EFFECTS OF GROUP SIZE AND THE MALE-TO-FEMALE RATIO ON THE SEXUAL PERFORMANCE AND AGGRESSIVE BEHAVIOR OF BULLS IN SERVING CAPACITY TESTS

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ABSTRACT

The purpose of the following study was to determine the effects of group size and the male-to-female ratio on the sexual and aggressive behaviors of bulls in the context of serving capacity tests. Tests were administered to two groups of 13 and 14 polled Hereford bulls, respectively, under four test conditions in which the number of bulls and the ratio of males to females was varied. The test conditions were as follows: 1) individual tests (single males were exposed to single females), 2) small-group tests (three or four bulls:three females), 3) large-group tests (13 or 14 bulls:3 females), and 4) male-only test (13 or 14 bulls were placed in the test area in the absence of females). In addition, the sexual performance of 44 Hereford and 12 Angus bulls was compared when competing (small-group tests) vs not competing (individual tests) for females. Ejaculation rate (serving capacity) was similar in individual and small-group tests in which a male-to-female ratio of approximately 1:1 was maintained. Increasing the male-to-female ratio to approximately 4.5:1 enhanced levels of aggression and reduced overall sexual performance. Angus bulls were more aggressive than their Hereford counterparts when competing for females and exhibited lower \( P < .05 \) ejaculation rates in small-group tests than when evaluated individually. We concluded that the sexual performance of polled Hereford bulls can be reliably evaluated when tested in small groups as long as a 1:1 male-to-female ratio is approximated. Estimating the serving capacity of bulls may be more difficult in tests with large groups of males, with relatively high male-to-female ratios, or with bulls of other breeds (e.g., Angus), which result in higher levels of internale aggressive behaviors.

Key Words: Cattle, Bulls, Sexual Behavior, Ejaculation, Aggressive Behavior


Introduction

Sexual performance evaluations of bulls (e.g., serving capacity tests) frequently are expedited by simultaneously testing several males in a single enclosure (Blockey, 1981a,b; Lunstra, 1981; Chenoweth, 1983; Crichton and Lishman, 1985; Price et al., 1986; Boyd and Corah, 1988; Boyd et al., 1989; Godfrey and Lunstra, 1989; Nwakalor and Ezinma, 1989). Requirements of time, labor, and facilities generally are less when testing bulls in groups rather than individually. In addition, sexual activity may be enhanced by the presence of other males (Lunstra, 1981) as long as the bulls are not crowded, the stimulus females are not spaced too closely together (Lane et al., 1983), and(or) dominant-subordinate relationships are not highly polarized, as in mixed-age bull groups (Blockey, 1979).

The dominant-subordinate relationships of yearling, beef bulls generally are unstable and are not expressed as intensely by yearlings as by older bulls (Blockey, 1979, 1981c). Agonistic behavior in groups of three to five yearling

1The authors would like to acknowledge R. Benson, L. Katz, and V. Smith for their assistance in data collection. R. Benson also arranged for the use of the Antonio Mt. Ranch bulls. R. Delmas, W. Neel, and R. Scadden were responsible for the day-to-day care of the U. C. Davis test subjects.

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Received February 20, 1990.

Accepted September 25, 1990.
bulls, when competing for two to four females restrained a minimum of 5 m apart, is sufficiently mild not to significantly affect their serving capacity scores (Blockey, 1981b,c; Crichton and Lishman, 1985; Luns-stra, 1986). However, negative correlations between aggression and serving capacity have been obtained when bulls were allowed to fight during relatively short (10-min) sexual performance tests (Olegun et al., 1981).

The purpose of the following study was to investigate the effects of group size (number of bulls) and the male-to-female ratio on the sexual and aggressive behaviors of relatively young Hereford bulls in the context of sexual performance (serving capacity) evaluations. Treatments included a higher male-to-female ratio (13 or 14 males:3 females) than has been previously used. Also, a breed comparison was made possible by testing herds of polled Hereford and Angus bulls.

Materials and Methods

Animals. The subjects were 73 polled Hereford and 12 black Angus bulls and 16 ovariectomized Hereford heifers. Twenty-seven of the Hereford bulls (UC Davis herd) were born in two consecutive years and reared as separate groups of 13 (A) and 14 (B) individuals. The 16 heifers were also born in consecutive years and reared similarly to the bulls. Rearing of these subjects was described in greater detail in Price and Wallach (1991). The remaining 46 Hereford and 12 Angus bulls were reared at the Antonio Mountain Ranch near Roseville, CA. The age range of the latter polled Hereford bulls was 146 d; 82 d separated the youngest and oldest Angus bulls. The subjects were weaned at approximately 7 mo and were subsequently reared on variable-size pastures with breeds segregated.

Testing. Groups A and B were tested for sexual behaviors every 3 mo from 3 to 24 mo of age (Price and Wallach, 1991). At 3 and 6 mo, before reaching sexual maturity, the subjects were exposed in groups of 13 (group A) and 14 (group B) individuals to two hormone-induced estrous females, one restrained (Price, 1987) and the other unrestrained, for two 120-min tests administered 4 d apart in a 10- × 20-m enclosure. The observer recorded mounts and mount attempts directed at the estrous females. At 9, 12, 15, 18, 21, and 24 mo, these bulls were tested in a 12 × 24-m arena under each of the following four treatment conditions: individual tests (40 min), in which single males were exposed to single females; small-group tests (40 min), in which three or four bulls were exposed to three females restrained approximately 7 m apart; large-group tests (120 min), in which 13 or 14 bulls were exposed to three restrained females; and all-male tests (120 min), in which 13 or 14 bulls were placed in the test arena in the absence of females. Sexual behaviors recorded during these tests that were relevant to this report included mount attempts, mounts without ejaculation (M), and mounts with ejaculation (E). From these data, a measure of serving efficiency was computed by dividing E by E plus M. Aggressive behaviors recorded included sparring, butts directed at conspecifics in the act of mounting, and other butts and displacements. More detailed descriptions of these behaviors were discussed previously (Price and Wallach, 1991). Eight tests were administered 2 to 3 d apart in the following order at each of the aforementioned ages: 1) individual test, 2) small-group test, 3) large-group test, 4) large-group test, 5) small-group test, 6) individual test, 7) males-only test, and 8) males-only test.

Differences between individual and small-group tests reflected the effects of group size on sexual performance because the male-to-female ratio was approximately the same (1:1) in each case. Differences between small-group and large-group tests reflected the importance both of group size (3 or 4 vs 13 or 14 bulls, respectively) and of the male-to-female ratio (approximately 1:1 vs 4.5:1, respectively). Differences between large-group and male-only tests were attributed to the presence (or absence) of females.

Antonio Mt. Ranch bulls were given two individual 15-min sexual performance tests, 7 d apart, when the bulls averaged 13, 18, and 24 mo of age. A single small-group test (four bulls:three females), also 15 min in duration, was administered to all the bulls 7 d after the last individual test when they were 24 mo old. Sexual behaviors recorded included flehmen (lip curl) responses, mount intentions (one front foot is raised as if the animal is going to mount), mount attempts (both front feet are raised off the ground), mounts without ejaculation, and mounts with ejaculation (see Price and Wallach, 1991 for more detailed descriptions of these behaviors).
TABLE 1. LEAST SQUARES LOG MEANS (± SE) AND ACTUAL MEAN (± SE) NUMBER OF SEXUAL BEHAVIORS EXHIBITED BY GROUP A AND B BULLS (N = 27) DURING INDIVIDUAL AND SMALL-GROUP TESTS (40 MIN EACH) AND THE FIRST 40 MIN OF LARGE-GROUP TESTS ADMINISTERED AT 12, 18, AND 24 MOA

<table>
<thead>
<tr>
<th>Variable</th>
<th>Test type</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Individual</td>
<td>Small-group</td>
<td>Large-group</td>
<td></td>
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<tr>
<td>Least squares log means</td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>MA b</td>
<td>.45 ± .04c</td>
<td>.64 ± .04d</td>
<td>.64 ± .04d</td>
<td></td>
</tr>
<tr>
<td>M b</td>
<td>2.69 ± .07c</td>
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</tr>
<tr>
<td>E</td>
<td>.98 ± .04c</td>
<td>.98 ± .04c</td>
<td>.65 ± .04d</td>
<td></td>
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<tr>
<td>E/M + E</td>
<td>.15 ± .01c</td>
<td>.18 ± .01c</td>
<td>.11 ± .01d</td>
<td></td>
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<tr>
<td>Actual (raw) means</td>
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</tr>
<tr>
<td>MA</td>
<td>.75 ± .10</td>
<td>1.10 ± .12</td>
<td>1.14 ± .12</td>
<td></td>
</tr>
<tr>
<td>M</td>
<td>13.76 ± .89</td>
<td>11.49 ± .70</td>
<td>10.23 ± .65</td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>2.15 ± .18</td>
<td>2.26 ± .21</td>
<td>1.23 ± .14</td>
<td></td>
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<tr>
<td>E/M + E</td>
<td>.15 ± .01</td>
<td>.18 ± .02</td>
<td>.11 ± .01</td>
<td></td>
</tr>
</tbody>
</table>

aGroups and ages were combined in reporting these results because they did not interact with test type.
bData were transformed to logarithms prior to analysis. MA = mount attempt; M = mount without ejaculation; E = mount with ejaculation.
c/dRow means with different superscripts differ (P < .05). (Least squares means were used in means comparisons.)

Statistical Analyses. The effect of group size and the male-to-female ratio (test type) on the sexual performance of UC Davis bulls was analyzed by comparing data from individual test (40 min), small group tests (40 min), and the first 40 min of large-group tests in a three-factor (test type, bull groups, and ages) repeated measures analysis of variance. Data (i.e., individual scores) were averaged for the two tests of each test type administered at each age because preliminary analyses did not identify a replication effect. Data analysis was limited to tests administered at 12, 18, and 24 mo, developmental ages when the bulls were attaining puberty (12 mo), experiencing their peak of libido (18 mo), and had the most sexual experience (24 mo). Log transformations of the data were made when variances were not homogenous. Mean comparisons of the least squares means were conducted using t-tests, with probabilities adjusted for the number of comparisons.

The effect of the presence (or absence) of females on the incidence of male-male mounting was assessed by comparing data from 120-min large-group and male-only tests administered to group B bulls at 9 to 24 mo of age. A two-factor (test type and ages) repeated measures analysis of variance was used with t-tests for comparing means.

The effect of an increase in group size and the male-to-female ratio on the aggressive behavior of UC Davis bulls was analyzed by comparing data from small-group tests (40 min) and the first 40 min of both large-group and male-only tests administered to group B bulls. Data used were limited to tests at 12, 18, and 24 mo and were analyzed using a two-factor (test type and ages) repeated measures analysis of variance test.

The effect of group testing on the sexual performance of Antonio Mt. Ranch bulls was assessed by comparing data from the two test types (individual and small-group tests) administered at 24 mo to both Hereford and Angus bulls. A two-factor (test type and breed) analysis of variance was used for these comparisons. Breed differences in aggressive behaviors during small-group tests were analyzed using t-tests.

Results

The effect of group size and the male-to-female ratio (test type) on the sexual performance of UC Davis bulls is summarized in Table 1. Test type effects were found for mount attempts (P < .04), mounts without ejaculation (P < .025), ejaculations (P < .001), and serving efficiency (P < .001). Individual and small-group tests yielded similar frequencies of mounts (without ejaculations), ejaculations, and serving efficiency, but frequencies of these variables generally were lower (P < .05) in large-group tests (Table 1). Mount attempts were more frequent (P < .05) in small-group and large-group tests than in individual tests. Bull groups (A and B) and
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TABLE 2. LEAST SQUARES LOG MEANS AND ACTUAL MEAN (± SE) NUMBER OF MALE-MALE MOUNTS PLUS MOUNT ATTEMPTS INITIATED IN 120-MIN LARGE-GROUP AND MALE-ONLY TESTS ADMINISTERED TO GROUP B BULLS (N = 14) AT 9 TO 24 MO OF AGEa

<table>
<thead>
<tr>
<th>Variable</th>
<th>Age, mo</th>
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<th>15</th>
<th>18</th>
<th>21</th>
<th>24</th>
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<tr>
<td>Least squares log meansb</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Male-only tests</td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>Large-group tests</td>
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<td>.54ef</td>
<td>.32ef</td>
<td>.09f</td>
<td>.26f</td>
<td>.08f</td>
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</tr>
<tr>
<td>Male-only tests</td>
<td>1.37cd</td>
<td>.82de</td>
<td>.53ef</td>
<td>.62ef</td>
<td>.50de</td>
<td>1.67c</td>
<td></td>
</tr>
<tr>
<td>Actual (raw) means</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Large-group tests</td>
<td>1.04 ± .39</td>
<td>1.07 ± .46</td>
<td>.61 ± .35</td>
<td>.11 ± .06</td>
<td>.41 ± .20</td>
<td>.11 ± .08</td>
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<tr>
<td>Male-only tests</td>
<td>3.96 ± .86</td>
<td>2.25 ± .90</td>
<td>1.11 ± .45</td>
<td>1.21 ± .40</td>
<td>2.46 ± .81</td>
<td>4.93 ± .80</td>
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</tbody>
</table>

aData were transformed to logarithms prior to analysis.
bPooled SE = .15.
c,d,e,f Row x column means with different superscripts differ (P < .05). (Least squares means were used in mean comparisons.)

ages (12, 18, and 24 mo) did not interact with test type (P > .05 for all variables).

The effect of the presence (or absence) of females on the frequency of homosexual mounting is summarized in Table 2. Male-male mounting (including mount attempts) was more frequent (P < .001) in 120 min male-only tests than in 120 min large-group tests administered to Group B bulls at 9 to 24 mo of age. Test type interacted (P < .001) with age; differences were greatest at 9 and 24 mo.

The effect of group size and the male-to-female ratio (test type) on the frequency of aggressive behaviors exhibited by UC Davis bulls is summarized in Table 3. Test-type effects were found for sparring, butts while mounting, and other butts/displacements (P < .001, in all cases). Male-only tests yielded the fewest aggressive interactions (P < .05) for all variables recorded. Sparring was more common (P < .05) in large-group than in small-group tests. “Butts while mounting” and “other butts/displacements” did not differ between large- and small-group tests.

The effect of group testing on the sexual performance of Antonio Mt. Ranch bulls at 24 mo is summarized in Table 4. Flehmen and mounts (without ejaculation) were exhibited more frequently (P < .025, in each case) in individual than in small-group tests. Main effects for breeds (Hereford vs Angus) were not significant, but test type x breed interactions were obtained for mount intentions (P < .01) and ejaculations (P < .001). Testing Angus bulls in small groups, rather than individually, increased the frequency of mount

TABLE 3. LEAST SQUARES LOG MEANS (± SE) AND ACTUAL MEAN (± SE) NUMBER OF AGGRESSIVE BEHAVIORS EXHIBITED BY UC DAVIS GROUP B BULLS DURING SMALL-GROUP TESTS AND THE FIRST 40 MIN OF LARGE-GROUP AND MALE-ONLY TESTS ADMINISTERED AT 12, 18, AND 24 MO (AGES WERE COMBINED IN COMPUTATION OF DATA PRESENTED)a

<table>
<thead>
<tr>
<th>Variable</th>
<th>Test type</th>
<th>Small-group</th>
<th>Large-group</th>
<th>Male-only</th>
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<tr>
<td>Least squares log means</td>
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<td></td>
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<tr>
<td>Sparring</td>
<td>2.48 ± .06c</td>
<td>3.08 ± .06b</td>
<td>2.40 ± .06d</td>
<td></td>
</tr>
<tr>
<td>Butts while mounting</td>
<td>1.01 ± .06b</td>
<td>1.15 ± .06b</td>
<td>.06 ± .06c</td>
<td></td>
</tr>
<tr>
<td>Other butts/displacements</td>
<td>1.83 ± .07b</td>
<td>1.93 ± .07b</td>
<td>1.17 ± .07c</td>
<td></td>
</tr>
<tr>
<td>Actual (raw) means</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sparring</td>
<td>13.08 ± 1.14</td>
<td>23.68 ± 1.74</td>
<td>8.54 ± .96</td>
<td></td>
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<tr>
<td>Butts while mounting</td>
<td>2.50 ± .40</td>
<td>3.16 ± .55</td>
<td>.07 ± .03</td>
<td></td>
</tr>
<tr>
<td>Other butts, displacements</td>
<td>6.83 ± .78</td>
<td>7.07 ± .65</td>
<td>2.71 ± .33</td>
<td></td>
</tr>
</tbody>
</table>

aData were transformed to logarithms prior to analysis.
bc,d Row means with different superscripts differ (P < .05). (Least squares means were used in mean comparisons.)
intensities and decreased the frequency of ejaculations. The frequency of mount intensions and ejaculations of the Antonio Mt. Hereford bulls did not differ between individual and small-group tests. Angus bulls were more aggressive toward one another than Hereford bulls were in small-group tests (P < .05; Table 5).

Discussion

The ejaculation rate and serving efficiency of the Hereford bulls were similar in individual and small-group tests. We concluded that testing small groups of young, same-age, sexually experienced bulls of this breed does not depress their sexual performance as long as a 1:1 male-to-female ratio is maintained and the stimulus females are restrained an appropriate distance apart (7 m in this study). As in the present study, Morris (1987) found no difference in the serving capacity of young Santa Gertrudis bulls tested individually (one bull and five restrained, nonestrous females) vs in small groups (three bulls and four restrained, nonestrous females). In contrast, Lane et al. (1983) reported that the sexual performance of bulls was greater when tested individually rather than in groups of six males.

However, they noted that intermale aggression and interference with copulation was increased in their group tests due to spacing the stimulus females only 2 m apart.

Sexually inexperienced bulls may benefit from the social facilitation provided by small groups of males. Lunstra (1981) reported that the sexual performance of sexually inexperienced, 15-mo-old bulls was greater when tested in groups of three or five males than when tested individually. In individual tests administered by Lunstra, 79% of the bulls mounted and 47% ejaculated, whereas in groups of three males, 89% mounted and 73% ejaculated. In the present study, the percentage of bulls that mounted and ejaculated in individual tests at 15 mo were 100% and 78%, respectively. Perhaps sexual experience, in the present study, compensated for the lack of social stimulation in the individual tests.

Sexual performance can be depressed by relatively frequent or prolonged bouts of aggression such as that observed in large-group tests in which group size and the male-to-female ratio was approximately 4.5 times greater than in the small-group tests. The incidence of sparring in large-group tests was nearly double the rate in small-group tests; nonsignificant increases in “butts while mounting” and “other butts/displacements” were also noted.

The efficacy of testing polled Hereford bulls in small groups may not apply to other breeds or populations (e.g., Angus, horned Herefords). The ejaculation rate of Angus bulls from the Antonio Mt. Ranch was reduced when they were tested in small groups. The frequency and intensity of aggressive interactions exhibited by these bulls when competing for females were substantially greater than for
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their polled Hereford counterparts from the same ranch. Mount intention movements by these Angus bulls would consistently precipitate attacks from other males in close proximity, thus preventing mounting and, thereby, ejaculation.

Allowing sufficient space between the stimulus females in multimale serving capacity tests should reduce the frequency of agonistic interactions and more subtle forms of interference between males and, thus, improve the reliability of sexual performance scores. However, bulls will sometimes congregate around a single female even when females are widely spaced and a 1:1 male-to-female ratio is maintained. If intermale competition becomes too intense under such conditions, bulls may elect to disperse (i.e., redistribute themselves to unclaimed females). When bulls are reluctant to disperse, it may be appropriate for animal handlers (on foot or on horseback) to prevent them from congregating and(or) to terminate prolonged or intense aggressive interactions. An alternative plan is to test several bulls in individual side-by-side pens where the animals are able to view one another (Garcia et al., 1986).

The well-being of female stimulus animals may be jeopardized when large numbers of bulls are allowed to congregate around and repeatedly service certain individuals. Large-group tests, such as those employed in the present study, greatly increase the probability that one or more stimulus females will receive inhumane treatment. Hence, serving capacity tests involving groups of more than five or six bulls should be avoided.

The animals used in this study were relatively young (2 yr or less) and had been reared together (i.e., familiar with one another) in same-age groups. Considering that each of these conditions (young age and long-term cohabitation) tends to minimize the frequency and intensity of agonistic interactions (Kilgour and Campin, 1973), sexual performance in small-group tests might have been considerably lower if the subjects had been older (3 yr or more), mixed in age, and(or) unfamiliar with one another (Blockey, 1979, 1981c).

Flehmen responses and mounts without ejaculation were exhibited less frequently in small-group tests than in individual tests by both Hereford and Angus bulls at the Antonio Mt. Ranch (Table 4). Considering that the ejaculation rate of Hereford bulls did not decline in small-group tests, one could propose that the flehmen response is superfluous to the sexual performance of bulls of this breed in the context of serving capacity tests and that competition for females improves their serving efficiency. However, this latter hypothesis (i.e., regarding serving efficiency) was not supported by data obtained with the UC Davis bulls (Table 1).

Male-male mounting frequency was lower when males were competing for females (large-group tests) than when they were placed in the test arena in the absence of females (males-only test). Price et al. (1988), working with male sheep, also noted that male-male mounting is more frequent in the absence of females. Why this treatment difference was greatest at 9 and 24 mo of age in the present study is not clear.

Obtaining data on aggressive behaviors in male-only tests served as a useful control in assessing the effect of competition for females on the frequency of aggressive interactions. Interestingly, males almost never butted other bulls in the act of mounting a male penmate. When interacting with females, however, the slightest mount intention movement (directed toward a female) often initiated an attack by a nearby bull. This result suggests that the motivation to mount other males is not as strong as the motivation to mount females.

Implications

The administration of serving capacity tests to beef bulls requires less time and labor and fewer facilities when bulls are tested in groups rather than individually. The serving capacity of polled Hereford bulls was not reduced when tests were conducted with groups of three or four young, same-age animals, a 1:1 male-to-female ratio was maintained and the females were spaced an adequate distance apart. Estimating the serving capacity of bulls may be more difficult in tests with larger groups, higher male-to-female ratios or other breeds of bulls (e.g., Angus), which result in higher levels of intermale aggressive behaviors. Relatively large groups of males and high male-to-female ratios may also jeopardize the well-being of stimulus females and should be avoided.
Literature Cited