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Original article

Factors affecting length of productive life and lifetime production traits in a commercial swine herd in Northern Thailand

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The length of productive life (LPL) and lifetime production traits are economically important in commercial swine production systems. This study investigated factors that may influence the LPL and lifetime production traits of sows in a commercial swine population in Thailand. The dataset consisted of information from 2768 sows that had their first farrowing from 1989 to 2012. Three breed groups of sows were represented: 122 Duroc, 1944 Landrace and 702 Yorkshire. The traits analyzed were the LPL, lifetime piglets born alive (LBA), lifetime piglets weaned (LPW), lifetime piglets birth weight (LBW) and lifetime piglets weaning weight (LWW). The model consisted of year-season of first farrowing, breed group and age at first farrowing as fixed effects and the residual as a random effect. Year-season of first farrowing was an important source of variation for all traits ($p < 0.0001$). Yorkshire sows had the longest LPL ($p < 0.05$) and the highest LPW ($p < 0.05$) of all sow breed groups, whereas Duroc sows had the lowest least squares means for all traits. Landrace and Yorkshire sows had similar LBA, LBW and LWW. Thus, Yorkshire sows had the highest production efficiency (the longest LPL and highest LPW) of the three breed groups in this population. Age at first farrowing was negatively associated with LPL, LBA, LPW, LBW and LWW. The favorable association between age at first farrowing with LPL and LPW could be used to increase the efficiency of swine production in this population.

Introduction

Duroc, Landrace and Yorkshire sows are important breeds for producing crossbred gilts to supply commercial swine operations in Thailand where the replacement rate in a commercial swine herd ranges from 25 to 50% per year (Keonouchanh, 2002; Engblom et al., 2007). Usual reasons for removing sows from the herd are reproductive problems, old age and disease (Stalder et al., 2004). Approximately 15%–20% of the sows are culled after the first parity and more than 50% are culled before their fifth parity (Lucia et al., 2000; Engblom et al., 2007). Unfortunately, high replacement rates increase costs of production. The current level of economic competition in Thailand has stimulated swine producers to aim at having large numbers of sows with high production and reproduction efficiency. Thus, selection of sows for production efficiency is important for commercial swine enterprises because it is positively associated with herd productivity and profitability.

The length of productive life (LPL; the number of days between sow age at first farrowing and sow age at weaning of her last farrowing) and lifetime production traits (the sum of all individual measurements of each trait during the lifetime of a sow) are very important for the profitability of swine production systems because of their association with stayability, productivity and the cost of production. Increasing a sow's LPL results in higher sow lifetime productivity and lower gilt replacement costs. Shorter sow LPL values result in lower sow lifetime productivity and higher replacement costs. Thus, if commercial swine producers could control the proportion of sows in the herd with long LPL, their operations would be more competitive and profitable.

The LPL of sows depend on a variety of genetic and environmental factors (for example, sow biology, breed composition, season, management, housing, nutrition, age at first farrowing; Koketsu et al., 1999; Tummaruk et al., 2000; Yazdi et al., 2000a; Engblom et al., 2008; Serenius et al., 2008). In particular, younger

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ages at first farrowing were found to be favorable to the LPL (Engblom et al., 2008; Serenius et al., 2008) and to lifetime production traits (Koketsu et al., 1999; Yazdi et al., 2000a). To improve the LPL and associated lifetime production traits, producers will need to know the factors (genetic and non-genetic) that significantly affect LPL traits in their population. Thus, the objective of this study was to characterize factors affecting the LPL and lifetime production traits of sows raised in a commercial swine population under tropical conditions in Northern Thailand.

Materials and methods

Data, animals and traits

Data were collected from a commercial swine population in Northern Thailand (Chiang Mai province). The dataset consisted of production records from 122 Duroc, 1944 Landrace and 702 Yorkshire sows that had their first farrowing from July 1989 to December 2012. Records consisted of sow identification number, sire, dam, breed group, parity, birth date, farrowing date, weaning date, age at first farrowing (AFF), length of productive life (LPL), lifetime piglets born alive (LBA), lifetime piglets weaned (LPW), lifetime piglets birth weight (LBW) and lifetime piglets weaning weight (LWW). Contemporary groups were defined as year-season of first farrowing. The LPL was defined as the number of days between the age of a sow at first farrowing and the age at weaning of her last farrowing.

Only sows that had their first parity record, known farrowing date for each parity and no missing parities were considered for analysis. Cross-fostering and incomplete records were eliminated from the dataset. All sows had completed their productive life and had been removed from the production system. Sows with extreme values for age at first farrowing (250 d or less and 520 d or more) were removed from the dataset. Seasons were classified as winter (November to February), summer (March to June) and rainy (July to October). The number and percentage of records per parity were: 1 (267 records; 9.65%), 2 (349 records; 12.61%), 3 (291 records; 10.51%), 4 (231 records; 8.35%), 5 (279 records; 10.08%), 6 (299 records; 10.80%), 7 (415 records; 14.99%), 8 (303 records; 10.95%), 9 (202 records; 7.30%) and 10 (132 records; 4.77%). Age at first farrowing of sows ranged from 272 d to 519 d.

Nutrition and management

All gilts and sows received the same management, feeding and health care in an open-house system with foggers (gilts and non-lactating sows) or dippers (nursing sows) that were activated when the ambient temperature rose above 33 °C. Breeder boars were kept in a close-house system with an evaporative cooling system. Breeder sows were fed 2.50 kg feed/d (16% crude protein and 3200 to 3500 kcal/kg feed) divided into two feeding times (0700 hours and 1300 hours). Farrowing and nursing sows were fed 5.0–6.0 kg feed/d (16–17% crude protein and 4600 kcal/kg feed) split into four feeding times (0700 hours, 1000 hours, 1300 hours and 1500 hours).

Replacement gilts were selected based on their own phenotype, pedigree and estimated breeding value for production traits (total number of piglets born, number of piglets born alive, litter birth weight, number of piglets weaned and litter weaning weight) and growth traits (average daily gain, hip width, shoulder width, body length and number of nipples). Gilts were inseminated for the first time at age 8 to 9 mth or 140 kg of body weight. After mating, sows were moved to a farrowing building and kept in individual farrowing pens from mating until approximately 1 wk before parturition. Piglets were weaned at age 26–30 d (approximately 7 kg weight). When selected gilts and sows showed estrus, they were inseminated with semen from a boar chosen according to the same selection criteria used for gilts. Gilts and sows were inseminated twice with the same boar (12 h after detection of estrus and 12 h after the first insemination).

Statistical analysis

A fixed linear model was used to determine the importance of genetic and environmental factors affecting the LPL, LBA, LPW, LBW and LWW. The model included the fixed effects of first farrowing year-season, breed group (Duroc, Landrace and Yorkshire) and age at first farrowing as a covariate and residual as a random effect. Random residual effects were assumed to have mean equal to zero, common variance and be uncorrelated. The model can be described by Equation (1):

$$y_{ijk} = \mu + FYS_i + BG_j + b_1AFF + e_{ijk} \quad (1)$$

where y_{ijk} is a phenotypic observation for the LPL, LBA, LPW, LBW and LWW, μ is the population mean, FYS_i is the ith first farrowing year-season (i = 1 to 70), BG_j is the jth breed group of sow (j = 1 to 3; 1 = Duroc, 2 = Landrace and 3 = Yorkshire), AFF is the age at first farrowing in days, b_1 is the linear regression coefficient of the LPL, LBA, LPW, LBW and LWW on AFF and e_{ijk} is the random residual. The e_{ijk} were assumed to have mean zero and common variance σ_e^2. The expected value of y_{ijk} was equal to $\mu + FYS_i + BG_j + b_1AFF$, and the variance of y_{ijk} was equal to σ_e^2 for all y_{ijk}. Descriptive statistics (mean, SD, minimum, maximum) for the complete dataset were obtained using the MEANS procedure of the Statistical Analysis System (SAS, 2003). Least squares estimates of effects in the model were computed using the GLM procedure of SAS. Significant differences were considered at $\alpha = 0.05$. Least square means (LSM) for first farrowing year-seasons and breed groups were compared using a t test adjusted with a Bonferroni correction.

Results and discussion

The numbers of records, mean, SD, minimum and maximum values for each trait (LPL, LBA, LPW, LBW and LWW) in the complete dataset are presented in Table 1. The mean LPL for sows in this commercial population was shorter than those reported for two farms in Northeastern Thailand (807.59–883.58 d for farm 1 and 804.93–832.87 days for farm 2; Keonouchanh, 2002).

First farrowing year-season

The effect of first farrowing year-season was important for all traits ($p < 0.0001$). The LSM ranged from 144.96 ± 45.21 d (2012-rainy) to 1038.80 ± 149.41 d (1996-winter) for LPL, from 14.09 ± 3.25 piglets (2012-rainy) to 70.74 ± 11.81 piglets (1997-rainy) for LBA, from 11.80 ± 2.92 piglets (2012-rainy) to 64.90 ± 10.60 piglets (1997-rainy) for LPW, from 24.27 ± 5.17 kg (2012-rainy) to 104.92 ± 5.37 kg (2009-rainy) for LBW and from 88.51 ± 22.15 kg (2012-rainy) to 431.21 ± 22.75 kg (2009-rainy). Thus, variation in environmental conditions (climate, management, nutrition and health care) in this commercial farm during the years of this study markedly affected the least squares estimates of first farrowing year-season effects for all traits in this study.

These findings were in agreement with a previous study in Northeastern Thailand, where first farrowing year-season also significantly influenced LPL and lifetime sow productivity (Keonouchanh, 2002). Tummaruk et al. (2004) found that Landrace and Yorkshire sows that farrowed in the rainy season (August and September) tended to have a lower total number of piglets born and

Table 1
Descriptive statistics for length of productive life and lifetime production traits.

Trait	*n*	Mean	SD	Minimum	Maximum
Length of productive life (d)	2768	665.84	408.28	25	1596
Lifetime piglet born alive (piglets)	2768	51.12	28.76	0	130
Lifetime piglets weaned (piglets)	2768	44.72	26.12	0	124
Lifetime piglets birth weight (kg)	2741	81.31	45.59	1.20	220.60
Lifetime piglets weaning weight (kg)	2728	328.12	194.86	6.00	979.50

number of piglets born alive than sows that farrowed in winter and summer (November to June). Similarly, Tantasuparuk et al. (2000) found that sows that farrowed in the rainy season had smaller litter sizes than sows that farrowed in other seasons. Thus, part of the observed variation in LPL, LBA, LPW, LBW and LWW was likely the outcome of changes in climate patterns, nutritional regimens and husbandry practices as well as health care by swine farmers in Northern Thailand over time.

Breed groups

The breed group of the sow was an important factor ($p < 0.0001$) for all traits in this study. The values LSM for LPL, LBA, LPW, LBW and LWW by breed group of sow are presented in Table 2. Landrace and Yorkshire sows had similar LSM for LBA, LBW and LWW. Duroc sows had the lowest LSM for all traits. Yorkshire had longer LPL than Duroc (196.00 ± 38.67 d; $p < 0.0001$) and Landrace (53.01 ± 19.09 d; $p = 0.0055$). Yorkshire also had higher LBA than Duroc (19.71 ± 2.78 piglets; $p < 0.0001$), and larger LPW than Duroc (21.72 ± 2.50 piglets; $p < 0.0001$) and Landrace (3.18 ± 1.23 piglets; $p = 0.0100$). Furthermore, Yorkshire had heavier LBW (29.77 ± 4.56 kg; $p < 0.0001$) and heavier LWW (163.48 ± 19.63 kg; $p < 0.0001$) than Duroc. The lower LPL and lifetime production traits of Duroc sows than Landrace and Yorkshire sows could have been due to the different culling and selection pressures for these three breeds in this population. Commercial operations utilize Duroc as a terminal boar line (emphasis on growth traits), whereas Landrace and Yorkshire are used as terminal dam lines (emphasis on reproduction traits). The longer LPL and higher LPW in Yorkshire sows than in Duroc and Landrace sows may be an indication that Yorkshire sows were better adapted than Duroc and Landrace sows under the environmental conditions on this commercial farm. It may also indicate that culling and selection for reproductive and productive traits was either more intense or more effective on Yorkshire sows than on Duroc and Landrace sows. This last aspect may be more relevant for Duroc sows if culling and selection emphasized growth traits (individual or litter) than reproduction traits.

The difference in the LPL and LPW between Landrace and Yorkshire sows found here was in contrast to the results of Keonouchanh (2002) who found that Landrace and Yorkshire sows had similar LPL, LBA, LPW and lifetime number of piglets born under an open-house system in Northeastern Thailand. Further, Tantasuparuk et al. (2000) found a higher number of piglets born per litter, number of piglets born alive per litter, average birth weight and farrowing rate in Landrace than in Yorkshire sows. Similarly, López-Serrano et al. (2000) reported that Yorkshire sows had lower ability to survive and higher culling rates than Landrace sows. Conversely, Sobczyńska et al. (2013) found that Yorkshire sows had a longer LPL (601 days vs. 652 days) and LPW (41.5 piglets vs. 44.0 piglets) than Landrace sows in Poland.

Age at first farrowing

Age at first farrowing (AFF) significantly influenced all traits ($p < 0.0004$ to $p < 0.0001$). The regression coefficients of all traits on AFF were negative (from −1.06 ± 0.22 d of LPL per day of AFF to −0.06 ± 0.01 kg LPW per day of AFF; Table 3). These regression coefficients suggest that sows that began to farrow at younger ages had significantly longer LPL, higher LBA, higher LPW, heavier LBW and heavier LWW than sows that farrowed at older ages.

Segura-Correa et al. (2011) reported that sows farrowing at 330 d or less and between 331 d and 347 d (younger ages) stayed longer in the production system than sows farrowing at 348 d or more (older ages). Other studies found that sows and gilts that reached puberty at an earlier age had their first mating at younger ages or farrowed at younger ages, became pregnant more quickly, had larger litter sizes and stayed in the farm longer than sows that reached puberty at later ages (Le Cozler et al., 1998; Yazdi et al., 2000a,b; Serenius and Stalder, 2004, 2007; Hoge and Bates, 2011) in agreement with the results in the current study. Older age at first farrowing may also indicate that these sows had difficulty in conceiving at their first insemination service (Hoge and Bates, 2011). Furthermore, sows that farrowed at older ages had a greater risk of being culled from the herd. Sows that began farrowing at age 420 d had a greater (16%) risk of removal than sows that farrowed at age 360 d (Engblom et al., 2008). Conversely, Keonouchanh (2002) and Babot et al. (2003) found that sows that began to farrow at older ages had longer LPL and higher lifetime production traits than sows that started farrowing at younger ages.

Le Cozler et al. (1998) suggested that sows farrowing at approximately 356 d had high production efficiency in a commercial swine production. Other studies indicated that the optimal age at first conception would be between age 200 d and 210 d (Schukken et al., 1994; Tummaruk et al., 2001). However, reducing age at first farrowing or making replacement gilts farrow at

Table 2
Least squares means ± SE for length of productive life and lifetime production traits in Duroc, Landrace and Yorkshire sows.

Breed group	Trait				
	LPL (d)	LBA (piglets)	LPW (piglets)	LBW (kg)	LWW (kg)
Duroc	557.54 ± 36.26[c]	33.67 ± 2.61[b]	26.91 ± 2.34[c]	49.54 ± 4.29[b]	161.35 ± 18.51[b]
Landrace	700.53 ± 12.94[b]	51.23 ± 0.93[a]	45.46 ± 0.93[b]	76.91 ± 1.49[a]	307.95 ± 6.32[a]
Yorkshire	753.54 ± 16.05[a]	53.47 ± 1.16[a]	48.63 ± 1.04[a]	79.31 ± 1.85[a]	324.84 ± 7.82[a]

[a, b, c] = least squares means within a column with different superscripts are significantly different at $p < 0.05$.
LPL = length of productive life; LBA = lifetime piglets born alive; LPW = lifetime piglets weaned; LBW = lifetime piglets birth weight and LWW = lifetime piglets weaning weight.

Table 3
Regression coefficients of length of productive life and lifetime production traits on age at first farrowing.

Trait	Regression coefficient	p-value
Length of productive life (d)	−1.06 ± 0.22	<0.0001
Lifetime piglet born alive (piglets)	−0.07 ± 0.02	<0.0001
Lifetime piglets weaned (piglets)	−0.06 ± 0.01	<0.0001
Lifetime piglets birth weight (kg)	−0.09 ± 0.03	0.0003
Lifetime piglets weaning weight (kg)	−0.39 ± 0.11	0.0004

younger ages should be accompanied by better management to guarantee that they reach puberty at an appropriate body weight. To maintain a high level of production efficiency, producers should not mate immature sows, which would create reproductive problems later on and would ultimately shorten their LPL.

Non-genetic (first farrowing year-season and age at first farrowing) and genetic factors (breed group) were found to affect length of productive life and lifetime production traits in a commercial swine population composed of three breeds in Northern Thailand. Sows farrowing for the first time at young ages had a longer LPL and higher lifetime productivity. Yorkshire sows had a longer LPL and a higher lifetime productivity than Duroc and Landrace sows. Sows farrowing at younger ages should receive appropriate feeding, management and health care to optimize productivity. Sows with a longer LPL and a higher lifetime productivity should continue to be favored in commercial swine production system because of their high production efficiency.

Conflict of Interest

No conflicts of interest influenced this research.

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