FULL PAPER *Theriogenology*

Reproductive Productivity Measurements in Japanese Swine Breeding Herds

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ABSTRACT. To set productivity standards and targets, and investigate inter-relationships between key measurements in swine breeding herds, farm productivity measurements were analyzed on 87 Japanese commercial farms in 14 prefectures. The 87 herds were ranked on the basis of number of pigs weaned per mated female per year (PWMFY), and 23 herds in the upper 25th percentile of this ranking were designated as high-performing farms. Productivity measurements on the high-performing farms were compared with values for the remaining farms. The high-performing farms had shorter farrowing intervals, greater litters per mated female per year (LMFY), greater pigs weaned per sow (PWS), and greater mean parity of culled sows than the remaining farms ($P<0.01$). No difference in lactation duration was found between the two groups ($P>0.10$). For both farm groups, correlations of key reproductive measurements were determined. Lactation duration was not correlated with LMFY, PWS and PWMFY on the high-performing farms, while short lactation duration was correlated with greater LMFY and PWMFY on the remaining farms ($P<0.01$). In contrast to lactation duration, farrowing interval was correlated with PWS on the high-performing farms, but not on the remaining farms. Mean parity of culled sows were correlated to PWS and pigs born alive per sow on the high performing farms, but not with any measurements on the remaining farms. These results suggest that high-performing farms have used different herd management from the remaining farms.

KEY WORDS: fertility, productivity, reproductive performance, sow.

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Benchmarking in swine breeding herds is the process of continually measuring performance and comparing it with established standards and targets to identify improvement in herd productivity [4]. Production standards and targets are useful for veterinarians and animal scientists to diagnose suboptimal reproductive failure and to improve productivity on swine farms. However, recent standards and targets in swine breeding herds were not well documented in Japan.

The best measurements of reproductive efficiency in swine breeding herds is the number of pigs weaned per mated female per year (PWMFY), which is dependent on number of litters per mated female per year (LMFY) and number of pigs weaned per sow (PWS) [1]. The interrelationships between measurements within a productivity tree of swine breeding herds including PWMFY, LMFY and PWS have been reported in Canadian and U.S.A. herds [6,8] but not in Japanese herds. Using 685 U.S.A. farms, lactation duration for high-performing farms based on PWMFY was not associated with LMFY. In contrast, for the remaining farms, shorter lactation duration was significantly associated with greater LMFY [5]. Short lactation duration (early weaning) has been frequently used in the U.S.A. to improve herd health, LMFY, and farrowing facility utilization [2], although early weaning may have negative effects on reproductive performance in individual sows [3]. The relationships between lactation duration and LMFY or PWS on Japanese farms may be different from U.S. farms because production system differs between both countries. Using farms with the same computerized record system, the objectives in this study were, therefore, to establish standards and targets of production measurements for benchmarking purposes; and to investigate the interrelationships between measurements in swine breeding herds in Japan.

MATERIALS AND METHODS

Data collection and selection criteria: All producers in Japan using the computerized record system (PigCHAMP) developed by the University of Minnesota (St. Paul, U.S.A.) were requested to mail backup copies of their data files to the Global Pig Farms, Inc. when they purchased PigCHAMP. All data recorded on a farm were kept in the electronic file for each farm. Data files were checked for missing records and changes in herd size. Farms with >5% missing records of farrowing, weaning, and mating events were excluded from the study. Farms in which average inventory changed >500%, compared with 1998, were also eliminated, because an extreme inflation in female inventories may influence on herd productivity. Changes in average inventory of ≤500% were confirmed to be not associated with PWMFY, LMFY, or PWS in preliminary analyses.

Measurements of herd productivity for 1999 were obtained from each data file and used for analyses. Herds included in the study were ranked on the basis of PWMFY. Herds in the upper 25th percentile of this ranking were designated as high-performing farms, and the remaining farms were used as the reference group for comparisons with the high-performing farms.

Definitions: A gilt was defined as a breeding-female entered into a herd but not farrowed, and a sow was a breeding-female farrowed at least once. Females were used to indicate gilts and sows. Non-productive days for breeding females were defined as the average number of days in the year in which female were neither pregnant nor lactating. Total pigs born include pigs born alive and dead pigs per sow at farrowing. Farrowing interval is the sum of lactation

duration and weaning-to-farrowing interval (PigCHAMP, MN). Lifetime pig born alive was defined as the sum of the number of pigs born alive for a sow over all her parities [4].

Statistical analysis: The observational unit is the farm. Summary statistics were obtained using the Univariate procedure in SAS (SAS institute, NC). Herd productivity measurements between high-performing farms and the other farms were compared using ANCOVA in SAS. The covariate was percent changes in average female inventory to the previous year. Partial correlation analysis between measurements within a productivity tree was performed in SAS, using percentage change in average female inventory as a controlled variable.

RESULTS

Data files for 108 herds were obtained. Of 108 farms, 21 were removed from the dataset because 14 farms started their computerized recording in 1999, six herds had >5% missing records and one herd had >500% increased female inventory. Thus, productivity measurements on 87 farms were subsequently analyzed. Mean female inventory in the study population was 284 (32 SE) ranging from 46 to 2601. Descriptive statistics for key herd measurements are shown in Table 1.

High-performing farms had greater LMFY and greater PWS than the remaining farms ($P<0.01$; Table 2). High-performing farms also had lower percentages of remated females (%), shorter non-productive days, shorter farrowing interval, higher farrowing rate, greater pigs born alive per sow, and lower preweaning mortality than the remaining farms ($P<0.01$). However, no difference in lactation duration was found between both farm groups. Additionally, high-performing farms had greater mean parity of culled sows than the remaining farms ($P<0.01$), while no differences in culling rate (%) and mean parity of farrowed sows were found between the two farm groups (Table 2).

A negative correlation was found between LMFY and PWS ($P<0.01$) for the high performing farms, whereas no correlation was found between LMFY and PWS for the remaining farms (Table 3). The LMFY was not correlated with greater PWMFY on high-performing farms, while all eight measurements were correlated with PWMFY on the remaining farms ($P<0.05$; Table 3). Lactation duration was not correlated with PWS and pigs born alive on the high-performing farms ($P<0.01$: Table 3). However, longer farrowing interval was correlated to greater PWS and pigs born alive on the high-performing farms ($P<0.05$), while farrowing interval was not correlated to PWS and pigs born alive on the remaining farms. Furthermore, weaning-to-farrowing interval was positively correlated to PWS and pigs born alive on only high-performing farms ($P<0.05$). Additionally, mean parity of culled sows was positively correlated to PWS on the high-performing farms ($P<0.01$). Mean breeding female inventory, culling rate and replacement rate were not correlated to PWMFY, LMFY and PWS.

DISCUSSION

Measurements of productivity of the high-performing farms in this study provide feasible targets for reproductive efficiency of swine breeding herds in Japan. The variability in breeding herd productivity among 87 farms is relatively large. The large difference (9.0 weaned pigs per female per year) of PWMFY between the highest and lowest farms indicates spaces to improve reproductive efficiency on Japanese swine farms.

Greater mean parity of culled sows on high-performing farms than on the remaining farms suggests that the high-performing farms in Japan have been practiced more judicious culling on sows than the remaining farms in order to improve herd efficiency. Additionally, this management difference on mean parity of culled sows was not found on U.S.A. farms [5].

A negative correlation between LMFY and PWS on the high-performing farms observed in this study was consistent to a previous report on the U.S.A. farms [5]. However, on U.S.A. high-performing farms, shorter lactation duration was also associated with fewer pigs born alive at subsequent farrowing and PWS, but not with LMFY [5]. On the Japanese high-performing farms, lactation duration was not correlated to either LMFY or PWS. This discrepancy is due, at

Table 1. Descriptive statistics of nine key measurements for productivity on Japanese swine breeding farms[a)]

Measurement	Mean	SE	Range	
			Minimum	Maximum
Pigs weaned per mated females per year	21.13	0.21	15.7	24.7
Pigs weaned per sow	9.28	0.06	7.0	10.6
Litters per mated female per year	2.28	0.01	1.96	2.49
Non-productive days	60.0	2.03	25.3	94.8
Lactation duration	21.3	0.24	15.2	28.7
Pigs born alive per sow	10.60	0.06	8.8	11.8
Preweaning mortality, %	12.6	0.45	4.8	26.0
Farrowing interval, days	151	0.62	142	165
Mean parity of culled sows	5.09	0.11	2.3	7.4

a) Eighty seven farms.

Table 2. Comparison of herd measurements during 1999 for 23 high-performing farms (upper 25th percentile on the basis of number of pigs weaned per mated per year) and for 64 other farms in Japan

Annual measurement	High-performing farms Mean	SEM	Other farms Mean	SEM
Mating performance				
Remated females, %	8.0[a)]	0.62	12.5[b)]	0.68
Sows bred by 7 days after weaning, %	86.5	1.33	84.1	1.43
Weaning-to-first-mating interval, day	7.2	0.37	8.2	0.32
Average nonproductive days for mated females	41[a)]	1.7	61[b)]	1.8
Farrowing performance				
Farrowing interval, day	148[a)]	0.7	152[b)]	0.8
Farrowing rate, %	85.7[a)]	0.76	78.2[b)]	0.90
Mean pigs born alive per sow	11.0[a)]	0.07	10.4[b)]	0.07
Mean stillborn pigs and mummies per sow	1.1	0.05	1.2	0.04
Preweaning mortality, %	10.5[a)]	0.52	13.1[b)]	0.53
Litters per mated female per year	2.38[a)]	0.013	2.24[b)]	0.015
Weaning performance				
Mean pigs weaned per sow	9.85[a)]	0.07	9.07[b)]	0.07
Mean weaning weight, kg	6.3	0.10	6.2	0.10
Adjusted 21-day litter weight, kg	63.4[a)]	0.74	59.6[b)]	0.88
Pigs weaned per mated female per year	23.4[a)]	0.12	20.3[b)]	0.20
Lifetime performance				
Lifetime pigs weaned per removed sow	51.2[a)]	1.88	43.0[b)]	1.18
Farrowing facility utilization				
Litters per farrowing crate per year	12.0[a)]	0.38	10.6[b)]	0.23
Pigs weaned per farrowing crate per year	112[a)]	6.1	94[b)]	2.6
Population and management factors				
Lactation duration, day	21.3	0.37	21.3	0.30
Mean breeding female inventory	202	25	313	42
Multiple matings (%)	94.9	0.85	90.5	1.70
Mean parity of farrowed sows	3.93	0.081	3.92	0.054
Mean parity of culled sows	5.56[a)]	0.20	4.92[b)]	0.13
Replacement rate, %	44.4	1.57	42.0	1.62
Culling rate, %	36.7	1.66	39.0	5.33
Female death rate, %	5.17	0.60	5.74	0.49

a, b) Rows with different superscripts differ ($P<0.05$).

least in part, to relatively long lactation duration (21.3 days) on the Japanese farms compared to the U.S.A. In the 685 U.S. herds, mean lactation duration was 18.2 days [5], and short lactation duration beyond a critical point was suggested to significantly reduce pigs born alive per sow [3].

Instead of lactation duration, farrowing interval may be a key on the Japanese high-performing farms because shorter farrowing interval was correlated to fewer PWS and higher LMFY. Weaning-to-farrowing interval was also correlated to PWS on the Japanese high-performing farms only. In a previous report [7], short lactation duration and/or short farrowing-to-mating interval decreased embryo survival. Lactation duration, farrowing-to-mating interval and weaning-to-farrowing interval are parts of farrowing interval in swine. Furthermore, a previous study indicated that shorter farrowing interval was associated with fewer pigs born alive at subsequent farrowing [3]. On the high-performing farms in this study, shorter farrowing intervals or farrowing-to-mating intervals may have reduce the pigs born alive per sow and PWS while lactation duration was relatively long. Meanwhile, on the remaining farms, farrowing interval was not correlated to PWS because farrowing interval may not be short enough to decrease PWS. Additionally, LMFY for high-performing farms was maximized by using shorter lactation duration and shorter farrowing interval on U.S.A. farms [5].

The results in this study suggest that the Japanese high-performing farms could improve PWMFY by improving PWS because LMFY is already maximal. PWS could be improved by increasing pigs born alive and reducing preweaning mortality. Meanwhile, the remaining farms could increase their productivity by improving both PWS and LMFY.

The limitation of this study is that the farms were not randomly selected, therefore, the findings in this study may not apply to all swine farms in Japan. Additionally, the results

Table 3. Correlation matrix for key herd measurements on high-performing farms and the remaining (other) farms

	PWMFY	LMFY	PWS	NPD	LD	PBA	PWM	FI
				High-performing farms				
PWMFY	1.00							
LMFY	0.27	1.00						
PWS	0.56***	-0.64***	1.00					
NPD	-0.22	-0.88***	0.58***	1.00				
LD	-0.24	-0.25	0.01	-0.22	1.00			
PBA	0.36	-0.42*	0.64***	0.46**	-0.14	1.00		
PWM	-0.27	-0.30	-0.48**	-0.25	-0.04	0.34	1.00	
FI	0.07	-0.56***	0.52**	0.36	0.47**	0.51**	0.00	1.00
WFI	0.13	-0.47**	0.49**	0.24	0.56***	0.37*	-0.12	0.92***
				Other farms				
PWMFY	1.00							
LMFY	0.67***	1.00						
PWS	0.72***	-0.03	1.00					
NPD	-0.66***	-0.94***	-0.00	1.00				
LD	-0.25**	-0.54***	0.16	0.25**	1.00			
PBA	0.48***	-0.01	0.66***	-0.07	0.25**	1.00		
PWM	-0.35***	-0.01	-0.46***	-0.03	0.11	0.34***	1.00	
FI	-0.51***	-0.72***	0.02	0.64***	0.51***	0.00	0.03	1.00
WFI	-0.41***	-0.60***	0.00	0.50***	0.53***	0.11	0.14	0.91***

The aberrations: pigs weaned mated female per year (PWMFY); litter mated female per year (LMFY); pigs weaned per sow (PWS), non-productive days (NPD); lactation duration (LD); pigs born alive (PBA); preweaning mortality (PWM); farrowing interval (FI) and weaning-to-farrowing interval (WFI) were used.
***, **, and * indicate $P<0.01$, $0.01\leq P<0.05$ and $0.05\leq P<0.10$, respectively.

in this study should not be interpreted as a causality but an association, because this is an observational study using commercial farms. However, even with these limitations, this research provides veterinarians and animal scientists with information of targets of reproductive measurements and inter-relationships in Japanese swine breeding herds.

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