Efficacy of Altrenogest in Synchronizing Estrus in Two Swine Breeding Programs and Effects on Subsequent Reproductive Performance of Sows


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ABSTRACT: In two herds that used different breeding and housing schemes, altrenogest (15 mg/d) was fed for 14 d to gilts or 10 d to sows in .45 kg of a diet formulated to meet or exceed their nutrient requirements. In Herd 1 (five breeding seasons per year), 63 of 123 gilts and 40 of 70 sows in seven replications were fed in individual crates to ensure proper intake. In Herd 2 (continuous breeding), 244 of 484 gilts in 20 replications received the treated feed in individual feeding stalls to which animals had free access. Average and median days to estrus were reduced (P < .01) for treated gilts and sows compared with controls in both herds. Of 29 treated gilts that did not mate or become pregnant, three had cystic follicles, compared to 1 of 14 controls. There were no statistically significant treatment differences in litter size born or number of stillborn pigs in either herd, but farrowing rates of cycling gilts were 8% lower (P < .05) in Herd 2 for treated gilts than for controls. Overall, altrenogest could be a valuable tool for improving reproductive efficiency by allowing producers to better control the estrous cycle.

Key Words: Synthetic Progestogens, Pigs, Estrous Synchronization, Reproductive Performance

Introduction

Swine producers are interested in control of the estrous cycle because it can allow more efficient use of labor and artificial insemination and better scheduling of facilities and requires retention of fewer replacement gilts. Early research ascertained that use of exogenous hormones can influence the estrous cycle (Baker et al., 1954; Nellor, 1960). Many compounds, however, often caused undesirable side effects, including cystic follicles, decreased fertility, or teratogenic effects (Webel, 1978).

One synthetic progestogen, altrenogest (17-α-allyl-estratriene-4-9-11, 17-β-ol-3-one), has been effective in controlling estrus in cycling gilts and weaned sows when it is fed at appropriate levels for a sufficient length of time (Webel, 1978; Kraeling et al., 1981; Redmer and Day, 1981; Boland, 1983). It also seems to be relatively free of undesirable side effects when it is used under controlled conditions (Webel, 1978; Kraeling et al., 1981), although Davis et al. (1979) and Redmer and Day (1981) found an increased incidence of cystic follicles, compared with controls, in group-fed gilts.

There is, however, some confusion as to the efficacy of altrenogest when it is used under field conditions (Mauleon et al., 1979; Webel and Day, 1982; Stevenson et al., 1985). Additionally, few studies have reported the effect of altrenogest on farrowing and weaning characteristics of gilts and sows. This study was designed to test the efficacy of altrenogest as an estrus synchronization compound under similar controlled and field trial conditions and to monitor the subsequent reproductive performance of sows and gilts.

1Financial assistance for the conduct of this study was supplied by Roussel-UCLAF. The authors also acknowledge the assistance of Bob Kelly, Dept. of Food Sci. and Technol., and Gene Ball, Virginia Tech Swine Center.


Received July 1, 1991.
Accepted December 31, 1991.

1357

Published December 11, 2014
Materials and Methods

Herd 1: Controlled Study. At the Virginia Tech Swine Center, 63 of 123 gilts and 40 of 75 sows in seven replications were fed 15 mg/animal of altrenogest daily for 14 and 10 d, respectively, immediately before the start of each breeding season (five seasons per year: October, January, March, May, July). Because of the intermittent nature of the breeding schedule, estrus detection was not continuous, and the estrous cyclicity of animals was not established before allotment to treatments. This situation is very similar to conditions often found in small herds, especially purebred operations that breed for specific shows or sales. Daily feed offered was 2.27 kg (gilts) or 1.8 kg (sows) of a diet formulated to meet or exceed NRC (1988) requirements. The altrenogest was fed in .45 kg of the diet, and the treated feed or a like amount of control feed was fed before the remainder of the diet was offered. Sows and gilts were housed individually in gestation crates to ensure that each animal received the appropriate amount of altrenogest.

After withdrawal of altrenogest from the feed, gilts and sows were checked twice daily for signs of behavioral estrus using a mature boar, and the number of days to first estrus or mating was calculated using two different methods. Days to estrus calculated using the date that heat checking began as d 0 is designated as ESC, and ESW is days to estrus calculated using the date that altrenogest was withdrawn as d 0. It was necessary to use both variables because in some replications control animals were bred before withdrawal of altrenogest from treated animals.

All gilts and sows were white crossbreds produced from a rotation of the Yorkshire, Landrace, and Chester White breeds. They were inseminated artificially with fresh, extended semen when they were detected in estrus and every 24 h thereafter until they were no longer in estrus. Sires were purebred Hampshire, Duroc, Yorkshire, and Chester White boars that were assigned to gilts and sows based on a static rotation crossbreeding system. Farrowing data (number of pigs born alive, number stillborn, number of mummies, number weaned, and 21-d litter weight) were collected on all sows and gilts at weaning. Treated animals that did not exhibit estrus or become pregnant were slaughtered at the Virginia Tech Meats Laboratory, and their reproductive tracts were examined for abnormalities.

Herd 2: Field Study. At a 500-sow commercial operation, 244 of 484 white-cross (Yorkshire and Landrace) gilts in 20 replications were fed 15 mg of altrenogest daily for 14 d in .45 kg of the Herd 1 sow diet, which was transported to the farm in labeled containers. Control gilts received .45 kg of untreated sow diet. The remaining 1.8 kg of diet was mixed on the farm and was formulated to meet the nutritional requirements of the gilts. Unlike Herd 1, treated and control gilts were housed in two outdoor pens, each equipped with individual free-access feeding stalls for each animal. The confinement-reared gilts were placed in the pens (one pen per treatment) after selection at market weight in an attempt to induce estrous cyclicity (Christenson and Ford, 1979). The .45 kg of control or treated diet was placed daily in the feed trough of each stall before all gilts were allowed access to the stalls. After the gilts consumed the .45 kg, the remaining diet was fed. Although total control over feed consumption was not possible, gilts were acclimated to the feeding routine before altrenogest was fed.

After cessation of altrenogest feeding, gilts were moved indoors to pens in the breeding barn, where exposure to boars occurred for the first time. Estrus was checked daily with a mature boar, and the number of days to first estrus (ESC and ESW) was calculated. Each gilt was hand-mated to the same Yorkshire, Landrace, or crossbred (Duroc-Hampshire) boar (chosen randomly) once daily until estrus ended. Data were also collected on all gilts that farrowed. All treated gilts that failed to exhibit estrus were slaughtered in the Virginia Tech Meats Lab, along with a random sample of control gilts that were not detected in estrus. Treated and control gilts that did not exhibit estrus in the first 21 d were bred during a subsequent breeding season if they showed estrus.

Statistical Analysis. Analysis of data was conducted using the GLM procedure of SAS (1987); frequency data (percentage cycling and farrowing) were compared using chi-square analysis (PROC FREQ®). The LIFETEST® procedure of SAS (1987) was used to determine the median days to estrus of treated and control animals, using ESW, and to obtain probability distribution functions for ESW.

For Herd 1 breeding data (ESC), the GLM model included effects for replication, treatment, parity, breed of sire of the sow or gilt, breed of litter sire, and two-way interactions. Breeding weight, age of sow or gilt, and previous parity information on sows were included in preliminary models as covariates to assess their possible impact. In the final model, nonsignificant effects, interactions, and covariates were not included. Litter data (number born alive, number of stillborn pigs and mummies, number weaned, and 21-d litter weight) were analyzed similarly, with ESW, sow weight loss during lactation, and age of pigs at weaning included as covariates in preliminary analyses. In the chi-square and LIFETEST analyses, gilts and sows were analyzed separately.
ALTRENOGEST EFFECTS ON REPRODUCTION

Table 1. Estrous traits of altrenogest-fed and control gilts and sows in Herd 1

<table>
<thead>
<tr>
<th>Item</th>
<th>Treated&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Control&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Exposed</td>
<td>Cycling</td>
</tr>
<tr>
<td>Avg ESC&lt;sup&gt;bc&lt;/sup&gt;</td>
<td>5.5 ± 0.5</td>
<td>8.1 ± 0.6</td>
</tr>
<tr>
<td>Median ESW&lt;sup&gt;d&lt;/sup&gt;</td>
<td>5.5</td>
<td>10.3</td>
</tr>
<tr>
<td>% Cycling</td>
<td></td>
<td></td>
</tr>
<tr>
<td>by d 7&lt;sup&gt;f&lt;/sup&gt;</td>
<td>86</td>
<td>38</td>
</tr>
<tr>
<td>by d 10&lt;sup&gt;f&lt;/sup&gt;</td>
<td>92</td>
<td>55</td>
</tr>
<tr>
<td>by d 21</td>
<td>94</td>
<td>85</td>
</tr>
<tr>
<td>Sows</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Avg ESC&lt;sup&gt;bc&lt;/sup&gt;</td>
<td>7.4 ± 0.7</td>
<td>13.0 ± 0.7</td>
</tr>
<tr>
<td>Median ESW&lt;sup&gt;d&lt;/sup&gt;</td>
<td>5.1</td>
<td>11.4</td>
</tr>
<tr>
<td>% Cycling</td>
<td></td>
<td></td>
</tr>
<tr>
<td>by d 7&lt;sup&gt;f&lt;/sup&gt;</td>
<td>95</td>
<td>94</td>
</tr>
<tr>
<td>by d 10&lt;sup&gt;f&lt;/sup&gt;</td>
<td>55</td>
<td>9</td>
</tr>
<tr>
<td>by d 21</td>
<td>83</td>
<td>30</td>
</tr>
</tbody>
</table>

<sup>a</sup>Percentages are relative to the total number of animals checked for estrus (Exposed) and those that were detected in estrus within 21 d of altrenogest withdrawal (Cycling).
<sup>b</sup>ESC = days to estrus after withdrawal of altrenogest (least squares mean ± standard error).
<sup>c</sup>Effects of treatment and parity were significant (P < .001). Parity × treatment interaction was significant (P < .05).
<sup>d</sup>Median ESW = point in time after estrus detection began that 50% of gilts or sows had been detected in estrus.
<sup>e</sup>Proportion differed by treatment (P < .01).
<sup>f</sup>Proportion differed by treatment within basis (Exposed or Cycling) (P < .001).

Herd 2 breeding data were analyzed using a model that included effects for replication, treatment, breed of sire of gilts, litter sire breed, and two-way interactions. Selection and breeding weights were included as covariates in preliminary analyses. Nonsignificant effects were dropped from the final model, which was run on two subsets based on number of days after altrenogest withdrawal (0 to 20 d and 21 to 95 d). These subsets were constructed to account for the 21-d estrous cycle. Because of fewer data points, however, the later cycles were combined for analysis. Chi-square and LIFETEST analyses were similar to those used on Herd 1 data, without the effect of parity.

Results

Herd 1. As presented in Table 1, 94% of gilts and 95% of sows fed altrenogest came into estrus during the 21-d heat check period after the withdrawal of altrenogest. The proportions were not different from those of controls. During the first 7 and 10 d of the 21-d period, however, a higher proportion of altrenogest-fed gilts and sows exhibited estrus than did controls (P < .001), and the average number of days required to express estrus after checking began (ESC) was significantly less for altrenogest-fed gilts and sows, indicating that synchronization of estrus did occur. Parity had an effect (P < .001) on ESC; gilts were detected in estrus an average of 7.0 ± 4 d after checking began, whereas sows required 10.5 ± 5 d on average. There also was a significant parity × treatment interaction, because control sows cycled later than control gilts. This effect probably was a manifestation of the natural synchronization that occurs after weaning and the fact that sows often cycled once or twice during the period between weaning and breeding because of the intermittent breeding seasons.

Median days to estrus (calculated using ESW) for treated gilts and sows was less (P < .01) than that for controls (Table 1). Figures 1 and 2 illustrate the probabilities (statistically derived from the actual distributions) that gilts and sows would show estrus on a given day, which is useful in extrapolating from these data to similar populations.

Chi-square analysis of overall farrowing rates indicated no significant difference due to feeding altrenogest to either gilts or sows (Table 2). Farrowing rates of treated gilts and sows exhibiting estrus within 7 or 10 d of altrenogest withdrawal were higher (P < .10, .05, .01, .001) than those of controls when rates were based on number of animals exposed or in estrus, as shown in Table 2. When farrowing rates were based on number of animals bred within 7 and 10 d after altrenogest withdrawal, however, there were no differences. There also were no differences be-
between treated and control gilts and sows for number of pigs born alive, stillborn pigs, or mummies (Table 3). There was, however, a significant parity effect for number of live pigs born to gilts and sows, with sows farrowing more pigs than gilts. Number of pigs weaned and 21-d litter weight (Table 3) also did not differ between treated and control animals.

**Herd 2.** Data from the commercial farm were divided into subsets based on the 21-d estrous cycle. Overall, and during the first 20 d after the end of the 14-d period in which altrenogest was fed, there was no difference in the proportion of treated and control gilts that came into estrus (Table 4). For those gilts detected in estrus during the first 20 d, however, average ESC was less \( P < .01 \) for altrenogest-fed gilts than for control gilts. The median ESW was different \( P < .001 \) both overall and for the first 20-d period. As shown by the probability distribution function (Figure 3) and the data in Table 4, a high degree of synchrony was achieved for treated gilts that showed estrus within 20 d. None of the treated gilts was detected in estrus before d 3 after withdrawal of altrenogest, and 87% of treated gilts that showed estrus within the first 20 d after withdrawal of altrenogest came into heat during the first 7 d, compared with 24% of control gilts \( P < .001 \). By d 10, 95% of altrenogest-fed gilts that exhibited estrus within 20 d had been mated, compared with 44% of the control gilts.

An additional 27% (60 of 244) of altrenogest-fed and 24% (47 of 194) of control gilts showed estrus during the remainder of the heat-check periods (21 to 95 d), with no difference between treated and control gilts for average ESC (data not shown). This lack of significance is not surprising given the number of observations and the fact that there also were no overall differences between treated and control gilts for average ESC over the entire heat-check period of 95 d (Table 4). However, the median ESW for the entire period, calculated based on the cumulative survival function in LIFETEST, was 6.0 and 15.9 d \( P < .001 \) for treated and control gilts, respectively (Figure 3), which clearly indicates that most of the treated gilts exhibited estrus early.

As presented in Table 4, there were no differences in farrowing rates for treated and control gilts based on number exposed to boars, which agrees with the results from Herd 1. There was, however, a significant difference in farrowing rates of those gilts that exhibited estrus and of those that exhibited estrus in e 20 d. Treated gilts had a lower \( P < .01 \) farrowing rate than control gilts in both situations. The only exception was during the peak synchronization period (d 3 to 10), if farrowing rates were expressed

![Figure 1. Probability distribution function of days from altrenogest withdrawal to estrus (ESW) for altrenogest-fed (+) and control (△) gilts in Herd 1.](image1)

![Figure 2. Probability distribution function of days from altrenogest withdrawal to estrus (ESW) for altrenogest-fed (+) and control (△) sows in Herd 1.](image2)
Table 2. Farrowing percentages of altrenogest-fed and control gilts and sows in Herd 1

<table>
<thead>
<tr>
<th>Statistic</th>
<th>Treated</th>
<th></th>
<th></th>
<th></th>
<th>Control</th>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Exposed</td>
<td>Cyc</td>
<td>Far</td>
<td></td>
<td>Exposed</td>
<td>Cyc</td>
<td>Far</td>
<td></td>
</tr>
<tr>
<td>Gilts</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>% Farrowing</td>
<td>66</td>
<td>63***</td>
<td>67**</td>
<td>72</td>
<td>66</td>
<td>79</td>
<td>74</td>
<td></td>
</tr>
<tr>
<td>d 7</td>
<td>66</td>
<td>71</td>
<td>71</td>
<td></td>
<td>45</td>
<td>53</td>
<td>76</td>
<td></td>
</tr>
<tr>
<td>d 10</td>
<td>66*</td>
<td>71†</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sows</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>% Farrowing</td>
<td>63</td>
<td>66</td>
<td>68</td>
<td>72</td>
<td>66</td>
<td>72</td>
<td></td>
<td></td>
</tr>
<tr>
<td>d 7</td>
<td>30*</td>
<td>32*</td>
<td>55</td>
<td>6</td>
<td>6</td>
<td>7</td>
<td>67</td>
<td></td>
</tr>
<tr>
<td>d 10</td>
<td>53*</td>
<td>55*</td>
<td>64</td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

Table 3. Litter traits of altrenogest-fed and control gilts and sows in Herd 1

| Statistic | Treated | Control | Sows | Treated | Control | |
|-----------|---------|---------|------|---------|---------| |
| No. of pigs born live | 8.8 ± .4 | 8.7 ± .4 | 9.5 ± .6 | 10.2 ± .7 | |
| No. of pigs stillborn | .4 ± .1 | .6 ± .1 | .4 ± .2 | .3 ± .2 | |
| No. of mummies | .4 ± .1 | 1.1 ± .1 | .2 ± .2 | .1 ± .2 | |
| No. weaned | 7.9 ± .5 | 7.2 ± .5 | 8.3 ± .7 | 7.7 ± .8 | |
| 21-d Litter wt, kg | 46.5 ± 2.3 | 43.0 ± 2.5 | 46.5 ± 3.5 | 46.3 ± 3.6 | |

Discussion

Estrus Synchronization. Results of these experiments support the findings of other researchers who also obtained a high degree of estrus synchronization in gilts by using altrenogest (Webel, 1978; O'Reilly et al., 1979; Boland and Gordon, 1981; Kraeling et al., 1981; Pursel et al., 1981; Redmer and Day, 1981; Stevenson and Davis, 1982). Although other studies have not reported median days to estrus, the results are in line with average days to estrus. Because the median reflects the frequency with which values occur, it is to be expected that the median days to estrus would be less than the average if synchronization occurred. The fact that none of the treated gilts in Herd 2 was detected in estrus until at least 3 d after altrenogest withdrawal also demonstrates the effect of altrenogest on the luteal phase of the estrous cycle (Webel and Day, 1982; Guthrie and Bolt, 1985).

Studies on sows are harder to compare because researchers have fed altrenogest for various lengths of time after weaning (3 to 18 d) and the natural synchronization due to weaning makes comparisons among studies more difficult. There also are no studies reporting the results of feeding altrenogest to nonpregnant sows just before the start of breeding. In general, however, previous results indicate good synchronization of sows fed 15 to 20 mg/animal daily for seven or more days postweaning (Webel, 1978; Webel and Day, 1982; Boland, 1983; Stevenson et al., 1985), which is similar to results found in Herd 1.
In Herd 2, there was very little evidence of estrus synchronization in treated gilts that did not exhibit estrus within 20 d of altrenogest withdrawal. A possible explanation is that the majority of such gilts may have been prepuberal at the time treatment began. On such gilts, altrenogest would have had no effect. This hypothesis is supported by results obtained by O’Reilly et al. (1979) and Kraeling et al. (1982), who found that altrenogest had no synchronizing effect on prepuberal gilts. Unfortunately, it was not possible to test the gilts in this study to ascertain their cyclicity status.

![Figure 3](image-url)

Figure 3. Probability distribution function of days from altrenogest withdrawal to estrus (ESW) for altrenogest-fed (+) and control (△) gilts in Herd 2.
before treatment. The movement of gilts from confinement finishing facilities to outdoor pens for a 7-wk period was done to encourage the onset of estrus (Christenson and Ford, 1979) but was seemingly only partially successful, given the low proportion of gilts bred during the 20-d period (Table 4). There is, however, evidence that weight and age also affect subsequent reproductive performance in gilts (Christenson and Ford, 1979). The gilts in Herd 2 were relatively young (approximately 215 d) at breeding. Before selection at market weight (which was on a time schedule, not when a specific weight was reached), they were fed the same finishing diet as slaughter pigs. Afterward, they were kept on a fairly restricted plane of nutrition. All these factors may have contributed to the relatively low proportion that were detected in estrus during the first 20 d, as well as to the number that showed estrus later.

However, some carryover of synchronization, or residual effect, may have occurred, as evidenced by the graph of the probability density function (Figure 3). Clearly, a greater number of altrenogest-treated gilts were bred because of the increase in the numbers of those gilts found in estrus around d 23 and 46. This study did not include enough experimental units for the difference to be statistically significant, but the carryover effect should be more closely studied.

Farrowing Rate. In Herd 1, there were no significant differences in farrowing rate for treated and control gilts or sows, which is in agreement with other reports (Webel, 1978; Mauleon et al., 1979; Pursel et al., 1981; Martinat-Botte et al., 1982; Boland, 1983; Varley, 1983; Davis et al., 1987; Rhodes et al., 1991). Webel and Day (1982), however, reported a study in which the farrowing rate was lower for controls than for treated animals. Other researchers (Webel, 1978; Rhodes et al., 1991) have reported no significant differences in farrowing rates for gilts but a trend toward higher rates for treated animals. Still others (Mauleon et al., 1979; Pursel et al., 1981; Varley, 1983; Britt et al., 1986) have reported tendencies for higher rates in control gilts.

In none of the studies were farrowing rates significantly lower for treated gilts, as was found in Herd 2. The reason for these findings is unclear. In most cases, so many sources contribute to variation in farrowing rate that pinpointing treatment effects applied before breeding is impossible. Also, many studies did not report how farrowing percentages were calculated. Examination of data in these experiments revealed that basing percentages on total number of animals exposed (as opposed to number bred by a certain day) resulted in a significant advantage in farrowing rate for treated animals compared with controls. This advantage existed because a higher proportion of treated animals than of controls had exhibited estrus by a certain time.

Litter Traits. In the two herds used for this study, there were no significant differences in litter size born or number of pigs born alive, which is in agreement with some studies (Martinat-Botte et al., 1982; Stevenson and Davis, 1982; Davis et al., 1985; Stevenson et al., 1985; Davis et al., 1987). Other researchers, however, have found an increase in litter size of animals fed altrenogest. Webel (1978) reported a study in which sows fed altrenogest had larger litters than did controls, but the standard errors were quite large (11.3 ± 2.8 vs 10.0 ± 3.3). Similarly, Boland (1983) reported an advantage of .5 pigs/litter for sows fed altrenogest 7 d, but standard errors were again large (11.0 ± 4.2 vs 10.5 ± 2.6).

Side Effects. The low incidence of cystic follicles in treated gilts in Herd 2 is consistent with other reports. When fed such that each animal receives a full dose, 15 mg/animal daily does not elicit an increase in cystic follicles (Webel, 1978; Kraeling et al., 1981; Webel and Day, 1982). Dose-response studies reviewed by Webel and Day (1982) showed that < 10 mg/animal daily resulted in an increased incidence of cystic follicles, and that such an increase probably was due to insufficient intake of altrenogest in group-feeding situations. Because the gilts in Herd 2 of this study were free to move from stall to stall during feeding, the possibility that some animals would receive less than their share of the treated feed always existed. Thus, although individual feeding gives the maximum protection against insufficient doses, prefeeding altrenogest before allowing animals the remainder of their feed is a satisfactory solution, especially if feeding stalls are available.

Implications

Altrenogest is effective for synchronizing estrus in cycling gilts and nonpregnant sows when it is fed at a level of 15 mg/animal for 14 or 10 d, respectively. There is a minimal incidence of cystic follicles and there seem to be few effects on litter traits, but there may be a residual synchronization effect on gilts not detected in heat within 10 d after drug withdrawal. Farrowing rates were lower in treated than in control gilts in the commercial herd.

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