Boar stud production analysis

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Summary

Objective: To evaluate productivity (doses per boar space per unit of time) in boars used for artificial insemination.

Method: Collection records of 1646 boars in seven United States studs were used to determine production averages and the effects of collection interval, boar age, and season of the year on productivity. An economic model to assess the most profitable collection interval was designed.

Results: Boars averaged 31.4 usable doses per boar space per week. Productivity increased with shorter collection intervals and older boars. Seasonal effects on productivity were small.

Implications: The optimal collection interval for a boar stud depends upon management priorities prevailing in that stud.

Keywords: swine, boars, semen, collection

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In recent years, the use of artificial insemination (AI) technologies has dramatically increased in the United States swine industry. However, relatively little literature is available regarding AI boar production performance. Kennedy, et al.,[1] evaluated 1970s collection data from a Canadian boar stud and reported that month, collection interval, and boar age all had effects on productivity. Potential doses were highest from November–January and lowest from April–June. Boars 24–29 months of age generated the most potential doses; boars < 8 months of age generated the fewest. Percent live sperm and motility were highest for young boars and decreased with age. Kemp, et al.,[2] conducted a prospective study to evaluate the effect of collection frequency on production. They concluded that only a short-run gain in sperm production was achieved by collecting boars at a higher frequency—five times per 2 weeks instead of three times per 2 weeks. In a different prospective study, Cameron[3] concluded that daily sperm production was greatest with 24-hour collection intervals; however, libido among those boars decreased toward the end of the study.

A study using in vitro fertilization found statistically significant boar effects on sperm per ejaculate, motility, and percentage sperm with normal morphology.[4] Other research has shown dietary effects on boar libido and percentage normal sperm cells per ejaculate.[5,6] We are unaware of additional literature describing boar productivity. However, with increased use of AI, it has become necessary to establish values of normal boar production (doses per boar space per unit of time).

In this study, we analyzed boar stud collection data to

- determine production parameters,
- determine the relationship between collection interval and productivity,
- determine production effects by boar age and by season, and
- develop an economic model for stud managers to assess optimal collection frequency.

Materials and methods

Eighteen boar studs were contacted to participate in this study. Seven United States on-farm and commercial studs participated, representing three genetic sources and the records of 1646 boars. Individual boar collection data were summarized for

- usable doses per collection,
- percent usable sperm per collection,
- percent usable collections, and
- collection frequency (number of collections per week).

"Usable" denotes nondefective sperm cells or ejaculates used to produce a saleable dose.[7] Usable doses per boar space per week were calculated for each stud. In addition, production averages were compared across studs.

Statistical analysis

All collection data were combined and analyzed in *Statistica*® (StatSoft, Inc., 1998). Average usable doses per collection were summarized for collection intervals of 1–10 days. Data were used to calculate usable doses per week (average usable doses per collection × the number of collections per week), and 95% confidence intervals were calculated. Data were plotted to assess the relationships of semen production and quality with collection interval, season, and boar age. Relationships were judged to be approximately linear. Correlations were calculated between production parameters, collection interval, and boar age. Analysis of variance (ANOVA) was performed on production data by season.

Economic model

Using the summary data for collection frequency, a spreadsheet-based economic model was developed to assess per-dose costs of production (available online at `http://www.aasp.org/shap.html`). Changes in net returns that result from varying the collection intervals were examined in a partial budget. Net return, measured as profit per boar space per week, was calculated with the following formula:

revenue per boar space per week –
cost per boar space per week

Revenue was defined as the number of saleable doses per boar space per week × the price per dose. Costs were divided into three categories:

- fixed cost per boar space,
- cost per collection, and
- cost per dose.

The model accounted for facility, labor,

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Table 1: Economic model of collection interval impact on cost and revenue potential

Cost estimates	$
Fixed costs per boar space per week	
facility	$6.30
feed	$3.00
utilities	$0.20
misc. health	$0.40
Cost per collection	
labor	$6.30
lab supplies	$5.50
Cost per dose	
extender	$0.20
bags & equipment	$0.20
labor (post evaluation)	$0.17
Sale price per dose	$6.00

Collection Interval	Avg. doses per collection	Cost per boar space per week	Revenue per boar space per week	Profit per boar space per week	Profit per boar space per year	Return on investment
1	19.6	$170.75	$823.70	$652.95	$34,046.51	3.82
2	21.2	$93.49	$445.16	$351.67	$18,336.98	3.76
3	25.5	$71.40	$357.52	$286.12	$14,919.36	4.01
4	27.3	$57.83	$287.16	$229.33	$11,957.98	3.97
5	27.7	$48.56	$233.01	$184.45	$9617.78	3.80
6	25.2	$40.40	$176.11	$135.71	$7076.30	3.36
7	29.3	$38.38	$175.58	$137.20	$7153.91	3.57
8	28.8	$34.61	$151.37	$116.77	$6088.57	3.37
9	29.9	$32.31	$139.33	$107.01	$5580.00	3.31
10	29.1	$29.76	$122.07	$92.32	$4813.63	3.10

Definitions:

interval: number of 24-hour periods between collections

cost per boar space per week: sum of fixed costs per boar space per week + cost per collection × (7 days ÷ interval) + cost per dose × (7 days ÷ interval) × average doses per collection at given interval

revenue per boar space per week: (7 days ÷ interval) × average doses per collection at given interval × sale price per dose

profit per boar space per week: revenue per boar space per week – cost per boar space per week

profit per boar space per year: profit per boar space per week × (365 days ÷ 7 days) **or** profit per boar space per week × number of weeks per year

return on investment: profit per boar space per week ÷ cost per boar space per week

feed, extender, laboratory supplies, packaging material, and animal health expenses (Table 1). Cost estimates were based on the authors' experience.

Cost per boar space per week was calculated as

> the fixed cost per boar space per week +
> the number of collections per week ×
> the cost per collection +
> the number of saleable doses per boar space per week ×
> the cost per dose

Individual boar cost was not included due to wide variability in payment methods. Profit:investment ratios were also calculated as

> revenue per boar space per week ÷
> total cost per boar space per week.

Results

On average, boars generated 31.4 usable doses per boar space per week, with an average of 1.1 collections per week. Four of seven studs consistently used 3×10^9 usable sperm cells per dose. Usable sperm cells per dose varied among the remaining three studs according to boar (range= $2.5\times10^9 – 5\times10^9$). Average boar stud production was 35.5 usable doses per boar space per week, with an average of 1.2 collections per week (Table 2).

Usable doses per collection increased with collection interval (r = .1349; $P < .01$). Percent usable sperm per collection decreased with collection interval (r = -.1175; $P < .01$). No statistically significant relationship was found between percent usable collections and collection interval.

Collection intervals decreased with increased boar age (r = .2527; $P < .0001$). There was a very low correlation between average usable doses per collection and boar age (r = .0768; $P < .001$). The distributions of usable doses per collection by boar age and percent usable sperm per collection by boar age appeared less variable among boars > 2 years of age (Figure 1). Percent usable sperm per collection increased with boar age (r = .810; $P < .001$), though no statistically

Table 2: Production parameters of boars and boar studs

	Boars (n=1646)		Studs (n=7)	
Parameter	Mean	Standard deviation	Mean	Standard deviation
Usable doses/boar space/week	31.4*	—	35.5	7.5
Usable doses/collection/boar	27.4	13.6	30.1	5.4
Collections/week (collection frequency)	1.1	1.0	1.2	0.25
Collections wasted	5.0%†	—	3.8%	3.0%
Usable sperm/collection	92.3%	11.1%	91.7%	1.4%

* calculated as: average doses per collection × (7 ÷ collection interval)

† calculated as: (wasted collections ÷ total collections) × 100

significant relationship was found between percent usable collections and boar age.

Differences among seasons were detected in usable doses per collection ($P < .001$), percent usable sperm per collection ($P < .01$), and percent usable collections ($P < .05$) (Table 3).

Increased collection frequency was associated with the potential to increase annual boar productivity (Table 4). According to the economic model, optimal collection frequency differs by goal (least cost, most profit, or greatest return on investment) (Table 1).

Figure 1: Effect of boar age on usable doses per collection (±SD)

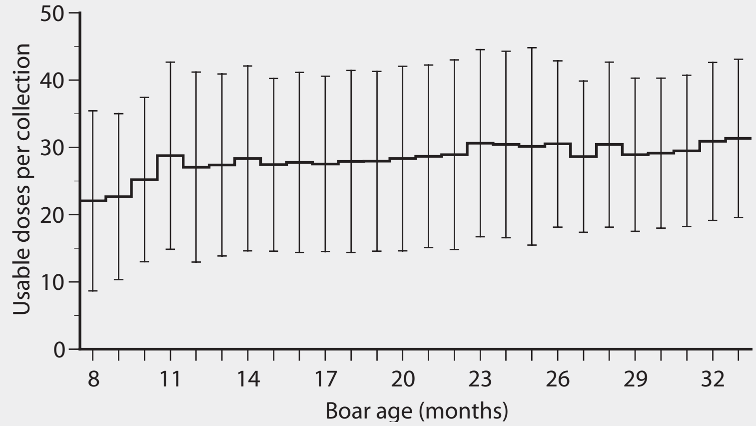


Table 3: Mean values of seasonal production analysis

Season	Usable doses per collection	Usable sperm per collection	Usable collections
Winter	27.8[a]	91.7%[d]	94.0%[g]
Spring	26.6[b]	93.2%[e]	95.7%[h]
Summer	26.3[b]	92.1%[f]	95.0%[i]
Fall	28.7[c]	92.4%[f]	95.4%[h,i]

ANOVA results:
abc $P < .001$ where superscripts differ
def $P < .01$ where superscripts differ
ghi $P < .05$ where superscripts differ

Table 4: Average usable doses per collection by collection interval

Interval (days)	Average usable doses/collection	Potential annual usable doses	95% confidence interval
1	19.6	7158	±2518
2	21.2	3869	±985
3	25.5	3107	±519
4	27.3	2496	±398
5	27.7	2025	±355
6	25.2	1530	±297
7	29.3	1526	±270
8	28.8	1315	±247
9	29.9	1211	±234
10	29.1	1061	±230

Discussion

Boars are collected as needed, so stud production data reflect semen demand, not production potential. We've described production in terms of usable doses per boar space per week to provide a basis for uniform comparison across studs. There is both inter- and intrastud variation in the number of usable sperm cells per saleable dose. For this reason, we investigated both percent usable sperm cells per collection and usable doses per collection. Usable doses per boar space per week reflects semen demand, collection frequency, stud occupancy, semen quality, and individual boar productivity (Figure 2). We believe collection frequency has greater impact on usable doses per boar space per week than does usable doses per collection. The increase of doses per collection as collection intervals increase is likely to reflect a greater number of sperm cells accumulated in epididymal reserves. Likewise, the decrease in percent usable sperm cells per collection as collection interval is increased may be associated with collecting older sperm cells.

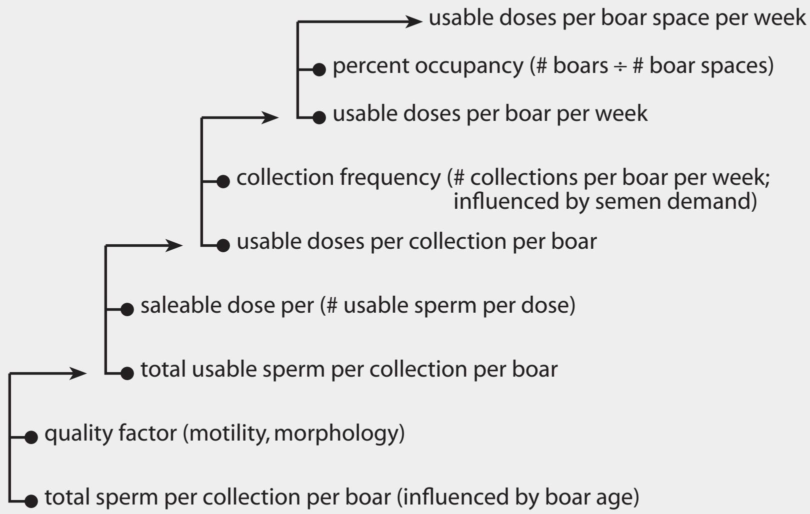
We examined boar productivity in the context of animal age and season of the year, since age and season are factors that affect sow herd productivity.[8] Boars in this study were most productive in fall and winter and least productive in spring and summer, which is consistent with the observations of Kennedy.[1] We, too, found analysis of production by boar age encouraging, though in our study the apparent change in usable doses per collection from boars > 24 months old may reflect culling practices (Figure 1). Because AI has the potential to propagate undesirable traits, productive boar longevity may afford stud owners the opportunity to progeny test boars before putting their semen on the commercial market.

In contrast to the profound effects of seasonal infertility in the sow herd, we also found interesting the numerically small, though statistically significant, differences associated with seasonal boar production.

Our economic model was based on averages derived from our experience in the industry. However, biological production—including semen production—is innately variable. The economic model does not incorporate risk attributes or address the economic ramifications of the high variability observed in production. A more sophisticated model is needed to incorporate the effects of biological variation; this, however, is beyond the scope of this paper.

Interpreting the most economically advisable collection interval is a matter of individual priorities—i.e., whether a producer is interested in the lowest costs, the most profit, or the best return on investment. Since labor accounts for a substantial portion of stud budgets, a least-cost approach

Figure 2: Boar stud production relationships



favors collecting boars less frequently to reduce labor cost. A most-profit approach favors generating the greatest possible number of doses; however, concerns about boar libido, variability in semen production, and high labor costs need to be considered. In our model, a best-return-on-investment approach favors collecting boars every 3 to 4 days (two times per week) to maximize return on input costs.

Limitations and conditions affecting usefulness

Although we've described production for the "average" boar in the "average" stud, it is important to note the high variability we observed. Specifically, usable doses per collection had a standard deviation of 13.6 and collection frequency had a standard deviation of 1.0. Too, the large number of samples can make biologically unexciting numerical differences statistically significant.

Data in this study were from only seven studs. Greater participation will improve industry accuracy and allow for future benchmarking and investigation into possible influences of housing, ventilation/cooling systems, and genetics on performance.

Implications

- Individual boar production may be increased by decreasing collection interval.
- Increased semen production among older boars suggests there may be an opportunity to progeny test stud boars.
- An economic model may be helpful in assessing optimal collection frequency.

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