The effect of individual piglet birth weight on profitability.

Darwin Kohler, D.V.M.; Chad Bierman, PhD.
Babcock Genetics Inc.

Introduction

Profitability drives swine production, and many production parameters drive profitability. The largest parameter differentiating profitable farms is the number of full-value pigs marketed from within the production system[12]. Key performance indicators (KPI) contributing to this parameter were largely driven by mortality, but also included number of pigs sold as culls, number of pigs weaned, and average daily gain (ADG) [12]. A large contributing factor to these KPI and resultant profitability is the quality of the pig. If pig quality is improved, profitability will also increase. From a genetic standpoint, showing improvement in any or all of the traits contributing to these KPI has been indicative of a successful genetic program, but has this success contributed to additional profitability for commercial herds?

A more recently publicized discovery is the effect of piglet birth weight on the capacity of a pig to become a full value market hog. Lighter birth weight pigs have been shown to be inferior to their heavier-weight siblings by showing reduced daily gain, higher mortality rates, reduced pork quality, and poorer feed conversion when taken to suitable market weights.[1,4,6,10] Additional research suggests decreased average piglet birth weight is a direct result of increasing litter size born. The number of pigs born alive is a KPI that many organizations have been successfully increasing at rapid rates in recent history (Pigchamp data 2007-2013). Foxcroft and others have indicated a negative relationship between litter size and average piglet birth weight within litter.[5] As litter size increases, average piglet birth weight within the litter decreases. In-house investigation into these claims confirms their findings, as well as the discoveries of others.[1,7,8,9,12] Additionally occurring within the litter as litter size increases, individual birth weight variation increases, the size of the smallest pig decreases, and the number of pigs below 2.8 lbs increases (personal communication; data unpublished). It has been postulated that this increase in litter size has negatively affected production, and quite possibly profitability.[11]

The effect of piglet birth weight on profitability is therefore in question. Profit margins have been reduced in recent years. Data from Iowa State University Extension and Outreach indicates an average profit/pig of $4.26 for farrow-to-finish hog production over the 10-year period ending in 2010.[11] Previous research has investigated the relationships between piglet birth weight and KPI, but has fell short of accurately following piglet mortality through the production system. Knowing the cost associated to pigs when they die, and how much the pig is worth when marketed, can have dramatic effects on the profitability of the system. Others have successfully modeled revenue differences between piglet birth weights, but have not included costs associated with being born into a specific birth weight category. The objective of this study was to further characterize the relationship between piglet birth weight and profitability, and ultimately determine profitable litter size as it relates to piglet birth weight.

Material and methods

Data on piglet birth weight was collected on day1 during litter processing beginning April 2011. Piglets were weighed individually. Pigs were weaned from their dams at 28 days and left in the farrowing crate until moved to the finisher at 63 days of age. Pigs were then followed through the finishing system until off test at market weight. Feeding consisted of three phases in the nursery, each phase requiring a separate diet formulation. Feeding in the finisher was comprised of 6 phases, blending a mixture of low and high protein levels to create each phase. Four genetic lines consisting of Yorkshire, Landrace, Hampshire, and Duroc comprised the dataset. Measurements of growth rate, ultrasound loin muscle size and backfat depth were determined at off test. A total of 25,622 individual birth weights were acquired.

Piglets were grouped according to birth weight, resulting in fourteen birth weight classes. Classes were separated by 0.25 lb increments, the first class including any pig born at less than 1.5 lbs, and incrementing to the heaviest class that included any pig born greater than or equal to 4.5 lbs. Frequency of the pigs in each birth weight class, along with mortality within each class, can be found in table 1.

Mortality was tracked each day for most piglets that failed to survive. Missing information for date of death could be narrowed to either a finishing or farrow/nursery timeframe. Missing data required estimation of replacement values. Age at death in the finisher was modeled from a uniform distribution between 63 and 170 days. Age at death in the nursery was modeled from a chi-square distribution with 3 degrees of freedom. The RAND function within Statistical Analysis Software was utilized for this procedure.[13]

Expenses due to mortality were modeled throughout the production phase, and were used to estimate the cost accrued due to piglet mortality. Piglet processing and daily utilities and labor cost were modeled at $0.35 and $0.10/day, respectively. Daily utilities and labor cost in the finisher were modeled at $0.12/day. Feed cost assigned pre-weaning through day 28 was $0.24/day, accounting for lactation feed intake of the sow, averaging 14 lbs of feed intake/day and nursing an average 11 pigs/sow. Feed intake expense was modeled in four phases post-weaning; three in the nursery and one in the finishing phase. Cost associated per pound of feed resulted in $0.32, $0.19, $0.18, and $0.13 for early-, mid-, late-nursery, and finishing phases, respectively. Polynomial and linear feed intake curves were modeled for nursery and finishing phases, respectively.

Market weight per birth weight class was modeled based on a linear regression developed from acquiring individual birth weight on 10,200 animals and following them from birth through off test. Information on 2,237 carcasses sold to Tyson Foods was used to determine carcass value differences, including grade premiums and sort discounts, between each birth weight class based on their respective predicted market weight. Feed efficiency was modeled for each piglet birth weight class based on results from Fix.[4] Within each piglet birth weight class, values for piglet mortality, carcass value, and feed cost were summed and comparisons between classes were established.

Final considerations to an optimal litter size were developed. A calculator requiring inputs for mean and variance of piglet birth weight within a litter was constructed. As individual piglet birth weight is normally distributed, assumptions to the number of piglets within a certain weight class can be formulated. A value can then be assigned to each birth weight class to predict the value of the litter based on the number of pigs in each class. Varying litter sizes and subsequent weight statistics can ultimately be compared.

Results and Discussion

Current practices in swine production result in the majority of pigs needing to be sold to market in a fixed-time system. This being true, the ability of a pig to reach a valuable market weight in this system will have a large influence on profitability. Previous analyses of the role of piglet birth weight on profitability have mainly considered revenue when comparing differences between birth weight classes. In this report we have set out to assess the effect of essential costs, in addition to revenue, that are involved in separating differences between piglet birth weight classes.

Profitability is largely affected by the amount of weight sold. Fifty pounds of live weight separates the average pig in the lowest and highest birth weight classes, resulting in a value difference of $35.00 for the pounds of pork sold. In addition, the opportunity for packer premiums for non light-weight pigs at market shows the potential for a $7.14 advantage to the heaviest birth weight classes over the lightest. Profit potential is much higher for heavier birth weight pigs when selling on a fixed-time system.

This fixed-time production system requires pigs to be marketed regardless of their weight. An interesting advantage to light weight pigs in this system is conversion of feed to weight. As previously discovered, feed efficiency actually benefits the lighter birth weight pig when the production constraint is time rather than weight.[4] From the lightest to heaviest birth weight category, the feed savings totals a $16.93 advantage to the light birth weight pig. Heavier pigs require more feed for maintenance, resulting in poorer conversion. If the pigs were allowed to reach optimal market weight, the advantage in feed conversion benefits the heavier birth weight pig (personal communication, data unpublished).[1,6,10]

Overall mortality from birth to market for this timeframe was 21.2%. Mortality by phase was 18.8% and 2.3% for farrow/nursery and finishing, respectively. Missing mortality observations resulted in estimation of 89 and 206 records in the farrow/nursery and finisher, respectively, equating to 5.43% of the total mortality records, or 1.63% and 3.8% of the total mortality observations in farrow/nursery and finishing, respectively. Mortality and birth weight are involved in a negative relationship where mortality decreases rapidly as birth weight increases from <1.5 lbs. to 2.75 lbs (Table 1). Lighter birth weight pigs have a higher tendency to die early compared to heavier birth weight pigs. Pigs dying later in life accrue more cost from feed, labor, and utilities, yet there are more pigs in the birth weight class to absorb the cost of these pigs, resulting in the decrease in cost per pig to be less dramatic as birth weight increases. To accurately account for the cost of mortality, the accrued fees from piglets dying throughout the production system must be absorbed by the surviving piglets within their respective birth weight class. As piglet mortality is highest for those in the lower birth weight classes, fewer pigs remain alive, and must therefore carry the extra cost of the pigs not surviving. Cost per pig was maximal in the lowest birth weight class and was at its lowest point in heavier birth weight classes (Table 2).

Heavier birth weight pigs are shown to be more profitable. The costs and fewer pounds of pork sold from selling pigs that were lighter weight at birth cannot be overcome by their advantage in feed efficiency. Additionally, the cost accrued from piglets that have died impedes on profit potential. Not modeled here, but something that should also be considered in future work, are the costs associated with potential health problems in heavier-birth weight pigs that are likely possible from sharing environments with health-challenged light weight pigs. Health challenges associated with low birth size have been reported in humans. Profitability is ultimately hindered for these lighter birth weight pigs.

Average piglet birth weight decreases as litter size increases.[1,5,7,8,9,12,14] Variation in piglet birth weight also increases (Figure 1). To estimate how this affects profitability of pigs born in differing litter sizes, simulation of birth weight variation and resultant profitability/litter was performed. Results indicate large differences in profitability occur from only minimal changes in birth weight variation when predicted profitability is $4.26. A difference of 0.40 lbs in the mean for piglet birth weight advances the overall profitability by $20.66 for a litter of 10 pigs marketed versus a litter of 12 (Table 3). Simulating higher numbers of pigs marketed with the 0.40 lb difference between mean birth weight and related increased variance indicates a requirement of 18 pigs before profitability swings to the lower mean birth weight litter (Table 3). More exactly, the tipping point is 6.6 additional pigs marketed/litter before the profitability advantage is realized in the lower mean birth weight litter. Increasing the number of pigs marketed/litter increases profitability assuming variation of birth weight within litter remains unchanged. When predicted profitability increases, fewer pigs marketed/litter are required to swing the profitability advantage to the litter with the lower average piglet birth weights, however 2 pigs are still required to be marketed to obtain this advantage when the predicted profitability/pig equals $15.00 (Table 3). These differences are largely driven by the fewer number of animals in the light birth weight categories, or by the number of pigs marketed that overcome costs of the non-profitable pigs.

Experimenting with a scenario where small birth weight pigs are not reared predicts differing outcomes as expected profitability changes. The number of pigs below 2.5 lbs at birth equates to approximately 20% of the litter in a litter of 10 marketable pigs. In times of low expected profitability ($4.26/pig), the farm that didn’t rear these two pigs (leaving 8 pigs left to market) profits $10.29 more on that litter of 8 pigs than did the farm rearing all 10 pigs. If profitability is expected to be $15.00/pig, the farm rearing the 10 piglets profited $10.83 more on the litter of 10 compared to the farm that reared the 8 large pigs. The calculator used in this simulation identifies the major role light birth weight pigs play in suppressing producer profitability, particularly in times of low predicted profitability/pig.

Summary

This research suggests a paradigm shift in the advancement for profitability in swine production. The goal should not be to maximize the number of pigs born alive, but rather to maximize the number of quality pigs marketed. The approaches to this objective may vary, but should include minimizing the number of light weight pigs at birth. One approach is to halt the push toward extremely large numbers of pigs born. A secondary approach is to include some form of selection, whether directly or indirectly, in a genetic program geared toward producer profitability. Heritability estimates have been made and suggest this as a possibility (Personal Communication, data unpublished).[2,4] This research suggests the possibility to calculate a litter quality score for use in genetic selection toward profitable sows and swine production. Maximizing the number of quality piglets born and ultimately marketed will drive profitability into the future.

References:

1. Berard, J., M. Kreuzer and G. Bee. 2008. Effect of litter size and birth weight on growth, carcass and pork quality, and their relationship to postmortem proteolysis. *J. Anim. Sci*. 86:2357-68.

2. Damgaard, L. H., L. Rydhmer, P. Lovendahl and K. Grandinson. 2003. Genetic parameters for within-litter variation in piglet birth weight and change in within-litter variation during suckling. *J. Anim. Sci*. 81:604-10.

3. Ellis, S. and J. D. Lawrence. 2011. Monthly Swine Farrow to Finish Returns. www.extension.iastate.edu/agdm.

4. Fix, J. S. 2010. Relationship of piglet birth weight and growth, efficiency, composition, and mortality. Dissertation. North Carolina State University, Raleigh, NC.

5. Foxcroft, G.R., W.T. Dixon, S. Novak, C.T. Putman, S.C. Town and M.D.A. Vinsky. 2006. The biological basis for prenatal programming of postnatal performance in pigs. *J. Anim. Sci.* 84 (E Suppl.):E105-E112.

6. Gondret, F., L. Lefaucheur, H. Juin, I Louveau and B. Lebret. 2006. Low birth weight is associated with enlarged muscle fiber area and impaired meat tenderness of the longissimus muscle in pigs. *J. Anim. Sci*. 84:93-103.

7. Holl, J. W. and T. Long. 2006. Improving weaned pig quality in today's large litters. In: *Proceedings of National Swine Improvement Federation Annual Meeting*, Nashville, TN.

8. Roehe, R. 1999. Genetic determination of individual birth weight and its association with sow productivity traits using Bayesian analyses. *J. Anim. Sci*. 77:330-43.

9. Quiniou, N., J. Dagorn, and D. Gaudré. 2002. Variation of piglets' birth weight and consequences on subsequent performance. *Livest. Prod. Sci.* 78:63-70.

10. Schinckel, A.P., M. E. Einstein, S. Jungst, C. Booher, and S. Newman. 2010. Evaluation of the impact of pig birth weight on grow-finish performance, backfat depth, and loin depth. *The Professional Animal Scientist* 26:51-69.

11. Schinckel A. P., M. E. Einstein, T. S. Stewart, C. Schwab and N. J. Olynk. 2010. Use of a stochastic model to evaluate the growth performance and profitability of pigs from different litter sizes and parities of dams. *The Professional Animal Scientist* 26:547-60.

12. Boyd, R. D. 2012. Integrating science into practice and getting it right. Howard Dunne memorial lecture, 2012 AASV annual meeting.

13. SAS Institute Inc., SAS 9.1.3 Help and Documentation, Cary, NC: SAS Institute Inc., 2002-2004.

14. Brandt, H. 1998. Individual piglet birth weight. Animal genetics and breeding unit (AGBU) pig genetics workshop. http://agbu.une.edu.au/pig_genetics/pdf/1998/Paper_7_Piglet_%20birth_weight_HBrandt_1998.pdf

Table 1. Distribution of mortality across birth weight class

	Birth Weight Class													
Frequency	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Farr/Nursery Mortality	112	213	160	519	277	558	313	722	404	677	219	312	116	220
Finishing Mortality	1	2	3	21	16	39	26	77	74	125	54	60	26	88
Survived	20	100	125	566	535	1406	1107	2606	2172	4019	1771	2376	1049	2336
Total	133	315	288	1106	828	2003	1446	3405	2650	4821	2044	2748	1191	2644
Overall Mortality (%)	85	68	57	49	35	30	23	24	18	17	13	14	12	12

Table 2. Birth weight class comparisons. Values compared to the 3.25 lb birth weight class.

Birth Weight		Actual Weight Range	Mortality Cost[1]	Market Weight Change[2]	Live Weight Value	Market Premium/ Discount[3]	Gain: Feed[4]	Feed Cost[5]	Pig Value[6]
(lbs)	(kg)								
1.50	0.680	<1.5	-$9.43	-27.0	-$18.87	-$6.12	0.029	-$10.16	-$24.25
1.75	0.794	1.5+	-$3.18	-23.1	-$16.17	-$1.92	0.024	-$8.62	-$12.65
2.00	0.907	1.75+	-$1.61	-19.3	-$13.48	-$1.92	0.018	-$7.10	-$9.91
2.25	1.020	2.0+	-$1.55	-15.4	-$10.78	-$1.16	0.014	-$5.61	-$7.89
2.50	1.134	2.25+	-$0.66	-11.6	-$8.09	-$1.16	0.009	-$4.14	-$5.76
2.75	1.247	2.5+	-$0.42	-7.7	-$5.39	-$1.16	0.006	-$2.72	-$4.25
3.00	1.361	2.75+	$0.44	-3.9	-$2.70	$0.00	0.003	-$1.34	-$0.92
3.25	1.474	3.0+	$0.00	0.0	$0.00	$0.00	0.000	$0.00	$0.00
3.50	1.587	3.25+	$0.09	3.9	$2.70	$0.00	-0.002	$1.28	$1.50
3.75	1.701	3.5+	$0.00	7.7	$5.39	$0.75	-0.004	$2.51	$3.63
4.00	1.814	3.75+	$0.41	11.6	$8.09	$0.75	-0.005	$3.68	$5.57
4.25	1.927	4.0+	$0.70	15.4	$10.78	$1.02	-0.005	$4.78	$7.73
4.50	2.041	4.25+	$0.56	19.3	$13.48	$1.02	-0.006	$5.81	$9.24
4.75	2.154	4.5+	$0.00	23.1	$16.17	$1.02	-0.005	$6.77	$10.42

[1] Accumulated mortality cost differences charged per pig between birth weight classes.
[2] Weight difference between birth weight classes.
[3] Packer premiums and discounts by live weight class based on 2,237 carcasses sold.
[4] Predicted Gain:Feed differences between birth weight classes.
[5] Differences in expenses due to feed between birth weight classes.
[6] Ultimate pig value differences between birth weight classes considering mortality, weight sold, and feed expenses.

Table 3. Marketed litter value of various birth weight means and standard deviations at two predicted profit levels/pig.

Within-litter Birth Weight Mean (lbs)	3.6	3.2	3.2	3.2	3.2	3.6	3.2
Within-litter Birth Weight Std.Dev.(lbs)	0.8	0.82	0.82	0.82	0.82	0.8	0.82
Pigs Harvested/ Litter	10	12	14	16	18	10	12
Birth weight class	Predicted Profitability[1]						
	$4.26 profit/pig					$15.00 profit/pig	
1.5	-$0.81	-$4.58	-$5.34	-$6.10	-$6.87	-$0.37	-$2.12
1.75	-$0.48	-$1.96	-$2.28	-$2.61	-$2.93	$0.14	$0.55
2	-$0.68	-$2.25	-$2.62	-$3.00	-$3.37	$0.61	$2.03
2.25	-$0.82	-$2.25	-$2.62	-$3.00	-$3.37	$1.60	$4.41
2.5	-$0.57	-$1.32	-$1.54	-$1.75	-$1.97	$3.55	$8.13
2.75	$0.00	$0.01	$0.01	$0.01	$0.01	$6.36	$12.24
3	$2.76	$4.49	$5.24	$5.99	$6.74	$11.65	$18.93
3.25	$4.47	$6.17	$7.20	$8.22	$9.25	$15.73	$21.72
3.5	$6.93	$8.18	$9.55	$10.91	$12.28	$19.85	$23.45
3.75	$9.88	$10.04	$11.72	$13.39	$15.06	$23.33	$23.71
4	$11.60	$10.21	$11.91	$13.61	$15.31	$24.27	$21.37
4.25	$12.08	$9.27	$10.81	$12.36	$13.90	$22.90	$17.57
4.5	$10.53	$7.09	$8.27	$9.45	$10.63	$18.91	$12.73
4.75	$18.83	$9.95	$11.60	$13.26	$14.92	$32.60	$17.22
Litter Value	$73.72	$53.06	$61.90	$70.75	$79.59	$181.12	$181.94
Comparison[2]	$0.00	-$20.66	-$11.81	-$2.97	$5.87	$107.40	$108.22

[1] Predicted profit per piglet birth weight category based on expected distribution of pigs in each birth weight class.
[2] Comparisons of each scenario compared to the left-most category where 10 pigs were harvested with a mean and standard deviation of birth weights of 3.6 lbs and 0.8 lbs, respectively.

Figure 1. Effect of litter size born on average piglet birth weight and variation of piglet birth weight.