Genetic basis for seasonal infertility?

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Seasonal breeding is a common phenomenon in a large number of wild animal species, including the wild boar, which is a short day breeder. Its ultimate objective is to ensure that offspring are born in optimal environmental conditions to maximise their chance of survival.

There is much anecdotal evidence that the domestic pig has retained an element of seasonality.

However, it is unknown whether the basis for such an effect is environmental or genetic. Environmental factors that are known to influence reproductive efficiency in the domestic pig, as well as day length, include temperature, nutrition, health and general management.

This is confirmed by observations in the tropics. In northern Europe, where there is negligible change in day length, but distinct hot, rainy and cool seasons, seasonal variation in sow fertility traits has been observed.

The wild boar

Seasonality in the wild boar is observed through a number of routes. In the male, during late spring and summer, these can be lower sperm number and motility, smaller testis size and reduced plasma testosterone levels. This phenomenon is still seen today by pig breeding companies in AI centres where heat stress is a common cause of high levels of abnormal spermatozoa. In the sow, there are a number of measures of reproductive efficiency that have been linked to a seasonal effect.

These include a longer return to oestrus in the summer, reduced ovulation rates and subsequent litter size, and increased returns to service. Studies in the European wild boar have shown that seasonality can be overcome substantially, if not completely, by higher levels of nutrition, shorter lactations, abrupt weaning and more regular exposure to males.

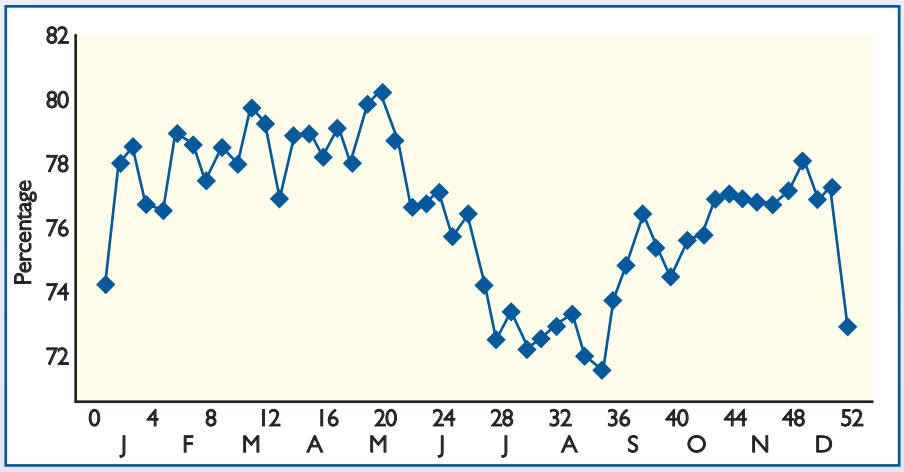
This would suggest seasonality to be an environmental, rather than genetic, effect. Commercial pig operations therefore, implement many of these practices in order to overcome the seasonal effect, as well as avoiding exposure to high summer temperatures.

However, there does still remain the question of whether there is a residual genetic basis for seasonality in the domestic pig.

Accordingly, a major survey has recently been undertaken at the University of Nottingham in collaboration with the Roslin Institute, sponsored by Defra and the University of Nottingham.

Most previous studies on seasonality have found it difficult to separate all the factors involved, so that conclusions drawn have been tenuous at best.

Fig. 1. Phenotypic evidence of seasonal breeding: % successful services over 52 weeks of the year (corresponding months are indicated for clarity).



The current survey sought to overcome this issue by utilising the breeding database of the Cotswold Pig Development Company (now JSR Genetics) from 1979 to 2001. The benefits of using a structured database, rather than random survey data from commercial production units, are considerable. Records in breeding company databases are significantly more accurate with greater standardisation of protocols for mating.

Semen usage in a breeding programme is from a single boar (essential for a boar effect to be assessed) and gene flows can be established. Whilst it is impossible to eliminate environmental factors as confounding variables, the approach adopted sought to minimise them.

Database analyses

Investigations to determine the existence of seasonal fluctuation in weekly mean numbers born alive (NBA), and successful (resulting in 'to term' pregnancy) service numbers (SERVE), were conducted on data from the database of fertility records from 18 indoor units throughout the UK, over the period 1979 to 2001.

Analyses included the time of year of farrowing for each record and its interaction between sire and unit * year cohort, using a sire model. This determines the variation in sire daughters, or unit * year cohort, for NBA and SERVE over the time of year.

If significant, the sire by time of year interaction would be unambiguous genetic evidence of seasonality. Interactions between unit * year cohort and time of year would provide evidence of an environmental effect of seasonality.

Initial analyses did provide phenotypic evidence of seasonal effects on reproductive performance (Figs. 1 and 2) and strongly suggests it to be temperature mediated, as it occurs in July and August, the two hottest months in the UK.

Of course July and August are also immediately after June 21st, the longest day, which could suggest a delayed response to the increasing day length of the months before.

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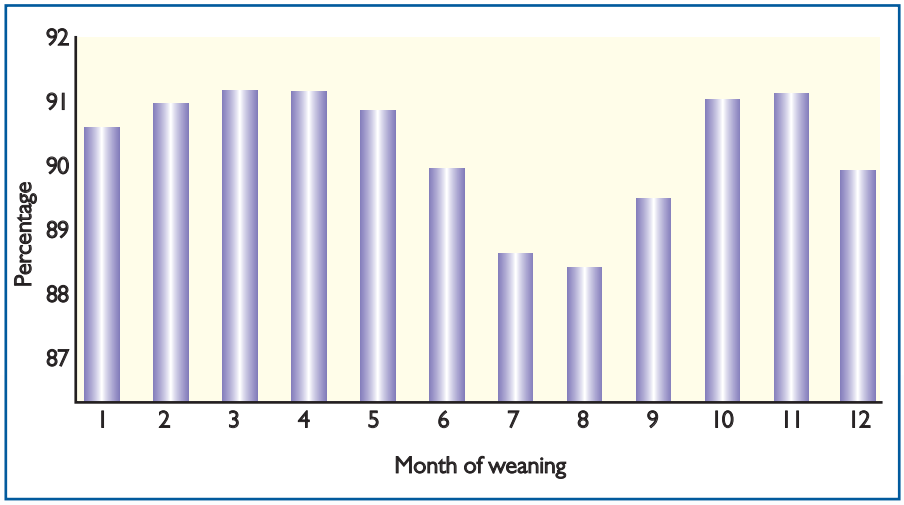

Fig. 2. Phenotypic evidence of seasonal breeding: % successful conception from first service.

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The reduction in weeks 52/1 in Fig. 1 demonstrates the influence management routines can have on these statistics, highlighting the disruption to running of units associated with the Christmas and New Year holidays in the UK.

An analysis of variation in service failure for a given week, between units with relatively common genotypes, revealed no evidence of seasonality. Greater levels of variation were seen across units, rather than across weeks, with no overall trend evident.

However, analysing service failure by week, individually across different years, suggested evidence of a seasonal effect, in that service failure rates increase in late summer.

This was not wholly consistent with the suggestion that failure rates were higher in the mid 1990s, then declined, but then increased towards the turn of the century.

No genetic basis

Further analyses failed to detect significant fluctuations in litter size and successful service (for example, leading to pregnancy) over the year. The failure to detect genetic variation in any fluctuations in NBA or SERVE over the year confirms that there is little or no additive genetic basis to susceptibility of NBA and SERVE to the time of year of farrowing.

Even examination of the mean weekly residuals from the preliminary analyses that contained no time of year component, does not reveal a convincing seasonal trend.

Thus, one might conclude that there is no seasonal influence on litter size or successful serve.

The identification of a significant unit by year interaction with the time of year may provide a partial explanation to the persistence of the issue.

The differential 'seasonal' effect on litter size and successful serves over years is likely to be due to factors that affect some, but not all, units and years. Therefore, photoperiod as a causal factor is not likely, since it is consistent over years and fairly similar across the UK, especially considering the artificial lighting often provided in indoor units.

Variables such as summer temperature, and the requirement and quality of staffing cover, show greater differences between years and units and are more likely causes of variation.

Therefore, what appears to be a seasonal effect on litter size, may in fact be an environmental effect that coincides with seasonal changes.

Conclusion

The current study has determined only very small, insignificant, fluctuations of NBA and SERVE over weeks three to 50 of the year, with no significant linear or polynomial effect of time of year detectable.

Analyses including interactions of sire with linear and polynomial time of year covariates, demonstrated that these interactions between sire and season were not significant and could be safely removed from a mixed model of NBA or SERVE, thus indicating a lack of detectable genetic variation causing fluctuation of NBA and SERVE over the time of year.

The message to breeding companies is that seasonality is not a genetically controlled trait. Therefore, seasonality cannot be influenced through selective breeding.

The message to producers is different. Seasonality of reproductive performance is evident and influenced by both environmental factors and management of the herd.

Producers wanting to avoid a downturn in performance due to seasonality should ensure that, where possible, environmental factors, such as temperature, are controlled and good management techniques are kept consistent throughout the year, despite the external pressures put on the unit by national holidays and local festivals. ■