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Optimal age of breeding gilts and its impact on lifetime performance

[1]Joab Malanda – [2]Péter Balogh – [1]Gabriella Novotni Dankó

[1]University of Debrecen, Faculty of Agricultural and Food sciences and Environmental Management, Department of Animal Husbandry, Hungary

[2]University of Debrecen, Faculty of Economics and Businesses, Institute of Sectoral Economics and Methodology, Hungary

mtolivet.livet@gmail.com

SUMMARY

Age at first breeding and lifetime reproductive performance was analyzed on 17,558 F1 Landrace x Yorkshire gilts from 9 piglet producing herds of Midwest, United States entered in herds between 1st Jan 2014 and 31st July 2016. At the time of data collection Dec 2018, 15% of the sows were still active in the herds hence excluded from the analysis. Individual gilt data included date of birth, age in days at first mating, piglet total born by parity, lifetime piglet total born and reason for culling. Quality data checks were done before analysis to eliminate all outlier values together with sows that had no entry information for any listed category. The total database of the sows was classified into 6 classes according to age at the first mating in days 170–190(n=754), 191–211(n=4683), 212–232(n=7123), 233–253(n=3385), 254–274(n=1002) and 275–369 (n=611). Piglet total born obtained from each sow during the lifetime production was significantly ($P < 0.05$) greater for gilts bred between 233–253 days of age at first mating. Gilts that were bred at <233 days appeared to have a higher risk of removal by farrowing productivity as compared to the other groups. However, the results show that the risk of being culled due to health problems and conformation issues increases as the age at first mating is delayed. Overall reproductive failure appears to be the most economical culling reason across all age groups. There is a need to evaluate the best management decisions for gilt initiation in a herd to maximize her lifetime performance. The results indicate that gilts mated for the first time at the right age, 233–253 days, are more productive, both in lifetime total born and have a minimal risk of culling due to farrowing productivity.

Keywords: *gilt, age at first breeding, lifetime performance, culling*

INTRODUCTION

Modern swine production has benefited from a large amount of research that greatly influences lifetime sow performance. One of the most critical factors driving the performance of sow herds is gilt management. Decisions regarding gilts have profound effects on sows' lifetime performance. Lifetime performance is normally assessed by the average productivity of the sows or the number of piglets born per sow for the entirety of her life in the herd Koketsu (2007). Lifetime sow performance is a critical indicator for producers managing a commercial sow herd. Increased lifetime performance and longevity in sows reduces costs of replacement gilts and improves herd performance and profitability Sasaki et al. (2008).

To decide when to start breeding gilts and how long they can be retained in the breeding herd, producers need to optimize herd management practices such as longevity and reproductive performance. Age at first breeding of a gilt is a management decision that has been shown to impact performance and retention of a gilt in a herd. Tummaruk et al. (2001) showed that gilt performance is affected by the decision on first mating that influences the overall productivity and subsequent reproductive performance. Initiating management practices that identify gilts with the greatest potential for lifetime performance is crucial to the productivity of swine production systems. Knowledge of when first to breed young replacement gilts is paramount. However, large variation exists with respect to the successful introduction of high value replacement gilts and retention in the breeding herd Culbertson (2008).

Variations have been noted in literature regarding the time to start breeding gilts from as low as 160 days of age to as high as 245 days of age. Elliason et al. (1991) showed that Swedish Yorkshire gilts reach sexual maturity between 170 days to as late as 260 days of age. Similarly, Tummaruk et al. (2007) reported that sexual maturity occurred at 180 to 210 days of age, while the research finding of Evans and O'Doherty (2001) indicates a range of 200 to 220 days. In Finland, age at first estrus has been reported by Tummaruk et al. (2001) to occur at day 245 on Landrace gilts. This large range appears to be too wide to be targeted on a well-managed sow herd because the number of estruses that gilts may be able to experience within this time range is highly variable. Even though, age at puberty can be genetically influenced Evans and O'Doherty (2001), different targets for breeding of gilts are recommended by various dam-lines companies. Management and selection of replacement gilts is of great importance as these gilts represent the future production potential of the herd. Regardless of whether they are raised from birth to puberty or purchased at various ages, they need to be managed with the goal of optimizing lifetime performance. Therefore, the objective of this study was to analyze from existing lifetime data the optimal age of first breeding gilts that results in greatest lifetime performance.

MATERIALS AND METHODS

Animal Welfare and Ethics Committee approval was not obtained for this study because the data used for this analysis was obtained from a private company's existing Porcitec database. (www.agritecsoft.com)

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Management

Gilts were purchased from multiplier herds within the US and Canada and transported to the selected farms for gilt development. The F1 Landrace x Yorkshire gilts in the selected herds were managed under similar management operations in all the farms hence no herd effect was put in consideration during our analysis. To be included in the present study, herds had to be free from incidences of Porcine Reproductive and Respiratory Syndrome (PPRS) and Porcine Epidemic Diarrhea (PED) which have been found to be the most economical diseases affecting swine industry in the US (Holtkamp et al., 2013).The herds were also selected on their merit of completeness and accuracy of recording data. Additional information about the gilt weight and their specific management within the farm (feeding regime, growth pattern, vaccinations, health level,) was not available.

Data

Data consisted of F1 Landrace x Yorkshire gilts entered in the herds from 1st Jan 2014 until 31st July 2016. At the time of data extraction Dec 2018, 15% of the gilts entered were still active in the herds and were not included in the study. The individual records of all sows which presently have been culled were used, so that their entire productive life was included in this analysis. The selected breed –wean farms were located in the Midwest of the United States. Swine production in these states can be visualized as a pyramid consisting of four levels (top-down): nucleus herds, multiplier herds, piglet producing herds, and fattening herds Simonsson and Rydhmer (1996). The following information was extracted from the database: date of birth, age in days at first mating, parity total born piglets, lifetime total born piglets, and reason for culling. The range of age in days at first mating was greater than 170 but less than 369 days. Gilts, designated as parity 0 (P0), were excluded from the analysis and sows greater than parity 6 (P6) were excluded since the private company's policy stipulates culling of P6 and older sows. All sows with missing values in the dataset were excluded and the final data set containing 17,558 individual sows and records was exported as excel-file into IBM SPSS Statistics version 25 (IBM SPSS Inc. Armonk NY, USA) where all statistical analysis was obtained.

Statistical analysis

A total of 17,558 F1 Landrace x Yorkshire sows were divided into 6 classes according to age at first breeding in days 170–190 (n=754), 191–211 (n=4683), 212–232 (n=7123), 233–253 (n=3385), 254–274 (n=1002) and 275–369 (n=611). The age at first breeding was selected because it represents the initial direct managerial decision towards the gilt to become productive first-litter gilt, although not all first matings are successful.

A detailed analysis of all the variables involved in the reproductive cycle of the sows, described in table 4, was conducted to assess these parameters on the lifetime total pigs productivity. The herd reproductive life of the sow was considered as the period between first mating recorded by the farmer and the culling date.

The statistical analyses were done using the IBM SPSS version 25.The study used the model of

$$TPB_{ijkl} = \mu + SAC_i + CP_j + RA_k + SAC_i{*}CP_j + \varepsilon_{ijkl}$$

where:

TPB_{ijkl} – Total Pigs Born (TPB) as a dependent variable; μ – overall mean; SAC_i – Service Age Category as a main effect; CP_j – Current Parity (CP) as a main effect; RA_k – Removal Age (RA) as a covariance; $SAC_i{*}CP_j$ – Interaction effectε_{ijkl} – Random Error.

RESULTS AND DISCUSSION

Mean parity total born pigs dependent on age at first service demonstrated in *Table 1*.

Table 1

Total pigs born dependent on age at 1st service

Dependent variable Age at 1st service(d)	n	%proportion in study	mean	std.error
170–190	754	4.3	61.142[a]	2.035
191–211	4683	26.7	59.276[a]	0.509
212–232	7123	40.5	57.245[ab]	0.434
233–253	3385	19.3	55.089[bc]	0.945
254–274	1002	5.7	54.530[bc]	1.099
Total	17,558	100		

a. Covariates appearing in the model are evaluated at the following values: Lifetime_farrow_rate = 84.53, Removal_age = 797.45.
b. Based on modified population marginal mean.
c. Adjustment for multiple comparisons:Bonferroni.

Figure 1 shows, that age at first mating between 233–253 days as a favored age due to evenly higher parity total born across all the 6 parities.

The results of the statistical analysis model of the effect of age at the first mating variables dealing with the lifetime total born productivity of the sows are presented in *Table 2*. The overall results clearly demonstrated that the age at the first mating does have a significant effect ($P < 0.05$) on the lifetime total born of the sows. It is also evident that current parity at removal and removal age has significant effect ($p<0.05$) on the lifetime total born pigs.

Culling reasons distribution according to age at first service is shown in *Figure 2*, reproductive failure is the most common culling reason across all the age groups.

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Figure 1: **Parity total born distribution according to age at first service**

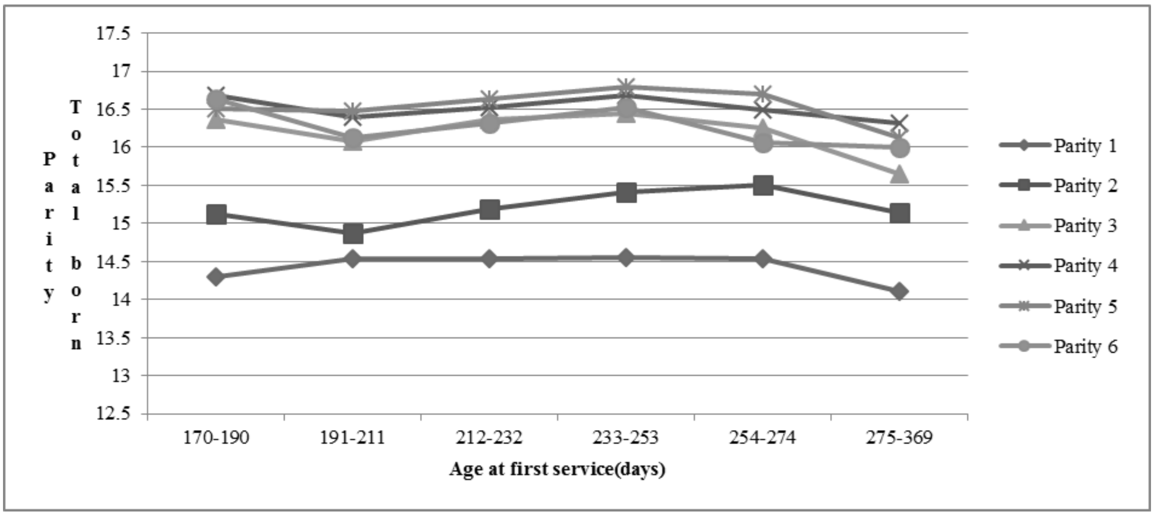


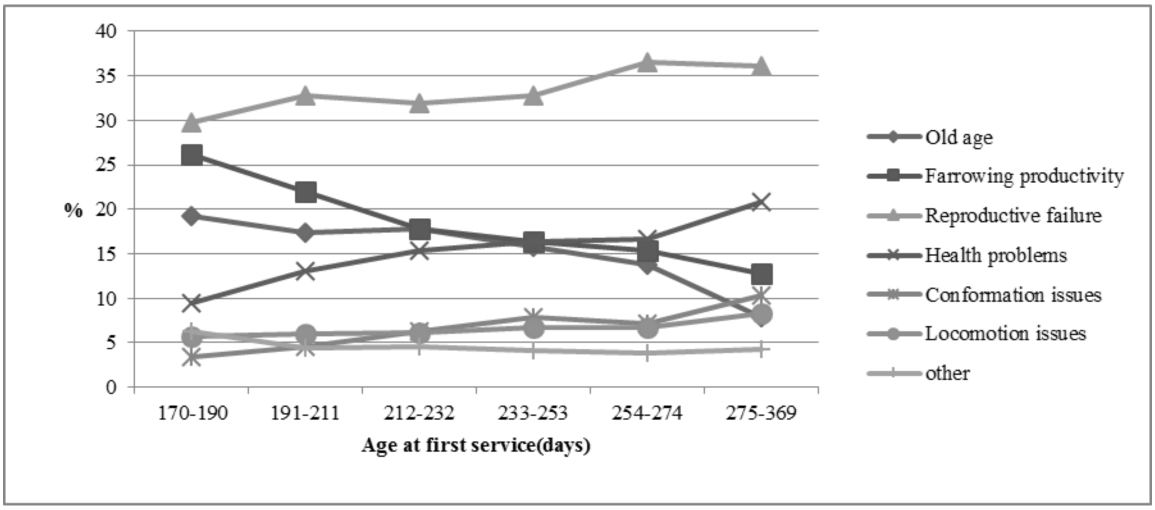
Table 2

Test of between subject effects dependent on total pigs

Source	Type III sum of squares	df	mean square	F	Sig
Corrected model	14080091.719a	36	391113.659	4264.654	0.000
Intercept	146499.190	1	146499.190	1597.409	0.000
Removal Age (RA)	2903.796	1	2903.796	31.663	0.000
Serv1 category (S1C)	2970.030	5	594.006	6.477	0.000
Current Parity (CP)	431815.667	5	86363.133	941.692	0.000
Serv1age_category* Current Parity (S1C*CP)	3842.948	25	153.718	1.676	0.019
Error	1606860.090	17521	91.711		
Total	65237662	17558			
Corrected total	15686951.809	17557			

a. R Squared = .897 (Adjusted R Squared = .897) significant at the 0.05 level

Figure 2: **Culling reasons distribution according to age at first service**



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DISCUSSION

Age at first time breeding of gilts is greatly influenced by management King (1989), Prunier (1991) and Le Cozler et al. (1997), therefore it is important to ensure there are sufficient breeding gilts available to serve in the correct condition, at the required time. Annual measurements of herd performance for females in high-performing herds based on the number of pigs born have been reported to provide productivity and lifetime performance benchmarks for the swine industry Koketsu (2007). In this study, age at first breeding of gilts significantly ($p<0.05$) affected the lifetime productivity of the sows. This influence of the age at first breeding has also been reported to affect sow's performance especially for the number of piglets born alive in studies done by Schukken et al. (1994), Xue et al. (1996) and Le Cozler et al. (1998). However, due to the significant interaction between the removal age, service 1 category and current parity, the expected lifetime performance (total pigs) depended on all the interactions in the model used (*Table 2*). Our results establish that first breeding between 233–253 days of age is a favorable period with a resulting increase in total born per parity across all the age groups for lifetime. This results are in agreement with recommended age for first breeding of gilts suggested by Tummaruk et al. (2000) (237days), Tummaruk et al. (2009) (249 days), Babot et al. (2003) (221–240 days) and Field and Taylor Robert E. (2012) (8 months). With a universal gestation length average of 114 days, Le Cozler et al. (1998) established that first farrowing of around 356 days appeared to be the easiest to apply and the more efficient from a reproductive point of view, this implies gilts having been first inseminated at day 242 which is in line with our study findings. From an economic point of view, in this study when gilts are first mated at between 233–253 days they appear to have a low risk of being culled due to farrowing productivity as compared to earlier matings. These sows are sustained in the herds for a long time as compared to gilts bred earlier in their lifetime (*Figure 2).* Additionally this could also explain the fact that as delay in age at first breeding is observed, gilts gain physiological maturity and vitality to withstand unproductiveness during their herd life performance. Babot et al. (2003) established that a higher age at first breeding is associated with increased total born. Overall, it is of great importance for the swine producer to have gilts with high annual productivity, achieved by gilts that reproduce well and remain in the herd for several parities. These findings appear to fall in agreement with Schukken et al. (1994) who recommended the optimal "economical age" for first conception of breeding gilts at 210–250 days. Sow prolificacy measured as Pigs Born Alive (PBA), is mainly affected by increasing ovulation rates. Increasing the age at the first mating most likely increases estrus number, and consequently the ovulation rate Brooks et al. (1980) and Vinsky et al. (2006). However, Dial et al. (1992) found out that breeding at a young age is associated with fewer nonproductive days and consequently with lower initial costs.

Lifetime Total Pigs Born (TPB) is an integrated measurement of gilt reproductive productivity that combines lifetime TPB with lifetime sow days. Lifetime TPB is commonly used as a benchmarking measurement to compare the productivity of breeding herds, either between herds in a country or between countries and also between various genotypes Dial et al. (1992). In our study gilt age at first breeding was significant ($p<0.05$) with Lifetime TPB. Parity total born gains an increasing trend as parity increases as seen in *Figure 1*. These results are in agreement with findings of Clark et al. (1988) and Iida and Koketsu (2014) who noted an increasing litter size till parity 4. However, when age at first mating is delayed >254 days there is a considerable decrease in total parity born with similar findings established by Tummaruk et al. (2001), who showed a decrease in litter size for sow parities 4 and 5 when age at the first mating increases from 7 to 11 months.

There has been an increasing litter size for the past 40 years in commercial swine farms in the United States, National Agricultural Statistic Service NASS (2011). Hyper-prolific maternal line females of today commonly have 14–16 piglets born alive and piglet pre-weaning mortality ranging from 11% to 24% predominantly in the first five days of age Baxter and Edwards (2013), our research has also established a similar finding with a mean parity total born of 14–17 piglets (*Figure 1*).

The results obtained on culling reasons indicate reproductive failure as the major removal reason of most sows in this study *(Figure 2*). Similar findings of reproductive failure being the major sow culling reason have been reported in studies done by Sehested and Schjerve (1996), Boyle et al. (1998) and Balogh et al. (2015). Reproductive failure as unplanned sow removal comprises of aspects such as no heat, failure to conceive, difficult farrowing and abortion. In this study, reproductive failure gains an increasing trend as age at first breeding of gilts is delayed (*Figure 2*). This could be explained by the fact that Stalder et al. (2012) showed that higher aged gilts at breeding have an increase in return to heat associated with degraded ovary and corpora lutea functions, as well as low progesterone concentrations.

In this study (*Figure 2*), gilts inseminated at an early age <233 days have an increased risk of culling due to farrowing productivity, mainly explained by the fact that such gilts haven't attained physiological maturity and vitality, a similar finding established by Schukken et al. (1994)

The significant ($p<0.05$) (*Table 2*) interaction between the service 1 age + current parity dependent on total born piglets represents a distinctive reproductive response of the sows under similar management. This response may be related to the overall similarities in management operations such like stipulated culling times.

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CONCLUSION

Age at first breeding of gilts has consequences on reproductive performance and longevity. This has been demonstrated by the fact that breeding at 233–253 days appears to be the optimal age for sow increased lifetime total born piglets and reduced sow culling by farrowing productivity. The established significant interaction between the age at first breeding of the gilts and removal age plus current parity provides evidence that lifetime reproductive performance of the gilt depends on the age at first breeding. Age at first breeding represents a managerial decision that has to be undertaken by swine producers for initiation of the gilts in the breeding herds. For both reproductive and herd life productivity, planning the age at the first breeding of gilts between 233–253 days appears to be the most effective age.

Though the present study was an observational analysis of records from commercial farms, our results could be biased by growth rate of gilts, weight at first breeding and backfat thickness at first breeding which we did not measure. Even with such limitations, the present study adds to scientific work by providing valuable information on the significance of age at first breeding on sow lifetime performance which swine producers and veterinarians can directly apply for practice and productivity in the swine industry.

Conflict of Interest

The authors declare no conflict of interest. The research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Availability of data and materials

This work was part of the Masters thesis research. The data sets in this study are not publicly available due to protection of privacy and farm details. The private company provided data only to be used in the master’s research thesis at University of Debrecen, Hungary by a particular research group.

REFERENCES

Babot, D.–Chavez, E. R.–Noguera, J. L. (2003): The effect of age at first mating and herd size on the lifetime productivity of sows. Animal Research, vol. 52, ss. 49–64.

Balogh, P.–Kapelan´ski, W.–Jankowiak, H.–Nagy, L.–Kovács, S.–Huzsvai, L.–Popp, J.–Posta, J.–Soltész, A. (2015): The productive lifetime of sows on two farms from the aspect of reasons for culling. Ann. Anim. Sci. 15, 747–758.

Baxter, E. M.–Edwards, S. A. (2013): Determining piglet survival. Soc Reprod Fertil. 68:129–143.

Boyle, L.– Leonard, F. C.–Lynch, B.–Brophy, P. (1998): Sow culling patterns and sow welfare. Irish Veterinary Journal 51, 354–357.

Brooks, P. H.–Smith, D. A. (1980): The effect of mating age on the reproductive performance, food utilisation and live weight change of the female pig. Livest. Prod. Sci. 7, 67–78.

Clark, L. K.–Leman, A. D.–Morris, R. (1988): Factors influencing litter size in swine: parity-one females. J. Am. Vet. Med. Assoc. 192, 187–194.

Culbertson, M. (2008): Measures of lifetime sow performance. In: 2008 Swine Breeding Management Workshop. Setting up the Herd, 2008, Edmonton, AB, Canada. Edmonton, AB: SBMW

Dial, G. D.–Marsh, W. E.–Polson, D. D.–Vaillancourt, J. P. (1992): Reproductive failure: differential diagnosis. In: Leman AL, Straw BE, Mengeling WL, D’Allaire S, Taylor DJ, editors. Disease of swine. 7th ed. Ames: Iowa State University Press; p. 83–137.

Eliasson, L.–Rydhmer, S.–Einarsson, S.–Andersson, K. (1991): Relationship between puberty and production traits in the gilt. Age at puberty. Anim. Reprod. Sci. 25, 143–154.

Evans, A. C. O.–O’Doherty, J. V. (2001): Endocrine changes and management factors affecting puberty in gilts. Livestock Production Science. 68:1–12.

Field, T. G.–Taylor, R. E. (2012): Scientific Farm Animal Production: An Introduction to Animal Science .Tenth edition page Published by Pearson Prentice Hall.pp 495.

Holtkamp, D. J.–Kliebenstein, J. B.–Neumann, E. J.–Zimmerman, J. J.–Rotto, H. F.–Yoder, T. K.–Wang, C.–Yeske, P. E.–Mowrer, C. L.–Haley, C. A. (2013): Assessment of the economic impact of porcine reproductive and respiratory syndrome virus on United States pork producers. J Swine Health Prod.21:72–84.

Iida, R.–Koketsu, Y. (2014): Interactions between pre- or postservice climatic factors, parity, and weaning-to-first-mating interval for total number of pigs born of female pigs serviced during hot and humid or cold seasons. Journal of Animal Science. 92:4180–4188.

King, R. H. (1989): Effect of live weight and body composition of gilts at 24 weeks of age on subsequent reproductive efficiency. Anim. Prod. 49, 109–115.

Koketsu, Y. (2007): Longevity and efficiency associated with age structures of female pigs and herd management in commercial breeding herds. Journal of Animal Science. 85: 1086–1091.

Le Cozler, Y.–Dagorn, J.–Dourmad, J. Y.–Johansen, S.–Aumaıtre, A. (1997): Effect of weaning-to-conception interval and lactation length on subsequent litter size in sows. Livest. Prod. Sci. 51, 1–11.

Le Cozler, Y.–Dagorn, J.–Lindberg, J. E.–Aumaître, A.–Dourmad, J. Y. (1998): Effect of age at first farrowing and herd management on long-term productivity of sows. Livestock Production Science, vol. 53, ss. 135–142.

National Agricultural Statistic Service NASS. (2011): Agricultural statistics book by year. Washington DC, USA: Government Printing Office

Prunier, A. (1991): Influence of age at nutritional restriction on growth and sexual development of gilts. Reprod. Nutr. Dev. 31, 647–653.

Sasaki, Y.–Koketsu, Y. (2008): Sows having high lifetime efficiency and high longevity associated with herd productivity in commercial herds. Livestock Science. 118: 140–146.

Sehested, E.–Schjerve, A. (1996): Aspects of sow longevity based on analyses of Norwegian sow recording data. In: Proceedings of Nordiska Jordbruksforskares Förening, Seminar no. 265, Research Centre Foulum, Denmark, vol 111, 9–16.

Simonsson, A.–Rydhmer, L. (1996): Pig production in Sweden. Pig News and Information 17, 25N–27N.

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Schukken, Y. H.–Burman, J.–Huirne, R. B. M.–Willemse, A. H.–Vernooy, J. C. M.–van den Broek, J.–Verheijden, J. H. M. (1994): Evaluation of optimal age at first conception in gilts from data collected in commercial swine herds. J. Anim. Sci. 72, 1387–1392.

Stalder, K.–D'Allaire, S.–Drolet, R.–Abell, C. (2012): Longevity in breeding animals. In: Zimmerman JJ, Karriker LA, Ramirez A, Schwartz KJ, Stevenson GW, editors. Diseases of swine. 10th ed. Chichester: John Wiley & Sons; p. 50–59.

Tummaruk, P.–Lundeheim, N.–Einarsson, S.–Dalin, A. M. (2000): Reproductive performance of purebred Swedish Landrace and Swedish Yorkshire sows: I. Seasonal variation and parity influence. Acta Agriculturae Scandinavia, Section A – Animal Science, vol. 50, ss. 205–216.

Tummaruk, P.–Lundeheim, N.–Einarsson, S.–Dalin, A. M. (2001): Effect of birth litter size, birth parity number, growth rate, backfat thickness and age at first mating of gilts on their reproductive performance as sows. Animal Reproduction Science, vol. 66, ss. 225–237.

Tummaruk, P.–Tantasuparuk, W.–Techakumphu, M.–Kunavongkrit, A. (2007): Age, body weight and backfat thickness at first observed estrus in crossbred Landrace × Yorkshire gilts, seasonal variations and their influence on subsequence reproductive performance. Animal Reproduction Science. 99:167–181.

Tummaruk, P.–Tantasuparuk, W.–Techakumphu, M.–Kunavongkrit, A. (2009): The association between growth rate, body weight, backfat thickness and age at first observed estrus in crossbred Landrace × Yorkshire gilts. Anim Reprod Sci. 110:108–122.

Vinsky, M. D.–Novak, S.–Dixon, W. T.–Dyck, M. K.–Foxcroft, G. R. (2006): Nutritional restriction in lactating primiparous sows selectively affects female embryo survival and overall litter development. Reprod Fertil Dev. 18:347–355.

Xue, J. L.–Dial, G. D.–Marsh, W. E.–Lucia, T.–Bahnson, P. (1996): An association of gilt age at first mating with female productivity.(abstract) J.Animal Sci 74,248 suppl 1.