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Seasonal Effects on Reproduction in the Domestic Sow in Finland - A Herd Record Study

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Peltoniemi OAT, Heinonen M, Leppävuori A, Love RJ: Seasonal effects on reproduction in the domestic sow in Finland - a herd record study. Acta vet. scand. 1999, 40, 133-144. – Seasonal effects on fertility of the domestic sow were assessed by retrospective analysis of the Finnish national computerised data management system covering 1081 herds in 1993. Multivariate analyses were used, where the reproductive parameter of interest (repeat breeding, weaning to oestrus interval, age of gilts at first farrowing, litter size, culling due to anoestrus or no conception) was designed as the response variable. The months of the year (each month compared with January) and all herds and breed were included in the models as explanatory variables. The study demonstrated clear seasonal effects on various aspects of fertility in the domestic sow. The poorest reproductive performance was consistently observed in late summer and autumn and was demonstrated in a number of ways. Firstly, the gilts born between December and April were older (>5 days) at farrowing than those born during the rest of the year ($p<0.01$). Secondly, the risk that a culled sow would be culled due to anoestrus was significantly increased during the autumn months (Odds Ratio (OR) ranged from 1.10 to 1.36). Thirdly, the risk of a repeat breeding was higher from July to November (OR = 1.16). Risk of a prolonged weaning-to-oestrus beyond day 10 was the highest from August to October (OR ranged from 1.70 to 1.77). Risk of a sow to be culled due to no conception was the highest in January and February (weaned in October-November). In addition, descriptive data gathered in a slaughterhouse in 1993 (a subpopulation of the sows included in the herd records) suggest that incidence of inactive ovaries is increased in summer-autumn ($p<0.05$). In conclusion, a marked reduction in fertility of the domestic sow in Finland is reported between July and November.

seasonal infertility; pig; reproduction; Finland.

Introduction

Seasonal effects on fertility of the domestic sow has been a topic of a large number of studies for the past 2 decades. Researchers from several countries have reported lowered fertility during late summer and early autumn. Manifestations of seasonal infertility include reduced farrowing rate (*Love* 1978), prolonged weaning to oestrus interval (reviewed by *Prunier et al.* 1996), later attainment of puberty (*Paterson et al.* 1991), and, arguably, reduced litter size in late summer and early autumn (*Tomes & Nielsen* 1979, *Xue et al.* 1994).

In economic terms, the most important aspect of seasonal infertility seems to be the reduced farrowing rate, which may result from a reduced conception rate (*Hancock* 1988, *Hurtgen*

& Leman 1980) or an increase in abortions and early embryonic death (*Almond et al.* 1985, *Wrathall et al.* 1986). The reduced farrowing rate is at least partly explained by an increase in the rebreeding rate; an increase in the number of sows returning to oestrus in summer-autumn is a common finding (*Love et al.* 1993). In addition, an increased occurrence of non pregnant sows has also been considered to contribute to a seasonal decrease in farrowing rates (*Love* 1978). The prolonged weaning-to-oestrus may be due to a silent oestrus, to anoestrus or to ovarian cysts (*Xue et al.* 1994, *Williamson et al.* 1980, *Britt et al.* 1983, *Hurtgen & Leman* 1981a, *Love* 1978).

Field observations made by veterinarians in Finland suggest that repeat breeding as well as culling sows due to reproductive failure may be more common in summer-autumn. Moreover, the pig industry has reported that the number of piglets available on the market is consistently lower in mid-winter, a phenomenon that lacks a logical explanation, other than that of reduced fertility of sows in summer-autumn. On the other hand, photoperiod has been identified as the primary factor underlying seasonal infertility (*Love et al.* 1993). As seasonal changes in the photoperiod are more profound towards the poles, one might expect more readily to see seasonal effects on fertility closer to the poles. Thus it would be reasonable to predict clear seasonal effects on fertility in the Nordic countries, where, however, only a few reports mention the condition (*Karlberg* 1980, *Ehnvall et al.* 1981, *Sterning et al.* 1990). Based on field observations by Finnish veterinarians, seasonal changes in number of piglets available on the market and profound seasonal change in the photoperiod in Finland, it can be hypothesised that there would appear a seasonal reduction in fertility of the sow in this country. The primary objective was therefore to investigate the role of season in productivity of the sow in Finland. A secondary objective was to obtain estimates of some essential reproductive characteristics in Finnish sow units, such as rebreeding rate, weaning-to-oestrus and culling for reproduction-related reasons.

Materials and methods

Animals and Herds

Data for the study were 48 643 gilts and sows that farrowed during 1993 (total number of records 89 069). The animals were Yorkshire (31.8%), Landrace (35.7%), F1 Yorkshire X Landrace crossings (26.6%) or other crossings. All herds (n=1081) that belonged to the Finnish national swine herd registry run by the Agricultural Data Processing Centre were included (information regarding each animal stored individually). The herds (on average 32 sows / herd, range 21-410) were located in 19 agricultural centres distributed throughout the country. The inclusion criteria were that complete information existed for the herd regarding relevant factors for the present study and the herd had belonged to the registry since the beginning of 1992 (5225 animals excluded). Descriptive statistics of some essential performance characteristics on the farms included are given in Table 1.

Reproductive parameters

Seasonal effects were investigated on the following reproductive parameters: rebreeding rate, age of gilts at first farrowing, weaning-to-service interval, culling rate due to anoestrus or no conception, as opposed to other causes for culling, and litter size.

Rebreeding rate was defined as the percentage of mated animals that returned to oestrus and had to be reinseminated or remated during the study period. To avoid too great an impact from problem sows (rebreeding syndrome), only the first rebreeding was included into the statistical analyses. Month of birth of the gilt was used for

Table 1. Descriptive statistics of herd and productivity characteristics on 1081 pig farms in Finland (Dec 1992 – Dec 1993).

Herd and reproductive characteristics	Mean	Sd
Average parity	3.2	-
Average age at first farrowing (days)	346.7	38.9
Average piglets born alive / litter	11.0	2.9
Average no. of litters / sow / year	2.18	-
Average number of weaned piglets / sow / year	20.4	2.3
Average weaning to oestrus interval*	6.1	2.5
Average length of suckling period in days	32.9	6.8
Average farrowing rate (%)	78.3	-
Average weaning to culling interval (days)		
Due to anestrus	37.8	21.9
Due to no conception	67.7	26.3

*max. 20 days

the analysis of age at the first farrowing. Gilts younger than 240 days or older than 480 days at farrowing were excluded from the statistical analyses. To study the weaning-to-oestrus interval, only those sows were included that had a preceding pregnancy of more than 111 days or less than 122 days in length. Sows that did not return to oestrus within 20 days after weaning were excluded. Date of weaning was used to study the seasonal effect on weaning-to-oestrus interval.

Sows and gilts culled during 1993 (N = 28 248) were included in the data; the reason for culling came from the manager of the herd. Reasons for culling included trauma, udderrelated, feet-related, difficulties in farrowing, anoestrus, no conception, old and poor performance. A weaning-to-culling period of 0-100 days was required for inclusion in the statistical analyses; other records were excluded (917 records).

A sow was classified as 'anoestrous' if the managing personnel detected no oestrus between weaning and culling, and as a 'conception failure' if the sow did come to oestrus but did not conceive up until culling. The culling data presented describe the rate of anoestrus or conception failure as a proportion of all sows culled for a specific reason. The culling date was used in the seasonal analysis. Litter size reported is the number of liveborn piglets per litter.

Reproductive organs

A proportion (n = 1708) of the culled sows and gilts was examined at culling for the status of their ovaries. Reproductive organs from sows and gilts slaughtered in a small slaughterhouse in southern Finland were collected for one year in 1993. No differentiation between sows or gilts was possible, and no reason for culling was available. They were slaughtered in the standard line of the slaughterhouse; no animals from the disease or casual slaughter lines were included in the study. The reproductive organs were deep-frozen in the slaughterhouse on the day of slaughter and collected from the freezer monthly for further examination.

The organs were examined after thawing. Anoestrous animals had inactive ovaries with neither corpora lutea (CL) nor follicles (F) less than 5 mm in diameter (*Almond* 1997). Cyst-like formations larger than 15 mm in diameter (>1 cyst/ovary) were recorded as multiple large ovarian cysts (*Tubbs* 1997).

Table 2. Seasonal distribution of rebreeding rate and the associated risk of rebreeding between the month of interest and January. The risk (Odds Ratio) is based on a logistic regression where herd, parity and breed were included as factors.

Month h	Rebreeding rate (%)	Odds Ratio (95% C.I.)
Jan	10.4	1
Feb	10.2	0.99 (0.86-1.14)
Mar	9.8	0.95 (0.83-1.10)
Apr	10.3	0.99 (0.86-1.14)
May	9.9	0.96 (0.83-1.10)
Jun	9.6	0.93 (0.81-1.07)
Jul	10.4	1.01 (0.88-1.16)
Aug	11.5	1.13 (0.99-1.29)
Sep	11.7	1.15 (0.97-1.35)
Oct	11.3	1.10 (0.93-1.30)
Nov	13.1	1.25 (1.08-1.46)
Dec	9.1	0.86 (0.73-1.02)

Statistical Analysis

For the retrospective data, multivariate models were used to evaluate the seasonal effects on reproductive parameters (Stata intercooled, 1997). Logistic regression was used to determine seasonal variation in the rebreeding rate. January was set as the baseline, and each month was compared with January. The random effect of a herd, the fixed effect of breed of the sow and parity were included as other factors. To detect trends over time, a 2-month moving average was displayed, giving the average of the observations made during the month of interest and the previous month. As the 2-month moving average suggested an increased trend toward repeat breeding between July and November, data from this period were pooled and compared with the rest of the year in a logistic regression model including the same independent variables as the previous model. A linear regression was used to determine seasonal effect on age of gilts at first farrowing. In addition to the gilt's month of birth, herd (random effect) and breed were also included as factors. To study the seasonal effect on the weaning-to-oestrus interval, sows were dichotomised according to whether or not they did come into oestrus before Day 10 after weaning (*Prunier et al.* 1996). Based upon that division, a logistic regression model was built in which herd (random effect), breed, parity and lactation length (more or less than 30 days) were included as factors in addition to the month of the year, again comparing each month with January. In order to examine seasonal variation in culling rate due to reproductive failure, a logistic regression model was developed in which risk was assessed of a culled sow to be culled due either to anoestrus or to conception failure. Month of the year with January as the baseline, herd (random effect), breed and parity were included as factors. Seasonal effect on litter size was examined with a linear regression where the month of the year, herd (random effect), breed and parity (1 or >2) were included as factors. In the slaughterhouse data, each month was compared with January by use of the Pearson chi-squared test. An approach in which seasonal effects on reproductive performance are examined in a multivariate analysis by comparing each month with a 'neutral' month has been used (*Xue et al.* 1994).

Results

Reproductive parameters

Rebreeding rate. Of the 64 167 insemination or mating events, 13.8% were repeat breeders. Of the returns, 80.5%, 15.5%, 2.7%, 0.7%, 0.2%, 0.1%, 0.02% and 0.2% accounted for the 1^{st} to 8^{th} repeat breedings, respectively. In the logistic regression analysis, with only the first rebreeding included, the risk of rebreeding was 1.25 times as high in November as in January (1.08-1.46, 95% confidence interval, C.I., see Table 2.). When the months between July and November were pooled and compared with the rest of the year, it was obvious that the risk of

Table 3. Proportion of sows becoming to oestrus by day 10 after weaning and the risk (odds) of a prolonged weaning to oestrus interval. January is regarded as the baseline.

Month	Percentage of sows oestrus before	coming into day 10 (n)	Odds Ratio* (95% C.I.)
	Parity 1	Parity >1	
Jan	91.4 (734)	95.6 (2463)	1
Feb	89.7 (729)	95.1 (2276)	1.14 (0.92-1.42)
Mar	87.7 (892)	94.3 (2645)	1.33 (1.09-1.63)
Apr	87.2 (1005)	93.5 (2635)	1.50 (1.23-1.82)
May	89.4 (1068)	94.8 (2541)	1.18 (0.96-1.44)
Jun	87.8 (960)	94.8 (2578)	1.29 (1.05-1.57)
Jul	83.9 (983)	94.2 (2755)	1.57 (1.29-1.90)
Aug	85.4 (848)	92.8 (2702)	1.70 (1.40-2.06)
Sep	85.0 (827)	92.9 (2833)	1.72 (1.42-2.08)
Oct	83.9 (929)	92.9 (2968)	1.77 (1.47-2.14)
Nov	87.3 (865)	95.4 (2744)	1.22 (0.99-1.49)
Dec	91.0 (1079)	95.8 (3353)	0.98 (0.90-1.20)

* Based on a logistic regression model where herd, breed, parity and lactation length were included as factors

rebreeding was 1.16 times as high during the autumn months (1.09-1.24, 95% C.I.). Moreover, compared with sows in parities >2, the risk of rebreeding was 1.58 times as high in gilts (1.46-1.70, 95% C.I.), 1.59 times as high in Parity 1 (1.46-1.73, 95% C.I.) and 1.18 times as high in Parity 2 (1.07-1.30, 95% C.I.). In comparison with that of the F1 Yorkshire X Landrace crossing sows, the risk of rebreeding was 1.20 times as high in Yorkshire sows (1.11-1.30, 95% C.I.) and 1.12 times as high in Landrace sows (1.03-1.21, 95% C.I.). No significant difference in rebreeding rate existed between the F1 Yorkshire X Landrace crossings and other crossings.

The period from weaning to oestrus. Among the sows that came into oestrus within 20 days after weaning, the average period from weaning to oestrus was 6.1 (± 2.5 S.D.) days. As shown in Table 3, the risk of this period being prolonged beyond day 10 after weaning was significantly increased during autumn (August-October, Odds Ratio ≥1.7). Compared with that in Parity 1, the risk of a prolonged weaning-to-oestrus was 0.42 times as low (0.39-0.45, 95% C.I.) in older sows. Sows with a lactation length >30 days were 0.81 times less likely to show a prolonged weaning-to-oestrus than sows weaned earlier (0.75-0.88, 95% C.I.). Landrace sows were 1.13 (1.03-1.23, 95% C.I.) times and the F1 Yorkshire X Landrace crossing sows 1.11 (1.01-1.23, 95% C.I.) times as likely to show a prolonged weaning-to-oestrus period as Yorkshire sows. Other crossing sows did not show a period different from that of the Yorkshire breed.

Age of gilts at first farrowing. The average age of gilts at their first farrowing was 346.7 ± 33.6 (S.D.) days (21 702 animals). All months were compared with January in a linear regression model, where herd of origin and breed were included as explanatory variables (see Table 4). Gilts born in January farrowed at a significantly older age than did those born after April ($p<0.01$). Moreover, gilts born in February farrowed older than did gilts born in Jan-

Table 4. Seasonal distribution of age of gilts at first farrowing. The data is based on the time of birth of the gilt. The p-value given is the student's t-test value between January and the month of interest in a linear regression, where herd and breed were considered as factors in the model. N = 21 702.

Month h	Mean (days)	S.D.	Regression coefficient	P
Jan	349.3	37.4	-	-
Feb	353.3	36.2	4.0	0.00
Mar	350.6	32.6	1.1	0.32
Apr	349.0	31.4	-0.3	0.82
May	344.3	30.2	-5.1	0.00
Jun	339.2	29.8	-10.2	0.00
Jul	340.9	31.2	-8.3	0.00
Aug	340.1	32.1	-9.4	0.00
Sep	341.6	33.1	-7.7	0.00
Oct	339.9	31.7	-9.3	0.00
Nov	342.9	35.6	-6.5	0.00
Dec	346.0	37.8	-3.4	0.00

Table 5. The seasonal distribution of sows culled because of anoestrus (100% = all sows culled during the month of interest). The odds ratio given describes the predicted risk of a sow to be culled due to anoestrus. In the logistic regression model, herd, breed and parity were considered as factors in the model.

Month	Parity 0-1	Parity 2	Parity >2	Summary odds ratio (95% C.I.)
Jan	12.4	13.4	5.8	1
Feb	11.9	8.7	5.8	0.92 (0.72-1.18)
Mar	14.8	10.6	5.4	1.00 (0.81-1.22)
Apr	14.7	12.3	4.2	0.94 (0.76-1.16)
May	14.4	15.2	3.5	0.94 (0.76-1.16)
Jun	15.2	13.3	5.1	1.04 (0.85-1.27)
Jul	18.5	11.9	4.4	1.08 (0.88-1.33)
Aug	17.5	17.2	5.3	1.22 (1.01-1.48)
Sep	14.0	16.2	5.8	1.10 (0.90-1.34)
Oct	19.0	16.1	6.8	1.36 (1.12-1.65)
Nov	14.8	19.4	6.0	1.23 (1.01-1.50)
Dec	12.2	9.1	4.6	0.87 (0.67-1.14)

uary ($p<0.01$). In the linear regression model developed, in addition to the month of birth of the gilt, both herd of origin and breed of gilt contributed significantly to the variation seen in the age of the gilt at first farrowing ($p<0.01$).

Littersize. Parity affected litter size as expected. The average litter size (total born) for all parity 1 sows was 10.3 ± 0.04 piglets, but was 12.3 ± 0.03 piglets for Parities ≥2. No significant effect of season on litter size was detected ($p>0.05$); seasonal variation in litter size was within 0.1 of a piglet in parity 1 and within 0.2 of a piglet in parities ≥2.

Culling data

For the 27 331 sows and gilts culled and included in the registry during 1993, the average weaning-to-culling period for sows was 32.4 ± 31.4 (S. D.) days. Less than one-fifth (18%) of the sows were culled within 5 days after weaning.

Culling due to anoestrus. Of all animals culled, 15.5% of gilts and 7.7% of sows were culled for anoestrus (945 gilts and 1731 sows). The sows were culled because they had not returned to heat after weaning, and the average weaning-to-culling period was 43.1 ± 21.9 (S. D.) days. Seasonal distribution of culling due to anoestrus is given in Table 5. In comparison with January, the culling rate due to anoestrus was significantly higher in August, October and November. These data show that this reason for culling was more common in Parities 0 and 1 than in other parities. The significantly increased rate of culling due to anoestrus in the latter half of the year was mainly due to the increased culling rate in low-parity sows. In comparison with the Parities>2, the risk of an animal to be culled due to anoestrus was 3.19 (2.90-3.51, 95% C.I.) times as high in Parities 0 and 1, and 2.89 (2.59-3.24, 95% C.I.) times as high in Parity 2.

Table 6. The seasonal distribution of sows culled due to no conception (100% = all sows culled during the month of interest). The odds ratio given describes the predicted risk of a sow to be culled due to no conception. In the logistic regression model, herd, breed and parity were considered as factors in the model.

Month	Parity 0-1	Parity 2	Parity >2	Summary odds ratio (95% C.I.)
Jan	20.2	32.4	25.1	1
Feb	22.0	33.0	23.3	0.97 (0.85-1.12)
Mar	19.1	26.1	22.7	0.86 (0.75-0.98)
Apr	13.9	21.4	18.3	0.64 (0.55-0.74)
May	16.8	23.6	19.9	0.73 (0.64-0.84)
Jun	16.7	22.7	19.6	0.72 (0.62-0.83)
Jul	14.6	25.9	20.5	0.74 (0.64-0.85)
Aug	17.5	28.0	22.5	0.85 (0.74-0.97)
Sep	15.4	31.6	22.2	0.83 (0.73-0.95)
Oct	18.7	22.2	21.4	0.79 (0.69-0.91)
Nov	19.4	25.3	24.3	0.90 (0.79-1.03)
Dec	14.3	24.5	24.3	0.89 (0.76-1.02)

Table 7. The seasonal distribution of percentage of animals with inactive ovaries and multiple ovarian cysts during the study period. P represents the p-value between January and the month of interest.

	Number of organs studied	Percentage of animals with inactive ovaries (P)	Percentage of animals with multiple ovarian cysts (P)
Jan	124	20.2	2.4
Feb	151	22.5 (0.63)	4.0 (>0.1)
Mar	176	19.3 (0.85)	2.8 (>0.1)
Apr	161	33.5 (0.01)	3.1 (>0.1)
May	211	23.3 (0.50)	2.8 (>0.1)
Jun	173	24.9 (0.34)	4.0 (>0.1)
Jul	136	27.2 (0.18)	1.5 (>0.1)
Aug	135	31.1 (0.04)	3.0 (>0.1)
Sep	139	26.6 (0.22)	1.4 (>0.1)
Oct	103	36.9 (0.005)	6.8 (>0.1)
Nov	98	21.4 (0.81)	3.1 (>0.1)
Dec	101	14.0 (0.22)	3.0 (>0.1)

Culling due to conception failure. Of all animals culled, 22.0% were culled for conception failure (6034 gilts and sows). In comparison with January and February, the culling rate for conception failure was lower in the remainder of the year ($p \leq 0.05$), see Table 6. The 2-month moving average indicated a peak during January and February followed by the nadir in April-June and a steady increase thereafter towards the end of the year. In comparison with Parities 0 and 1, the risk of a sow to have been culled due to no conception was 1.71 (1.57-1.87, 95% C.I.) times as high in Parity 2 and 1.35 (1.26-1.45, 95% C.I.) times as high in Parities >2.

Ovarian status upon culling. Altogether 1708 reproductive tracts from sows or gilts were examined with some variation in number from month to month (142 ± 10, presented as mean ± S.E.M.). The animals had inactive ovaries in 25.1% of cases, with ovaries more likely to be inactive in April, August and October ($p \leq 0.05$) than during the other months. Altogether 53 animals (6.2%) had multiple ovarian cysts with no obvious seasonal pattern in occurrence ($p > 0.1$). Table 7 shows the seasonal distribution of the percentage of animals with inactive ovaries and multiple large ovarian cysts.

Discussion

The study revealed seasonal variation in fertility in all aspects analysed except litter size. The poorest performance was consistently observed in late summer or autumn, with the reduced reproductive activity associated with this period demonstrated in several ways. Firstly, the gilts born between December and April (puberty between August and December) were older at farrowing (>5 days) than those born during the rest of the year. Secondly, more sows were culled because of anoestrus in August, October and November than during other months of the year. However, a delay of 46 days from weaning to culling for anoestrus in the present data implies that these sows would have been weaned from July to October. Weaning-to-oestrus period in primiparous sows was significantly prolonged in summer-autumn. Likewise, the rate of repeat breedings tended to be higher during the autumn months. In addition, a higher rate of sows culled because of conception failure was found in January and February. Finally, descriptive data obtained upon culling in a small slaughterhouse during the year of interest indicated that ovaries would more likely be inactive in summer-autumn.

The domestic pig is generally known to be reproductive throughout the year in contrast to its ancestor, the wild pig; the wild sow usually farrows only one litter per year in the spring, when the following months are most conducive to survival of the piglets (*Mauget* 1982). In the presence of good management practices (weaning, presence of boar, nutrition), the domestic sow can usually produce 2 litters per year (*Love et al.* 1993). Therefore little deliberate selection pressure has existed to negate her seasonal breeding pattern. In the modern pig industry it is increasingly important to keep the animal flow constant. The profitability of a breeding herd is strongly related to optimal reproductivity throughout the year. Planned culling of sows is important in achieving optimal reproductive performance. More animals were culled because of anoestrus during the second half of the year than during the first half, and a prolonged weaning-to-oestrus interval during summer-autumn was demonstrated. When the sow does not show oestrus at the usual time after weaning, the farmer is more likely to cull her for anoestrus. It may thus be feasible to advise farmers to wait longer before culling for anoestrus during the low period of fertility of the year.

Our finding of a marked seasonal trend in the rate of repeat breedings with significantly more occurring during the autumn months agrees with earlier reports of the effect of season on return-to-oestrus in the sow (*Love et al.* 1993, *Elbers et al.* 1994, *Xue et al.* 1994). Generally, the target for return to oestrus is set at about 10% (*Elbers et al.* 1994). The tendency seen in late summer and autumn, being above this target, has economic consequences for the pig industry. Our seasonal increase in rate of return to oestrus was far less than that reported by *Elbers et al.* (1994) but more than that reported by *Xue et al.* (1994). The differences in these data may be explained through different management and housing conditions, because individual housing, for instance, significantly reduces the seasonal effects on fertility (*Love et al.* 1995, *Leman* 1992). Herd size, on the other hand, may also have an impact on seasonal fluctuation in the rate of repeat breedings. The average herd size in the present study was only about 32 sows, whereas all herds in the study by *Elbers et al.* (1994) were at least 80-sow units. This is considered indirect evidence of herd size as being a factor of significance; larger herds may be more readily affected by season, leading to a more profound increase in the rate of repeat breedings in late summer and autumn. On the other hand, in Finland, large units are more likely to house the animals loosely, whereas small units more often have individual housing system.

The role of season on the weaning-to-oestrus interval was recently reviewed by *Prunier* and others (*Prunier et al.* 1996), who concluded that in primiparous sows, the weaning-to-oestrus interval is generally delayed in summer-autumn. The most important factor was considered to be high ambient temperature reducing the voluntary feed intake of sows during first lactation and thereby energy balances at weaning and the subsequent oestrus. Photoperiod was another factor involved; reducing the photoperiod from 16 h to 8 h increased the weight loss of lactating primiparous sows under high ambient temperatures (>25°) but not lower temperatures than that (*Prunier et al.* 1994). This would imply that ambient temperature, not photoperiod is the most important factor in the seasonally prolonged weaning-to-oestrus interval in primiparous sows, since a long photoperiod seems to stimulate rather than reduce the voluntary feed intake of sows during lactation. However, in the present extensive data, the seasonally prolonged weaning-to-oestrus interval - similar in magnitude to those reported earlier (*Britt et al.* 1983, *Armstrong et al.* 1986) - was seen in Finland from July to October. Altough high ambient temperatures could have had a marginal effect on the voluntary feed intake during lactation in Finland in July, one would not expect to see such an effect from August to October. Therefore the present data support the 'photoperiod' rather than the 'temperature' hypothesis of the seasonally prolonged weaning-to-oestrus interval.

To avoid including animals with a 'silent oestrus', the only sows included were those that did return to oestrus before day 20 after weaning. Had we included sows coming into oestrus after that, the results would have changed, yielding lower percentages for sows coming into oestrus before day 10. Nevertheless, the present data agree with other studies (reviewed by *Prunier et al.* 1996), demonstrating the seasonally prolonged weaning-to-oestrus interval in primiparous sows in summer-autumn.

The effect of season on age at first farrowing was greater than expected. Puberty was apparently delayed during the season of low fertility, leading to an increase in age at first farrowing, in accordance with other reports (*Paterson et al.* 1991, *Love et al.* 1993). However, the increased number of animals returning to oestrus after mating during summer-autumn (*Love et al.* 1993, *Elbers et al.* 1994) may also partly explain the monthly distribution of gilts' farrowing ages. A sufficient gilt pool is very important in the modern pig industry to keep the production going on with full capacity. The results of this study indicate that it may be judicious on farm level to have more gilts available for breeding during late summer and early autumn. A clear seasonal effect on the rate of sows culled because of conception failure was seen in the present data, with January and February showing a higher rate of animals culled for no conception than in other months. However, the average weaning-to-culling interval for sows culled due to conception failure during the period of the interest in Finland was 67 days. Even this part of the present data should therefore be evidence of unsuccessful breedings in September to November.

Claus & Weiler (1985) suggested that the seasonal effects on reproduction in the domestic sow were a vestige of an ancestral photoperiodic rhythm. *Leman* (1992), too, considered seasonal infertility to be a natural phenomenon occurring because the sow finds it prudent not to farrow in the early part of the winter. *Love et al.* (1993) and *Bassett et al.* (1996) suggested that variation may exist between sow traits involving inherent seasonality and that the frequency with which seasonal infertility is expressed could be reduced by active selection against the trait in long term. This is an interesting prospect that needs further elucidation.

According to *Sterning et al.* (1990), the great seasonal variations in daylight hours in Sweden are likely to be one of the main factors causing seasonal variation in fertility of sows. In Finland the variations are similar to or greater than those in Sweden. Photoperiod can be changed artificially, but the optimum light: dark schedule remains to be determined.

In tropical and temperate climates heat stress was earlier regarded as a major reason for depressed fertility in sows (*Love* 1978). However, later studies have refuted this 'temperature hypothesis ' for seasonal infertility (*Hurtgen & Leman* 1981b, reviewed by *Love et al.* 1993). One indirect effect of temperature is a decreased feed intake and accompanying energy and protein deficits that frequently occur during hot weather (*Almond* 1992). Because summer and autumn temperatures in Finland are reasonably low, they cannot be considered to have a great impact on fertility of sows. However, increased fluctuation in temperatures within a 24-h period may give rise to the increased abortions in late autumn (autumn abortion syndrome described by *Stork* 1979).

The increased rate of inactive ovaries in summer-autumn indicates that true anoestrus was likely to be the cause of culling for anoestrus, thus supporting the results in our herd record data. Sows slaughtered at weaning are usually in lactational anoestrus; however, only less than 20% of the sows in the present study were culled within 5 days after weaning, and the average weaning-to-culling interval was not under one month. Therefore, the animals studied for ovarian status were not very likely to be in lactational anoestrus at culling. Moreover, there appears to be no logical reason why producers would have culled animals sooner after weaning in summer-autumn, which would have biased the results. Lack of seasonal effect on incidence of ovarian cysts in the present descriptive slaughterhouse data would indicate that ovarian cysts do not significantly contribute to seasonal infertility. However, this remains to be determined.

In conclusion, this study has demonstrated clear seasonal effects on various aspects of fertility in the domestic sow. Farrowing age of gilts was strongly influenced by season, rate of anoestrous sows was significantly increased in late summer and autumn, weaning-to-oestrus was prolonged in summer-autumn and, in addition, pregnancy success-rate was decreased in autumn. Although much research effort has gone into the physiology of swine reproduction, we are not yet close to full understanding of the basis of seasonal reproduction in the pig.

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Sammanfattning

Årstidens inverkan på fruktbarheten hos tamsuggor i Finland - en studie baserad på data från svinkontrollen.

Årstidens inverkan på fertiliteten hos suggor och gyltor undersöktes med hjälp av retrospektiv analys av det Finska nationella ADB data management systemet baserat på 1081 svinbesättningar under året 1993. I studien utnyttjades multivarians analys där fertilitetsrelaterade parametrar av intresse (omlöpning, intervallet mellan avvänjning och brunst, gyltornas ålder vid första grisningen, kullstorlek, utslaktning baserad på avsaknad av brunst eller utebliven befruktning) användes som respons variabler. Månaden på året, (varje månad jämförd med januari), besättningen och rasen inkluderades som förklarande variabler i modellen. Studien påvisade ett klart samband mellan årstid och fertilitet hos tamgris suggor. Fertiliteten var lägst under sensommaren och hösten och detta kunde påvisas på flere olika sätt. För det första var gyltor födda mellan december och maj äldre (>5 dagar) då de grisade än gyltor födda under resten av året. För det andra var slaktor-

saken med signifikant ökad sannolikhet anestrus för en sugga slaktad under höstmånaderna (Odds Ratio = 1.10-1.36). För det tredje var risken för omlöpning förhöjd mellan juli och november (OR = 1.16). Risken för att intervallet mellan avvänjning och brunst förlägndes över 10 dagar var högst mellan augusti och oktober (OR = 1.70-177). Risken för att en sugga slaktades p.g.a. utebliven befruktning var störst i januari och februari. Dessutom tydde deskriptiva data insamlade från ett slakteri under 1993 (en subpopulation av suggorna som fanns inkluderade i besättningsstatistiken) att förekomsten av inaktiva ovarier ökade under sommaren och hösten (p>0.05). Slutledningen är att en märkbart minskad fertilitet kunde rapporteras hos tamsuggor mellan juli och november i Finland.

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