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# The association between environmental temperature, farrowing rate and sow litter size: a descriptive South African study

By

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# B. SUMMARY

The reproductive performance of pigs is the main determinant of the profit farmers make in pig production. There are many contributors to poor reproductive performance and in this study the influence of environmental temperature on farrowing rate and litter sizes has been described in the South African situation.

Literature on the influence of season on reproductive performance (‘seasonal infertility’), are somewhat conflicting. This is not surprising considering the variation between the situations of the studies performed, in terms of differing countries, management systems, nutrition, disease profiles, housing and genetics.

Data were collected from four commercial breeding units with good records on a weekly basis from December 2010 to August 2012. These data included the number of sows inseminated/mated, number of sows farrowed and the number of piglets born alive, as well as the number of stillbirths. Note was also taken of whether environmental temperature control mechanisms were employed in the breeding house and dry sow houses. Temperature data from weather stations within 100km of the breeding units was obtained from the South African Weather Service.

On all breeding units a decrease in farrowing rate following matings during severe average temperatures (>30°C) when compared to the farrowing rate following matings during mild average temperatures (<22°C) was observed.

The most significant observation of this study was that the trend was for farrowing rates to decrease following inseminations/matings during times of high ambient temperatures (>30°C). Environmental temperature control did not negate this effect, but the breeding units employing the environmental temperature control did show higher average farrowing rates overall.

# OPSOMMING

Reproduktiewe uitsette van sôe is die faktor wat bepaal hoeveel wins die varkboer maak. Daar is verskeie faktore wat bydra tot swak reproduktiewe prestasie van die kudde. Hierdie studie bestudeer die invloed van temperatuur op die jongingstempo en die werpselgrootte binne ‘n Suid-Afrikaanse konteks.

Literatuur oor die invloed van seisoen op reproduktiewe uitsette (‘seisoenale onvrugbaarheid’) is ietwat teenstrydig. Dis nie verbasend nie wanneer mens in ag neem die variasie in die omstandighede van die verskillende studies in terme van verskillende lande, bestuur, voeding, siektes, behuising en genetika.

Data was verkry vanaf vier kommersiële teeleenhede. Hierdie teeleenhede het goeie rekordhouding van weeklikse reproduktiewe uitsette tussen Desember 2010 en Augustus 2012. Die uitsette het ingesluit die hoeveelheid sôe ge-insemineer of gedek, die hoeveelheid sôe wat gejong het, die werpselgroottes en die hoeveelheid doodgebores. Dit was ook opgelet of daar meganismes van omgewings-temperatuur-beheer toegepas word in die dekkings-huis en die droë sôe huis. Temperatuur data was verkry van weerstasies binne 100km van die teeleenhede vanaf die Suid-Afrikaanse Weerdienste.

Op al die teeleenhede was ekonomiese beduidende vermindering van die jongingstempo waargeneem met dekkings gedurende tye van hoë gemiddelde temperature (>30°C) in vergelyking met die jongingtempo wat gevolg het van dekkings gedurende matige temperature (<22°C).

Die mees beduidende waarneming gedurende hierdie studie was die tendens vir die jongingstempo om te verminder met inseminasies of dekkings gedurende tye van hoë gemiddelde temperature (>30°C). Omgewings-temperatuur-beheer het nie hierdie tendens verander nie, maar die teeleenhede met omgewings-temperatuur-beheer het in die algemeen hoër gemiddelde jongingstempos gehad.

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# CHAPTER 1

## Literature Review

### 1.1 INTRODUCTION

Farmers are paid for the weight of pig meat sold, thus the more pigs sold, the more the farmer and the pig industry benefit. The biggest threat to this profit is poor reproductive performance, fewer piglets per sow means less carcasses sold, causing economic losses to the farmer. This also means more sows will need to be rebred, more culled and more replacement animals obtained, which causes indirect losses as well (Tast *et al.* 2005). There are many reasons for poor reproductive performance, ranging from infectious causes, nutrition, management, environment and genetics but one remains a mystery, namely, seasonal infertility.

Literature on the subject of seasonal infertility can, at times, be conflicting. This is not surprising considering the wide range of variation between the studies, which span different continents, countries, genetics, management systems, nutritional sources and disease statuses. This indicates that a local approach may be needed since each factor contributing to the syndrome may vary in prevalence and severity in specific areas. Boma & Bilkei (2006) even stated: "… it is notoriously difficult and even controversial to compare published reproductive data on seasonally related reproductive problems from different authors and continents in different seasons."

In South Africa ambient temperatures are generally relatively high and so may play a more significant role in seasonal infertility than in more temperate countries.

The term "seasonal infertility" or "summer infertility" has been associated with the syndrome of lowered reproductive performance during the summer season. This has been shown to be a problem in South Africa as well as various other countries by negatively affecting not only the reproductive performance but consequently the economic efficiency of pig herds (Chokoe & Siebrits 2009). The two most important parameters in pig reproduction are the farrowing rate, as the key factor for reliable production of piglets, and the litter size, as the determinant of the amount of product that can be marketed (Bloemhof *et al.* 2013).

## 1.2 SEASONAL INFERTILITY

Seasonal infertility has been defined as the difference in the fertility rate in the summer and winter of the same year (Auvigne *et al.* 2010). Seasonal infertility can be traced back to the origins of the domestic pig, which is the European wild boar. The European wild boar has a definite breeding season during early winter, after which a litter of piglets is born in springtime, thus producing only one litter a year followed by a period of anoestrus towards the end of summer (Koketsu & Dial 1996). The domestic pig retains vestiges of this seasonality, showing a reduced fertility in late summer and early autumn (Peltoniemi, Tast & Love 2000).

The effects of this syndrome are many and include: (Boma & Bilkei 2006; Peltoniemi, Tast & Love 2000; Chokoe & Siebrits 2009):

- Delayed puberty of gilts
- Increased weaning to oestrus period
- Increased weaning to conception interval
- Increased incidence of abortions and non-viable piglets
- Decreased farrowing rate
- Decreased birth mass
- Decreased litter sizes

## 1.3 TEMPERATURE

High ambient temperatures causing heat stress have been repeatedly linked to seasonal infertility (Peltoniemi, Tast & Love 2000). The domestic pig is prone to heat stress, as it lacks a way of aiding heat loss for example evaporative cooling via sweating (Babicz *et al.* 2012). Heat stress occurs when the temperatures are higher than the upper critical temperature of the pig's thermo-neutral zone, which is between 12°C and 22°C (Bloemhof *et al.* 2008). Heat stress causes embryonic death and abortion and so influences reproductive performance, but it also has welfare implications as it can lead to the death of sows and boars, which causes an even greater loss to the farmer (Mackinnon 2004). High ambient temperatures can cause reproductive losses by direct effects on the gametes, embryos or uterine function or indirectly via the endocrine system (Davies 1988).

Of concern is the future effect of global warming, as the increase in environmental temperature can have far-reaching consequences for the global pig industry, especially where open housing is generally utilized (Tummaruk *et al.* 2010).

One should also take into account that boars are also affected by seasonal infertility, with the longer photoperiod affecting sperm production and increased ambient temperature (>29˚C) having a direct damaging effect on the germinal cells (Mackinnon 2004) with a decline in sperm motility, a decrease in the number of sperm and a greater number of morphological defects of the sperm (Almond & Bilkei 2005).

*In vitro* studies by Suzuki, Watanabe & Fukui (2010) showed that porcine embryo production was significantly affected by temperature even though they can be produced during any season.

Peltoniemi, Tast & Love (2000) reported that attempts to overcome the effects of seasonal infertility with environmental cooling systems have not been successful, which is supported by the fact that seasonal infertility is present even in temperate climates. This is, however, contradicted by Davies (1988), who demonstrated an improvement in farrowing rate during the summer infertility period by implementing environmental and managemental strategies. This may indicate that the degree to which temperature versus photoperiod influences seasonal infertility may vary according to the prevailing environmental conditions in the specific country. This is corroborated by the statement by Boma & Bilkei (2006) that even though various countries suffer the effects of seasonal infertility, the hotter countries were generally more severely affected.

A study in France, by Prunier, Dourmad & Etienne (1994), compared different photoperiods with differing ambient temperatures to establish the effect on reproductive performance and found that temperature had a greater influence.

### 1.3.1 Farrowing rate

Farrowing rates were commonly found in literature to be lowered during summer with varying explanations. Tast *et al.* (2002) demonstrated that a decreased farrowing rate was, at least in part, caused by early disruption of pregnancy. This is supported by Peltoniemi, Tast & Love (2000) who state that during the summer period, certain sows conceive but just after implantation, the embryos die and the pregnancy is disrupted, with the sows then showing oestrus again 25-30 days post-insemination. It was also demonstrated that early pregnancy losses, measured by ultrasound and hormone profiles, were more common in the summer infertility period than during winter months (Tast *et al.* 2002). The reason for this early loss of pregnancy is given as a seasonal decrease in luteinizing hormone (LH) production, combined with restricted post-insemination feeding practices leading to decreased progesterone levels and a decrease in embryo viability (Peltoniemi, Tast & Love 2000). Boma & Bilkei (2006) also state that when sows are heat-stressed in the time around mating and nidation, the pregnancy is lost and one can have a regular return to oestrus.

Almond & Bilkei (2005) found that farrowing rates decreased when the ambient temperature went over 35˚C. Boma & Bilkei (2006) found that during the winter time farrowing rates increased. Bertoldo *et al.* (2009) suggest that lowered farrowing rates can be due to late pregnancy losses should the temperatures increase towards the end of gestation.

In Kenya, a study found that sows mated in summer, with an average temperature of 37.2°C, had an average farrowing rate of 70.8% when compared to sows mated in winter, with an average temperature of 25.2°C, which had an average farrowing rate of 80.1%. This study found that the major cause for this seasonal difference to be the varying ambient temperature, as when the sows were exposed to high ambient temperatures during the 3 weeks post-mating, it led to a decreased farrowing rate. (Boma & Bilkei 2006)

A similar study done in Croatia (Almond & Bilkei 2005) delivered similar results. Over a 6 year period it was found that sows mated in weeks with an average temperature

> 35°C, the average farrowing rate was 80%, whereas the rate for sows mated in weeks with the average temperature < 30°C , the average farrowing rate was 91%. Once again the conclusion was that high ambient temperatures resulted in a decrease in the farrowing rate.

In Thailand, it was found that daylength is practically constant (12±1h) during the year and that the seasonal effects seen were due to temperature and/or humidity (Tummaruk *et al.* 2010). A study in the French West Indies had a similar conclusion, but also found that the humidity there was comparable throughout the year, thus ambient temperature played a greater role in the seasonal differences seen (Gourdine *et al.* 2006). They found that the average farrowing rate was 74.8% in the warm season with an average temperature of 23.6°C, whereas the average farrowing rate was 61.4% in the hot season with an average temperature of 25.8°C, indicating that even though it is a small difference in average temperature, it causes a significant difference in farrowing rate.

A study was done in France to compare the relative roles of temperature and photoperiod in seasonal infertility. To accomplish this, the study had to be done over several years, on the premise that photoperiod should be repeatable on a yearly basis, whereas temperatures are not. They found that there was seasonal infertility every year, indicating that photoperiod plays a role, but that the effects on farrowing rate were worse in hotter years than in cooler years, which may indicate that high environmental temperature may play the bigger part in seasonal infertility (Auvigne *et al.* 2010).

A study was done by Davies (1988), on a farm in South Africa, which showed a problem with summer infertility. This farm showed a farrowing rate of between 44% and 47% during the summer compared with farrowing rates between 67% and 80% at other times of the year. Following environmental and managemental strategies to improve this problem, the farrowing rate during the summer improved to 83% versus between 80-86% at other times in the year. This example alludes to the fact that South African pig farms are possibly affected by seasonal infertility and that this may be alleviated by environmental and managemental strategies or that poor management can possibly worsen seasonal infertility.

### 1.3.2 Litter sizes

There is contradiction in the literature concerning the effect of seasonal infertility on litter sizes. In Germany it was found that litter sizes of sows inseminated when temperatures were over 25˚C were smaller (Hilgers & Hühn 2004). It has been noted that increased ambient temperatures can lead to a reduced ovulation rate (Boma & Bilkei 2006). Almond & Bilkei (2005) state that smaller litter sizes result when only some embryos die because of the heat stress and Mackinnon (2004) agrees that one may find a lowered fecundity rather than a decrease in fertility. Boma & Bilkei (2006) also state that heat stress around mating, and up to 3 weeks post-mating, can lead to embryonic death, which if not complete, can lead to smaller litter sizes. Tummaruk *et al.* (2010) stated that heat stress during early gestation decreases embryonic tissue via endocrine function effect, which results in a decrease in litter size.

Peltoniemi *et al.* (1999), however, state that no effect was found on the litter size but that there was a decrease in weaned litter weight. Koketsu & Dial (1996) also observed no effect on litter size, but that the sows farrowing in the hotter months had a decrease in weaned litter weight. These lighter weaned litter weights could be explained by sub-optimal feed intake caused by high ambient temperatures, which then depresses milk production in the sow causing the piglets to be lighter at weaning (Koketsu & Dial 1996). It was, however, found that high temperature, high relative humidity and/or high temperature humidity index during pregnancy significantly reduced the litter size (Tummaruk *et al.* 2010). They also suggest that the early period of gestation is more sensitive, which is corroborated by Quesnel, Boulot & Cozler (2005).

The study in Kenya (Boma & Bilkei 2006) found that litter sizes of sows mated in summer (average temperature 37.2°C) were on average 8 piglets, which is much lower than the average 9.2 piglets from sows mated in winter (average temperature 25.2°C). They state that this may, however, be compounded by poor worker morale during the hot temperatures.

In the study in Croatia (Almond & Bilkei 2005), it was found that sows mated during weeks where the average temperatures were > 35°C, produced a litter size of on average 8.3 piglets. In contrast, the sows mated during weeks of the average temperatures being < 30°C, produced a litter size of on average 10.4 piglets. This once again shows the effect of high ambient temperatures, during mating and early gestation, on litter size.

In Thailand it was found that there was a decrease in litter size when there were high ambient temperatures during the sow's gestation period and more especially in the first 5 weeks of gestation (Tummaruk *et al.* 2004). It was also found that high ambient temperatures during late gestation caused an increase in stillbirths (Tummaruk *et al.* 2010).

A study in Poland found that the period of parturition was increased and the resulting number of piglets born alive decreased incrementally when the temperatures increased above 25°C around the time of farrowing (Babicz *et al.* 2012). Similar results were obtained by Vanderhaeghe *et al.* (2010) in Belgium, who found that there were significantly more stillborn piglets when temperatures around farrowing were above 22°C.

## 1.4 PHOTOPERIOD

It has been suggested that photoperiod is the means by which the change in season is communicated to the pig (Peltoniemi, Tast & Love 2000). This helps the pig to determine when the environment will be most conducive to raising offspring (Chokoe & Siebrits 2009). Photoperiod is held to have an effect via melatonin secretion which affects gonodatrophin control in the hypothalamus. Bassett, Bray & Sharpe (2001) found that seasonal anoestrus can be prevented by melatonin implants but uncertainty remains regarding its function in affecting reproductive parameters in sows. It has been demonstrated that the domestic pig's circadian changes in melatonin are similar to those in the wild boar (Tast *et al.* 2005). Chokoe & Siebrits (2009) suggest that regulated photoperiod (decreasing photoperiod) improves farrowing rate and results in larger litter sizes.

A study in Finland found that regulating photoperiod eliminated the effects of seasonal infertility, but that it did not make a difference whether it was a short or a long photoperiod (Tast *et al.* 2005).

In Norway, the environmental temperatures rarely reach 25°C, thus seasonal infertility is taken to be caused by photoperiod. It was found that the litter size was smaller when the sow was inseminated during the long photoperiod (Gaustad-Aas, Hofmo & Karlberg 2004).

Chokoe & Siebrits (2009) performed a study on a farm in South Africa to compare the reproductive efficiency of sows in natural light conditions with those under regulated reduced photoperiods. They found that the minimum day-length in winter was 10.4h and the maximum in summer was 13.4h, giving a difference of 3h. The experimental animals received a regulated 10h of light per day. They found that the farrowing rate was significantly improved in the experimental group, with a farrowing rate of 95.4% compared to the control group's farrowing rate of 81.3% for the sows that were bred in early summer. The litter size also was improved in the experimental animals, with 12.1 piglets when compared to the control group's 11.7 piglets. However, the results of this study may be biased due to the fact that the temperature could not be adequately regulated and that the temperature was higher in the control group by up to 4°C. It can be concluded that more research is needed to establish whether photoperiod or temperature plays the most significant part in seasonal infertility in the South African situation.

## 1.5 OTHER ENVIRONMENTAL FACTORS

Compounding factors may interact with season to either aggravate the infertility problem or in fact to improve the fertility. These include: (Peltoniemi, Tast & Love 2000):

- Housing
- Feeding level
- Boar exposure
- Group size
- Interaction between females

Management can also play a role in the degree to which seasonal infertility affects the animals. Provision of roughage to eat and bedding may have a protective effect (Peltoniemi *et al.* 1999). Management of the climatic conditions in the house and nutrition may worsen seasonal infertility or may even cause infertility (Mackinnon 2004). Management problems include insufficient nutrition, problems with oestrus detection and grouping sows in the stress-sensitive time after mating (Tast *et al.* 2005). One of the main determinants of seasonal anoestrus in the wild boar is the availability of feed and this can be shown to still have an effect on modern sows. Nutrition has been shown to be a significant factor that has an effect on the reproductive physiology of the pig and that season should be one of the factors that should be considered in the feeding programme of the herd (Peltoniemi, Tast & Love 2000).

Studies have also suggested that individually housed sows are better 'protected' from seasonal infertility (Peltoniemi, Tast & Love 2000). This may be due to a reduction in social stress especially around feeding time when compared to sows in group housing, leading to some sows not getting enough feed whereas others get too much. It was found that group-housed sows had a decreased farrowing rate during the seasonal infertility period, while individually housed sows showed no reduction in farrowing rate at this time (Peltoniemi, Tast & Love 2000). Currently animal welfare legislation is moving away from individual stalls to group housing, where social stress will certainly play a role (Peltoniemi, Tast & Love 2000). This social stress can cause an increase in the levels of cortisol, leading to a disruption of pregnancy, which in turn promotes the occurrence of seasonal infertility, especially in low-ranking sows and gilts (Peltoniemi, Tast & Love 2000). Malmkvist *et al.* (2012), however, found that loose housed sows were more able to perform thermo-regulatory behaviour and thus are more able to compensate for high ambient temperatures.

Interestingly, Vanderhaeghe *et al.* (2010) showed that washing sows with warm water before parturition decreased the number of stillbirths.

Considering how many of these factors are not at all related to season, some authors have suggested that the term “seasonal or summer” infertility is incorrect and that stressors, including social, nutritional, managemental and environmental factors combine to cause this syndrome, which can then manifest at any time of the year. (Hennesy & Williamson 1984)

## 1.6 DISEASE

There are many infectious causes that influence reproduction in the sow and can mimic summer infertility. Table 1 contains diseases that have symptoms that can be confused with the symptoms of summer infertility by decreased farrowing rates, decreased litter sizes, anoestrus or irregular cycles. Many of these are not present in South Africa such as *Brucella suis*, Porcine Reproductive and Respiratory Syndrome, Transmissible Gastro-Enteritis, Swine Influenza, Pseudorabies, Classical Swine Fever and Japanese encephalitis virus and can thus be eliminated as a differential. Other diseases are vaccinated against to minimise the effect on reproductive performance, such as for *Leptospira* spp, *Erysipelothrix rhusiopathiae*, *E. Coli* and Parvovirus.

Another obscuring factor influencing sow reproduction is mycotoxins in the feed. Several mycotoxins have a significant influence on the reproductive performance of the sow and so can confuse the seasonal infertility picture even more, considering that mycotoxins may only be a problem seasonally e.g. wet conditions causing excessive mould growth. The main culprits will be discussed:

- Zearalenone: Produced by *Fusarium* spp. and mainly affecting maize and wheat. This toxin has a hyper-oestrogenic effect and can cause anoestrus, abortion, embryonic and foetal death as well as increased stillbirths. Smaller litters can be seen as a result.
- Ergot alkaloids: Produced by *Claviceps* spp. and mainly affecting rye, wheat and barley. This toxin can cause small litters, mummification, repeat oestrus and metritis.
- Tricothecenes (T2): Produced by *Fusarium tricinctum* growing on wheat, rye, maize and soybeans. Intoxication can affect reproduction leading to repeat breeders and small litters. (Kanora & Maes 2009)

**Table 1: List of diseases that can have symptoms similar to those of summer infertility.**

| Type of disease | Infertility (anoestrus or failure to conceive) | Type of disease | Decreased litter sizes (abortion, resorption, stillbirths) |
|---|---|---|---|
| **Bacteria** | *Brucella suis* | **Bacteria** | *Brucella suis* |
| | *Leptospira* spp | | *Leptospira* spp |
| | *Mycoplasma suis* | | *Mycoplasma suis* |
| | *Erysipelothrix rhusiopathiae* | | *Erysipelothrix rhusiopathiae* |
| **Virus** | Porcine Reproductive and Respiratory Syndrome | | *Streptococcus suis* |
| | Parvovirus | | *Chlamydia* spp |
| | Porcine entero- and teschovirus | | *Klebsiella* |
| | Menangle virus | | *Salmonella* spp |
| | Swine influenza | | *E. coli* |
| | Transmissible Gastro-enteritis | | *Pasteurella multicida* |
| | | | *Actinobacillus* spp |
| | | **Virus** | Porcine Reproductive and Respiratory Syndrome |
| | | | Parvovirus |
| | | | Pseudorabies |
| | | | Porcine circovirus type 2 |
| | | | Classical swine fever |
| | | | African swine fever |
| | | | Rubulavirus |
| | | | Porcine entero- and teschovirus |
| | | | Encephalomyocarditis virus |
| | | | Porcine cytomegalovirus |
| | | | Menangle virus |
| | | | Japanese encephalitis virus |
| | | | Swine influenza |
| | | | Transmissible Gastro-enteritis |
| | | **Protozoa** | *Toxoplasma gondii* |

*Compiled from Givens & Marley (2008) and Muirhead (1990).*

## 1.7 SOW-SPECIFIC FACTORS

The effects of seasonal infertility will vary in severity according to sow-specific factors as well, such as which parity animals are more affected by seasonal infertility. Literature on this subject is contradictory. Mackinnon (2004) states that "older, heavier sows" are more affected whereas Tast *et al.* (2002) state that "gilts and primiparous sows" are more affected. Literature, however, agrees that the reproductive performance is generally not as good in primiparous sows as in multiparous sows (Britt, Szarek & Levis 1983) with sows in the second to fifth parity having larger litter sizes born and greater litter weights at weaning (Koketsu & Dial 1996).

Tummaruk *et al.* (2004) found in a study in Thailand that the effect of season on litter size was more significant in gilt litters than sow litters. This was confirmed in another study in Thailand (Tummaruk *et al.* 2010), which found that the effect of season, temperature and humidity was more pronounced in primiparous animals. This was corroborated by Bloemhof, Mathur, Knol & Van der Waaij (2013) who found stronger correlations between temperature and farrowing rate and litter size in gilts that in sows, suggesting that gilts are more susceptible to heat stress due to the demands of growth combined with the production of a first litter.

Tummaruk *et al.* (2010) also found that crossbred sows were not more resistant to seasonal infertility than purebred sows. Vanderhaeghe *et al.* (2010) showed that certain breeds are more predisposed to stillbirths than others.

To establish whether certain sow lines are more resistant to seasonal infertility, Bloemhof *et al.* (2008) performed a study in Spain with sow lines from the Netherlands, adapted to a temperate climate and sow lines from Spain, adapted to the warmer climate of Spain. They found that the Dutch sow line had a better reproductive performance during the cooler periods, but a greater drop in reproductive performance in the hotter periods. The Spanish sow line was found to be more resistant to heat stress and thus had a better reproductive performance in the hotter period when compared to the Dutch sow line.

Bloemhof *et al.* (2012) found that farrowing rate and heat tolerance were both characteristics with low heritability. The correlation between these two traits was found to be negative, in that the more heat tolerant the sow, the smaller the litter sizes. However, they mentioned three motivations for the selection of more heat tolerant sows. Firstly, the selection for leaner animals leading to animals producing more internal heat and thus being less heat tolerant. Secondly, due to global warming, ambient temperatures have been seen to be increasing worldwide, and thirdly, as the human population is increasing, cheap sources of protein are required, which will result in pig production increasing in warmer climates.

As with all other aspects of this syndrome there is a complex interaction with sow specific factors such as age at first service, parity, lactation length, number of piglets weaned per litter and weaning to service interval also attributing to this syndrome. Thus management and culling protocols may need to be adjusted to select for more “seasonal infertility”-proof sows.

## 1.8 CONCLUSION

Prunier, Dourmad & Etienne (1994) concluded that temperature affected reproduction more than photoperiod, with Tummaruk *et al.* (2010) coming to the same conclusion. In South Africa photoperiod does not differ drastically from summer to winter, thus the effect of season will most likely be due to the difference in ambient temperature.

It is suggested that seasonality in pigs cannot be accounted for by just temperature or photoperiod, but most probably there is an interaction between the two (Chokoe & Siebrits 2009). It was, however, found that decreasing the photoperiod during times of high ambient temperature will not negate the negative effects on reproductive performance (Prunier, Dourmad & Etienne 1994).

It can be seen that there is a lack of published data available on the specific effect of high environmental temperature on farrowing rate and litter sizes in the South African situation.

# CHAPTER 2

# Research questions and objectives

## 2.1 RESEARCH QUESTIONS

South Africa experiences relatively high environmental temperatures during summer time and this study will attempt to describe whether these periods have had an effect on the farrowing rate, litter sizes and number of stillbirths, based on field data.

Certain farms in South Africa have environmental temperature control mechanisms to try and negate the effects of high environmental temperature, this study has attempted to observe whether this had an effect on sow reproductive performance during times of high ambient temperature.

## 2.2 RESEARCH OBJECTIVES

1. Observe and describe whether periods of high environmental temperature at the time of insemination/mating caused a decrease in farrowing rate
2. Observe and describe whether periods of high environmental temperature at the time of insemination/mating caused smaller litter sizes
3. Observe and describe whether periods of high environmental temperature at the time of farrowing caused smaller litter sizes
4. Observe and describe whether periods of high environmental temperature at farrowing caused an increase in the number of stillbirths.
5. Observe and describe whether environmental temperature control currently employed on pig farms in South Africa has an influence on negating the negative effects of high temperature on reproductive performance

# CHAPTER 3

# Materials and methods

## 3.1 EXPERIMENTAL DESIGN

Data was collected from functional commercial piggeries, specifically the breeding units. The requirements for the breeding unit to be included in the study was that the unit had to have good records of the reproductive performance of the sows in the unit, especially regarding how many sows were inseminated or mated, how many sows farrowed and the number of piglets born on a weekly basis. This data was collected in a table format, with the information presented on a week by week basis, from December 2010 up until end of August 2012. (For the format of the table, please see Annexure A)

Various farms were approached to participate in the study and many indicated an interest to participate, however, the full set of data was only forthcoming from 5 commercial breeding units. One unit was excluded as the data obtained was not utilizable for this study.

For background information on the breeding units, a questionnaire was completed (For the format of the questionnaire, please see Annexure B). The questionnaire covered:

- The perception of summer infertility and whether/what any measures are employed to negate the effects and whether these are effective.
- The breeding policy on the farm
- The lighting regimen on the farm
- The housing of the sows at the different stages
- The temperatures in the houses
- Heating/cooling methods employed in the houses
- The feeding regimen at each stage
- When the sows are moved
- When the piglets are weaned

These managemental differences were kept in mind when evaluating the data as certain factors may influence the extent to which the unit is affected by seasonal infertility. The feeding and movement information obtained from the breeding units did not lend itself to further investigation and was excluded for the purpose of this study.

Of importance was whether temperature control mechanisms are employed at the units and at which stage of the reproductive cycle and whether it can be seen if the units with these mechanisms are less affected by seasonal infertility than the units without.

As in the study by Tummaruk *et al.* (2010) environmental temperature information was obtained from weather stations within 100km of the breeding units. Bloemhof *et al.* 2012) used data from weather stations with an average distance of 117km between the farm and the weather station. In the current study this information was kindly provided by the South African Weather Service in the form of daily minimum and maximum temperatures.

# CHAPTER 4

# Results

## 4.1 Temperature information

The hottest weeks of the year needed to be determined. This would then be correlated to the critical reproductive times. Bloemhof *et al.* (2008) found that the upper critical temperature of sows adapted to warmer climates was 22°C. Thus the weeks were divided into 3 categories based on the average environmental temperature of that week:

- Mild: below 22°C
- Moderate: 22 – 29.9°C
- Severe: 30°C and above

For this study 75 weeks of sows bred were measured, all the sows bred were followed throughout their gestation until they farrowed, giving 91 weeks measured in total.

**Table 2: Number of weeks in each temperature category per breeding unit**

| Breeding unit | Mild (<22°C) | Moderate (22-29.9°C) | Severe (>30°C) |
|---|---|---|---|
| 1 | 4/91 | 43/91 | 44/91 |
| 2 | 13/91 | 64/91 | 14/91 |
| 3* | 19/91 | 58/91 | 14/91 |
| 4* | 19/91 | 58/91 | 14/91 |

*Breeding units 3 and 4 are in the same region and thus have the same temperature information

The breeding unit supplied the following information on a weekly basis (Annexure A):

- Number of sows bred
- Number of sows farrowed
- Number of piglets born alive
- Number of piglets born dead

From this information the farrowing rate (FR) as a percentage, the average litter size and the average number of stillborn piglets per litter were calculated on a weekly basis.

Farrowing rate was calculated as the number of sows farrowed divided by the number of sows that were bred sixteen weeks prior to that, as a percentage.

The average litter size was calculated as the number of piglets born alive in that week divided by the number of sows that farrowed that week.

The average number of stillborn piglets per litter was calculated as the number of piglets born dead that week, divided by the number of sows that farrowed that week.

The daily minimum and maximum temperatures were provided by the South African Weather Service, from which the average weekly temperatures were calculated.

### Table 3: Data collated from breeding unit 1

| Week of mating | Farrowing rate (%) | Ave litter size (born alive) | Ave stillborn per litter | Ave temp mating week (°C) | Ave temp farrowing week (°C) |
|---|---|---|---|---|---|
| 5-11 Dec 2010 | 93.3 | 12.5 | 1 | 32.7 | 27.3 |
| 12-18 Dec 2010 | 86.5 | 12.9 | 0.9 | 28 | 26.5 |
| 19-25 Dec 2010 | 84 | 13.2 | 0.8 | 31.7 | 24.5 |
| 26 Dec 2010 – 1 Jan 2011 | 87.8 | 12.9 | 1.1 | 32.1 | 26.2 |
| 2- 8 Jan 2011 | 91.5 | 11.6 | 0.7 | 30.1 | 26.2 |
| 9-15 Jan 2011 | 83.3 | 13 | 0.6 | 29.4 | 27 |
| 16-22 Jan 2011 | 90.3 | 12.2 | 0.8 | 31.3 | 27 |
| 23-29 Jan 2011 | 87.3 | 12.3 | 1.2 | 31.7 | 23.9 |
| 30 Jan – 5 Feb 2011 | 88.9 | 12.6 | 0.9 | 31.6 | 23.5 |
| 6-12 Feb 2011 | 84.9 | 11.4 | 1.2 | 33 | 22.1 |
| 13-19 Feb 2011 | 90.3 | 12.1 | 1.2 | 32.2 | 23.7 |
| 20-26 Feb 2011 | 76.7 | 13 | 0.5 | 31.6 | 23.6 |
| 27 Feb – 5 March 2011 | 95.9 | 11.9 | 0.6 | 33 | 24.3 |
| 6-12 March 2011 | 90.5 | 12.7 | 0.5 | 34.1 | 20.3 |
| 13-19 March 2011 | 94.6 | 12.3 | 0.8 | 31.6 | 19.3 |
| 20-26 March 2011 | 91.2 | 13.1 | 0.8 | 31.3 | 26.5 |
| 27 March – 2 Apr 2011 | 94.3 | 11.8 | 0.9 | 30.2 | 21.6 |
| 3-9 Apr 2011 | 80.8 | 11.7 | 1.2 | 27.3 | 24.1 |
| 10-16 Apr 2011 | 90.4 | 12.2 | 0.8 | 26.5 | 26.5 |
| 17-23 Apr 2011 | 78.4 | 13.1 | 0.5 | 24.5 | 21.3 |
| 24-30 Apr 2011 | 97.3 | 12.3 | 0.7 | 26.2 | 28.8 |
| 1-7 May 2011 | 89 | 12.3 | 0.9 | 26.2 | 29.3 |
| 8-14 May 2011 | 80 | 12.7 | 0.9 | 27 | 32 |
| 15-21 May 2011 | 70.7 | 13 | 0.6 | 27 | 30.7 |
| 22-28 May 2011 | 108.1* | 12.4 | 0.9 | 23.9 | 30.5 |
| 29 May – 4 June 2011 | 98.6 | 12.8 | 0.8 | 23.5 | 31.8 |
| 5-11 June 2011 | 87 | 12.7 | 1 | 22.1 | 27.2 |
| 12-18 June 2011 | 95.8 | 12.5 | 1 | 23.7 | 32.1 |
| 19-25 June 2011 | 86.8 | 12 | 0.7 | 23.6 | 31.5 |
| 26 June – 2 July 2011 | 90.3 | 12.8 | 0.8 | 24.3 | 36 |
| 3-9 July 2011 | 79.2 | 11.8 | 1.4 | 20.3 | 31.1 |
| 10-16 July 2011 | 107* | 12.2 | 0.8 | 19.3 | 35.9 |
| 17-23 July 2011 | 91.4 | 12.7 | 0.6 | 26.5 | 36.5 |
| 24-30 July 2011 | 92 | 12.7 | 0.7 | 21.6 | 30 |
| 31 July – 6 Aug 2011 | 94.5 | 13 | 0.6 | 24.1 | 32 |
| 7-13 Aug 2011 | 85.7 | 12.3 | 0.6 | 26.5 | 29.9 |
| 14-20 Aug 2011 | 93.2 | 12.3 | 0.9 | 21.3 | 31.4 |
| 21-27 Aug 2011 | 90 | 12.5 | 0.7 | 28.8 | 33.2 |
| 28 Aug – 3 Sept 2011 | 91.9 | 13 | 0.8 | 29.3 | 29.4 |
| 4-10 Sept 2011 | 90.5 | 11.7 | 1 | 32 | 35 |
| 11-17 Sept 2011 | 85.9 | 11.7 | 1.1 | 30.7 | 32.8 |
| 18-24 Sept 2011 | 91.7 | 12.1 | 0.8 | 30.5 | 30.1 |
| 25 Sept – 1 Oct 2011 | 102.9* | 12.2 | 0.7 | 31.8 | 31.1 |
| 2-8 Oct 2011 | 94.3 | 12.9 | 0.8 | 27.2 | 35.6 |
| 9-15 Oct 2011 | 83.3 | 12.3 | 1.1 | 32.1 | 32.6 |
| 16-22 Oct 2011 | 98.6 | 11.9 | 0.8 | 31.5 | 34.9 |
| 23-29 Oct 2011 | 82.7 | 12.7 | 0.5 | 36 | 35.3 |
| 30 Oct – 5 Nov 2011 | 91.5 | 13.2 | 0.7 | 31.1 | 34.4 |
| 6-12 Nov 2011 | 91.5 | 12.8 | 0.8 | 35.9 | 35.7 |
| 13-19 Nov 2011 | 87.7 | 12.6 | 0.7 | 36.5 | 30.3 |
| 20-26 Nov 2011 | 91.8 | 12.7 | 0.9 | 30 | 32.3 |
| 27 Nov – 3 Dec 2011 | 94.1 | 12 | 0.6 | 32 | 28.6 |
| 4-10 Dec 2011 | 86.3 | 12.6 | 0.8 | 29.9 | 26.8 |
| 11-17 Dec 2011 | 90.8 | 12.7 | 1 | 31.4 | 23.5 |
| 18-24 Dec 2011 | 89.3 | 12.6 | 0.7 | 33.2 | 28.5 |
| 25-31 Dec 2011 | 81.1 | 11.7 | 0.6 | 29.4 | 28.5 |
| 1-7 Jan 2012 | 97.3 | 12.3 | 0.5 | 35 | 31.3 |
| 8-14 Jan 2012 | 89.2 | 12.6 | 0.7 | 32.8 | 29.7 |
| 15-21 Jan 2012 | 81.7 | 12.4 | 0.9 | 30.1 | 27.9 |
| 22-28 Jan 2012 | 98.6 | 12.3 | 1 | 31.1 | 26.7 |
| 29 Jan – 4 Feb 2012 | 90.4 | 12.6 | 0.5 | 35.6 | 25.5 |
| 5-11 Feb 2012 | 88.6 | 12.1 | 0.7 | 32.6 | 24.4 |
| 12-18 Feb 2012 | 93.2 | 11.9 | 0.6 | 34.9 | 22.5 |
| 19-25 Feb 2012 | 91.5 | 11.8 | 1 | 35.3 | 25 |
| 26 Feb – 3 March 2012 | 81.9 | 12.6 | 1 | 34.4 | 25 |
| 4-10 March 2012 | 98.6 | 11.4 | 0.7 | 35.7 | 27.3 |
| 11-17 March 2012 | 97.2 | 12.2 | 0.9 | 30.3 | 24.8 |
| 18-24 March 2012 | 88.7 | 12 | 1 | 32.3 | 22.5 |
| 25-31 March 2012 | 90.5 | 12.4 | 0.8 | 28.6 | 26.3 |
| 1-7 Apr 2012 | 94.1 | 13 | 0.8 | 26.8 | 25.4 |
| 8-14 Apr 2012 | 95.8 | 12.1 | 0.9 | 23.5 | 22.6 |
| 15-21 Apr 2012 | 100 | 13.1 | 0.8 | 28.5 | 26 |
| 22-28 Apr 2012 | 84.7 | 13.6 | 0.9 | 28.5 | 32.1 |
| 29 Apr – 5 May 2012 | 88.4 | 12.7 | 0.7 | 31.3 | 32.4 |
| 6-12 May 2012 | 107* | 12.8 | 0.9 | 29.7 | 32 |

*Farrowing rate >100% indicates that some sows may have farrowed early or late, thus causing this inconsistency.

### Table 4: Data collated from breeding unit 2

| Week of mating | Farrowing rate (%) | Ave litter size (born alive) | Ave stillborn per litter | Ave temp mating week (°C) | Ave temp farrowing week (°C) |
|---|---|---|---|---|---|
| 5-11 Dec 2010 | 90.5 | 11 | 1.5 | 25.3 | 29.9 |
| 12-18 Dec 2010 | 92.3 | 11.3 | 1.9 | 26 | 25.3 |
| 19-25 Dec 2010 | 92.3 | 11.3 | 1.7 | 29.3 | 24.5 |
| 26 Dec 2010 – 1 Jan 2011 | 98 | 10.9 | 2 | 28.6 | 19.4 |
| 2- 8 Jan 2011 | 88.1 | 11.7 | 2 | 26.9 | 25.6 |
| 9-15 Jan 2011 | 89.4 | 11.9 | 1.8 | 26.9 | 23.3 |
| 16-22 Jan 2011 | 90.4 | 11.2 | 2.1 | 27.8 | 25.2 |
| 23-29 Jan 2011 | 91.5 | 10.6 | 2.1 | 28.3 | 24.7 |
| 30 Jan – 5 Feb 2011 | 92.3 | 11.1 | 1.4 | 27.3 | 22.9 |
| 6-12 Feb 2011 | 89.7 | 11.1 | 1.9 | 29.4 | 23.1 |
| 13-19 Feb 2011 | 82.1 | 12.1 | 1.9 | 28.4 | 21 |
| 20-26 Feb 2011 | 84.9 | 11.4 | 1.9 | 26.9 | 20.6 |
| 27 Feb – 5 March 2011 | 84 | 11.4 | 2 | 28.8 | 21.1 |
| 6-12 March 2011 | 86.5 | 11.7 | 2.4 | 30.6 | 22.5 |
| 13-19 March 2011 | 98.9 | 11.3 | 1.8 | 28.7 | 18.7 |
| 20-26 March 2011 | 82.7 | 10.7 | 1.8 | 30 | 18.2 |
| 27 March – 2 Apr 2011 | 86 | 11.3 | 1.7 | 29.9 | 23.2 |
| 3-9 Apr 2011 | 88.5 | 11.9 | 1.8 | 25.3 | 20.3 |
| 10-16 Apr 2011 | 85.7 | 12 | 1.5 | 24.5 | 20.9 |
| 17-23 Apr 2011 | 87 | 11 | 1.7 | 19.4 | 24.2 |
| 24-30 Apr 2011 | 86.1 | 11.8 | 1.9 | 25.6 | 19.2 |
| 1-7 May 2011 | 90.2 | 12.1 | 1.8 | 23.3 | 25 |
| 8-14 May 2011 | 87 | 11.6 | 1.9 | 25.2 | 26.3 |
| 15-21 May 2011 | 88.8 | 11.7 | 1.7 | 24.7 | 28.7 |
| 22-28 May 2011 | 86.1 | 12.1 | 1.5 | 22.9 | 27.1 |
| 29 May – 4 June 2011 | 86.2 | 12.3 | 1.7 | 23.1 | 26.2 |
| 5-11 June 2011 | 88.8 | 11.7 | 1.9 | 21 | 27.5 |
| 12-18 June 2011 | 97.1 | 11.8 | 2.1 | 20.6 | 24.4 |
| 19-25 June 2011 | 105.1* | 11.9 | 1.9 | 21.1 | 27.9 |
| 26 June – 2 July 2011 | 93.3 | 11.4 | 1.8 | 22.5 | 25.5 |
| 3-9 July 2011 | 90.7 | 11.5 | 1.9 | 18.7 | 31.9 |
| 10-16 July 2011 | 90.5 | 12 | 2.1 | 18.2 | 26.5 |
| 17-23 July 2011 | 93.1 | 11.8 | 2.2 | 23.2 | 30.9 |
| 24-30 July 2011 | 95.1 | 11.4 | 1.9 | 20.3 | 31.4 |
| 31 July – 6 Aug 2011 | 96 | 11.8 | 2.1 | 20.9 | 24.2 |
| 7-13 Aug 2011 | 88.7 | 11.9 | 1.9 | 24.2 | 26.1 |
| 14-20 Aug 2011 | 91.5 | 11.2 | 2.1 | 19.2 | 25.7 |
| 21-27 Aug 2011 | 104* | 11.3 | 3.3 | 25 | 26.7 |
| 28 Aug – 3 Sept 2011 | 111.9* | 12.2 | 1.7 | 26.3 | 28.8 |
| 4-10 Sept 2011 | 81.6 | 12.4 | 1.7 | 28.7 | 25.8 |
| 11-17 Sept 2011 | 84.3 | 12 | 2 | 27.1 | 31.4 |
| 18-24 Sept 2011 | 89.5 | 12 | 1.9 | 26.2 | 30.7 |
| 25 Sept – 1 Oct 2011 | 90.2 | 11.7 | 1.7 | 27.5 | 26.1 |
| 2-8 Oct 2011 | 82.4 | 12.6 | 1.9 | 24.4 | 28 |
| 9-15 Oct 2011 | 88.6 | 11.9 | 1.7 | 27.9 | 30.5 |
| 16-22 Oct 2011 | 89.6 | 12.3 | 1.6 | 25.5 | 30.9 |
| 23-29 Oct 2011 | 93.4 | 12 | 1.9 | 31.9 | 30.9 |
| 30 Oct – 5 Nov 2011 | 89.4 | 11.7 | 1.8 | 26.5 | 31 |
| 6-12 Nov 2011 | 88.5 | 11.8 | 1.7 | 30.9 | 30.4 |
| 13-19 Nov 2011 | 92.3 | 12.1 | 2 | 31.4 | 30.8 |
| 20-26 Nov 2011 | 93.3 | 12.1 | 1.9 | 24.2 | 28.2 |
| 27 Nov – 3 Dec 2011 | 93.3 | 11.1 | 1.8 | 26.1 | 27.9 |
| 4-10 Dec 2011 | 82.7 | 12.3 | 1.8 | 25.7 | 28.5 |
| 11-17 Dec 2011 | 85.8 | 11.3 | 2.1 | 26.7 | 24.3 |
| 18-24 Dec 2011 | 88 | 11.7 | 2.2 | 28.8 | 24.9 |
| 25-31 Dec 2011 | 90.3 | 11.3 | 1.9 | 25.8 | 25.8 |
| 1-7 Jan 2012 | 88.6 | 11.2 | 1.9 | 31.4 | 23.9 |
| 8-14 Jan 2012 | 89.4 | 11.8 | 2 | 30.7 | 30.9 |
| 15-21 Jan 2012 | 98 | 11.4 | 1.8 | 26.1 | 25.7 |
| 22-28 Jan 2012 | 91.3 | 11.7 | 1.8 | 28 | 25.8 |
| 29 Jan – 4 Feb 2012 | 87.7 | 11.5 | 1.8 | 30.5 | 23.6 |
| 5-11 Feb 2012 | 86.8 | 11.9 | 1.7 | 30.9 | 22.3 |
| 12-18 Feb 2012 | 86.9 | 11.6 | 1.7 | 30.9 | 22.3 |
| 19-25 Feb 2012 | 84.3 | 11.7 | 1.7 | 31 | 19.5 |
| 26 Feb – 3 March 2012 | 85.7 | 12 | 1.7 | 30.4 | 21.2 |
| 4-10 March 2012 | 84.9 | 11.7 | 1.8 | 30.8 | 23.4 |
| 11-17 March 2012 | 84 | 12.4 | 1.9 | 28.2 | 24 |
| 18-24 March 2012 | 82.6 | 11.5 | 2 | 27.9 | 22.3 |
| 25-31 March 2012 | 86.9 | 11.6 | 1.9 | 28.5 | 21.1 |
| 1-7 Apr 2012 | 90.1 | 12.1 | 2 | 24.3 | 22.3 |
| 8-14 Apr 2012 | 83 | 11.7 | 1.7 | 24.9 | 22.6 |
| 15-21 Apr 2012 | 87.9 | 11.8 | 2.3 | 25.8 | 21.6 |
| 22-28 Apr 2012 | 93.3 | 11.2 | 2.1 | 23.9 | 22.8 |
| 29 Apr – 5 May 2012 | 92.4 | 11.7 | 2.1 | 30.9 | 29 |
| 6-12 May 2012 | 88.7 | 11.8 | 1.9 | 25.7 | 28.7 |

*Farrowing rate >100% indicates that some sows may have farrowed early or late, thus causing this inconsistency.

**Table 5: Data collated from breeding unit 3**

| Week of mating | Farrowing rate (%) | Ave litter size (born alive) | Ave stillborn per litter | Ave temp mating week (°C) | Ave temp farrowing week (°C) |
|---|---|---|---|---|---|
| 5-11 Dec 2010 | 87.5 | 10.7 | 1.2 | 29.7 | 29 |
| 12-18 Dec 2010 | 85.7 | 10.6 | 1.1 | 25.5 | 25.7 |
| 19-25 Dec 2010 | 79.6 | 11.7 | 1 | 29.1 | 23.5 |
| 26 Dec 2010 – 1 Jan 2011 | 88.5 | 10.9 | 1 | 29.3 | 21.6 |
| 2- 8 Jan 2011 | 90.4 | 10.4 | 1.1 | 27.5 | 23.7 |
| 9-15 Jan 2011 | 75.5 | 10.7 | 1.1 | 26.4 | 23.3 |
| 16-22 Jan 2011 | 85.7 | 9.8 | 0.9 | 29.9 | 23.9 |
| 23-29 Jan 2011 | 92.3 | 9.8 | 1.8 | 28.4 | 24.5 |
| 30 Jan – 5 Feb 2011 | 76.9 | 8.7 | 1.8 | 28.3 | 21 |
| 6-12 Feb 2011 | 86.3 | 10.3 | 1.4 | 31.3 | 21.3 |
| 13-19 Feb 2011 | 80.4 | 10 | 1.3 | 28.8 | 19.7 |
| 20-26 Feb 2011 | 81.8 | 9.4 | 1.7 | 29 | 21.2 |
| 27 Feb – 5 March 2011 | 87.8 | 8.9 | 1.7 | 30.1 | 19.8 |
| 6-12 March 2011 | 73.8 | 9.8 | 1.2 | 31.8 | 20.6 |
| 13-19 March 2011 | 72 | 10.3 | 1 | 27.9 | 17.6 |
| 20-26 March 2011 | 83.3 | 11.8 | 0.7 | 29.2 | 19.6 |
| 27 March – 2 Apr 2011 | 104.1* | 11.5 | 1.1 | 29 | 22.9 |
| 3-9 Apr 2011 | 81 | 11.5 | 1.1 | 25.7 | 19.1 |
| 10-16 Apr 2011 | 62 | 12.5 | 1.5 | 23.5 | 21.4 |
| 17-23 Apr 2011 | 96.3 | 11.7 | 0.7 | 21.6 | 24.6 |
| 24-30 Apr 2011 | 86.4 | 11.9 | 1.6 | 23.7 | 18.6 |
| 1-7 May 2011 | 87 | 13 | 0.7 | 23.3 | 26 |
| 8-14 May 2011 | 69 | 13 | 1 | 23.9 | 27.1 |
| 15-21 May 2011 | 82 | 12 | 1 | 24.5 | 29.8 |
| 22-28 May 2011 | 87.7 | 12.2 | 1.3 | 21 | 26.5 |
| 29 May – 4 June 2011 | 91.8 | 10.5 | 0.8 | 21.3 | 26 |
| 5-11 June 2011 | 83.6 | 11.9 | 1.2 | 19.7 | 28.6 |
| 12-18 June 2011 | 86.7 | 11.1 | 1 | 21.2 | 24.5 |
| 19-25 June 2011 | 88 | 10.8 | 0.8 | 19.8 | 29.9 |
| 26 June – 2 July 2011 | 100 | 11.8 | 0.9 | 20.6 | 27.3 |
| 3-9 July 2011 | 74.5 | 11.7 | 1.2 | 17.6 | 33 |
| 10-16 July 2011 | 93.5 | 12 | 0.4 | 19.6 | 27 |
| 17-23 July 2011 | 80.4 | 11.4 | 0.7 | 22.9 | 32.1 |
| 24-30 July 2011 | 81.5 | 11.3 | 1.2 | 19.1 | 32.5 |
| 31 July – 6 Aug 2011 | 92.6 | 11.4 | 1 | 21.4 | 25.7 |
| 7-13 Aug 2011 | 94.3 | 10.9 | 0.9 | 24.6 | 28.5 |
| 14-20 Aug 2011 | 115.2* | 11.5 | 1 | 18.6 | 27.8 |
| 21-27 Aug 2011 | 87.7 | 12.8 | 0.5 | 26 | 29.7 |
| 28 Aug – 3 Sept 2011 | 83 | 12.3 | 1 | 27.1 | 30.2 |
| 4-10 Sept 2011 | 106.1* | 11.6 | 0.8 | 29.8 | 27.7 |
| 11-17 Sept 2011 | 94.8 | 12.5 | 1 | 26.5 | 32.1 |
| 18-24 Sept 2011 | 84.6 | 12.1 | 1 | 26 | 30.7 |
| 25 Sept – 1 Oct 2011 | 85.5 | 12.9 | 1 | 28.6 | 28.6 |
| 2-8 Oct 2011 | 91.5 | 10.7 | 1 | 24.5 | 29.7 |
| 9-15 Oct 2011 | 79.2 | 12.4 | 1.3 | 29.9 | 31.8 |
| 16-22 Oct 2011 | 100 | 12.1 | 1.2 | 27.3 | 29.8 |
| 23-29 Oct 2011 | 90 | 10.5 | 1 | 33 | 31.5 |
| 30 Oct – 5 Nov 2011 | 83 | 10.8 | 1.2 | 27 | 30.6 |
| 6-12 Nov 2011 | 83.3 | 11.2 | 1.5 | 32.1 | 31.3 |
| 13-19 Nov 2011 | 86.3 | 11.4 | 1.3 | 32.5 | 31.8 |
| 20-26 Nov 2011 | 88.7 | 10.6 | 1.5 | 25.7 | 27.4 |
| 27 Nov – 3 Dec 2011 | 87.9 | 12.2 | 0.8 | 28.5 | 29.7 |
| 4-10 Dec 2011 | 95.5 | 12.1 | 0.8 | 27.8 | 27.3 |
| 11-17 Dec 2011 | 79.6 | 12.7 | 0.9 | 29.7 | 25.8 |
| 18-24 Dec 2011 | 96 | 11.3 | 1 | 30.2 | 25.4 |
| 25-31 Dec 2011 | 97.8 | 11.7 | 1 | 27.7 | 26.8 |
| 1-7 Jan 2012 | 83.6 | 11.2 | 1.4 | 32.1 | 23.7 |
| 8-14 Jan 2012 | 85.2 | 12.2 | 0.9 | 30.7 | 29.9 |
| 15-21 Jan 2012 | 100 | 11.9 | 0.8 | 28.6 | 27.8 |
| 22-28 Jan 2012 | 82.7 | 12.1 | 0.4 | 29.7 | 24.7 |
| 29 Jan – 4 Feb 2012 | 75 | 12.7 | 1 | 31.8 | 24.2 |
| 5-11 Feb 2012 | 83.3 | 12.2 | 0.8 | 29.8 | 23.5 |
| 12-18 Feb 2012 | 90 | 12.5 | 0.7 | 31.5 | 20.8 |
| 19-25 Feb 2012 | 106.3* | 11.3 | 1.1 | 30.6 | 19.8 |
| 26 Feb – 3 March 2012 | 86.3 | 11.6 | 1.3 | 31.3 | 20.7 |
| 4-10 March 2012 | 86.3 | 12.5 | 0.5 | 31.8 | 22 |
| 11-17 March 2012 | 92.2 | 11.8 | 0.4 | 27.4 | 23.9 |
| 18-24 March 2012 | 84.6 | 12 | 0.7 | 29.7 | 21.3 |
| 25-31 March 2012 | 95.5 | 11.9 | 0.5 | 27.3 | 21.1 |
| 1-7 Apr 2012 | 90.4 | 11.8 | 1.1 | 25.8 | 22.9 |
| 8-14 Apr 2012 | 82.7 | 11.5 | 1 | 25.4 | 22.7 |
| 15-21 Apr 2012 | 96.5 | 11.8 | 0.8 | 26.8 | 18.1 |
| 22-28 Apr 2012 | 86.7 | 12.1 | 0.8 | 23.7 | 21.7 |
| 29 Apr – 5 May 2012 | 85.2 | 12.2 | 0.9 | 29.9 | 28.1 |
| 6-12 May 2012 | 81.3 | 13 | 0.7 | 27.8 | 27.7 |

*Farrowing rate >100% indicates that some sows may have farrowed early or late, thus causing this inconsistency.

**Table 6: Data collated from breeding unit 4**

| Week of mating | Farrowing rate (%) | Ave litter size (born alive) | Ave stillborn per litter | Ave temp mating week (°C) | Ave temp farrowing week (°C) |
|---|---|---|---|---|---|
| 5-11 Dec 2010 | 80 | 11.7 | 0.6 | 29.7 | 29 |
| 12-18 Dec 2010 | 84.5 | 11.4 | 0.6 | 25.5 | 25.7 |
| 19-25 Dec 2010 | 84.8 | 12.2 | 0.8 | 29.1 | 23.5 |
| 26 Dec 2010 – 1 Jan 2011 | 80.3 | 12 | 0.4 | 29.3 | 21.6 |
| 2- 8 Jan 2011 | 90.9 | 11.5 | 1 | 27.5 | 23.7 |
| 9-15 Jan 2011 | 86 | 11.4 | 1.4 | 26.4 | 23.3 |
| 16-22 Jan 2011 | 83 | 11.2 | 0.9 | 29.9 | 23.9 |
| 23-29 Jan 2011 | 83.3 | 12.1 | 1.3 | 28.4 | 24.5 |
| 30 Jan – 5 Feb 2011 | 95 | 11.3 | 1.1 | 28.3 | 21 |
| 6-12 Feb 2011 | 91.2 | 11.4 | 0.5 | 31.3 | 21.3 |
| 13-19 Feb 2011 | 94.5 | 12.3 | 1 | 28.8 | 19.7 |
| 20-26 Feb 2011 | 87.5 | 11.8 | 1.6 | 29 | 21.2 |
| 27 Feb – 5 March 2011 | 88.3 | 12.2 | 1.1 | 30.1 | 19.8 |
| 6-12 March 2011 | 84.5 | 11.6 | 0.5 | 31.8 | 20.6 |
| 13-19 March 2011 | 87.3 | 11.9 | 0.6 | 27.9 | 17.6 |
| 20-26 March 2011 | 85 | 11.5 | 1.1 | 29.2 | 19.6 |
| 27 March – 2 Apr 2011 | 83.6 | 12 | 0.8 | 29 | 22.9 |
| 3-9 Apr 2011 | 84.4 | 11.5 | 1 | 25.7 | 19.1 |
| 10-16 Apr 2011 | 74.1 | 11.3 | 1.4 | 23.5 | 21.4 |
| 17-23 Apr 2011 | 89.5 | 12.1 | 0.8 | 21.6 | 24.6 |
| 24-30 Apr 2011 | 94.7 | 12.4 | 1 | 23.7 | 18.6 |
| 1-7 May 2011 | 85.2 | 12.2 | 1 | 23.3 | 26 |
| 8-14 May 2011 | 88.7 | 12 | 0.9 | 23.9 | 27.1 |
| 15-21 May 2011 | 91.1 | 12.9 | 0.9 | 24.5 | 29.8 |
| 22-28 May 2011 | 91.4 | 12.1 | 1 | 21 | 26.5 |
| 29 May – 4 June 2011 | 91.1 | 12.5 | 0.9 | 21.3 | 26 |
| 5-11 June 2011 | 85.5 | 12.2 | 0.7 | 19.7 | 28.6 |
| 12-18 June 2011 | 91.4 | 12.5 | 1.1 | 21.2 | 24.5 |
| 19-25 June 2011 | 92.7 | 11.2 | 0.8 | 19.8 | 29.9 |
| 26 June – 2 July 2011 | 91.4 | 12.1 | 0.8 | 20.6 | 27.3 |
| 3-9 July 2011 | 89.1 | 12.7 | 1.2 | 17.6 | 33 |
| 10-16 July 2011 | 94.6 | 12.5 | 1.1 | 19.6 | 27 |
| 17-23 July 2011 | 82.5 | 12 | 0.6 | 22.9 | 32.1 |
| 24-30 July 2011 | 90.9 | 12.7 | 0.9 | 19.1 | 32.5 |
| 31 July – 6 Aug 2011 | 86 | 12.2 | 1.2 | 21.4 | 25.7 |
| 7-13 Aug 2011 | 81.5 | 12 | 0.9 | 24.6 | 28.5 |
| 14-20 Aug 2011 | 94.7 | 12.3 | 1.1 | 18.6 | 27.8 |
| 21-27 Aug 2011 | 89.8 | 12.8 | 1.3 | 26 | 29.7 |
| 28 Aug – 3 Sept 2011 | 91.8 | 12.2 | 0.9 | 27.1 | 30.2 |
| 4-10 Sept 2011 | 86.8 | 12.9 | 1.3 | 29.8 | 27.7 |
| 11-17 Sept 2011 | 84 | 12.4 | 1.1 | 26.5 | 32.1 |
| 18-24 Sept 2011 | 88.9 | 11.6 | 1.1 | 26 | 30.7 |
| 25 Sept – 1 Oct 2011 | 92.3 | 12.7 | 0.6 | 28.6 | 28.6 |
| 2-8 Oct 2011 | 92.5 | 12.4 | 1.1 | 24.5 | 29.7 |
| 9-15 Oct 2011 | 94.8 | 12.1 | 1.6 | 29.9 | 31.8 |
| 16-22 Oct 2011 | 96.4 | 12.1 | 1.2 | 27.3 | 29.8 |
| 23-29 Oct 2011 | 88.9 | 11.9 | 0.8 | 33 | 31.5 |
| 30 Oct – 5 Nov 2011 | 87.1 | 12.5 | 1.1 | 27 | 30.6 |
| 6-12 Nov 2011 | 94.8 | 11.7 | 0.8 | 32.1 | 31.3 |
| 13-19 Nov 2011 | 88.7 | 12.1 | 1.2 | 32.5 | 31.8 |
| 20-26 Nov 2011 | 94.6 | 11.1 | 0.9 | 25.7 | 27.4 |
| 27 Nov – 3 Dec 2011 | 90.6 | 12.5 | 1.3 | 28.5 | 29.7 |
| 4-10 Dec 2011 | 88.9 | 11.9 | 1.5 | 27.8 | 27.3 |
| 11-17 Dec 2011 | 84.9 | 12.1 | 1.4 | 29.7 | 25.8 |
| 18-24 Dec 2011 | 92.7 | 12 | 1.3 | 30.2 | 25.4 |
| 25-31 Dec 2011 | 98.2 | 12.4 | 1 | 27.7 | 26.8 |
| 1-7 Jan 2012 | 87.5 | 12.8 | 0.8 | 32.1 | 23.7 |
| 8-14 Jan 2012 | 91.1 | 12 | 1.1 | 30.7 | 29.9 |
| 15-21 Jan 2012 | 96.4 | 12.6 | 1 | 28.6 | 27.8 |
| 22-28 Jan 2012 | 92.3 | 12.3 | 1 | 29.7 | 24.7 |
| 29 Jan – 4 Feb 2012 | 93.4 | 11.8 | 1.4 | 31.8 | 24.2 |
| 5-11 Feb 2012 | 90.2 | 12.4 | 1 | 29.8 | 23.5 |
| 12-18 Feb 2012 | 90.3 | 12.8 | 1.2 | 31.5 | 20.8 |
| 19-25 Feb 2012 | 98 | 12.7 | 1.2 | 30.6 | 19.8 |
| 26 Feb – 3 March 2012 | 87.7 | 12.1 | 1 | 31.3 | 20.7 |
| 4-10 March 2012 | 84.6 | 12.2 | 0.9 | 31.8 | 22 |
| 11-17 March 2012 | 92.7 | 12.3 | 1.2 | 27.4 | 23.9 |
| 18-24 March 2012 | 93 | 11.7 | 1.1 | 29.7 | 21.3 |
| 25-31 March 2012 | 87.9 | 11.4 | 1.3 | 27.3 | 21.1 |
| 1-7 Apr 2012 | 88.2 | 11.9 | 1 | 25.8 | 22.9 |
| 8-14 Apr 2012 | 90.9 | 12.6 | 1.3 | 25.4 | 22.7 |
| 15-21 Apr 2012 | 94.5 | 12 | 1.5 | 26.8 | 18.1 |
| 22-28 Apr 2012 | 88.9 | 13.1 | 1.2 | 23.7 | 21.7 |
| 29 Apr – 5 May 2012 | 96.4 | 12.2 | 1.1 | 29.9 | 28.1 |
| 6-12 May 2012 | 91.1 | 12.6 | 1.1 | 27.8 | 27.7 |

To simplify the data was averaged to discover what trends can be seen in the various breeding units. It is also to be noted that all the farms utilise similar genetic material.

### 4.1.1 Breeding unit 1

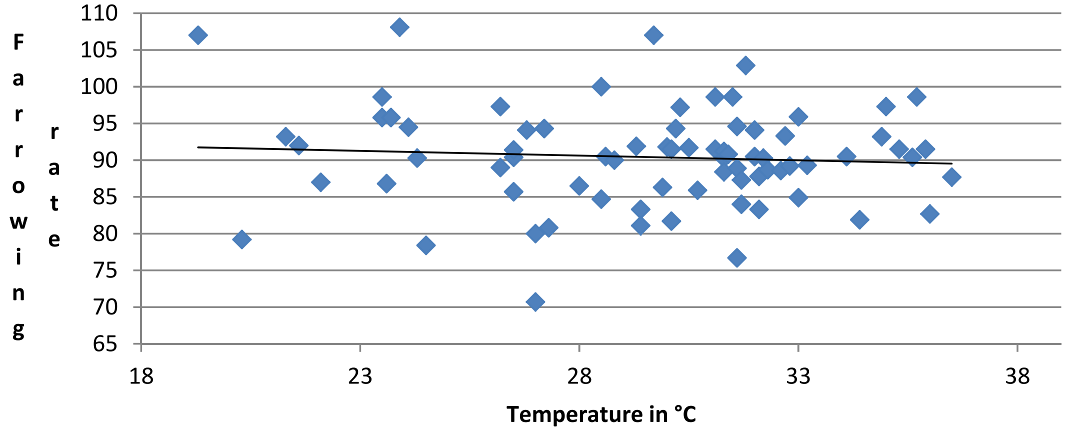
Breeding unit 1 is an approximate 1400 sow unit, that utilises artificial insemination, artificial lighting and flush feeding. They use an all-in, all-out management system and wean at 28 days. The unit utilises natural ventilation with automatic side panels in the breeding houses that function with a thermostat. The unit is situated in the summer rainfall area, that is in the temperate interior according to the SANS 204-2 standard and is Arid, Steppe, Hot arid in the Köppen-Geiger Climate Classification (Conradie 2012).

**Table 7: Average data from breeding unit 1**

| | **Average farrowing rate** | **Average litter size (number born alive for temp at mating)** | **Average litter size (number born alive for temp at farrowing)** | **Average stillborn per litter** |
|---|---|---|---|---|
| **Mild temperatures** | 92.9 | 12.3 | 12.3 | 0.7 |
| **Moderate temperatures** | 90 | 12.6 | 12.4 | 0.8 |
| **Severe temperatures** | 90.5 | 12.3 | 12.5 | 0.8 |

In breeding unit 1 it can be seen that the highest farrowing rate on average was during the mating periods of mild temperatures (< 22°C) with not much difference between mating periods of moderate or severe temperatures. The average litter size seemed not to be effected by the temperature during mating. The average litter size remained relatively constant with a slight tendency to increase as the temperatures increased around the time of farrowing. The average amount of stillborn piglets per litter also remained relatively constant with a slight increase as temperatures increased around the time of farrowing.

Figure 1: Breeding unit 1 Farrowing rate vs Temperature around time of mating



In figure 1 a graphic representation can be seen of the average temperatures around the time of mating and associated farrowing rates for breeding unit 1. A trend line shows that the trend in breeding unit 1 is for the farrowing rate to decrease with an increase in average environmental temperature at the time of mating.

Figure 2: Breeding unit 1 Temperature around time of mating vs Litter size

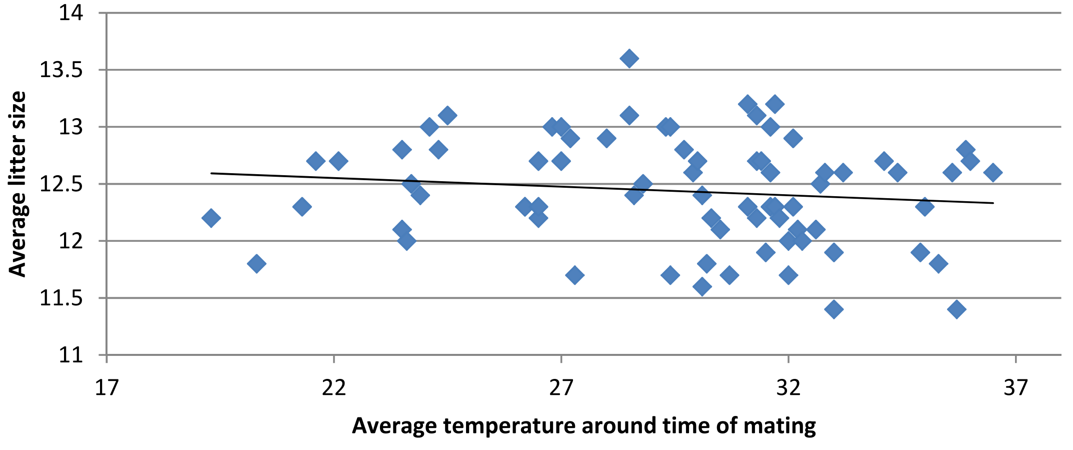


Figure 2 shows a graphic representation of the average litter size plotted against the temperatures around the time of mating for breeding unit 1. The trend line shows that the trend is for the litter size to decrease as the average temperatures increase around the time of mating.

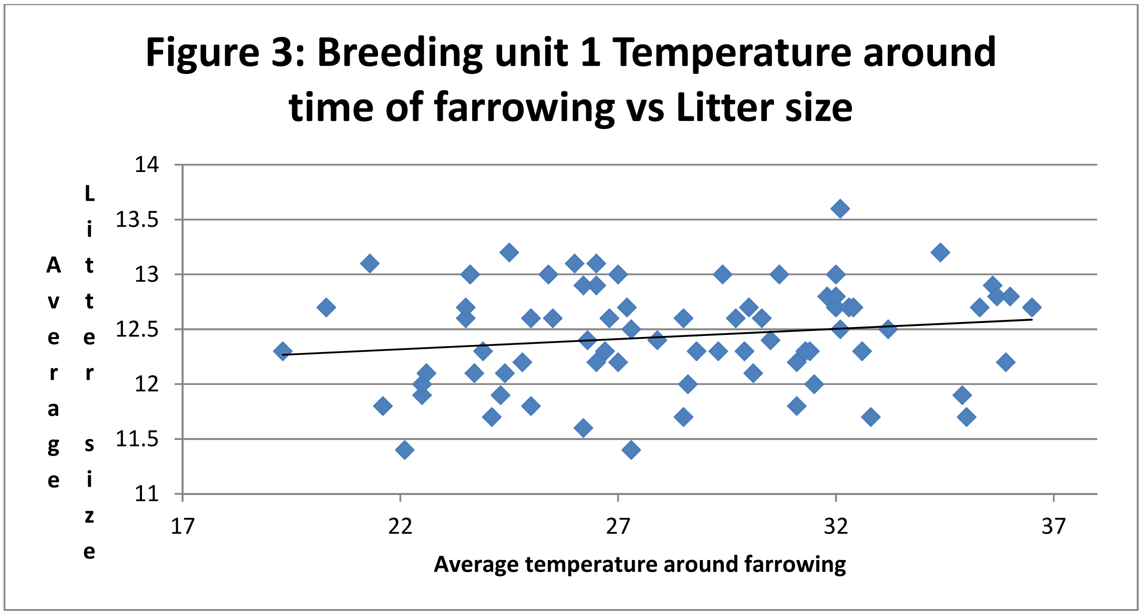


Figure 3 shows a graphic representation of the average litter size plotted against the average temperature around the time of farrowing for breeding unit 1. The trend line shows the trend for the average number of piglets born alive to increase as the average environmental temperatures around farrowing increases.

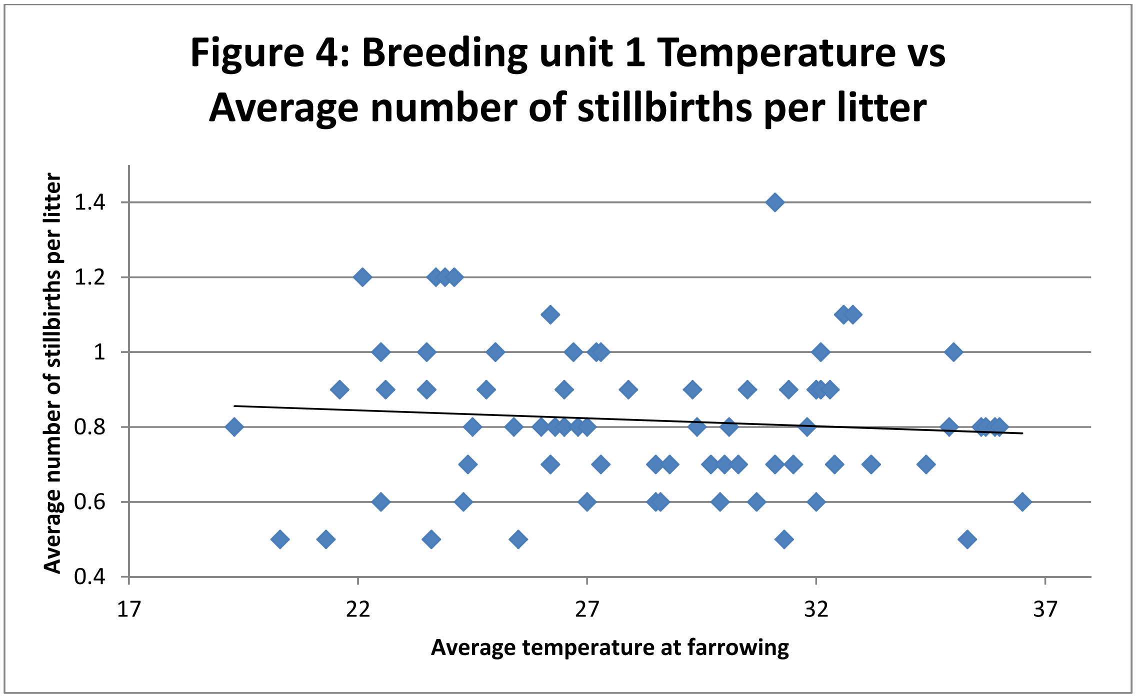


Figure 4 shows a graphic representation of the average number of stillbirths plotted against the average environmental temperature around the time of farrowing for breeding unit 1. The trend line shows the trend is for the average number of stillbirths to decrease as the average temperature around farrowing increases.

### 4.1.2 Breeding unit 2

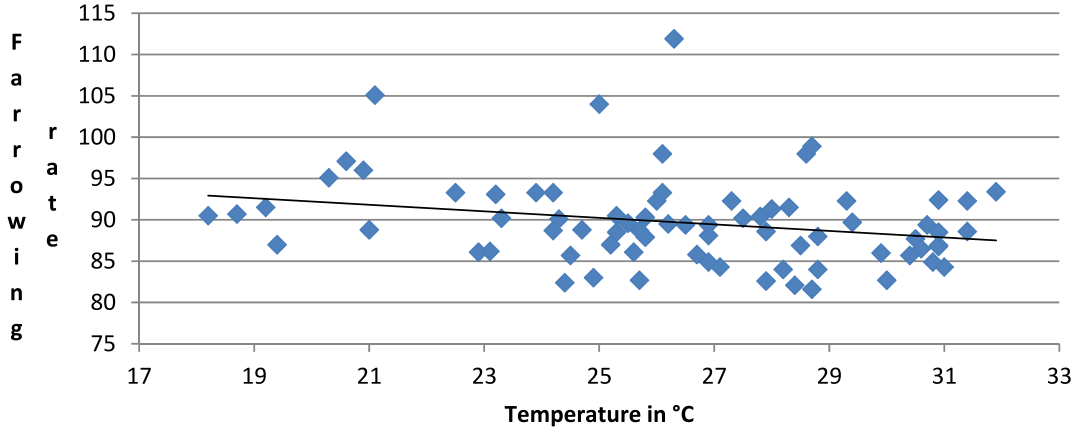
Breeding unit 2 is an approximate 2100 sow unit, that utilises artificial insemination, artificial lighting and flush feeding. They also wean at 28 days. The unit utilises a cooling system which sprays mist from a water tower and uses extractor fans for ventilation. The unit is situated in the summer rainfall area, that is in the temperate interior according to the SANS 204-2 standard and is Arid, Steppe, Cold arid in the Köppen-Geiger Climate Classification (Conradie 2012).

**Table 8: Average data from breeding unit 2**

| | **Average farrowing rate** | **Average litter size (number born alive for temp at mating)** | **Average litter size (number born alive for temp at farrowing)** | **Average stillborn per litter** |
|---|---|---|---|---|
| **Mild temperatures** | 93.5 | 11.6 | 11.6 | 1.9 |
| **Moderate temperatures** | 89.5 | 11.7 | 11.6 | 1.9 |
| **Severe temperatures** | 87.9 | 11.7 | 11.9 | 1.9 |

From the data collected from breeding unit 2 it can once again be seen that the highest farrowing rate is when mating took place at milder temperatures with a steady decrease as the temperatures increased. The average litter size remained rather constant at varying temperatures around the time of mating. The average litter size remained relatively constant, with an increase at high temperatures around the time of farrowing. The average number of piglets stillborn per litter remained constant despite differing environmental temperatures around the time of farrowing.

**Figure 5: Breeding unit 2 Farrowing rate vs Temperature around time of mating**



The graph of the data of the temperatures around the time of mating and the resulting farrowing rate from breeding unit 2 shows a definite trend for the farrowing rate to decrease as environmental temperature increases around the time of mating.

**Figure 6: Breeding unit 2 Temperature around time of mating vs Litter size**

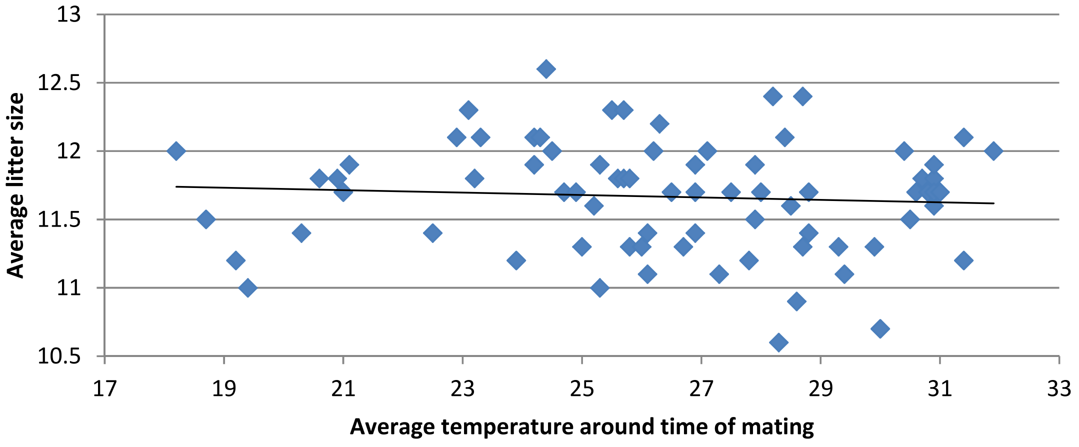


Figure 6 shows a graphic representation of the average litter size plotted against the temperatures around the time of mating for breeding unit 2. The trend line shows that there is a slight trend for the litter size to decrease as the average temperatures increase around the time of mating.

Figure 7: Breeding unit 2 Temperature around time of farrowing vs Litter size

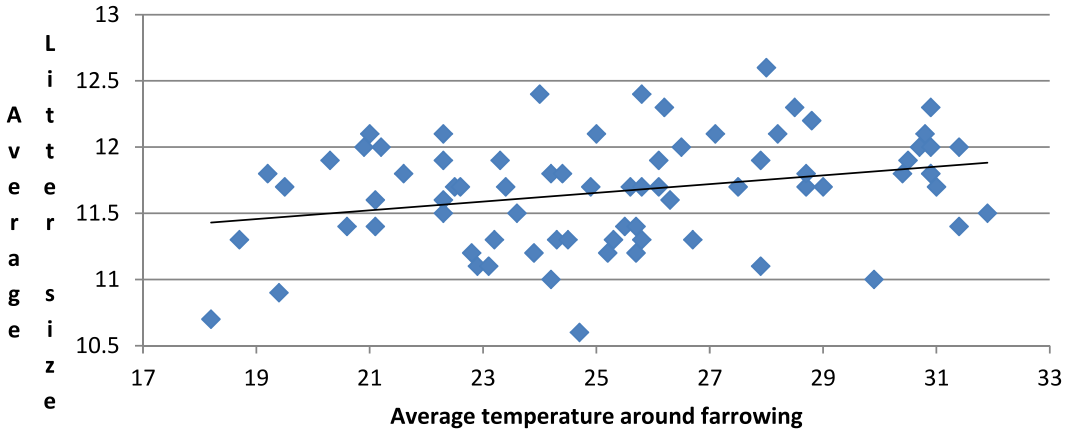


Figure 7 shows a graphic representation of the average litter size plotted against the average temperature around the time of farrowing for breeding unit 2. The trend line shows the trend for the average number of piglets born alive to increase as the average environmental temperatures around farrowing increases.

Figure 8: Breeding unit 2 Temperature vs Average number of stillbirths per litter

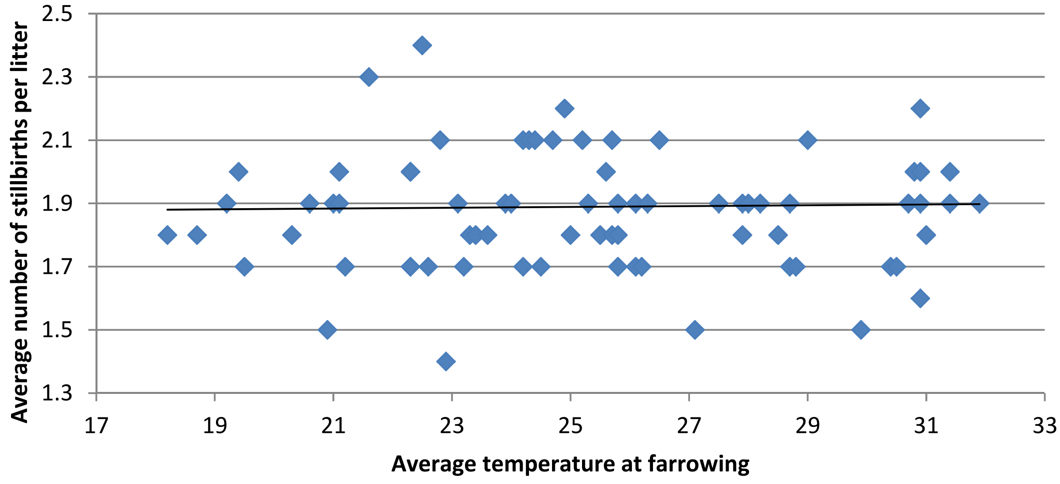


Figure 8 shows a graphic representation of the average number of stillbirths plotted against the average environmental temperature around the time of farrowing for breeding unit 2. The trend line shows a very slight trend for the average number of stillbirths to increase as the average temperature around farrowing increases.

### 4.1.3 Breeding unit 3

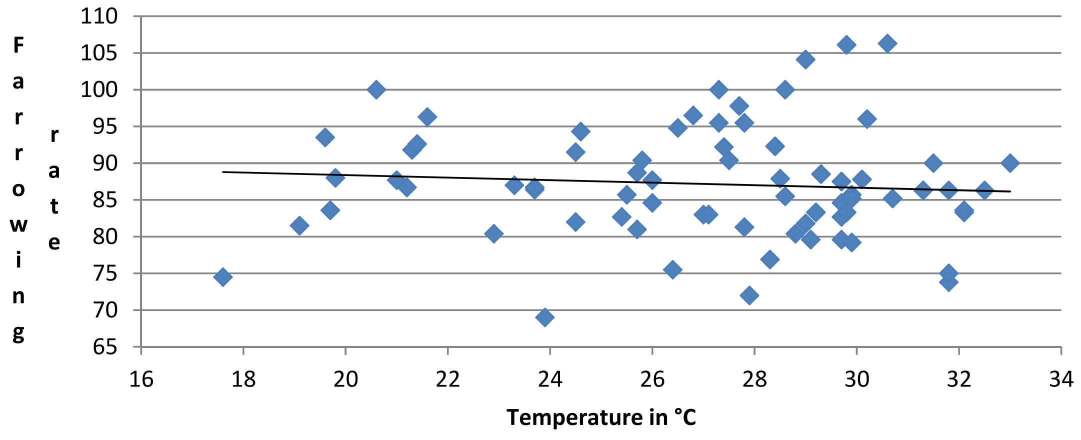
Breeding unit 3 is an approximate 950 sow unit, that utilises artificial insemination and flush feeding. They use an all-in, all-out management system and wean at 21 days. The unit utilises natural ventilation with open-sided breeding houses. The unit is situated in the summer rainfall area, that is in the cold interior according to the SANS 204-2 standard and is Warm temperate, Winter dry, Warm summer in the Köppen-Geiger Climate Classification (Conradie 2012).

**Table 9: Average data from breeding unit 3**

| | **Average farrowing rate** | **Average litter size (number born alive for temp at mating)** | **Average litter size (number born alive for temp at farrowing)** | **Average stillborn per litter** |
|---|---|---|---|---|
| **Mild temperatures** | 91 | 11.5 | 11 | 1.2 |
| **Moderate temperatures** | 86.4 | 11.6 | 11.7 | 1 |
| **Severe temperatures** | 87.6 | 11.2 | 11.6 | 1.1 |

From the data collected from breeding unit 3 it can once again be seen that the highest farrowing rate is when mating took place at milder temperatures with the farrowing rate remaining relatively constant at moderate and severe temperatures around the time of mating. The average litter size remained rather constant with varying temperatures around the time of mating with the smallest average litter size at severe temperatures. The average litter size increased at moderate and severe temperatures around the time of farrowing. The average number of piglets stillborn per litter remained constant despite differing environmental temperatures around the time of farrowing.

Figure 9: Breeding unit 3 Farrowing rate vs Temperature around mating



In figure 9 a graphic representation can be seen of the average temperatures around the time of mating and associated farrowing rates for breeding unit 3. A trend line shows that the trend in breeding unit 3 is for the farrowing rate to decrease with an increase is average environmental temperature around the time of mating.

Figure 10: Breeding unit 3 Temperature around time of mating vs Litter size

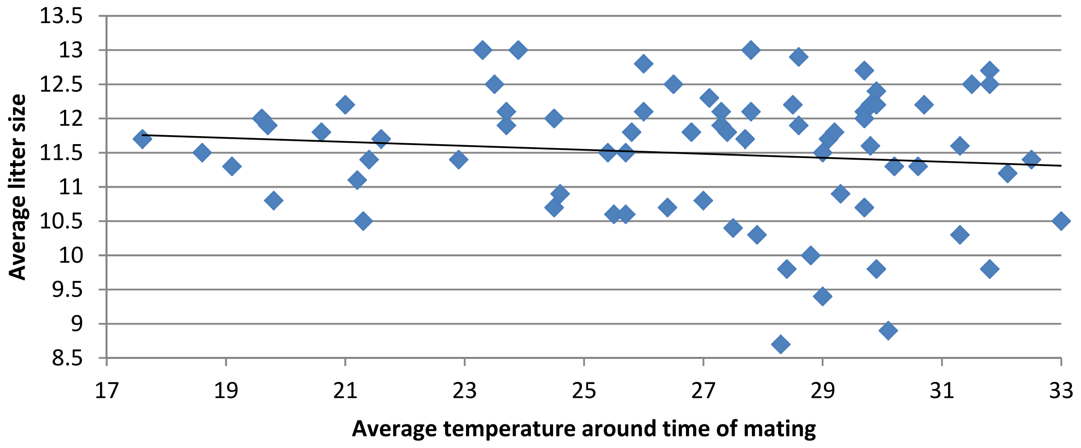


Figure 10 shows a graphic representation of the average litter size plotted against the temperatures around the time of mating for breeding unit 3. The trend line shows that the trend is for the litter size to decrease as the average temperature increases around the time of mating.

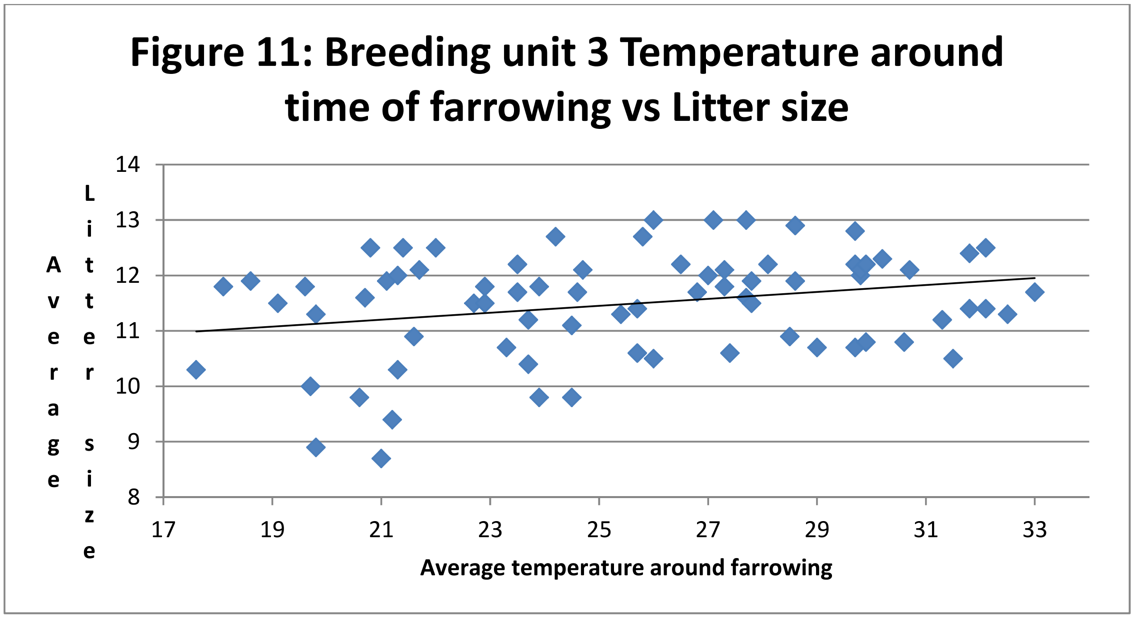


Figure 11 shows a graphic representation of the average litter size plotted against the average temperature around the time of farrowing for breeding unit 3. The trend line shows the trend for the average number of piglets born alive to increase as the average environmental temperatures around farrowing increases.

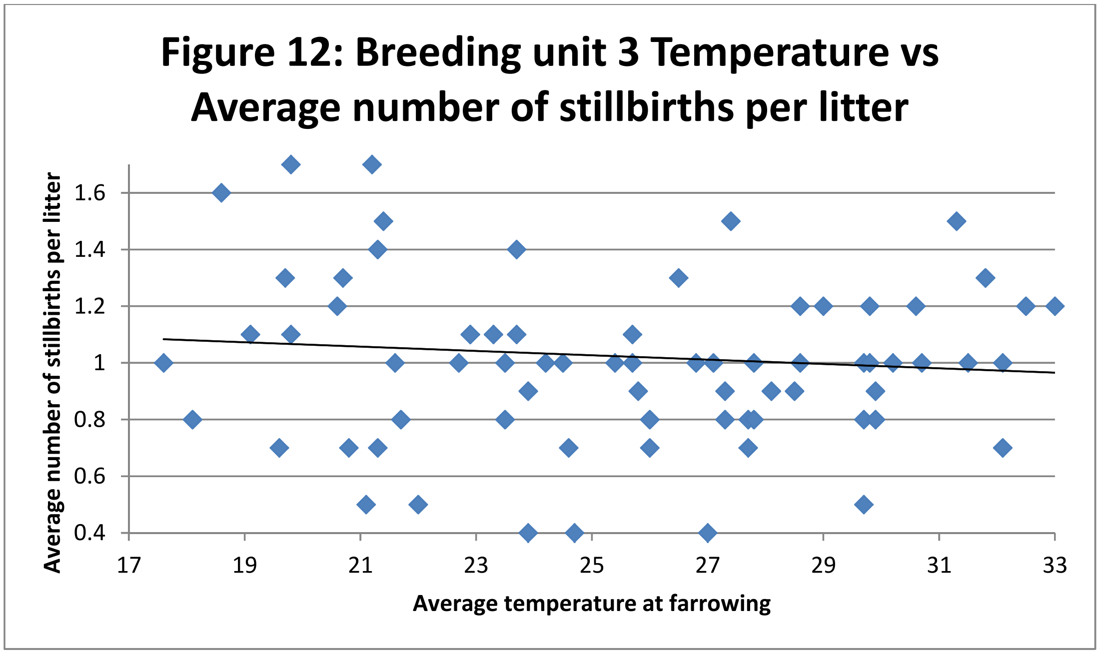


Figure 12 shows a graphic representation of the average number of stillbirths plotted against the average environmental temperature around the time of farrowing for breeding unit 3. The trend line shows a trend for the average number of stillbirths to decrease as the average temperature around farrowing increases.

### 4.1.4 Breeding unit 4

Breeding unit 4 is an approximate 1050 sow unit, that utilises artificial insemination, artificial lighting and flush feeding. They use an all-in, all-out management system and wean at 21 days. The unit utilises natural ventilation with moveable sides in the breeding houses. The unit is situated in the summer rainfall area, that is in the cold interior according to the SANS 204-2 standard and is Warm temperate, Winter dry, Warm summer in the Köppen-Geiger Climate Classification (Conradie 2012).

**Table 10: Average data from breeding unit 4**

| | Average farrowing rate | Average litter size (number born alive for temp at mating) | Average litter size (number born alive for temp at farrowing) | Average stillborn per litter |
|---|---|---|---|---|
| **Mild temperatures** | 90.7 | 12.3 | 11.9 | 1 |
| **Moderate temperatures** | 88.8 | 12.1 | 12.2 | 1 |
| **Severe temperatures** | 90.1 | 12.1 | 12.2 | 1 |

From the data collected from breeding unit 4 it can once again be seen that the highest farrowing rate is when mating took place at milder temperatures with the farrowing rate remaining relatively constant at moderate and severe temperatures around the time of mating. The average litter size remained rather constant with varying temperatures around the time of mating with the biggest average litter size at mild temperatures. The average litter size increased at moderate and severe temperatures around the time of farrowing. The average number of piglets stillborn per litter remained constant despite differing environmental temperatures around the time of farrowing.

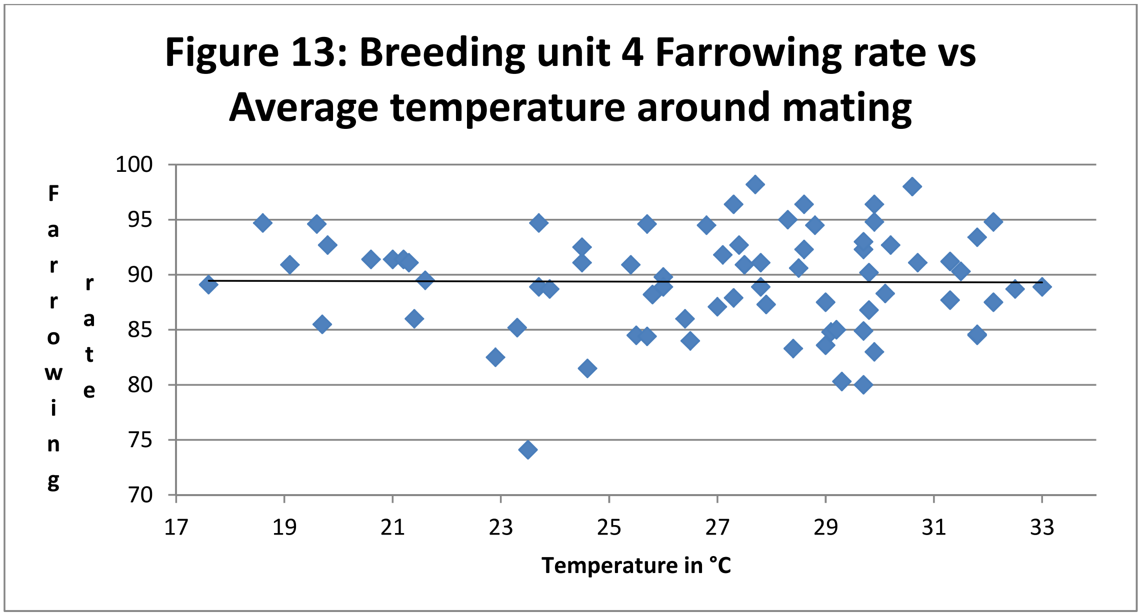


Figure 13: Breeding unit 4 Farrowing rate vs Average temperature around mating

In figure 13 a graphic representation can be seen of the average temperatures around the time of mating and associated farrowing rates for breeding unit 4. A trend line shows that the trend in breeding unit 4 is a slight decrease in the farrowing rate as the average environmental temperature increases around the time of mating.

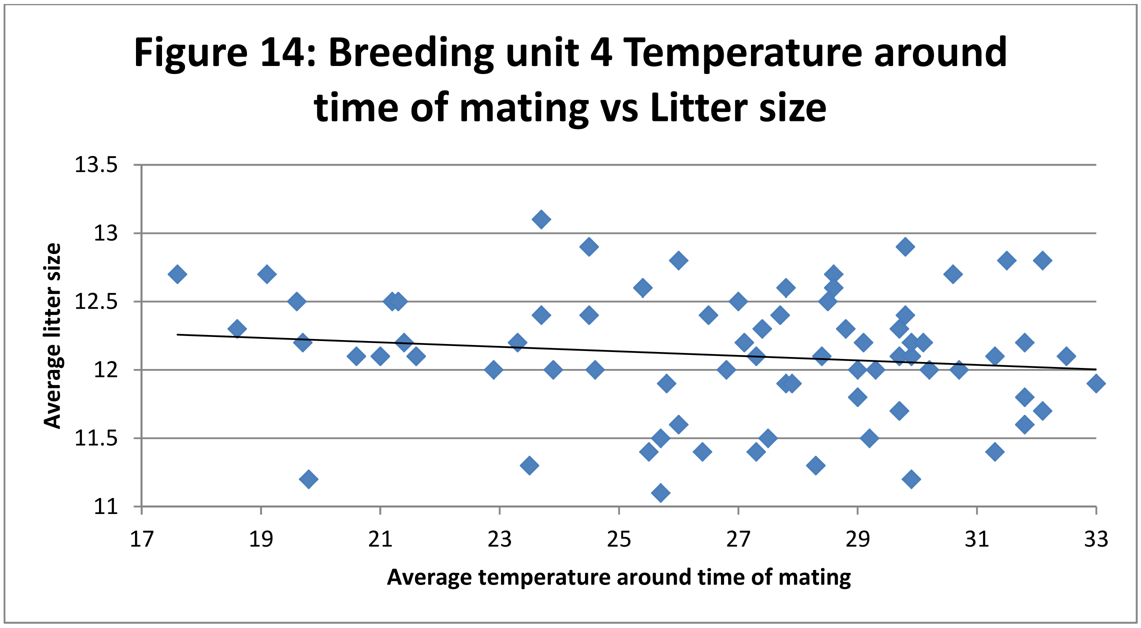


Figure 14: Breeding unit 4 Temperature around time of mating vs Litter size

Figure 14 shows a graphic representation of the average litter size plotted against the temperatures around the time of mating for breeding unit 4. The trend line shows that the trend is for the litter size to decrease as the average temperature increases around the time of mating.

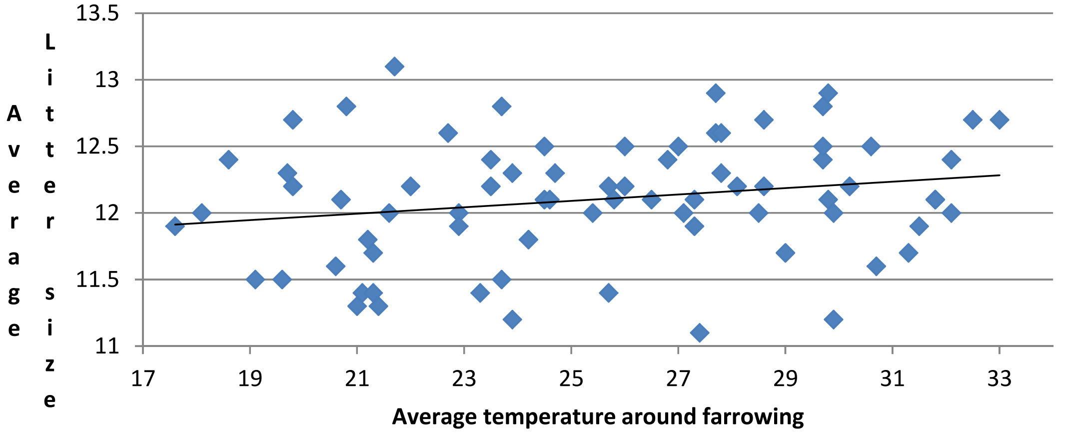


**Figure 15: Breeding unit 4 Temperature around time of farrowing vs Litter size**

Figure 15 shows a graphic representation of the average litter size plotted against the average temperature around the time of farrowing for breeding unit 4. The trend line shows the trend for the average number of piglets born alive to increase as the average environmental temperatures around farrowing increases.

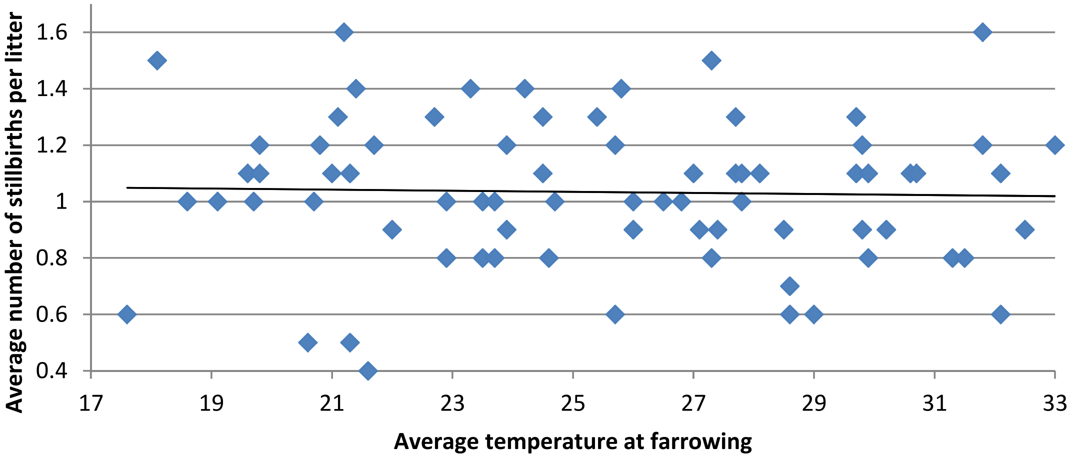


**Figure 16: Breeding unit 4 Temperature vs Average number of stillbirths per litter**

Figure 16 shows a graphic representation of the average number of stillbirths plotted against the average environmental temperature around the time of farrowing for breeding unit 4. The trend line shows a very slight trend for the average number of stillbirths to decrease as the average temperature around farrowing increases.

## 4.2 Summary

**Table 11: Summary of trends**

| | Trend at increasing average environmental temperatures | | | | |
|---|---|---|---|---|---|
| | Farrowing rate | Litter size (temp at mating) | Litter size (temp at farrowing) | Stillbirths | Environmental temperature control |
| Breeding unit 1 | ↓ | ↓ | ↑ | ↓ | Yes |
| Breeding unit 2 | ↓ | ↓ | ↑ | ↑ | Yes |
| Breeding unit 3 | ↓ | ↓ | ↑ | ↓ | No |
| Breeding unit 4 | ↓ | ↓ | ↑ | ↓ | No |

# CHAPTER 5

## Discussion

As mentioned in the introduction, when looking at the possibility of the influence of ambient temperature on reproductive performance, a local approach is needed, considering the varied and often conflicting information on this subject. This study attempted to describe some of the effects of ambient temperature on pig reproductive performance on four selected farms in South Africa.

During the period for which the temperatures were collected, 5 December 2010 to 12 May 2012, the highest average temperature was 36°C and the lowest average temperature was 17.6°C per week. Thus it can be seen that in general the average ambient temperature is higher on the farms that were selected. The greatest proportion of weeks was outside the pig's thermo-neutral zone of 12°C and 22°C (Bloemhof *et al.* 2008).

This study focused on describing the effects of ambient temperature on only two aspects of reproductive performance, namely farrowing rate and litter sizes. More studies will be needed to investigate the effect of ambient temperature on weaning to oestrus interval, weaning to conception interval, age of puberty in gilts and birth mass of piglets.

Similar to the findings by Peltoniemi, Tast & Love (2000), Almond & Bilkei (2005) and Boma & Bilkei (2006), in all four breeding units evaluated in this study it was observed that the trend was for the farrowing rate to decrease as the environmental temperatures increased around the time of mating.

**Table 12: Farrowing rates for different breeding units**

| Breeding unit | Mild temperatures | Severe temperatures | Difference |
|---|---|---|---|
| 1 | 92.9% | 90.5% | -2.5% |
| 2 | 93.5% | 87.9% | -5.6% |
| 3 | 91% | 87.6% | -3.4% |
| 4 | 90.7% | 90.1% | -0.6% |

It can be seen from table 12 that the results were similar to those found by Boma & Bilkei (2006) in Kenya, with a decrease in farrowing rate following matings during severe average temperatures (>30°C) when compared to the farrowing rate following matings during mild average temperatures (<22°C). These results are also comparable with the results from the study done by Almond & Bilkei (2005) in Croatia as well as from a study in the French West Indies by Gourdine *et al.* (2006).

In a recent study by Canaday *et al.* (2013) it was found under experimental conditions that between 15°C and 30°C around the time of mating there was no significant difference in the farrowing rate. These findings are corroborated by Williams *et al.* (2013) as they also found no significant reproductive difference following experimental temperature control at 18°C - 20°C and 24°C - 30°C. However, they acknowledge that the experimental conditions were perhaps not enough to simulate the irregular and erratic natural temperature conditions in the field and may have led to the sows adapting more readily to the constant high ambient temperature.

Davies (1988) found in a study performed on a South African pig farm that they experienced lower farrowing rates during the summer when compared to the rest of the year, but that this could be improved by environmental and managemental strategies. In the current study environmental temperature control was only employed in breeding units 1 and 2 as seen in Table 13.

**Table 13: Farrowing rates associated with environmental temperature control**

| Breeding unit | Average Farrowing Rate (FR) per year | Difference FR mild vs FR severe | Environmental temperature control |
|---|---|---|---|
| 1 | 91.1% | -2.5% | Yes |
| 2 | 90.3% | -5.6% | Yes |
| 3 | 88.3% | -3.4% | No |
| 4 | 89.9% | -0.6% | No |

It was found that the environmental temperature control did not have a significant effect on improving the difference of the farrowing rate between matings during mild and severe temperatures, which is similar to the findings of Peltoniemi, Tast & Love (2000). However, the average farrowing rates throughout the year were observed to be improved on the breeding units with environmental temperature control when compared to those without.

A recent study by Bloemhof *et al.* (2013) found that the period when heat stress has the most adverse effect on farrowing rate was 21 to 14 days before the first insemination. This can be correlated with the period of lactation in the sow. At this time the sow is more susceptible to heat stress and the resultant decrease in feed intake could result in decreased levels of LH which could hamper follicle development. If the minimum number of embryos are not produced for maternal recognition to occur, sows will return to oestrus, resulting in a lowered farrowing rate. Further studies in South Africa are required to determine if this is the most sensitive time period for sows, under local conditions.

The observations of this study with regard to the trends of litter sizes were similar to those by Boma & Bilkei (2006); Tammaruk *et al.* (2010) and Quesnel, Boulot & Cozler (2005) following mating and early gestation with high ambient temperature. However, as per table 14, it did not have a significant influence on the average number of piglets born alive. Bloemhof *et al.* (2013) recently found that the litter size was most affected when sows underwent heat stress from 7 days before insemination to 12 days after, with the most significant day being the day of insemination. An observation made is that the breeding units that employed environmental temperature control did not have a drop in average litter size following matings during times of high ambient temperatures.

**Table 14: Average litter size following mating at mild and severe temperatures**

| Breeding unit | Mild temperatures | Severe temperatures | Difference | Environmental temperature control |
|---|---|---|---|---|
| 1 | 12.3 | 12.3 | 0 | Yes |
| 2 | 11.6 | 11.7 | +0.1 | Yes |
| 3 | 11.5 | 11.2 | -0.3 | No |
| 4 | 12.3 | 12.1 | -0.2 | No |

It was observed in all four breeding units that the trend was for the average number of piglets born alive to increase as the environmental temperature around the time of farrowing increased.

**Table 15: Average litter size with farrowing at mild and severe temperatures**

| Breeding unit | Mild temperature | Severe temperature | Difference |
|---|---|---|---|
| 1 | 12.3 | 12.5 | +0.2 |
| 2 | 11.6 | 11.9 | +0.3 |
| 3 | 11 | 11.6 | +0.6 |
| 4 | 11.9 | 12.2 | +0.3 |

This could possibly be due to the effect of the environmental temperature on the piglets rather than the sows, improving the survivability of the piglets around the birthing process. As was seen in a study by Malmkvist *et al.* (2012), who showed that supplementary floor heating in the farrowing pen increased the survivability of the neonatal piglets. It is also noteworthy that sows farrowing during higher environmental temperatures would have been mated during times of milder environmental temperatures. A study looking at the effect of ambient temperature, per week of gestation, on the number of piglets born alive would be beneficial to identify the critical times of gestation with regard to improving litter sizes.

Previous studies (Tummaruk *et al.* 2010; Babicz *et al.* 2012 and Vanderhaeghe *et al.* 2010) have found that high ambient temperatures around the time of farrowing increased the number of stillbirths.

**Table 16: Average number of stillbirths with farrowing at mild and severe temperatures**

| | Mild temperature | | Severe temperature | | Difference | |
|---|---|---|---|---|---|---|
| Breeding unit | Stillborn per litter | As % of litter | Stillborn per litter | As % of litter | Stillborn per litter | As % of litter |
| 1 | 0.7 | 5.7% | 0.8 | 6.4% | +0.1 | +0.7% |
| 2 | 1.9 | 16.4% | 1.9 | 16.0% | 0 | -0.4% |
| 3 | 1.2 | 10.9% | 1.1 | 9.5% | -0.1 | -1.4% |
| 4 | 1 | 8.4% | 1 | 8.2% | 0 | -0.2% |

It can be seen in the current study that the trend in three of the four breeding units was for the percentage of stillbirths per litter to decrease with increasing temperature around the time of farrowing, which is contrary to the above mentioned findings. This could possibly be attributed to improved viability of the piglets at higher temperatures. One of the four breeding units showed a tendency for the percentage of stillbirths per litter to increase at higher temperatures at farrowing. This is similar to the findings of the above mentioned studies. Thus the observation of this parameter was inconclusive and may indicate that managemental factors, such as intervention during dystocias, preventing overlays or ensuring the piglets are dry and drink from the dam, may be of greater importance in influencing the number of stillbirths.

# CHAPTER 6

## Conclusion

The most significant observation of this study was that the trend was for farrowing rates to decrease following matings during times of high ambient temperatures (>30°C). Environmental temperature control did not negate this effect, but the breeding units employing the environmental temperature control did show higher average farrowing rates overall.

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## ANNEXURE A: TABLE OF BREEDING UNIT DATA

| Week | No. sows bred | No. sows farrowed | No. piglets born alive | No. piglets born dead | Comments (if any): |
|---|---|---|---|---|---|
| 5-11 Dec 2010 | | - | - | - | |
| 12-18 Dec 2010 | | - | - | - | |
| 19-25 Dec 2010 | | - | - | - | |
| 26 Dec 2010 – 1 Jan 2011 | | - | - | - | |
| 2- 8 Jan 2011 | | - | - | - | |
| 9-15 Jan 2011 | | - | - | - | |
| 16-22 Jan 2011 | | - | - | - | |
| 23-29 Jan 2011 | | - | - | - | |
| 30 Jan – 5 Feb 2011 | | - | - | - | |
| 6-12 Feb 2011 | | - | - | - | |
| 13-19 Feb 2011 | | - | - | - | |
| 20-26 Feb 2011 | | - | - | - | |
| 27 Feb – 5 March 2011 | | - | - | - | |
| 6-12 March 2011 | | - | - | - | |
| 13-19 March 2011 | | - | - | - | |
| 20-26 March 2011 | | | | | |
| 27 March – 2 Apr 2011 | | | | | |
| 3-9 Apr 2011 | | | | | |
| 10-16 Apr 2011 | | | | | |
| 17-23 Apr 2011 | | | | | |
| 24-30 Apr 2011 | | | | | |
| 1-7 May 2011 | | | | | |
| 8-14 May 2011 | | | | | |
| 15-21 May 2011 | | | | | |
| 22-28 May 2011 | | | | | |
| 29 May – 4 June 2011 | | | | | |
| 5-11 June 2011 | | | | | |
| 12-18 June 2011 | | | | | |
| 19-25 June 2011 | | | | | |
| 26 June – 2 July 2011 | | | | | |
| 3-9 July 2011 | | | | | |
| 10-16 July 2011 | | | | | |
| 17-23 July 2011 | | | | | |
| 24-30 July 2011 | | | | | |
| 31 July – 6 Aug 2011 | | | | | |
| 7-13 Aug 2011 | | | | | |
| 14-20 Aug 2011 | | | | | |
| 21-27 Aug 2011 | | | | | |
| 28 Aug – 3 Sept 2011 | | | | | |
| 4-10 Sept 2011 | | | | | |
| 11-17 Sept 2011 | | | | | |
| 18-24 Sept 2011 | | | | | |
| 25 Sept – 1 Oct 2011 | | | | | |
| 2-8 Oct 2011 | | | | | |
| 9-15 Oct 2011 | | | | | |
| 16-22 Oct 2011 | | | | | |
| 23-29 Oct 2011 | | | | | |

| Week | No. sows bred | No. sows farrowed | No. piglets born alive | No. piglets born dead | Comments (if any): |
|---|---|---|---|---|---|
| 30 Oct – 5 Nov 2011 | | | | | |
| 6-12 Nov 2011 | | | | | |
| 13-19 Nov 2011 | | | | | |
| 20-26 Nov 2011 | | | | | |
| 27 Nov – 3 Dec 2011 | | | | | |
| 4-10 Dec 2011 | | | | | |
| 11-17 Dec 2011 | | | | | |
| 18-24 Dec 2011 | | | | | |
| 25-31 Dec 2011 | | | | | |
| 1-7 Jan 2012 | | | | | |
| 8-14 Jan 2012 | | | | | |
| 15-21 Jan 2012 | | | | | |
| 22-28 Jan 2012 | | | | | |
| 29 Jan – 4 Feb 2012 | | | | | |
| 5-11 Feb 2012 | | | | | |
| 12-18 Feb 2012 | | | | | |
| 19-25 Feb 2012 | | | | | |
| 26 Feb – 3 March 2012 | | | | | |
| 4-10 March 2012 | | | | | |
| 11-17 March 2012 | | | | | |
| 18-24 March 2012 | | | | | |
| 25-31 March 2012 | | | | | |
| 1-7 Apr 2012 | | | | | |
| 8-14 Apr 2012 | | | | | |
| 15-21 Apr 2012 | | | | | |
| 22-28 Apr 2012 | | | | | |
| 29 Apr – 5 May 2012 | | | | | |
| 6-12 May 2012 | | | | | |
| 13-19 May 2012 | - | | | | |
| 20-26 May 2012 | - | | | | |
| 27 May – 2 June 2012 | - | | | | |
| 3-9 June 2012 | - | | | | |
| 10-16 June 2012 | - | | | | |
| 17-23 June 2012 | - | | | | |
| 24-30 June 2012 | - | | | | |
| 1-7 July 2012 | - | | | | |
| 8-14 July 2012 | - | | | | |
| 15-21 July 2012 | - | | | | |
| 22-28 July 2012 | - | | | | |
| 29 July – 4 Aug 2012 | - | | | | |
| 5-11 Aug 2012 | - | | | | |
| 12-18 Aug 2012 | - | | | | |
| 19-25 Aug 2012 | - | | | | |
| 26 Aug – 1 Sept 2012 | - | | | | |

## ANNEXURE B: BREEDING UNIT QUESTIONNAIRE

### Questionnaire

1. **Is your farm affected by summer infertility?**
    a. **Why do you say so?**
    b. **If yes, do you employ any measures to negate the effects?**
    c. **If yes please describe:**
    d. **In your opinion, are the measures effective?**

2. **Please describe the breeding policy on farm:**

3. **Describe the lighting regime on the farm:**

### LACTATING SOWS:

4. **Where and how are the lactating sows kept?**

5. **What is the temperature in the farrowing house generally?**

6. **Are there any heating/cooling mechanisms in place in the farrowing house and if so please describe?**

7. **What is the lactating sow feeding regime?**

8. **When are the piglets weaned?**

### BREEDING SOWS:

9. **Where and how are the breeding sows kept?**

10. **What is the temperature in the breeding house generally**

**11. Are there any heating/cooling mechanisms in place in the breeding house and if so please describe?**

**12. When and how are breeding sows bred?**

**13. How much are breeding sows fed?**

**<u>DRY SOWS:</u>**

**14. Where and how are the dry sows kept?**

**15. What is the temperature in the dry sow housing generally?**

**16. Are there any heating/cooling mechanisms in place in the dry sow housing and if so please describe?**

**17. When are the dry sows moved to the farrowing house?**

**18. How much are the dry sows fed?**

**GENERAL COMMENTS:**