usual, but appetite returns to normal (eating ad lib) a day or two after farrowing. This program works best on sows with a condition score of between 2-3 and that tend to have a gestation of 115+ days.

Other points to note when feeding sows are:

- Check that the sows ate their last feed;
- Clean feeders out of any stale or mouldy feed before adding new feed;
- Check that there are no sharp edges in feeder where sows could hurt themselves;
- If sows aren't actually farrowing, make sure they get up at feeding;
- Record how much feed a sow is eating each day (sentinel sows, once a month);
- To encourage sows to eat as much as possible each day, feed at least 3 times a day;
- Make an effort to feed the sows at the same time every day, and
- Report any problems with the feed (strange smells, colour, sows reluctance to eat) to the unit manager and leading hand

Water: Water needs to be available at the correct temperature and flow rate. Up to 10 litres of water per day are required just for inclusion into milk. Sows that produce large amounts of milk also have a high metabolic rate. This in turn increases their heat production and also their water requirement. Dry sows require on average 11 litres of water/day (can vary between 5-18 litres/day); lactating sows require on average 17 litres/day (can vary between 13-25 litres/day).

The flow rate of the drinker (output should be between 1-2 litres/minute) and also temperature of the water should be checked. Sows are a bit lethargic when it comes to drinking; they tend to prefer troughs, where they can drink large amounts of water quickly. So if a drinker doesn't have a sufficient flow rate (between 1-2 litres/minute), sows won't stay there drinking until they drink enough; they will drink a bit and then just lie down or move away. Sows that don't drink enough water, don't produce enough milk and the piglets' growth rates are affected.

Water intake will also be affected by both environmental and water temperature. An increase in the environmental temperature will result in increased demand for water, but pigs may refuse to drink water (even if the environmental temperature is quite high) if the water temperature is also high (eg. as a result of water pipes being in full sun).

Post-farrowing sow checks: Sows should also be checked carefully and frequently just after farrowing to make sure they are healthy and that their litters have settled and are feeding well. Sick sows may have:

- Abnormal discharges (copious creamy or bloody in colour);
- Gross engorgement and firmness of the udder i.e. touching the udder will leave "handprints";
- Sow and udder hot to touch, udder blotchy in appearance;
- Rectal temperature is greater than 40^0C;
- Sow has tendency to sit on udder;
- Sow is bloated;
- Sow may be constipated (hard rounded balls);
- Sow not urinating;
- If urinating, sow's urine dark with distinctive nasty odour;
- Sow reluctant to get up;
- Sow not eating, drinking and
- It's very difficult to draw milk from a teat

These symptoms may vary in number and severity, but if you are unsure, the best indicators of sow health are the piglets (Figure1).

Figure 1. Scouring litter of piglets (sow required treatment for mastitis).

If the sow is sick,

- The piglets tend to be unsettled;
- The piglets tend to crowd the udder line and try to sleep close to the sow (even if the heating in the piglet area is perfect);
- Piglets may have hollow flanks, facial fight marks, scrapes and abrasions on feet and joints from trying to gain access to teats, they may be scouring and
- Will "vocalise" (whinge, be sooky) for extended periods when other litters have settled.

TAKE HOME MESSAGES

Take care of the sow and she will be able to take care of her pigs. So…

- **Check she is comfortable**
- **Check she is eating**
- **Check she has water**
- **Check her litter, and**
- **Get involved sooner rather than later**

1.2 Piglet Requirements

Newborn piglets have two main requirements that must be met soon after birth if they are to survive. These are warmth and colostrum (Figure 2).

Figure 2. Heat lamps set up at the front, mid-way and rear of a farrowing crate. Rear heaters were turned off 24 hours post-farrowing. Heaters midway were turned off 48 hours post-farrowing.

Warmth: Temperature needs of piglets and sows differ dramatically. Newborn pigs have very little stored energy reserves. If their thermal requirements are not met, their energy reserves will be mobilised rapidly. Chilled piglets cannot compete for teats, suckle properly, are more susceptible to infections, can't get out of the sow's way quickly enough and are therefore at risk of being overlaid by the sow. There are a number of drying agents available that producers can use to dry piglets immediately after birth which reduces the risk of the piglets becoming chilled. The drying agents allow the pigs to dry off and get warm without using up too much energy, so they can direct more energy towards finding a teat and drinking colostrum.

The temperature requirements of the sows and piglets in the farrowing shed can be summarised as follows:

- SOWS
  - 18-20°C pre/post farrowing
- PIGLETS
  - 30-36°C first 48 hours
  - 30-32°C rest of the first week
  - 28-30°C second week
  - 26-28°C third week
  - 24-26°C fourth week

Piglets are very good indicators of the temperature of their creep area. You must look at the piglets carefully; interpreting their behaviour will give you the best idea of the temperature. If they're huddled in a pile directly under the heat source, or next to or on top of the sow - they're too cold (Figure 3).

Figure 3. Piglets huddling to keep warm. Lamp is set too high to provide sufficient heat.

If piglets are spread out well away from the heat source - they're too hot. So, adjust heater height accordingly. Also when piglets huddle next to or on top of the sow this can also mean they're sick; check crate surrounds and piglets carefully for signs of ill-health.

Colostrum: Colostrum is essential for the survival of many young animals because it is rich in energy and it is also the way that immunity is transferred from the mother to her offspring. Colostrum is very important and without it, piglets cannot survive.

TAKE HOME MESSAGES

Newborn pigs have very little stored energy reserves. If they get cold they can't compete for teats very well, suck properly, are more at risk to infections and are at greater risk of being overlain. So….make sure all lamps or heaters are working properly and lamps are set at the right height - check temperature at piglet level with a laser thermometer. Also check for draughts at piglet level using smoke pens. In farrowing huts, make sure there is sufficient straw to provide warmth and protection, but not too much so the piglets get lost and struggle to reach the sow.

2. The Importance of Colostrum

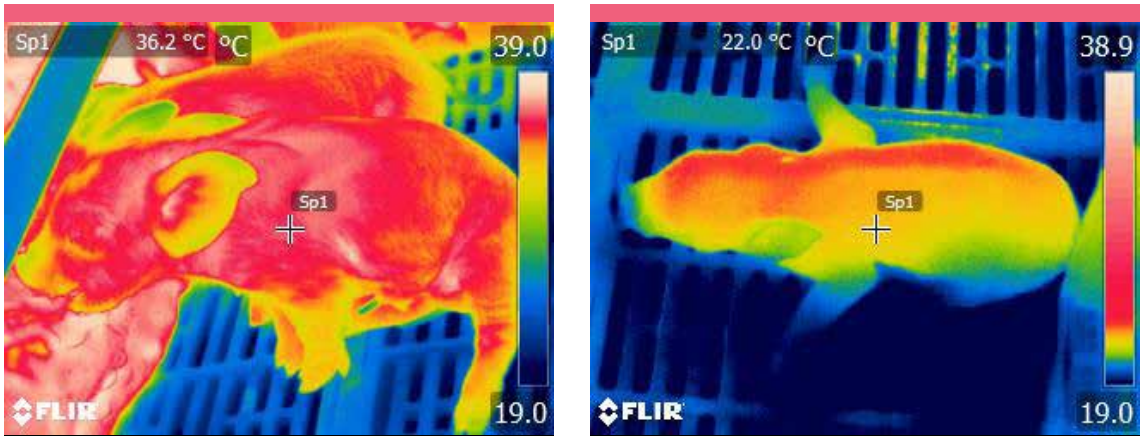
Colostrum is the first milk produced by a sow and other mammals as well. Colostrum can be gently squeezed from a sows teats for a few hours before birth and can flow quite freely during the birth. Its production decreases rapidly during the first 14 hours post-farrowing and has been completely replaced by 34 hours post-farrowing with a fatty milk containing less antibodies.

Colostrum is a good source of energy - its rich in protein, fat and carbohydrates, while also having antibodies and many nutritional factors that aid piglet growth and development. Colostrum is very important for piglets as they are born with very little energy reserves and at birth, piglets are suddenly exposed to a drop in temperature, as well as being cut off from their nutrition source when their umbilical cord breaks. The combination of the drop in temperature and the lack of energy reserves mean that a newborn piglet will rapidly become colder, while also using up the energy reserves they have. So, finding a teat quickly is crucial for the newborn piglet. As a piglet begins to suck and receive colostrum, both energy and warmth are provided which act together to increase body temperature (Figure 4), increasing the piglets' chances of survival. Piglets cannot survive without colostrum.

2.1 When is colostrum produced?

Colostrum production in the mammary gland occurs prior to the birth of the first piglet and the total amount produced can vary greatly. Colostrum is secreted from the udder immediately after farrowing and is continuously supplied to piglets from farrowing for approximately two to four hours after farrowing commences. Colostrum concentration is highest at farrowing but decreases rapidly during the first 14 hours, and by 34 hours has been replaced with a fatty milk containing less antibodies. Piglets feed about 15 times in the first 12 hours of life drinking about 15 ml per feed, spending about a third of their first day suckling on the sow.

Figure 4. Thermal image detecting skin temperature of newborn piglets that are receiving colostrum (left: 36.3˚C), and a piglet who has not received colostrum (right: 22.1˚C). Image taken by J. Alexopoulos.



2.2 Colostrum and piglet protection

Antibodies and immunoglobulins form part of an immune protection system that helps fight diseases that animals may come into contact with during their life. Piglets are born with very little immunity to diseases and gain a great deal of their immunity from the antibodies in colostrum. Although colostrum is produced in the sow's udder, the vast majority of immunoglobulins in colostrum come from those antibodies which are already circulating in the serum of the sow or gilt. Good management practices such as careful gilt preparation through puberty and the pre-mating period as well as vet recommended vaccination programs are the best ways to maximise antibody levels in colostrum. Immunoglobulins are concentrated in the colostrum during the last few days of gestation. If gilt preparation is inadequate or vaccination programs for both sows and gilts have not been followed, colostral immunoglobulin levels in the herd may not be sufficient to protect piglets.

2.3 Colossal Colostrum- whole of life importance

The beneficial effects of colostrum are felt for much longer than just the piglet phase; colostrum actually influences growth and development for most of the pig's life. For example piglets with increased colostrum intakes have shown improved growth and higher weaning weights. Colostrum intake also improves the development of the small intestine and could positively influence feed conversion later in life. Colostrum has also been shown to stimulate the development of brain, skeletal muscle and heart muscle in pre-weaned pigs. This stimulation is not just associated with crucial nutrient intake. Instead, some colostral components are required to achieve a maximum rate of protein synthesis and growth. So, colostrum is important as a source of nutrients, potential growth stimulators as well as antibodies for passive immunity.

The impact of lower colostrum intake can even last to when a female piglet has her own litter. The offspring of sows that had low colostrum intakes as piglets have been shown to have lower growth rates with lower levels of immunoglobulins early in life. So lower colostrum intake may affect a female piglet's ability to make good quality colostrum when she has her own litter.

2.4 Best timing for colostrum intake

Immunoglobulins present in the colostrum are very large compounds that can only be absorbed properly for about the first 24 hours after birth. The small intestine of newborn pigs is able to non-selectively absorb these and other large compounds eaten and released by digestion. The piglet's ability to absorb immunoglobulins falls rapidly and gut closure is usually complete by 24-36 hours after birth. The control of this gut closure is directly linked to the non-specific absorption of nutrients i.e. glucose, lactose as well as artificial and natural colostrum. Pigs that were starved or given water only show a delayed onset of gut closure. So, disadvantaged piglets should receive supplementary colostrum **before** they receive glucose or any other supplemental feed.

TAKE HOME MESSAGES

Colostrum is a good source of energy - it is rich in protein, fat and carbohydrates, while also containing antibodies and many nutritional factors that aid piglet growth and development.

- **Colostrum concentration is highest at farrowing but falls rapidly during the first 14 hours; by 34 hours post farrowing has been replaced with milk**
- **Careful gilt preparation and vaccination programs maximise antibody levels in colostrum**
- **Colostrum influences growth and development for most of the pig's life**
- **Colostral immunoglobulins are only absorbed properly for the first 24 hours after birth**
- **Disadvantaged piglets should receive supplementary colostrum before they receive glucose or any other supplemental feed**

2.5 Disadvantaged piglets

Given the opportunity, piglets can consume much more colostrum than they normally drink from a sow. The amount of colostrum a piglet will normally drink will depend upon the piglet's ability to reach the teat, attach properly and the piglet's own liveliness. On occasions, some piglets fail to thrive on their own mothers and the skill required here is to be able to detect that this is going to occur, before the piglets have actually lost too much condition. The easiest way to pick up a fall-back before they lose too much condition and give up is to watch how the piglets behave. Look for piglets that:

- Keep trying to scrounge a drink when the others in the litter have settled for a sleep;
- Appear hollow or if their coats are "fluffy";
- Don't settle down quickly to feed i.e. they try to push others away to attach to a teat several times in a feeding session;
- Are "whinging" or "sooking", and
- Huddle near the teats (even if creep temperature adequate) instead of the creep area.

If you can recognise these signs and attend to the piglet's needs, you'll stop them from becoming a statistic.

Other piglets which are also disadvantaged include:

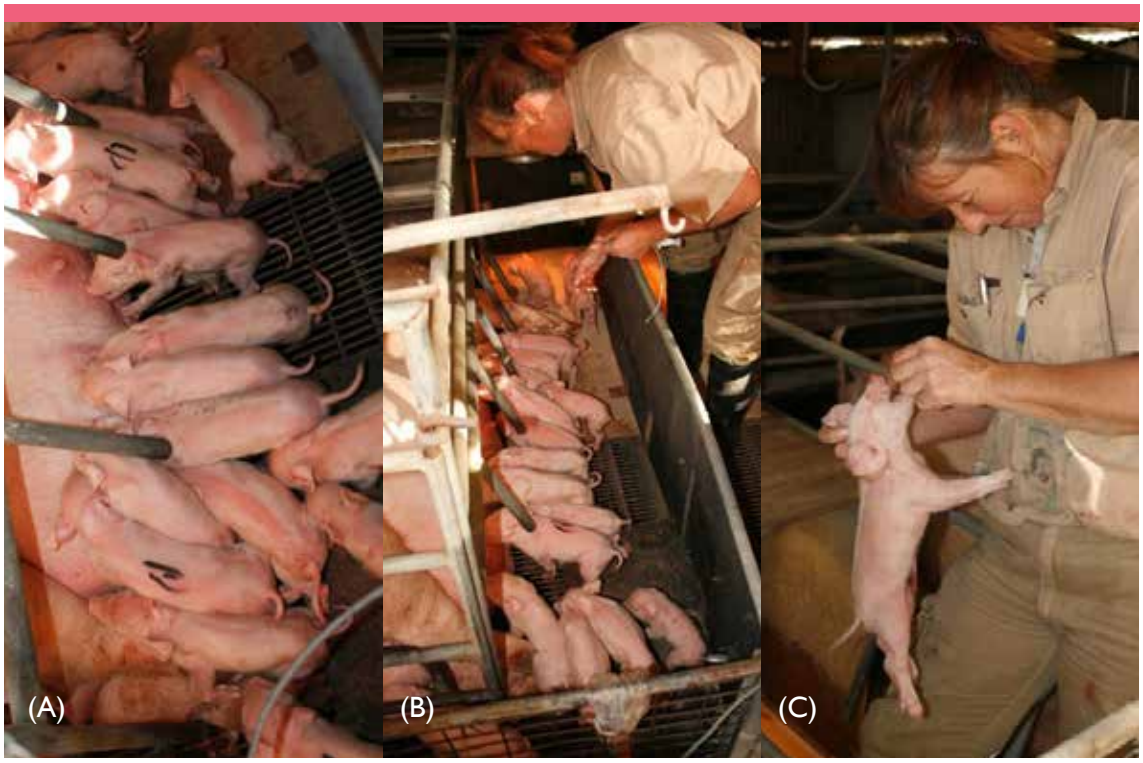
- Piglets born into a very large litter;
- Runts or low birth weight piglets;
- Piglets born towards the end of the farrowing;
- Exposed or chilled piglets;
- Anaemic piglets, and
- Splay-legged piglets.

Piglets born into a very large litter (Figure 5): A useful technique to try and maximise colostrum intake for all piglets in a very large litter is "Split suckling", which should occur as close to farrowing as possible and prior to 24 hours post farrowing. Split sucking is useful when a sow has given birth to a large litter and you need to make sure that all of them have enough colostrum before moving them to another sow.

For example, if a sow has 16 piglets, split the litter into two groups of 10 and 6 piglets - group the 10 smallest piglets together and leave them to suck for three to four hours. In addition, tube or bottle feed the piglets that are away from the sow at least twice during a shift with supplementary colostrum. If the small pigs are a concern and the nights are cold, leave the smallest pigs in a safe warm place overnight. Follow this routine until you can organise all piglets on a permanent mother. A three hour session allows a few milk-let down events for the 'at risk' piglets whilst balancing any potential impacts on the piglets removed from the sow.

Runts or low birth weight piglets: These piglets are under 800g. These piglets should be put in a safe warm place where they are not in any danger from a sow. Tube feed piglets regularly. If the piglet is very small, leave in the protected warm area (a crib is ideal) overnight[1]. When the piglet is strong enough return to the sow. If you have quite a few runts born at the same time and they are falling behind on their own mothers, try to put them all together onto a suitable mother i.e. a small sow with a good temperament that has small teats and low udder line who accepts the runts well.

Figure 5. Selection and marking up of the largest piglets in a litter of 21 born alive that were tube fed colostrum before being placed in the crib during the first split suckling shift.



[1] Even without a night shift, it is possible to leave pigs in the crib overnight if you provide a drinker

Piglets born towards the end of a long farrowing: Quite often these piglets are quite lethargic and slow to start feeding. Remove these pigs from the farrowing crate and place in a warm, protected place. Tube feed regularly. If they respond well to the treatment and seem strong enough, they can be returned back to the sow after 2-3 doses.

Exposed or chilled piglets: Very easily recognisable, usually found well away from the heat source, eyes are glassy and staring, they may even appear dead. These piglets must be treated immediately. Give the piglets energy through tube feeding them colostrum and then warm them up. Support the piglets in a warm bath until they start moving freely. Dry each piglet thoroughly and place in warm safe place. Tube feed regularly. If they respond well to the treatment and seem strong enough, they can be returned back to the sow after 2-3 doses.

Anaemic piglets: Also known as "bleeders". If cord is still bleeding use a cord clamp or tape. Initially, give piglets a dose of oral iron then give them an injectable dose at 4 days of age. Delay ear-notching (if done) and cutting the tails of anaemic piglets until the 4th day of age. If piglets are very weak, they should be placed in a warm safe place and fed supplementary colostrum until they are strong enough to go back to their mother.

Splay–legged piglets: Tape the piglet's back legs a little bit more than the piglet's hip width apart. If piglet is severely splayed in both front and back legs it may be necessary to make a harness. After you've finished taping the pig's legs, place pig in safe, warm, place and tube feed it colostrum. Leave in the protected warm area (a crib is ideal) overnight. When the pig is strong enough or walking well return to the sow. It can also help if a piece of carpet or thick sack is placed on the floor of the crib. This helps the piglet's feet to grip and it helps muscle development.

While their mother's colostrum is the best source of colostrum for a piglet, other ways of ensuring colostrum intake of piglets is through supplementation of either milked sow colostrum, or artificial (usually bovine derived) colostrum products.

These techniques are all useful and may help with improving a disadvantaged piglet's chances of maximising colostrum intake and survival. Quite often piglets may also need a different mother and this is where a good understanding of fostering is useful.

TAKE HOME MESSAGES

In the absence of physical signs in a piglet (such as splay legs), piglet behaviour is the key to detecting disadvantaged pigs before they lose too much condition. Disadvantaged piglets need to be kept safe, kept warm, given a few feeds of either sow or artificial colostrum, and have all their other needs met (e.g. splay legs taped up) to have any chance of surviving and thriving.

3. What is fostering?

Fostering is a process by which piglets are moved from one sow to another. The major reason for fostering is to improve a piglet's chances of getting adequate nourishment and thriving. It's important to remember that when you move a pig you break the contact between a sow and her offspring; some sows and piglets adapt very well and some will not take to it at all. So, with this in mind, try and also take into account the behavioural needs of the sows and piglets.

Fostering can be carried out;

- To even out litter size and numbers following a sow giving birth to more piglets than she can look after;
- When piglets appear to be losing condition on a sow;
- When a sow is ill and unable to care for a litter, and
- If a sow dies.

3.1 Selection of a foster sow

Not all sows will make successful foster sows - always check the sow's recorded history to see how she has performed as a mother with previous litters. If she has weaned good numbers of pigs with low or no mortalities, she may be worthwhile picking as a foster sow. Whilst the sow's performance history does not indicate the future performance as a nurse sow, it can be an indication, particularly if she did not raise the last litter well. Try to pick a younger sow (less than parity four) that has at least 12 small but well-formed functional teats, is good natured (not shy or scared of people), tends to go from a standing to a sitting or lying position slowly, and positions herself to expose all her teats when feeding piglets. Quite often a gilt will make the best foster mother if you have very small piglets that need fostering.

3.2 Choosing gilts as foster mothers

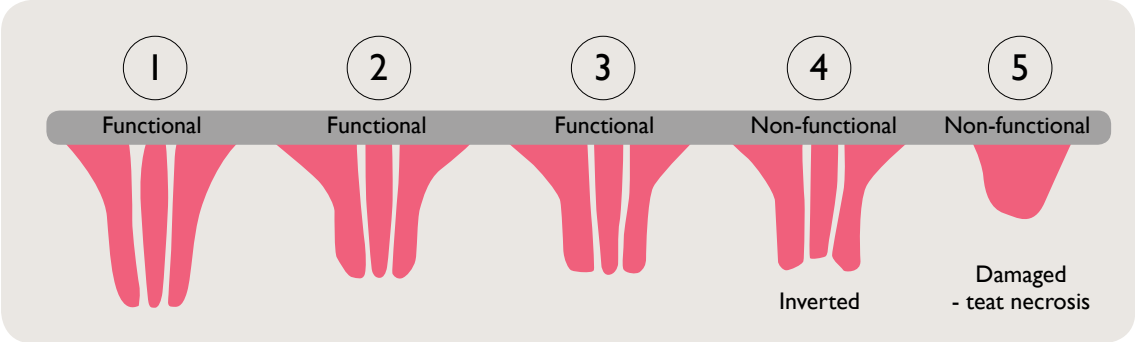
Gilts properly prepared and conditioned during puberty and prior to mating and farrowing should be able to care for as many pigs as they have teats and quite often make great foster mothers. So, load them up! A first parity sow must have all teats activated by piglets to maximise milk production for her future litters. Whether she is a foster sow or looking after her own piglets, she should be allocated one extra piglet than the number of functional teats. This management technique is a common practice in many Danish herds and is also a recommendation in the McRebel fostering procedures (see section 4.2 - Fostering using the McRebel system) and can be applied across all sow parities. But this technique is especially important for gilts as it could set up her lactation production for the rest of her life. If a gilt is loaded to at least teat capacity for the first two days, the improvement in milk production for the next litter will be apparent even after piglets are removed later during the first lactation.

Even though gilts may be quite capable of rearing a runt litter, it is probably better to use a parity 1-2 sow as a foster litter for runts. You really need to maximise udder stimulation for a gilt mother, which is probably best achieved by using bigger and more vigorous piglets.

3.3 Udder Assessment

The number of functional teats available per piglet is associated with piglet survival. Fostering should take in to account the number of functional teats available. A functional teat produces enough milk to rear a piglet. A non-functional teat can be described as inverted, blind or small/ extra teat that cannot be suckled, or produces a reduced amount of milk; limiting rearing capacity and increasing vulnerability to mastitis. Piglets nursing from inverted teats cannot survive. Classifying a teat as functional can be performed at any time by visual inspection (Figure. 6), or if a teat is manipulated around farrowing to ensure production of milk.

Figure 6. Guide for defining whether a teat is functional or non-functional on visual appearance. (*http://www.thepigsite.com/pighealth/article/222/udder/*)



Not only the number of teats, but also positioning for those teats, are important for access (Figure. 7). On younger parity sows, teats are more accessible, but with older parities, larger udders may make teat access for piglets more difficult. Older sows may also have very large teats which may prove very difficult for smaller pigs to attach successfully.

Figure 7. Parity 2 sow with 14 small well positioned functional teats, raising 12 piglets

3.4 Calming foster sows

Sometimes foster sows will not take their pigs willingly and you may have to calm and soothe them into accepting their new pigs. Some techniques which can work to soothe a stubborn sow include:

- Give her special feed/mash;
- Give her bran or sawdust to "play" with;
- If she's just farrowed, rub her afterbirth over the piglets you want to foster onto her and lock her own piglets and the fostered piglets up together for at least 20 minutes or so;
- If the afterbirth has already been picked up, spray her piglets and the foster piglets with air freshener. Then confine her own piglets and the fostered piglets up in the same space. Just before you put all the piglets back on the sow, spray around her nose with the same air freshener, and
- If she is really upset, sedate her.

Leave fostering until late morning or early afternoon when the sows have settled down. This also gives you the opportunity to observe the sow and make sure she is feeding them and not sulking (laying on her udder) or aggressive towards the piglets. It also gives you a chance to split suckle any sows that farrowed overnight before the piglets are moved.

Continue to check litters frequently especially for the first two to three days after fostering to ensure that the sow and piglets have settled down and piglets have started to put on condition. You will be able to determine whether piglets have settled in well by their behaviour (see previous descriptions above in **Section 2.5 Disadvantaged pigs** for behavioural descriptions of pigs that haven't settled into a drinking routine). From time to time, it will be necessary to also provide supplementary milk in drinkers for the foster litters to ensure they don't fall back. You need to watch these litters very carefully; do not leave intervening until the last minute when piglets have already started to fall back in condition.

TAKE HOME MESSAGES

Fostering should only be carried out to make sure a piglet gets a drink. Not all sows will make good foster sows, so choose them with care. Try to:

- **Select a young sow with at least 12 well-formed functional teats**
- **Check teat accessibility when the sow is lying down**
- **Leave fostering until late morning or no later than early afternoon after sows have settled down from the morning routine. This also gives you enough time to make sure sows have accepted the new pigs before you finish work for the day, and**
- **Check foster litters frequently especially for the first two to three days after fostering.**

Gilts properly prepared and conditioned should be able to care for as many pigs as they have teats and quite often make great foster mothers. Gilts:

- **Should be allocated one extra piglet than the number of functional teats, and**
- **Must have all teats activated by piglets to maximise milk production for her future litters.**

4. Piglet Fostering

The major reason for fostering is to improve a piglet's chances of getting adequate nourishment and thriving. You have to work out a system that provides the best results and suits your farm situation the most. This system should be developed in consultation with your veterinarian and farm manager. Fostering works better when carried out earlier during lactation i.e. in the first 24 hours. Piglet movement after that time had reduced suckling success on foster sows, vocalisations were more frequent and they were the target of more sow aggression than those moved at less than 24 hours of age.

There are several types of fostering methods. The ones that work most effectively are:

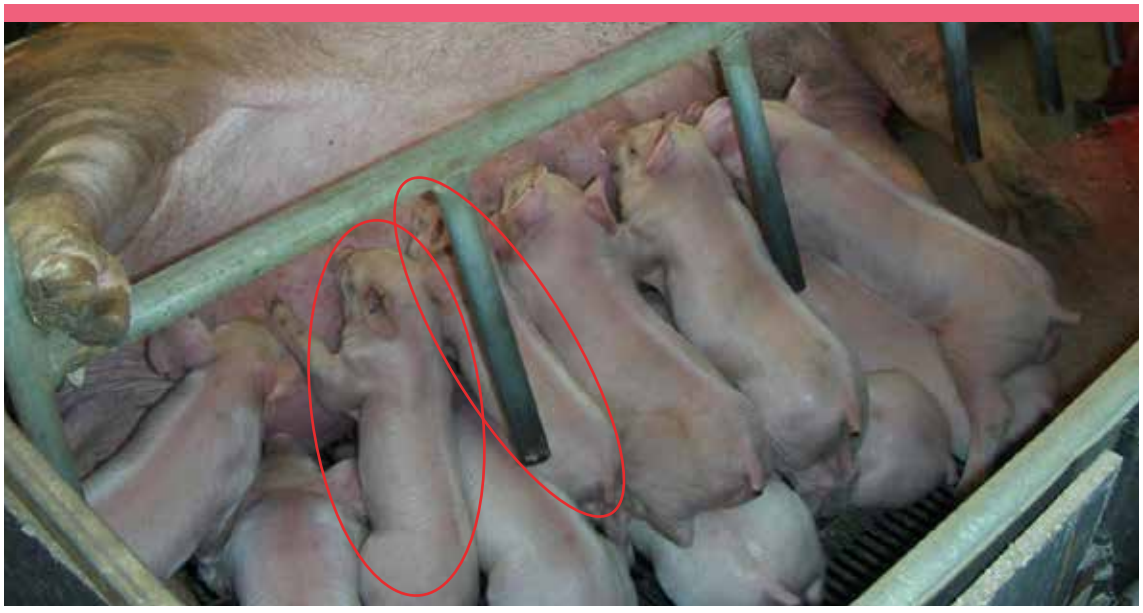
- Fostering to make sure piglets from big litters all have a teat, and
- Back fostering - creation of nurse sows

4.1 Fostering to make sure piglets from big litters all have a teat

For example two sows farrow with 15 and 6 piglets respectively. The sow with 15 pigs has 12 functional teats, while the sow with 6 pigs has 11 functional teats. Move 4 pigs from the sow with 15 pigs and place with the other sow with 6 piglets. It is not necessary to completely even up litters. Remember every time you move a piglet, it stresses the piglet and unsettles both mothers. You only foster the pigs to get them a drink.

While younger sows may give birth to large litters of piglets that may be of similar weight, older sows may give birth to large litters where the individual pig weights can vary greatly. In cases where a sow gives birth to a large litter that has a few small piglets that are drinking well, it may be better to move the larger piglets and leave the smaller ones with their mother.

Figure 8. Two smaller piglets (circled in red) that are healthy and thriving although they are the smallest of the pigs in the litter.



On the other hand, if there are only one or two small piglets that look like they are struggling (sow may not have enough functional teats or the teats they've attached to aren't providing enough milk) then they can be fostered to a sow with other small piglets. However, just because a pig is small doesn't mean it's a runt or even that it won't thrive when left with larger litter mates; being small is NOT a reason to move a pig; a small piglet that has attached to a good teat and kept its place by the end of 24-48 hours of age will continue to thrive (Figure 8) - missing out on a drink is the only reason to foster a piglet. But regardless of whether these small piglets remain with their mother or are fostered to another sow, they need to be regularly checked to make sure they continue to thrive. Careful monitoring of runt litters should also occur.

Can we foster to create piglet size or sex uniformity in litters? e.g. 5 sows farrow with a total litter size of 60 with some variation in sizes but really not major size differences. Piglets are all grouped together and re-sorted onto the 5 different sows so that all sows have 12 pigs of similar weight and size even though many of them will not be their original litter mates. Does this really work? Creating litter uniformity through "grading" does not assist optimising piglet survival and growth and will in fact do the exact opposite. So when should this "grading" happen……?

NEVER!

Routine sorting of pigs according to sex or size even within the 24 hour time limit can result in less than 20% of piglets being raised by their own mothers, while also effectively spreading bacterial pathogens to other litters. Moving and mixing so many pigs also upsets the piglets delaying their successful attachment to a teat which increases the risk of a piglet not thriving. This situation is even worse for weak piglets, who may not have the energy to persist in trying to get a drink, and remain close to the foster sow's udder for warmth instead of staying in the creep area, increasing their chances of becoming overlain.

People may think that with group housing, mixing of sows after mating and also the close proximity of sows to each other in farrowing sheds or paddocks should even out any contact with various bacterial pathogens should even out so that sow immunity would be pretty well standard across the sow herd. Unfortunately, this is not true; the immunity of sows can vary across and within parities, across various groups of sows or even within the same group of sows for many different reasons. This variation in immunity also results in variation in colostral antibodies.

So when you extensively foster pigs within the first 24 hours of life to sex them or grade them for size, all you really do (besides stressing the piglets and sows), is to have made sure that pigs come into contact (and sometimes a great deal of contact) with pathogens they may have very little immunity against because:

1. Their mother may not have produced enough colostral antibodies,
2. You've moved the piglets before they've had a chance to really have sufficient colostrum
3. They may be too distressed to really attach properly to the foster sow and drink to keep up their temperature and energy levels, and
4. The foster sow may have already stopped producing colostrum, so the fostered piglets are at a terrible disadvantage.

TAKE HOME MESSAGES

- **You only foster the pigs to get them a drink;**
- **Fostering works better when carried out earlier during lactation i.e. in the first 24 hours**
- **Being small is NOT a reason to move a pig; a small piglet that has attached to a good teat and kept its place by the end of 24-48 hours of age will continue to thrive; missing out on a drink is the only reason to foster a piglet, and**
- **NEVER foster pigs to create size or gender uniformity in litters.**

4.2 Fostering using the McRebel system

This mismatch in immunity occurs with both bacterial and viral pathogens. Fortunately, fostering systems developed in other countries to assist with the management of viral diseases such as *porcine reproductive and respiratory syndrome* (PRRS) will also work for the bacterial diseases present in the Australian herd. The most publicised and successful fostering management system is known as McRebel (Management Changes to Reduce Exposure to Bacteria to Eliminate Losses) system.

The McRebel procedures[2] were developed in 1994 by Dr. Monte McCaw, DVM, North Carolina State University (NCSU). The McRebel system limits fostering to the first 24 hours of a piglet's life. There are only two exceptions: when a sow is sick or dies and when the sow's udder is drying up and the piglets need to be moved to a functioning teat.

The McRebel procedures are:

- **Stop fostering of piglets between litters for grading, sexing or saving sick pigs, fall-behinds, and runts.**
- **Foster piglets to equalize number of piglets per litter only within the first 24 hours of age.** Load sows with only the number of pigs they can successfully nurse plus one additional pig based upon their past weaning performance and udder condition.
- **Only move pigs within farrowing rooms at birth. Do not move sows or piglets between rooms.**
- **Stop use of nurse sows for weak-born or infected pigs, fall-behinds, and runts.**
- **Immediately euthanise piglets that become very sick and are unlikely to recover completely.**
- **Minimize handling of piglets, especially routine antibiotic or extra iron injections.**
- **Hold NO pigs back. DO NOT move fall-behind or lightweight pigs backward to younger rooms or nurse sows. Euthanise small piglets with poor body condition at weaning rather than holding them back!** Hand feeding, high quality pre-starter rations, ensuring they find the waterers, supplemental heat sources, etc. will help HEALTHY small pigs at weaning successfully adapt to the nursery.

[2] Adapted from https://projects.ncsu.edu/project/swine_extension/healthyhogs/book1995/mccaw.htm

As long as fostering is conducted within the first 24 hours, there is limited impact on the pigs or the sows. After 24 hour's and if pigs are continually moved, fostering becomes a very negative experience for both sows and piglets with detrimental results including disrupted nursing episodes, increased fighting between piglets, increased likelihood of sow aggression, all of which affect the welfare and growth rates of both the original litter and fostered piglets.

TAKE HOME MESSAGES

The McRebel system is a set of guidelines to manage fostering in a way that will minimise the potential negative impacts of fostering on the health of not only the piglets but the entire herd. In the McRebel system fostering of piglets between litters for grading, sexing or saving sick pigs, fall-behinds, and runts, is not allowed. Fostering to equalize number of piglets per litter should only be done within 24 hours of birth.

4.3 Nurse Sows- Fostering after 24 hours.

Sometimes fostering must be done after the 24 hour time limit for a number of reasons including the death of a sow, or a sow becomes very sick and cannot look after her pigs or (on a more positive note) to provide udder space when the litter size that day may be very high i.e. the number of piglets born exceeds the available number of teats. The best way to manage this is through nurse sows. Nurse sows are sows or gilts that rear pigs which are not their own.

Nurse sows should be chosen carefully. A nurse sow should be:

- Young - preferably parity one to three;
- Have at least 12 well-formed and functional teats;
- Is well natured (calm, responds well to humans, does not have a history of savaging or overlaying pigs);
- Is in good body condition, and
- Has looked after her piglets very well.

Nurse sows cannot be allowed to remain in lactation for extended periods of time, and must be weaned after they have been lactating for 40 days or preferably earlier.

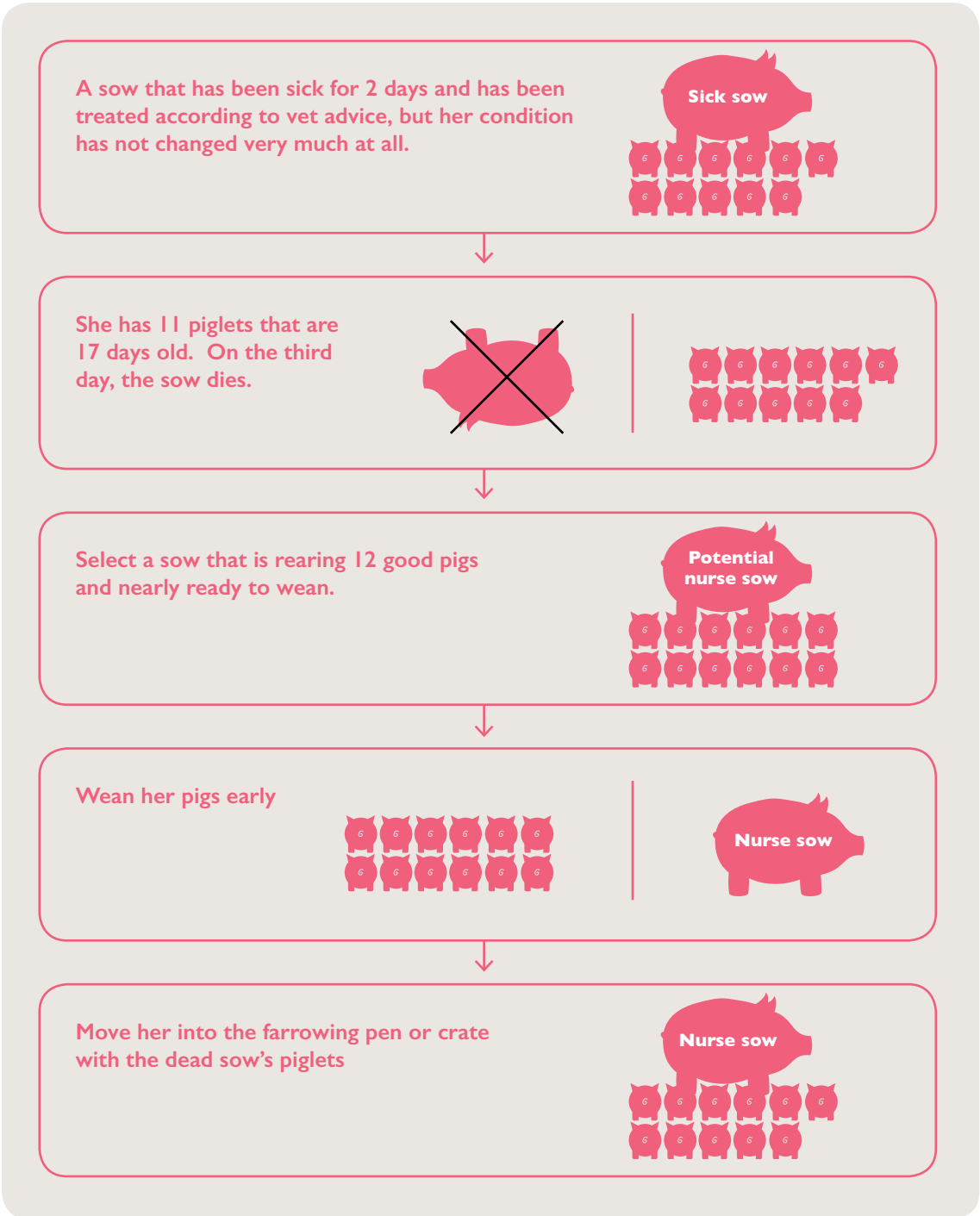
The process to setting up a nurse sow can either be:

- direct (older piglets are placed on to the weaned nurse sow) or
- indirect involving a staged approach which may include two or more sows and their litters.

Process for setting up a nurse sow: Example 1 - the DIRECT process (Figure 9): You have a sow that has been sick for 2 days and you've been treating her according to the instructions from your vet, but her condition has not changed very much at all. She has 11 piglets that are 17 days old (the average weaning age on your farm is 28 days) and you've placed a milk drinker in the pen with them, just to make sure that if the sow's milk supply is affected, they won't miss out on a feed.

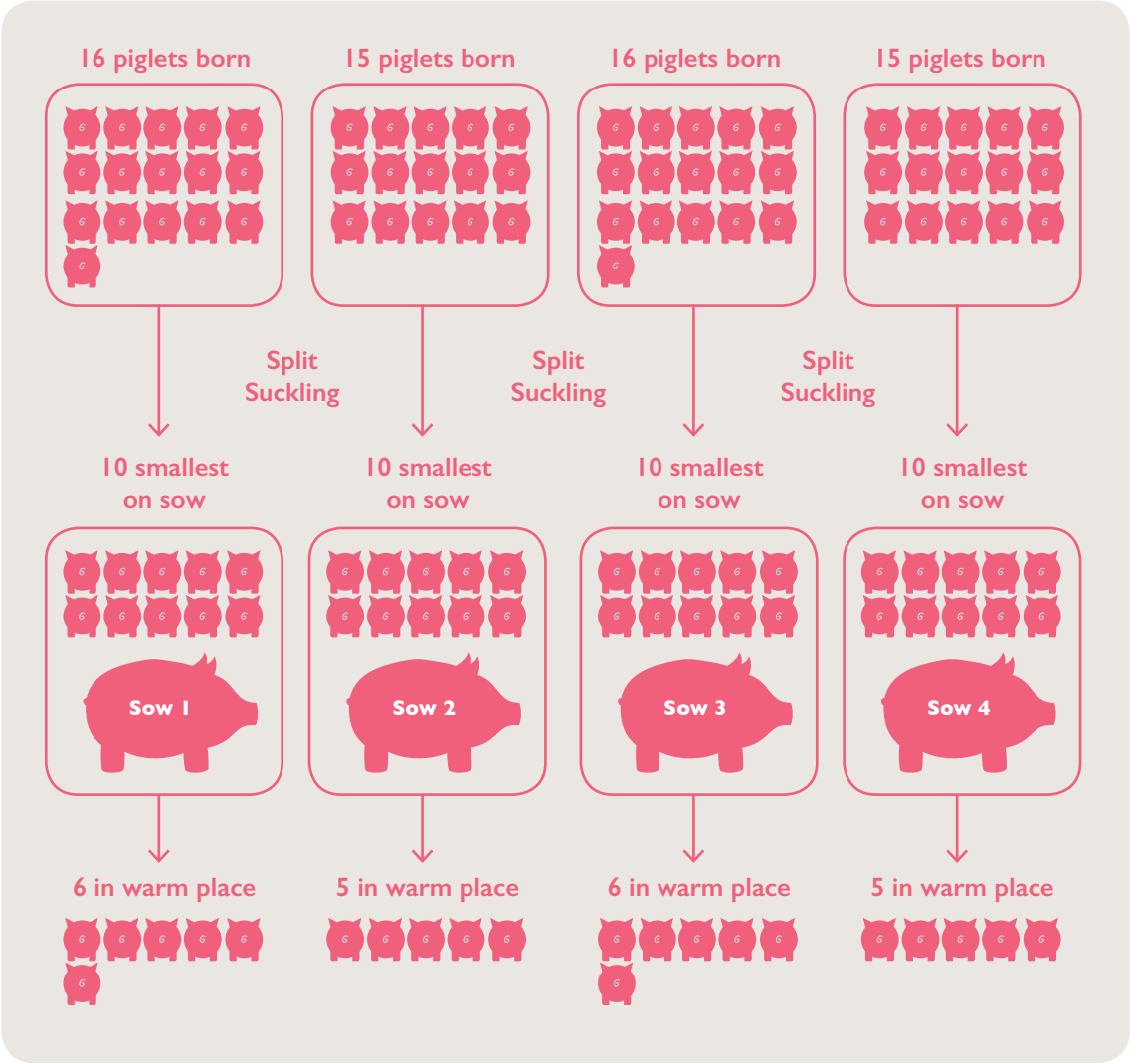
On the third day, the sow dies. Place her piglets in a safe place while she is removed. Then select a sow that will be weaned that week, that is rearing 12 good piglets and move her into the farrowing pen or crate with the dead sow's piglets. You should always move the sow because the piglets should remain with the same aged piglets in that room. If at all possible younger piglets should never be moved into a room with older piglets. The age difference of piglets in the same area, room/shed (preferably) should be no greater than about 7 days.

Figure 9. Process for setting up a nurse sow: Example 1- the DIRECT process



Process for setting up a nurse sow: Example 2 - the INDIRECT process (Figure 10 a, b and c): You've just walked into the farrowing shed and you have 4 sows that have farrowed a total of 62 pigs born alive. Before you start organising movements, divide each litter individually to set up split suckling (to make sure the all the piglets will have received sufficient colostrum) (Figure 10a).

Figure 10a. Split sucking for litters with more piglets than teats available to ensure adequate colostrum intake for all piglets.



Then select a sow that is due to be weaned that week (the average weaning age on this farm varies from 25-28 days of age) and wean her litter.

Figure 10b. Process for setting up a nurse sow: Example 2-the INDIRECT process

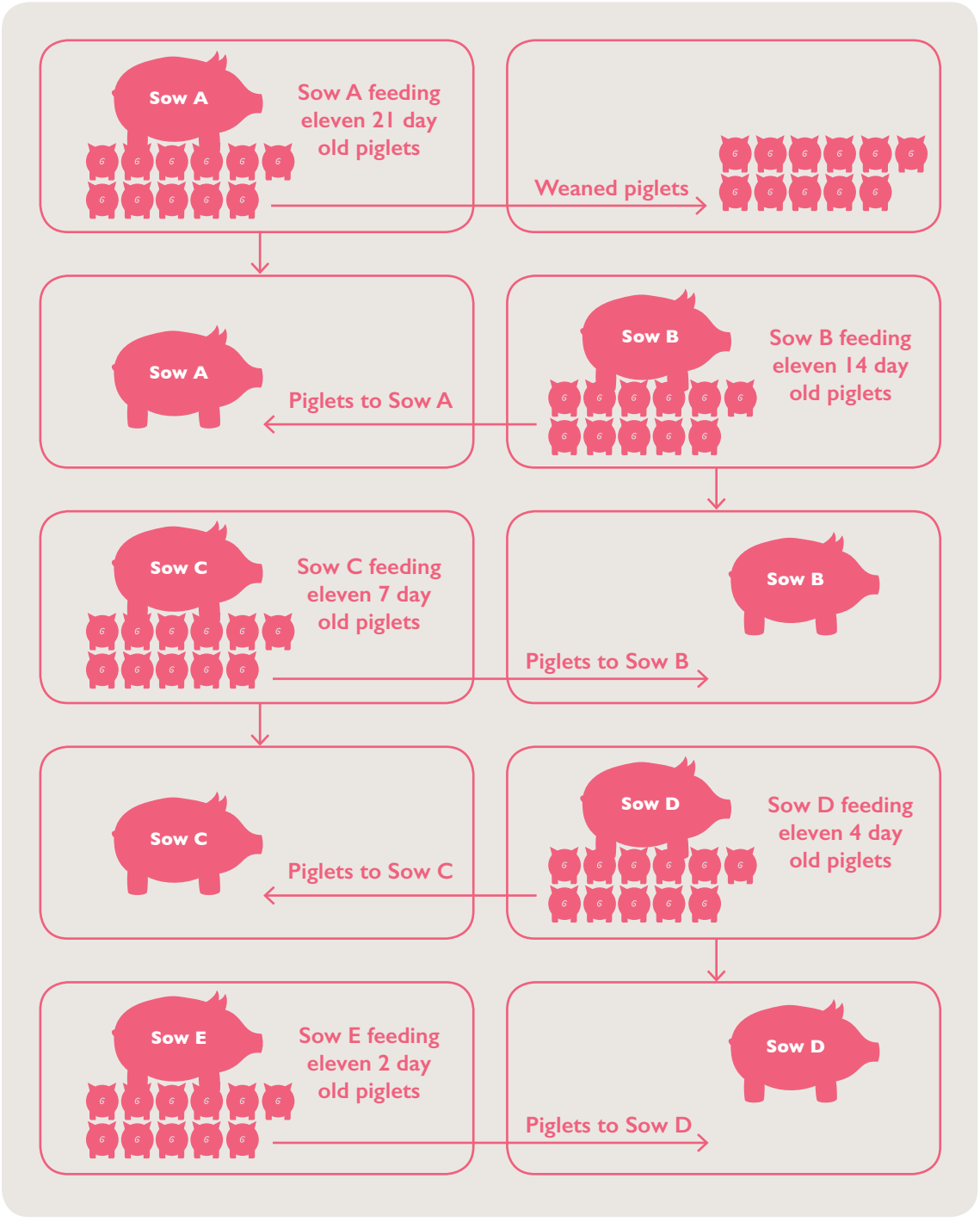
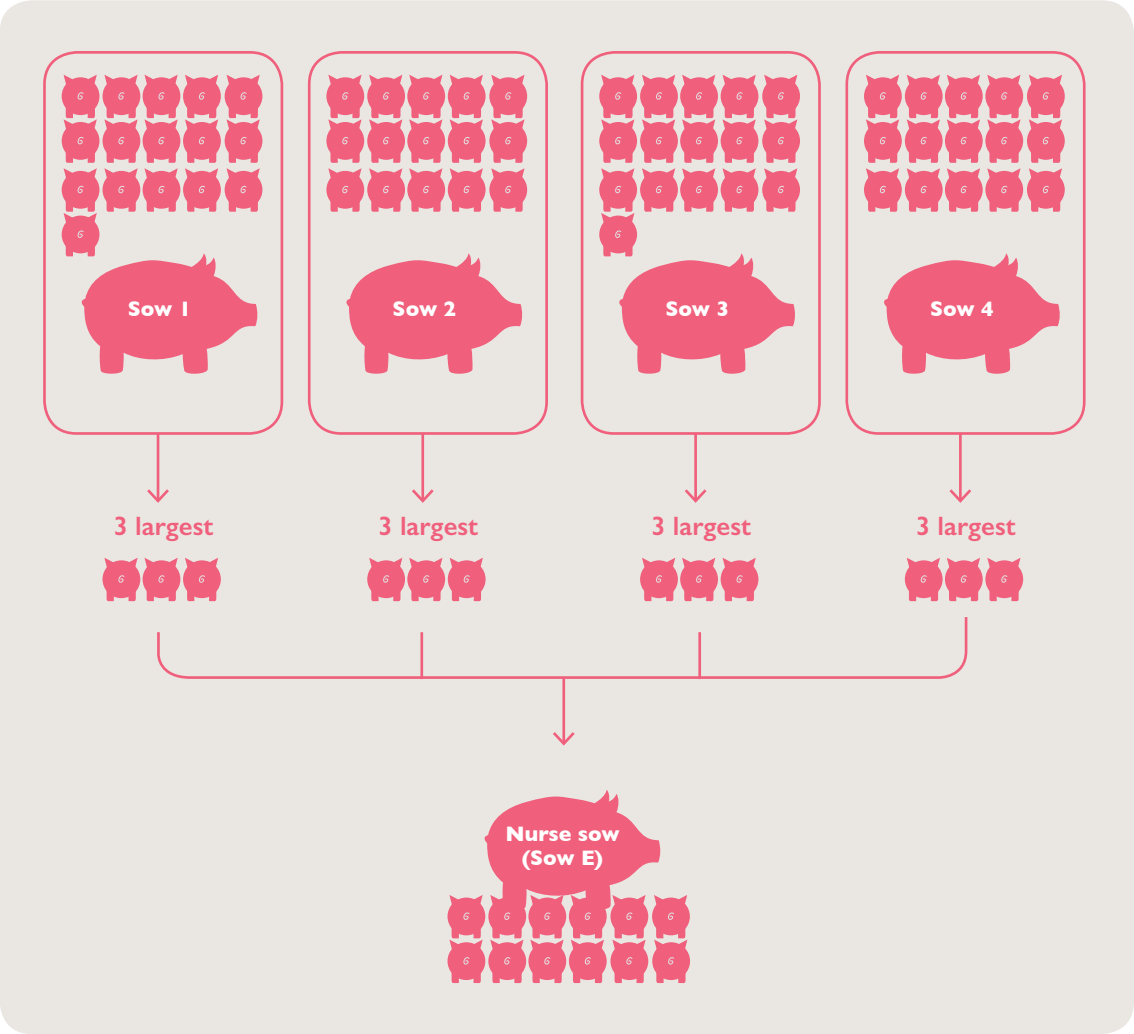


Figure 10c. Fostering excess piglets onto nurse sow (Sow E)



Move other litters down the line until you have an "empty" sow that farrowed 2-3 days previously.

This process takes a bit more skill than the direct process as you're dealing with different aged pigs that are drinking different amounts of milk that is different in composition. So there are some rules of thumb which may help in selecting sows and litters to be involved in the indirect process.

- Piglets between one to two weeks of age are placed on a sow that has been lactating for no more than five to seven days of difference the age of the piglets e.g. A litter 10 days of age could be placed on a sow that has been lactating for 15 days but not a sow that has been lactating 19 days.
- Piglets between three to seven days of age should be placed on a sow that has been lactating for no more than three days of difference the age of the pigs e.g. A litter four days of age could be placed on a sow that has been lactating for six days but not a sow that has been lactating seven days.
- Piglets that are between one to two days of age should only be placed on a sow that has been lactating for no more than 1 day of difference the age of the piglets e.g. A litter one day of age could be placed on a sow that has been lactating for two days but not a sow that has been lactating three days. Make sure that the piglets you place on this sow have had their **full requirement of colostrum** and try to put the biggest piglets possible onto that sow (Figure 10c).
- Monitor the nurse sow and her nurse litter carefully to make sure that she has accepted the new litter. See section 3.4 - Calming foster sows for suggestions for calming sows that may not be accepting their new litter willingly.

These "rules of thumb" are important to remember so that the transition of mothers for the piglets is as smooth as possible. Also, if possible move only whole litters/littermates.

A less commonly studied or utilised approach is double nursing, in which a sow nurses her own litter for half the day, and another litter of piglets for the remainder. This may be an attractive option when no sow can be weaned for nurse purposes, or when farrowing crate space is limited. Artificial rearing is another means to deal with excess or weak piglets, and while similar growth rates are possible, very strict attention to hygiene is required. Supplemental milk may also be provided in the farrowing crate to assist weak piglets, and has shown to result in improved growth especially in later lactation.

TAKE HOME MESSAGES

Nurse sow are sows or gilts that rear pigs that are not their own. A nurse sow should be:

- **Young- preferably parity one to three**
- **Have at least 12 well-formed and functional teats**
- **Is well natured (calm, responds well to humans, does not have a history of savaging or overlaying)**
- **Is in good body condition**
- **Has looked after her own pigs very well**

In making up a nurse sow, plan movements so that the litters moved will still be with pigs of approximately the same age i.e. younger pigs aren't moved into a room/shed with older pigs and vice versa.

5. Summary

Piglet fostering depends on the results of many animal husbandry tasks which must be done well to provide the tools to guarantee fostering success. There are a number of key principles which are important to consider when fostering piglets and these are:

- Colostrum gives piglets' energy and warmth, as well as immunity. It is best accessed in the first 12 hours after farrowing from the birth sow. Therefore no piglet fostering should occur before piglets are 12 hours old.
- The piglet's ability to absorb immunoglobulins in colostrum falls rapidly and gut closure is usually complete by 24-36 hours. The control of this gut closure is directly linked to the non-specific absorption of nutrients i.e. glucose, lactose as well as artificial and natural colostrum.
- Stop fostering of piglets between litters for grading, sexing or saving sick pigs, fall-behinds, and runts.
- Piglet fostering should occur when the pigs are between 12-24 hours of age, but movement should be minimal to reduce disease spread.
- Foster piglets to equalize number of piglets per litter only within the first 24 hours of age. (Load sows with only the number of pigs they can successfully nurse plus one additional pig based upon their past weaning performance and udder condition).
- Just because a pig is small doesn't mean it's a runt or even that it won't thrive when left with larger litter mates; being small is NOT a reason to move a pig; a small piglet that has attached to a good teat and kept its place by the end of 24-48 hours of age will continue to thrive; missing out on a drink is the only reason to foster a piglet.
- Piglets should not be fostered after 24h of age and alternate strategies, such as setting up nurse sows, should be used when piglets need to be moved later in lactation.
- Colostrum intake impacts on the lifetime performance of the pig. Management techniques, such as split suckling, can achieve a more even intake of birth sow colostrum. These techniques must be used before pigs are moved.
- Udder assessment should occur as close to farrowing as possible for the number of functional teats as well as teat accessibility.
- Gilts should receive as many piglets as the udder allows, but older parities (>P6) should be carefully assessed for rearing ability.

If these principles are followed, piglet survival and growth should be maximised.

6. References

1. Theil, P.K., C. Lauridsen, and H. Quesnel (2014) Neonatal piglet survival: impact of sow nutrition around parturition on fetal glycogen deposition and production and composition of colostrum and transient milk. *Animal*. 8(07): p. 1021-1030.
2. Le Dividich, J., J.A. Rooke, and P. Herpin (2005) Nutritional and immunological importance of colostrum for the new-born pig. *The Journal of Agricultural Science*. 143(06): p. 469-485.
3. Vasdal, G., I. Østensen, M. Melišová, B. Bozděchová, G. Illmann, and I.L. Andersen (2011) Management routines at the time of farrowing—effects on teat success and postnatal piglet mortality from loose housed sows. *Livestock Science*. 136(2): p. 225-231.
4. Le Dividich, J. and J. Noblet (1981) Colostrum intake and thermoregulation in the neonatal pig in relation to environmental temperature. *Neonatology*. 40(3-4): p. 167-174.
5. Rooke, J.A. and I.M. Bland (2002) The acquisition of passive immunity in the new-born piglet. *Livestock Production Science*. 78(1): p. 13-23.
6. Bartol, F.F., A.A. Wiley, D.J. Miller, A.J. Silva, K.E. Roberts, M.L.P. Davolt, J.C. Chen, A.L. Frankshun, M.E. Camp, K.M. Rahman, J.L. Vallet, and C.A. Bagnell (2013) Lactation Biology Symposium: Lactocrine signaling and developmental programming. *Journal of Animal Science*. 91(2): p. 696-705.
7. Klobasa, F., E. Werhahn, and J.E. Butler (1981) Regulation of humoral immunity in the piglet by immunoglobulin of maternal origin. *Research in Veterinary Science*.
8. Tuboly, S., S. Bernath, R.K. Glavits, and I. Medveczky (1988) Intestinal absorption of colostral lymphoid cells in newborn piglets. *Veterinary Immunology and Immunopathology*. 20(1): p. 75-85.
9. Bandrick, M., M. Pieters, C. Pijoan, S.K. Baidoo, and T.W. Molitor (2011) Effect of cross-fostering on transfer of maternal immunity to Mycoplasma hyopneumoniae to piglets. *Veterinary Record*. 168(4): p. 100.
10. Edwards, S.A. (2002) Perinatal mortality in the pig: environmental or physiological solutions? *Livestock Production Science*. 78(1): p. 3-12.
11. Quesnel, H., C. Farmer, and N. Devillers (2012) Colostrum intake: Influence on piglet performance and factors of variation. *Livestock Science*. 146(2-3): p. 105-114.
12. Varley, M.A., A. Maitland, and A. Towle (1986) Artificial rearing of piglets: the administration of two sources of immunoglobulins after birth. *Animal Production*. 43(01): p. 121-126.
13. Ferrari, C.V., P.E. Sbardella, M.L. Bernardi, M.L. Coutinho, I.S. Vaz Jr, I. Wentz, and F.P. Bortolozzo (2014) Effect of birth weight and colostrum intake on mortality and performance of piglets after cross-fostering in sows of different parities. *Preventive Veterinary Medicine*. 114(3–4): p. 259-266.
14. Devillers, N., J. Le Dividich, and A. Prunier (2011) Intake of colostrum intake on piglet survival and immunity. *Animal*. 5(10): p. 1605-1612.
15. Xu, R.J., F. Wang, and S.H. Zhang (2000) Postnatal adaptation of the gastrointestinal tract in neonatal pigs: a possible role of milk-borne growth factors. *Livestock Production Science*. 66(2): p. 95-107.
16. Burrin, D.G., Davis, T.A., Ebner, S., Schoknecht, P.A., Fiorotto, M.L., & Reeds, P.J. (1997). Colostrum enhances the nutritional stimulation of vital organ protein synthesis in neonatal pigs. *Journal of Nutrition*, *127*, 1284-1289.
17. Burrin, D.G., T.A. Davis, S. Ebner, P.A. Schoknecht, M.L. Fiorotto, P.J. Reeds, and S. McAvoy (1995) Nutrient-independent and nutrient-dependent factors stimulate protein-synthesis in colostrum-fed newborn piglets. *Pediatric Research*. 37(5): p. 593-599.
18. Lallès, J.P., P. Bosi, H. Smidt, and C.R. Stokes (2007) Nutritional management of gut health in pigs around weaning. *Proceedings of the Nutrition Society*. 66(02): p. 260-268.
19. Allan, G.M., F. McNeilly, J. Ellis, S. Krakowka, A. Botner, K. McCullough, H. Nauwynck, S. Kennedy, B. Meehan, and C. Charreyre (2004) PMWS: experimental model and co-infections. *Veterinary Microbiology*. 98(2): p. 165-168.
20. Elbers, A.R.W., M.F. de Jong, and G.J. Wellenberg (2006) Industrial risk factors of pigs with clinical occurrences of PNWS or PDNS in the Netherlands: a case-controlled inspection. *Tijdschrift Voor Diergeneeskunde*. 131(9): p. 318-325.
21. Vallet, J.L., J.R. Miles, L.A. Rempel, D.J. Nonneman, and C.A. Lents (2015) Relationships between day one piglet serum immunoglobulin immunocrit and subsequent growth, puberty attainment, litter size, and lactation performance. *Journal of Animal Science*. 93(6): p. 2722-2729.
22. Farmer, C. and H. Quesnel (2009) Nutritional, hormonal, and environmental effects on colostrum in sows. *Journal of Animal Science*. 87(13): p. 56-65.
23. Loisel, F., C. Farmer, P. Ramaekers, and H. Quesnel (2014) Colostrum yield and piglet growth during lactation are related to gilt metabolic and hepatic status prepartum. *Journal of Animal Science*. 92(7): p. 2931-2941.
24. King'Ori, A.M. (2012) The pre-weaning piglet: colostrum and milk intake: a review. *Journal of Animal Production Advances*. 2: p. 277-83.

25. Fraser, D. (1984) The role of behaviour in swine production - a review of research. *Applied Animal Ethology*. 11(4): p. 317-339.
26. Fraser, D. and J. Rushen (1992) Colostrum intake by newborn piglets. *Canadian Journal of Animal Science*. 72(1): p. 1-13.
27. Cabrera, R.A., X. Lin, J.M. Campbell, A.J. Moeser, and J. Odle (2012) Influence of birth order, birth weight, colostrum and serum immunoglobulin G on neonatal piglet survival. *Journal of Animal Science and Biotechnology*. 3(1): p. 42-51.
28. Quesnel, H. (2011) Colostrum production by sows: variability of colostrum yield and immunoglobulin G concentrations. *Animal*. 5(10): p. 1546-1553.
29. Craig, J.R., J.J. Cottrel, U.A. Wijesiriwardana, J.B. Furness, F.R. Dunshea, and J.R. Pluske (2017) Gilt progeny have lower serum immunoglobulin G (IgG) concentrations than sow progeny, but not as a result of concentrations in colostrum and milk. in *10th International Conference on Pig Reproduction*. Missouri, USA.
30. Devillers, N., C. Farmer, J. Le Dividich, and A. Prunier (2007) Variability of colostrum yield and colostrum intake in pigs. *Animal*. 1(7): p. 1033-1041.
31. Lines, D.S., *Split suckling to improve colostrum ingestion, survival and performance of gilt progeny*. 2015, Australian Pork Limited. project number 2014/490.
32. Devillers, N., J. van Milgen, A. Prunier, and J. Le Dividich (2004) Estimation of colostrum intake in the neonatal pig. *Animal Science*. 78: p. 305-313.
33 Deen, M.G.H. and G. Bilkei (2004) Cross fostering of low-birthweight piglets. *Livestock Production Science*. 90(2-3): p. 279-284.
34. Depassille, A.M.B. and J. Rushen (1989) Suckling and teat disputes by neonatal piglets. *Applied Animal Behaviour Science*. 22(1): p. 23-38.
35. Svendsen, L.S., B.R. Weström, J. Svendsen, B.G. Ohlsson, R. Ekman, and B.W. Karlsson (1986) Insulin involvement in intestinal macromolecular transmission and closure in neonatal pigs. *Journal of Pediatric Gastroenterology and Nutrition*. 5(2): p. 299-304.
36. Donovan, T.S. and S.S. Dritz (2000) Effect of split nursing on variation in pig growth from birth to weaning. *Journal of the American Veterinary Medical Association*. 217(1): p. 79-81.
37. Tokach, M. (2004) Dealing with variation in market weight. *Advances in Pork Production*. 15: p. 281-290.
38. Kirkden, R.D., D.M. Broom, and I.L. Andersen (2013) Invited review: piglet mortality: management solutions. *Journal of Animal Science*. 91(7): p. 3361-3389.
39. Kyriazakis, I. and S.A. Edwards (1986) The effect of "split-suckling" on behaviour and performance of piglets. *Applied Animal Behaviour Science*. 16(1): p. 92.
40. Vallet, J.L. (2013) Use of the Immunocrit to monitor a split-suckle program in commercial production. in *International Conference on Pig Reproduction IX*. Olsztyn, Poland: Control of Pig Reproduction.
41. Huser, J.S., K.J. Plush, W.S. Pitchford, T.E. Kennett, and D.S. Lines (2015) Neonatal split suckling improves survival of small piglets. *Animal Production Science*. 55(12): p. 1477-1477.
42. Hansen, C.F., R. Muller, E. Kanitz, M. Tuchscherer, and F. Thorup (2013) Porcine colostrum supplementation increases serum immunoglobulin concentration of light piglets. in *Manipulating Pig Production XIV*. Melbourne.
43. Muns, R., M. Nuntapaitoon, and P. Tummaruk (2017) Effect of oral supplementation with different energy boosters in newborn piglets on pre-weaning mortality, growth and serological levels of IGF-I and IgG1. *Journal of Animal Science*. 95(1): p. 353-360.
44. Farmer, C., M.-F. Palin, P.K. Theil, M.T. Sorensen, and N. Devillers (2012) Milk production in sows from a teat in second parity is influenced by whether it was suckled in first parity. *Journal of Animal Science*. 90(11): p. 3743-3751.
45. Farmer, C., M. Amezcua, R. Bruckmaier, O. Wellnitz, and R. Friendship (2017) Does duration of teat use in first parity affect milk yield and mammary gene expression in second parity? *Journal of Animal Science*. 95: p. 681-687.
46. Bierhals, T., D. Magnabosco, R.R. Ribeiro, J. Perin, R.A. da Cruz, M.L. Bernardi, I. Wentz, and F.P. Bortolozzo (2012) Influence of pig weight classification at cross-fostering on the performance of the primiparous sow and the adopted litter. *Livestock Science*. 146(2–3): p. 115-122.
47. Thaker, M.Y.C. and G. Bilkei (2005) Lactation weight loss influences subsequent reproductive performance of sows. *Animal Reproduction Science*. 88(3): p. 309-318.
48. Zhang, T., L. Wang, H. Shi, Y. Hua, L. Zhang, L. Xin, P. Lei, J. Liang, Y. Zhang, and K. Zhao (2016) Hritabilities and genetic and phenotypic correlations of litter uniformity and litter size in Large White sows. *Journal of Integrative Agriculture*. 15(4): p. 848-854.
49. Tummaruk, P. and K. Sang-Gassanee (2013) Effect of farrowing duration, parity number and the type of anti-inflammatory drug on postparturient disorders in sows: a clinical study. *Tropical animal Health and Production*. 45(4): p. 1071-1077.
50. Baer, C. and G. Bilkei (2005) Ultrasonographic and gross pathological findings in the mammary glands of weaned sows having suffered recidiving mastitis metritis agalactia. *Reproduction in Domestic Animals*. 40(6): p. 544-547.

51. Andersen, I.L., E. Nævdal, and K. Bøe (2011) Maternal investment, sibling competition, and offspring survival with increasing litter size and parity in pigs (Sus scrofa). *Behavioral Ecology and Sociobiology*. 65(6): p. 1159-1167.
52. Li, Y.Z. and H.W. Gonyou (2013) Comparison of management options for sows kept in pens with electronic feeding stations. *Canadian Journal of Animal Science*. 93(4): p. 445-452.
53. Anil, S.S., L. Anil, and J. Deen (2009) Effect of lameness on sow longevity. *Journal of the American Veterinary Medical Association*. 235(6): p. 734-738.
54. Pluym, L.M., A. Van Nuffel, S. Van Weyenberg, and D. Maes (2013) Prevalence of lameness and claw lesions during different stages in the reproductive cycle of sows and the impact on reproduction results. *Animal*. 7(07): p. 1174-1181.
55. Oldham, J.G. (1985) Clinical measurement of pain, distress and discomfort in pigs. in *Proceedings of the British Veterinary Association of Animal Welfare Foundation 2nd Symposium. p. 89-91*
56. Johnson, R.W. (1997) Inhibition of growth by pro-inflammatory cytokines: an integrated view. *Journal of Animal Science*. 75(5): p. 1244-1255.
57. Bach, A., M. Dinarés, M. Devant, and X. Carré (2007) Associations between lameness and production, feeding and milking attendance of Holstein cows milked with an automatic milking system. *The Journal of Dairy Research*. 74(1): p. 40.
58. Jarvis, S., R.B. D'Eath, and K. Fujita (2005) Consistency of piglet crushing by sows. *Animal Welfare*. 14(1): p. 43-51.
59. Rodriguez, C., J. Rodriganez, and L. Silio (1994) Genetic-analysis of maternal ability in iberian pigs. *Journal of Animal Breeding and Genetics-Zeitschrift Fur Tierzuchtung Und Zuchtungsbiologie*. 111(3): p. 220-227.
60 Jonas, E., H.J. Schreinemachers, T. Kleinwächter, C. Ün, I. Oltmanns, S. Tetzlaff, D. Jennen, D. Tesfaye, S. Ponsuksili, and E. Murani (2008) QTL for the heritable inverted teat defect in pigs. *Mammalian Genome*. 19(2): p. 127-138.
61. Chalkias, H., L. Rydhmer, and N. Lundeheim (2013) Genetic analysis of functional and non-functional teats in a population of Yorkshire pigs. *Livestock Science*. 152(2-3): p. 127-134.
62. Vasdal, G. and I.L. Andersen (2012) A note on teat accessibility and sow parity; consequences for newborn piglets. *Livestock Science*. 146(1): p. 91-94.
63. Nielsen, O.L., A.R. Pedersen, and M.T. Sørensen (2001) Relationships between piglet growth rate and mammary gland size of the sow. *Livestock Production Science*. 67(3): p. 273-279.
64. Balzani, A., H.J. Cordell, and S.A. Edwards (2016) Relationship of sow udder morphology with piglet suckling behavior and teat access. *Theriogenology*. 86(8): p. 1913-1920.
65. Ocepek, M., I. Andersen-Ranberg, S.A. Edwards, and I.L. Andersen (2016) Udder characteristics of importance for teat use in purebred and crossbred pigs. *Journal of Animal Science*. 94(2): p. 780-788.
66. Balzani, A., H.J. Cordell, E. Sutcliffe, and S.A. Edwards (2016) Heritability of udder morphology and colostrum quality traits in swine. *Journal of Animal Science*. 94(9): p. 3636-3644.
67. Neal, S.M. and K.M. Irvin (1991) The effects of crossfostering pigs on survival and growth. *Journal of Animal Science*. 69(1): p. 41-46.
68. Heim, G., A.P.G. Mellagi, T. Bierhals, L.P. de Souza, H.C.C. de Fries, P. Piuco, E. Seidel, M.L. Bernardi, I. Wentz, and F.P. Bortolozzo (2012) Effects of cross-fostering within 24h after birth on pre-weaning behaviour, growth performance and survival rate of biological and adopted piglets. *Livestock Science*. 150(1): p. 121-127.
69. Baxter, E.M., K.M.D. Rutherford, R.B. D'Eath, G. Arnott, S.P. Turner, P. Sandoe, V.A. Moustsen, F. Thorup, S.A. Edwards, and A.B. Lawrence (2013) The welfare implications of large litter size in the domestic pig II: management factors. *Animal Welfare*. 22(2): p. 219-238.
70. Quesnel, H., L. Brossard, A. Valancogne, and N. Quiniou (2008) Influence of some sow characteristics on within-litter variation of piglet birth weight. 2(12):1842-1849.
71. Skok, J. and D. Skorjanc (2014) Group suckling cohesion as a prelude to the formation of teat order in piglets. *Applied Animal Behaviour Science*. 154: p. 15-21.
72. Li, Y.Z., J.E. Anderson, and L.J. Johnston (2012) Animal-related factors associated with piglet mortality in a bedded, group-farrowing system. *Canadian Journal of Animal Science*. 92(1): p. 11-20.
73. Milligan, B.N., D. Fraser, and D.L. Kramer (2001) Birth weight variation in the domestic pig: effects on offspring survival, weight gain and suckling behaviour. *Applied Animal Behaviour Science*. 73(3): p. 179-191.
74. Muns, R., C. Silva, X. Manteca, and J. Gasa (2014) Effect of cross-fostering and oral supplementation with colostrums on performance of newborn piglets. *Journal of Animal Science*. 92(3): p. 1193-1199.
75. Souza, L.P., H.C.C. Fries, G. Heim, J.E. Faccin, L.F. Hernig, B.T. Marimon, M.L. Bernardi, F.P. Bortolozzo, and I. Wentz (2014) Behaviour and growth performance of low-birth-weight piglets cross-fostered in multiparous sows with piglets of higher birth weights. *Arquivo Brasileiro De Medicina Veterinaria E Zootecnia*. 66(2): p. 510-518.
76. Marcatti, N.A. (1986) Effect of cross fostering on piglets preweaning performance. *Arquivo Brasileiro de Medicina Veterinaria Zootecnia*. 38: p. 413-417.
77. Cutler, R.S., V.A. Fahy, E.M. Spicer, and G.M. Cronin (1992) Preweaning mortality. *Diseases of Swine*. 7: p. 847-860.
78. Baxter, E.M., S. Jarvis, J. Palarea-Albaladejo, and S.A. Edwards (2012) The weaker sex? The propensity for male-

biased piglet mortality. *Public Library of Science*. 7(1): p. e30318.

79. Bereskin, B., C.E. Shelby, and D.F. Cox (1973) Some factors affecting pig survival. *Journal of Animal Science*. 36(5): p. 821-827.
80. Dunshea, F.R. (2001) Sexual dimorphism in growth of sucking and growing pigs. *Asian Australasian Journal of Animal Sciences*. 14(11): p. 1610-1615.
81. McCaw, M.B. (2000) Effect of reducing crossfostering at birth on piglet mortality and performance during an acute outbreak of porcine reproductive and respiratory syndrome. *Journal of Swine Health and Production*. 8(1): p. 15-21.
82. Price, E.O., G.D. Hutson, M.I. Price, and R. Borgwardt (1994) Fostering in swine as affected by age of offspring. *Journal of Animal Science*. 72(7): p. 1697-1701.
83. Giroux, S., S. Robert, and G.P. Martineau (2000) The effects of cross-fostering on growth rate and post-weaning behavior of segregated early-weaned piglets. *Canadian Journal of Animal Science*. 80(4): p. 533-538.
84. Robert, S. and G.P. Martineau (2001) Effects of repeated cross-fosterings on preweaning behavior and growth performance of piglets and on maternal behavior of sows. *Journal of Animal Science*. 79(1): p. 88-93.
85. Horrell, I. and J. Bennett (1981) Disruption of teat preferences and retardation of growth following cross-fostering of 1-week old pigs. *Animal Production*. 33(AUG): p. 99-106.
86. Straw, B.E., C.E. Dewey, and E.J. Bürgi (1998) Patterns of crossfostering and piglet mortality on commercial US and Canadian swine farms. *Preventive Veterinary Medicine*. 33(1-4): p. 83-89.
87. Wattanaphansak, S., L. Larriestra, and J. Deen (2002) The effect of cross-fostering on the risk of light weaning weight. in *Proceeding of the 17th Congress of IPVS Annual Meeting. Ames, Iowa, USA. June*.
88. Wattanaphansak, S., S. Luengyosluechakul, A. Larriestra, and J. Deen (2002) The impact of cross-fostering on swine production. *Thai Journal of Veterinary Medicine*. 32: p. 101-106.
89. Straw, B.E. (1997) Veterinary Practice: art, science and politics. *Proceedings Western Canadian Association of Swine Practitioners* p. 1-31.
90. Reese, Duane and Straw, Barbara, "The Case Against Evening-Up Litters Until Weaning" (2006). Nebraska Swine Reports. 212. http://digitalcommons.unl.edu/coopext_swine/212
91. Muns, R., M. Nuntapaitoon, and P. Tummaruk (2016) Non-infectious causes of pre-weaning mortality in piglets. *Livestock Science*. 184: p. 46-57.
92. Sorensen, J.T., T. Rousing, A.B. Kudahl, H.J. Hansted, and L.J. Pedersen (2016) Do nurse sows and foster litters have impaired animal welfare? Results from a cross-sectional study in sow herds. *Animal*. 10(4): p. 681-686.
93. Alexopoulos, J., D.S. Lines, and K.J. Plush (2017) Nurse sows display altered reproduction in the next gestation. *Animal Production Science*. 57: p. 2445.
94. Amdi, C., V.A. Moustsen, L.C. Oxholm, E.M. Baxter, G. Sørensen, K.B. Eriksson, L.H. Diness, M.F. Nielsen, and C.F. Hansen (2017) Comparable cortisol, heart rate and milk let-down in nurse sows and non-nurse sows. *Livestock Science*. 198: p. 174-181.
95. Houben, M.A.M., T.J. Tobias, and M.M.C. Holstege (2017) The effect of double nursing, an alternative nursing strategy for the hyper-prolific sow herd, on herd performance. *Porcine Health Management*. 3: p. 2.
96. Prims, S., B. Tambuyzer, H. Vergauwen, V. Huygelen, S. Van Cruchten, C. Van Ginneken, and C. Casteleyn (2016) Intestinal immune cell quantification and gram type classification of the adherent microbiota in conventionally and artificially reared, normal and low birth weight piglets. *Livestock Science*. 185: p. 1-7.
97. Rzezniczek, M., L. Gygax, B. Wechsler, and R. Weber (2015) Comparison of the behaviour of piglets raised in an artificial rearing system or reared by the sow. *Applied Animal Behaviour Science*. 165: p. 57-65.
98. Dunshea, F.R., J.M. Boyce, and R.H. King (1998) Effect of supplemental nutrients on the growth performance of sucking pigs. *Australian Journal of Agricultural Research*. 49(5): p. 883-888.
99. Pastoret, P.-P., Griebel, P., Bazin, H., & Govaerts, A. (1998). Immunology of the pig. In, *Handbook of Vertebrae Immunology*.(pp. 373-419). London, Academic Press.
100. Roth, J.A. (1992). Immune System. In A.D. Leman, B.E. Straw, W.L. Mengeling, S. D'Allaire, & D.J. Taylor (Eds.), Diseases of Swine. (pp. 21-39). Ames, Iowa USA: Iowa State University Press.
101. Klobasa, F., & Habe, F. (1990). The duration of intestinal uptake of colostral immunoglobulins in newborn piglets. Proceedings, International Pig Veterinary Society, 11th Congress, July 1-5, 1990, Lausanne, Switzerland, 287
102. Puppe, B., Langbein, J., Bauer, J., Hoy, S., 2008. A comparative view on social hierarchy formation at different stages of pig production using sociometric measures. Livest. Sci. 113, 155–162
103. www.nationalhogfarmer.com/mag/farming_crossfostering_less



AUSTRALIAN PORK LIMITED
ABN 83 092 783 278

Level 2, 2 Brisbane Avenue, Barton ACT 2600
PO Box 4746 Kingston ACT 2604 Australia

P: 02 6285 2200 F: 02 6285 2288
E: apl@australianpork.com.au

www.australianpork.com.au