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Determining optimal culling parity in commercial swine breeding herds

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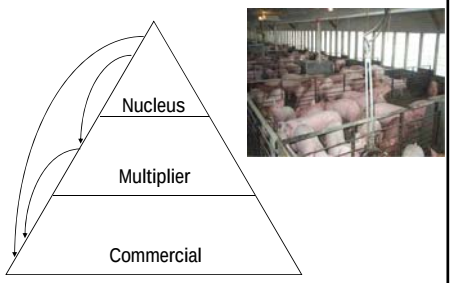
Structure of the Swine Industry



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Gilt Selection and Gilt Development

- Gilts must be selected to replace sows being removed or culled from the commercial herd.
- Adequate time is necessary for immunization against common diseases - vaccinations
- Not all gilts selected will farrow
  (Moeller et al., 2004 – 80%)

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Production by Parity

- Sows farrow larger litters and produce heavier pigs at weaning than gilts
- As sows pass ME age, production declines
  - Mature Equivalent Age is P3-P6

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Genetic Lag Time

- Time for improvement at nucleus level to reach commercial level
- Depends on crossbreeding system and generation level

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Genetic Gain Theory

$$\frac{\Delta G}{Yr} = \frac{i\,A\,\sigma\,p}{L}$$

- $\Delta G/yr$ – Rate of Genetic Change per Year
- i – Selection Intensity
- A – Accuracy of Selection
- σ_p – Phenotypic Variance
- L – Generation Interval

Objective

- **To determine the optimal culling parity for commercial sow herds**

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Assumed Values

- **2.25 litter/sow/year**
- **Age at first farrowing:** 1 year
- **Genetic Gain per generation:**
  Number Born Alive – 0.3 pigs
  21 Day Litter Weight – 1.36 kg
  Days to Market – 3.0 days
- **Economic Values:**
  Number Born Alive – $22/pig
  21 Day Litter Weight – $1.54/kg
  Days to Market – $0.17/day
  (NSR & NSIF)

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Calculations

- **Age of sows by generation**

  ((Farrowing Interval)*(Parity – 1) + 1)/(Generation Interval)

- **Genetic Lag**

  (Age of sows by Generation)*(Genetic Gain per generation)

- **Value of Genetic Loss**

  (Genetic Lag)*(Economic Value)

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Parity	Age at Farrowing (years)	Age in Generation Units
1	1.00	0.67[2]
2	1.44	0.96
3	1.89	1.26
4	2.33	1.56
5	2.78	1.85
6	3.22	2.15
7	3.67	2.44
8	4.11	2.74
9	4.56	3.04
10	5.00	3.33
11	5.44	3.63
12	5.89	3.93
13	6.33	4.22
14	6.78	4.52
15	7.22	4.81

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	Trait		
Parity	NBA	W21	D113
1	0.20	0.91	2.00
2	0.29	1.31	2.89
3	0.38	1.71	3.78
4	0.47	2.12	4.67
5	0.56	2.52	5.56
6	0.64	2.92	6.44
7	0.73	3.32	7.33
8	0.82	3.73	8.22
9	0.91	4.13	9.11
10	1.00	4.53	10.00
11	1.09	4.94	10.89
12	1.18	5.34	11.78
13	1.27	5.74	12.67
14	1.36	6.15	13.56
15	1.44	6.55	14.44

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Calculation of Value of the difference in genetic potential between sows in the herd and a potential replacement gilt

$$V = G_{NBA(P)}*E_{NBA} + G_{W21(P)}*E_{W21} + G_{D250(P)}*E_{D250(P)} + G_{BF(P)}*E_{BF} + (G_{D250(P)}*E_{D250} + G_{BF(P)}*E_{BF})N_P + (G_{D250(P-1)}*E_{D250} + G_{BF(P-1)}*E_{BF})N_{(P-1)} +\ldots + (G_{D250(1)}*E_{D250} + G_{BF(1)}*E_{BF})N_1$$

- **V is the value of the genetic lag**
- **G is the genetic lag for each trait at parity P**
- **E is the economic value for each trait**
- **N is the total number of pigs that were produced by the sow at parity P**

Materials and Methods

- **Developed a spreadsheet to determine the value of the genetic loss associated with keeping sows in the herd for additional parities**

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Value of genetic loss per sow in the herd at each parity with each generation interval

	Generation Interval at the Seedstock Level			
Parity	1.5	2.0	2.5	3.0
1	$9.06[2]	$6.79	$5.43	$4.53
2	$16.50	$12.38	$9.90	$8.25
3	**$25.67**	**$19.25**	**$15.40**	**$12.84**
4	$36.32	$27.24	$21.79	$18.16
5	**$48.27**	**$36.20**	**$28.96**	**$24.13**
6	$61.33	$46.00	$36.80	$30.67
7	**$75.32**	**$56.49**	**$45.19**	**$37.66**
8	$90.20	$67.65	$54.12	$45.10
9	$105.76	$79.32	$63.46	$52.88
10	$122.29	$91.72	$73.38	$61.15
11	$139.75	$104.81	$83.85	$69.87
12	$157.56	$118.17	$94.54	$78.78
13	$176.52	$132.39	$105.91	$88.26
14	$196.64	$147.48	$117.98	$98.32
15	$217.90	$163.43	$130.74	$108.95

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	Full Economic Value	50% of Full Economic Value
	NBA - $22.00/pig W21 - $1.54/kg	NBA - $11.00/pig W21 - $0.77/kg
Parity	D113 - $0.17/day	D113 - $0.09/day
1	$9.06	$2.31
2	$16.50	$4.25
3	$25.67	$6.63
4	$36.32	$9.42
5	$48.27	$12.54
6	$61.33	$15.96
7	$75.32	$19.62
8	$90.20	$23.53
9	$105.76	$27.61
10	$122.29	$31.94
11	$139.75	$36.53
12	$157.56	$41.21
13	$176.52	$46.19
14	$196.64	$51.47
15	$217.90	$57.06

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Percent of Sows at each Parity with Each Parity distribution
(Dhuyvetter et al., 2000)

Parity	Parity of Forced Culling														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	100.0	55.2	40.5	33.3	29.1	26.4	24.5	23.2	22.2	21.5	20.9	20.5	20.2	19.9	19.7
2		44.8	32.9	27.0	23.6	21.4	19.9	18.8	18.0	17.4	17.0	16.6	16.4	16.1	16.0
3			26.7	21.9	19.2	17.4	16.2	15.3	14.6	14.2	13.8	13.5	13.3	13.1	13.0
4				17.8	15.6	14.1	13.1	12.4	11.9	11.5	11.2	11.0	10.8	10.6	10.5
5					12.6	11.5	10.6	10.1	9.7	9.3	9.1	8.9	8.8	8.6	8.5
6						9.3	8.6	8.2	7.8	7.6	7.4	7.2	7.1	7.0	6.9
7							7.0	6.6	6.4	6.2	6.0	5.9	5.8	5.7	5.6
8								5.4	5.2	5.0	4.9	4.8	4.7	4.6	4.6
9									4.2	4.1	3.9	3.9	3.8	3.8	3.7
10										3.3	3.2	3.1	3.1	3.0	3.0
11	Culling Rate: 18.8% per parity = 42.3 @ 2.25 L/S/Y										2.6	2.5	2.5	2.5	2.4
12												2.1	2.0	2.0	2.0
13													1.7	1.6	1.6
14														1.3	1.3
15															1.1

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Average value of the difference in genetic potential between sows in the herd and a potential replacement gilt by parity and generation interval

	Generation Interval			
Parity of forced culling	1.5	2.0	2.5	3
1	$9.06	$6.79	$5.43	$4.53
2	$12.39	$9.30	$7.44	$6.20
3	**$15.94**	**$11.95**	**$9.56**	**$7.97**
4	$19.56	$14.67	$11.74	$9.78
5	**$23.19**	**$17.39**	**$13.91**	**$11.59**
6	$26.74	$20.05	$16.04	$13.37
7	**$30.15**	**$22.61**	**$18.09**	**$15.07**
8	$33.38	$25.04	$20.03	$16.69
9	$36.42	$27.31	$21.85	$18.21
10	$39.25	$29.43	$23.55	$19.62
11	$41.86	$31.40	$25.12	$20.93
12	$44.26	$33.19	$26.55	$22.13
13	$46.44	$34.83	$27.87	$23.22
14	$48.43	$36.32	$29.06	$24.22
15	$50.23	$37.68	$30.14	$25.12

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Average value of the difference in genetic potential between sows in the herd and available replacement gilts by parity and differing genetic improvement rates per generation

	Genetic Improvement (NBA, W21, and D113)			
Parity	0.15, 0.68, 1.5	0.2, 0.91, 2.0	0.25, 1.13, 2.5	0.3, 1.36, 3.0
1	$4.53	$6.04	$7.55	$9.06
2	$6.20	$8.26	$10.33	$12.39
3	**$7.97**	**$10.62**	**$13.28**	**$15.94**
4	$9.78	$13.04	$16.30	$19.56
5	**$11.59**	**$15.46**	**$19.32**	**$23.19**
6	$13.37	$17.82	$22.28	$26.74
7	**$15.07**	**$20.10**	**$25.12**	**$30.15**
8	$16.69	$22.26	$27.82	$33.38
9	$18.21	$24.28	$30.35	$36.42
10	$19.62	$26.16	$32.71	$39.25
11	$20.93	$27.91	$34.89	$41.86
12	$22.13	$29.50	$36.88	$44.26
13	$23.22	$30.96	$38.70	$46.44
14	$24.22	$32.29	$40.36	$48.43
15	$25.12	$33.49	$41.86	$50.23

Results and Discussion

- **It is not profitable to replace sows in the breeding herds at the rates currently employed by most commercial swine operations.**
- **Value of genetic improvement must be greater than or equal to gilt development variable costs.**
- **When sows are retained for additional parities, gilt development costs can be spread out over a greater number of piglets produced.**
- **If enough time has not passed for the genetic supplier to make genetic progress for the economically important production traits aggregate genetic value is equal or difference is very small.**

Other considerations

- **Cost of replacement gilt**
- Cull sow value
- Parity production differences
- Progeny performance differences between young sows and older sows
- Genetic progress modeled in the current study likely represent the upper limits for rate of improvement

Cost of replacement Gilt

- **Cost estimates reported in the literature for replacing a sow**
  - Initial cost - $200
  - Breeding costs - $10 to $15
  - Housing, feed, veterinary costs, for isolation and acclimation - $36
  - Costs of developing gilts that never enter the breeding herd must be covered by gilts that do enter the breeding herd - $10

Other considerations

- Cost of replacement gilt
- **Cull sow value**
- Parity production differences
- Progeny performance differences between young sows and older sows
- Genetic progress modeled in the current study likely represent the upper limits for rate of improvement

Cull Sow Value

Cull sow value by weight (Fitzgerald et al., 2008)

Weight of Cull Sows	Cull Sow Value
136-205kg (300-450lbs)	$99.28 - $149.65
205-227kg (450-500lbs)	$164.00 - $181.60
227-250kg (500-550lbs)	$188.41 - $207.50
250-341kg (550-750lbs)	$217.50 - $296.67

Other considerations

- Cost of replacement gilt
- Cull sow value
- **Parity production differences**
- Progeny performance differences between young sows and older sows
- Genetic progress modeled in the current study likely represent the upper limits for rate of improvement

Parity Production Differences

Adjustment factors (NSIF, 1997)

Parity	NBA (pigs)	W21 (lbs)
1	1.2	6.2
2	0.9	0.0
3	0.2	1.0
4	0.0	3.8
5	0.0	6.2
6	0.2	9.5
7	0.5	11.6
8	0.9	15.2

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Other considerations

- Cost of replacement gilt
- Cull sow value
- Parity production differences
- **Progeny performance differences between young sows and older sows**
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Other considerations

- Cost of replacement gilt
- Cull sow value
- Parity production differences
- Progeny performance differences between young sows and older sows
- **Genetic progress modeled in the current study likely represent the upper limits for rate of improvement**

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How does this impact the entire sow herd?

- **If culling rate and maximum parity at culling is known**
  - Can predict distribution of sows in each parity
  - Can determine the average value of the genetic lag under different parity distributions

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Implications

- **Producers should focus on sound development of replacement gilts to enhance sow longevity**
- **Producers should retain sows for as long as they are reproductively and productively sound**
- **Advantages of herds with sows in older parities suggest the importance of selecting for sow longevity at the seedstock level**

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Questions???