Influence of Grazing Cattle and Sheep Together and Separately on Animal Performance and Forage Quality

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ABSTRACT: Cattle and sheep grazed together and separately from April to October during 3 yr. Initial forage composition was 29% Kentucky bluegrass (Poa pratensis L.), 11% white clover (Trifolium repens L.), and 60% weeds. There were six Angus cow-calf pairs or six ewes (1/2 Dorset × 1/4 Finn × 1/4 Rambouillet) with 11 lambs per each of three pasture replications for single animal species. Six cow-calf pairs plus six ewes and 11 lambs grazed in each of three replications of the mixed animal species treatment. There were approximately one cow and calf or five ewes with lambs per .44 ha. Lambs were weaned at 41 kg or by September 1. Calves were weaned approximately October 10. Lamb daily gain (.23 kg/d), total gain (23 kg), and weaning weights (43 kg) were greater (P < .01) and target weaning weights were reached 14 d earlier in the grazing season when both animal species grazed together than when lambs were in pastures with sheep alone (.18 kg/d, 19 and 38 kg, respectively). Calf gains were not influenced by treatment. Grazing pressure increased throughout the grazing season for cattle alone, peaked in midsummer, and then decreased by autumn for sheep alone, whereas grazing pressure initially increased then remained relatively constant with mixed-species grazing. Forage quality in pastures where sheep grazed alone was lower (P < .05) than in pastures where cattle grazed alone until lambs were weaned in late summer, whereas forage quality with mixed-species grazing was generally intermediate. Mixed grazing resulted in earlier weaning and increased lamb performance and BW of ewes, but not in increased animal production per hectare.

Key Words: Mixed Grazing, Stocking Rate, Grazing Systems, Sheep, Cattle

Introduction

The narrow margin of profit for most cattle and sheep enterprises necessitates development of methods to increase efficiency of forage use. Different species of animals differ in grazing habits (Van Keuren and Parker, 1967), offering opportunities for complementary pasture use. Sheep consume forage near dung, whereas cattle often reject such forage (Brelin, 1979). Moreover, sheep graze a variety of weeds, even in the presence of other forages considered more desirable (Van Keuren and Parker, 1967). In some studies, output per unit area has been greater with mixed-species grazing than with single-species grazing (Bennett et al., 1970); however, live weight gain by steers was similar when they grazed alone or with sheep (Van Keuren and Parker, 1967). Reynolds et al. (1971) reported that performance by individual animal species in mixed grazing was variable, with benefits occurring only in certain periods.

Most previous research on mixed-species grazing has been with stocker cattle and weaned lambs or nonlactating ewes. Little is known concerning effects of mixed grazing by dams and their offspring. Our objectives were to determine effects of grazing ewes and cows with their respective offspring together or separately on 1) animal performance and forage quality, 2) seasonal change in stocking rate and grazing pressure, and 3) time spent grazing by cows and ewes.

Experimental Procedures

The experiment was conducted during 1988, 1989, and 1990 at the Virginia Agricultural Experiment Station, Middleburg (77°43'30 west longitude, 38°57'30 north latitude, elevation 155.5 m) to investigate effects of cows and ewes with their respective offspring, grazing alone or together, simultaneously.

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Angus cows (average BW of 486 kg, SE = 17) and 1/2 Dorset x 1/4 Finn x 1/4 Rambouillet crossbred ewes (average BW of 69 kg, SE = 3) with their offspring were continuously stocked on Kentucky bluegrass (Poa pratensis L.)- white clover (Trifolium repens L.) pastures during the grazing season (April/May to October) of each year. Forages were established during 1981 or earlier and were used in a previous grazing study (Allen et al., 1992). At the beginning of our experiment, pastures were composed of 29% bluegrass, 11% white clover, and 60% weeds, including broadleaf weed and other grass species (Abaye, 1992).

Based on visual evaluation, species present other than bluegrass and white clover were orchardgrass (Dactylis glomerata), chickweed (Stellaria media), dandelion (Taraxacum officinale), and sheperds purse (Capsella bursa-pastoris). Thistle (Cirsium spp.) and geranium (Geranium spp.) occurred occasionally.

The experiment was located on a Chester-Brandywine silt loam complex, rolling phase, with 7 to 14% slopes. Chester is a Typic hapludult, fine-loamy, mixed mesic. Brandywine is a Typic dystrochrept, sandy skeletal, mixed mesic.

Each of three treatments, 1) cattle alone, 2) sheep alone, and 3) cattle plus sheep (mixed grazing), were replicated in three pastures each for a total of nine pastures in a randomized complete block design. Each replication of Treatment 1 included six cow-calf pairs on 2.7 ha, and Treatment 2 included six ewes with 11 lambs on .5 ha. Treatment 3 included six cow-calf pairs plus six ewes with 11 lambs on 3.2 ha, for an experiment total of 36 cows and 36 ewes each year. The allocation of areas for sheep and cattle was based on the assumption that five ewes approximate one mature beef cow; hence, each spring there were approximately one cow-calf pair or five ewe-lamb groups per .44 ha. Grazing began on April 25, May 18, and April 26 and ended October 19, September 28, and October 16 for 1988, 1989, and 1990, respectively. Angus cows were bred in the pastures to Angus bulls during a 75-d breeding season that began June 15 of each year. Ewes were bred in the pastures to Hampshire rams beginning October 1 of each year for a 45-d breeding season.

Target weaning weight for lambs was 41 kg. Lambs that did not reach this target were weaned by September 1 to allow time for ewes to recover before the breeding season. All calves were weaned at the end of the grazing season.

Sheep were treated for internal parasites with Ivomec (MSD-Agvet Division, Merck, Rahway, NJ) every 3 wk, with the exception that the week before weaning, Tramisol (American Cyanamid, Agriculture Division, Wayne, NJ) was used. Cows were not treated for internal parasites; however, calves were treated at weaning with Ivomec. Sheep were treated for foot rot by a ZnSO4 (10% wt/vol solution) foot bath, and foot trimming was done as needed. Trace mineral salt (96% NaCl, 20% Zn, 20% Mn, 50% Fe, .045% Cu, .002% I, and .007% Co; Cargill, Cedar Rapids, MN) was provided free choice to all animals.

Cows and ewes were weighed initially before going to pasture in spring, blocked each year by age and weight, and allocated randomly each year to treatments within animal weight/age blocks. Additionally, ewes were blocked by number of offspring. All ewes had twin lambs, with the exception of one ewe with a single lamb in each replicate in each year. Thus, effects of animal variation as well as field variation were blocked. Full and shrunken (feed and water withheld overnight) weights of all animals were taken at the beginning and end of the grazing season, and full weights were taken every 28 d.

Animal-forage relationships were calculated (FGTC, 1992). Animal units (AU) were calculated on the basis of BW 75; one AU was a 500-kg, nonlactating cow. Grazing pressure was calculated as mean AU/forage mass at given points in time during the grazing season. Stocking rate was calculated both as animals/hectare and as AU/hectare over the grazing season.

In yr 3, one cow and one ewe in each replication were equipped with a Vibracorder (Model TVW 24/8, Agro Instruments, Winchester, VA; Alden, 1962) to determine time spent grazing. Two trials were conducted over two consecutive 7-d periods. Day 1 was discarded and data from 6 d were used for analysis. Trial 1 began on September 4, and Trial 2 began on September 11. Animals were allotted randomly to vibracorders, with the exception that animals used in Trial 1 were not used in Trial 2, which should have minimized individual animal effects and avoided prolonged stress on the animals. Vibracorders were attached over the left shoulder for ewes and the left side of the head for cows (Abaye, 1992). All animals that were equipped with vibracorders were observed from a distance using binoculars three to four times daily to ensure the proper operation and location of clocks, and to record activities to verify information obtained from the Vibracorders.

Forage mass was determined immediately before the beginning of grazing and every 28 d throughout the grazing season by clipping 12, 300-cm x 53-cm strips (at 2.5-cm height) per treatment replication with a rotary mower. Forage samples for chemical analyses were obtained by clipping at 2.5 cm above ground level every 20 paces diagonally across each pasture every 28 d. Samples were dried in a forced-air oven at 60°C, ground (1-mm screen) in a stainless steel Wiley Mill (Thomas-Wiley Mill, Model ED-5, Arthur H. Thomas Co., Philadelphia, PA), and analyzed for ADF (Van Soest, 1963), NDF (Van Soest and Wine, 1967; Goering and Van Soest, 1970), permanganate lignin and cellulose, hemicellulose (NDF - ADF), and IVDMD (Tiley and Terry, 1963; as modified by Barnes, 1966). Total N was determined colorimetrically (McKenzie and Wallace, 1954) with a Technicon Autoanalyzer (Technicon Industrial Systems, Tarrytown, NY; 1976).

Data were analyzed as a randomized complete block design (SAS, 1982). Effect of treatment, field block, date, and year and all two- and three-way interactions were tested. Treatment effects were tested using the treatment × block interaction mean square as the error term. Treatment differences were further tested using orthogonal contrasts as follows: 1) mixed- vs single-species grazing, and 2) sheep alone vs cattle alone.

Results

Weather

Precipitation during May and July was greater than the 32-yr average, and precipitation during the remainder of the year was generally less than average (Figure 1). Average annual precipitation during the experiment was less (86.6 cm) than the 38-yr average (96 cm). Mean temperature reflected a typical temperature pattern for this region. Average high temperatures in May, July, and September were 23, 32, and 23°C, respectively, and average low temperatures were 11, 20, and 13°C, respectively.

Animal Performance

Initial BW and total gain by cows were influenced \((P < .01)\) by year (Table 1). There was no difference \((P > .05)\) in final BW or gain by cows grazed alone compared with those grazed with sheep. Ewes differed by year \((P < .05)\) in initial and final BW and total gain. Ewes grazed with cows gained BW during the grazing season, whereas ewes grazed alone lost BW \((P < .05)\).

Weaning weights of steer calves grazed with sheep tended \((P < .09)\) to be greater than for those grazed alone, but no effect of treatment on weaning weight of heifers was detected (Table 2). However, averaged over sex, there were no differences \((P > .05)\) in initial BW, total gain, and daily gain by calves grazed alone or with sheep (data not shown).

Total gain, daily gain, and weaning weight of both wether and ewe lambs were greater \((P < .05)\) when they grazed with cattle than when they grazed alone (Table 2). Differences in daily gain were greater in yr 1 and 3 than in yr 2 for wether lambs (year × treatment interaction, \(P < .05\)). Wether and ewe lambs grazed with cattle were weaned 17 and 10 d earlier \((P < .05)\), respectively, than those grazed alone. In yr 2, however, all lambs were weaned at the same time (year × treatment interaction, \(P < .05\)). Differences in days to weaning were not measured for calves because all calves were weaned at the end of the grazing season.

Grazing sheep alone resulted in more total kilograms of weaned offspring/hectare than either of the other two systems (data not shown). Total weaned

Table 1. Influence of sheep and cattle grazing alone and together on body weight and gain by cows and ewes\(^a\)

<table>
<thead>
<tr>
<th>Item</th>
<th>Cows(^b)</th>
<th>Ewes(^b)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Grazed alone</td>
<td>Grazed with sheep</td>
</tr>
<tr>
<td>Initial BW</td>
<td>491(^c)</td>
<td>481</td>
</tr>
<tr>
<td>Final BW</td>
<td>515</td>
<td>519</td>
</tr>
<tr>
<td>Total gain</td>
<td>24(^c)</td>
<td>37</td>
</tr>
</tbody>
</table>

\(^a\)Averaged over 1988, 1989, and 1990.
\(^b\)Each value is the mean of 54 animals.
\(^c\)Effect of year \((P < .05)\).
\(^d\)Effect of treatment \((P < .05)\).
weights of offspring were 490, 791, and 548 kg/ha for cattle alone, sheep alone, and mixed-species grazing, respectively. Total gain for the three respective systems was 309, 386, and 348 kg/ha.

**Time Spent Grazing**

During morning and evening, cows spent more \( (P < .05) \) time grazing when they were alone than when mixed with sheep, but this effect was reversed during the night \( (P < .001) \), resulting in a similar total grazing time between these two groups (Table 3). There was no difference \( (P > .05) \) in time spent grazing between ewes grazed alone and those grazed with cattle during the morning, but ewes spent more \( (P < .001) \) time grazing during midday and night and more \( (P < .05) \) total time grazing when they were with cattle than when they grazed alone. Ewes grazed alone spent more \( (P < .001) \) time grazing during the evening compared with those grazed with cows.

**Forage-Animal Relationships**

**Animal Weight/hectare.** When grazing began, total animal weight/hectare in sheep in pastures where sheep grazed alone tended \( (P < .10) \) to be less than that of cattle where cattle grazed alone (Figure 2a). Total animal weight in mixed-grazed pastures was similar to that observed in pastures where cattle grazed alone. This trend between cattle and sheep as single species continued until the end of July (d 213), at which time no difference \( (P > .05) \) was observed. Total animal weight/hectare in pastures occupied by mixed species was greater \( (P < .05) \) in June (d 186) than that in pastures grazed by a single species. During the remainder of the grazing season, total animal weight/hectare in mixed-grazed pastures changed very little because weaning and removal of lambs was offset by increased weight gains by cows, ewes, and calves. Total animal weight/hectare in cattle-alone pastures continued to increase until the end of the grazing season. Weaning and removal of lambs from sheep-alone pastures resulted in a sharp decrease in total weight/hectare. Following weaning of lambs, ewes gained weight, which was reflected in a slight increase in total animal weight/hectare at the end of the grazing season.

**Stocking Rate.** Stocking rate can be calculated on the basis of animal number/hectare or on the basis of AU/hectare. When calculated as animal number/hectare, there was no variation in stocking rate until lambs began to be weaned in midseason (Figure 2b). Because there were proportionally more lambs than ewes in pastures grazed by sheep alone, these pastures experienced a large decrease in stocking rate during the latter part of the grazing season. Weaning of lambs in pastures grazed by mixed species resulted

<table>
<thead>
<tr>
<th>Item</th>
<th>Calves Grazed alone(^a)</th>
<th>Calves Grazed with sheep(^b)</th>
<th>Calves SEM</th>
<th>Lambs Grazed alone(^c)</th>
<th>Lambs Grazed with cattle(^d)</th>
<th>Lambs SEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial BW, kg</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Males</td>
<td>69(^f)</td>
<td>74</td>
<td>4</td>
<td>21(^f)</td>
<td>20</td>
<td>1</td>
</tr>
<tr>
<td>Females</td>
<td>70(^f)</td>
<td>68</td>
<td>3</td>
<td>19(^f)</td>
<td>19</td>
<td>1</td>
</tr>
<tr>
<td>Total gain, kg</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Males</td>
<td>141(^f)</td>
<td>150</td>
<td>4</td>
<td>19(^fg)</td>
<td>23</td>
<td>1</td>
</tr>
<tr>
<td>Females</td>
<td>141(^f)</td>
<td>136</td>
<td>3</td>
<td>19(^fg)</td>
<td>23</td>
<td>1</td>
</tr>
<tr>
<td>Daily gain, kg</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Males</td>
<td>.90(^f)</td>
<td>.94</td>
<td>.1</td>
<td>.15(^fg)</td>
<td>24</td>
<td>.01</td>
</tr>
<tr>
<td>Females</td>
<td>.88(^f)</td>
<td>.84</td>
<td>.1</td>
<td>.16(^g)</td>
<td>22</td>
<td>.01</td>
</tr>
</tbody>
</table>

\(^a\) = 26 steers and 28 heifers.
\(^b\) = 28 steers and 26 heifers.
\(^c\) = 49 wethers and 47 ewe lambs.
\(^d\) = 50 wethers and 48 ewe lambs.
\(^e\) = Day of the year.
\(^f\) = Effect of year \( (P < .05) \).
\(^g\) = Effect of treatment \( (P < .01) \).
\(^h\) = Year \( \times \) treatment interaction \( (P < .01) \).
\(^i\) = Effect of treatment \( (P < .09) \).
in less change in stocking rate. Because no animals were either added or removed in pastures occupied by cattle alone, stocking rate calculated on an animal number basis was constant throughout the grazing season.

When stocking rate was calculated on the basis of AU/hectare, changes over the grazing season were relatively constant. Throughout the grazing season, and that observed in rate in pastures where cattle alone grazed increased by a single species than in pastures grazed by both animal species (Figure 2c). By September, grazing pressure increased sharply in all pastures as a result of the decrease in forage mass (Figure 2d), but the greatest increase was observed in pastures where cattle grazed alone. Pastures in which both animal species were present exhibited the least increase in grazing pressure in September and maintained the most uniform grazing pressure over the entire grazing season. Grazing pressure in mixed-species pastures was generally similar until September to that observed in pastures where cattle grazed alone. By the end of the grazing season, removal of lambs and the increase in forage mass resulted in a sharp decrease in grazing pressure in pastures where sheep grazed alone.

**Forage Quality.** At the time our study was initiated, there were no differences \((P > .05)\) among pastures in botanical composition (Abaye, 1992). Forage quality as measured by CP, fiber components, and IVDMD was influenced by year \((P < .01)\) and date \((P < .05)\), and there were date \(\times\) treatment \((P < .05)\), date \(\times\) year \((P < .05)\), and year \(\times\) treatment \((P < .05)\) interactions. Thus, each date was examined separately for each chemical component (Figure 3).

Seasonal changes in cell wall composition, CP, and IVDMD were typical of cool-season forages (Figure 3). However, from April through July, forages in sheep-alone pastures were generally higher \((P < .05)\) in NDF, ADF, cellulose, and hemicellulose, whereas CP and IVDMD were lower \((P < .05)\) than forage in cattle-alone pastures. By October, forage in sheep pastures did not differ in permanganate lignin and IVDMD but was slightly higher \((P < .06)\) in cellulose at this date than forage in cattle pastures.

Forage in pastures where both animal species were present was generally intermediate in quality to forage in pastures where sheep and cattle grazed alone; however, lower \((P < .05)\) CP concentrations in July and September were observed, and IVDMD was

### Table 3. Influence of sheep and cattle grazing alone and together on time spent grazing during September 1990

<table>
<thead>
<tr>
<th>Grazing treatment</th>
<th>Cows&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Ewes&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Grazed alone</td>
<td>Grazed with sheep</td>
</tr>
<tr>
<td><strong>Time/h</strong></td>
<td>min/24 h</td>
<td>min/24 h</td>
</tr>
<tr>
<td>Morning 0500-1100</td>
<td>210&lt;sup&gt;b&lt;/sup&gt;</td>
<td>182</td>
</tr>
<tr>
<td>Midday 1100-1500</td>
<td>91</td>
<td>80</td>
</tr>
<tr>
<td>Evening 1500-2000</td>
<td>245&lt;sup&gt;c&lt;/sup&gt;</td>
<td>208</td>
</tr>
<tr>
<td>Night 2000-0500</td>
<td>65&lt;sup&gt;d&lt;/sup&gt;</td>
<td>119</td>
</tr>
<tr>
<td>Total/24 h</td>
<td>611</td>
<td>589</td>
</tr>
</tbody>
</table>

<sup>a</sup>Each value represents a mean of six animals.

<sup>b</sup>Grazing alone differs from mixed grazing \((P < .05)\).

<sup>c</sup>Grazing alone differs from mixed grazing \((P < .01)\).

<sup>d</sup>Grazing alone differs from mixed grazing \((P < .001)\).
lower in July and August. By October, NDF, ADF, and hemicellulose were higher \((P < .05)\) and CP was lower \((P < .05)\) in forage available to mixed species than the mean of forage available to each animal species grazed alone.

**Discussion**

One basic objective of forage-livestock systems is to match needs of grazing animals with changes that
Figure 3. Influence of sheep and cattle grazing alone and together on fiber components, crude protein (CP), and in vitro dry matter disappearance (IVDMD). Pooled SE for each month are shown along the x-axis. ADF = acid detergent fiber, NDF = neutral detergent fiber.
occur in quality and quantity of forage throughout the grazing season. Forage-livestock systems are complex and are composed of numerous interactive, changing factors.

In our experiment, pastures occupied by cattle alone had an excess of forage early in the grazing season. By midseason, calves were growing and were reaching an age at which forage was increasingly important to their diet (Blaser et al., 1986). By the end of the grazing season, when forage needs were greater, forage mass was at its lowest point. Stacking rates calculated on the basis of AU/hectare and grazing pressure increased over the grazing season, although the number of animals/hectare did not change (Figure 2b, c, and e). By the end of the grazing season, grazing pressure for cattle alone increased rapidly after August, reflecting both growth by calves and decreases in forage growth. Stacking rate calculated as animals/hectare (Figure 2b) did not change over the grazing season.

Pastures in which sheep grazed alone generally decreased in both forage mass and quality while the lambs were in the pasture. These decreases in forage quality and mass were partly a result of a decrease in the percentage of white clover in pastures occupied by sheep alone. White clover in pastures grazed by sheep decreased from an initial 14% to less than 4% by midseason. Similar results were obtained by Bosewell and Cranshaw (1978) and were attributed partially to selective grazing. Sheep practice a greater degree of selection than do cattle (Van Keuren and Parker, 1967; Bedell, 1968). Sheep also probably grazed a greater proportion of leafy forage, leaving stemier plant parts that were lower in quality (Arnold, 1981).

The period of high forage need for sheep before weaning lambs occurred in mid- to late summer when growth of cool-season forages is often decreased by high temperatures and low precipitation. Growth by lambs contributed to greater ($P < .05$) grazing pressure into August (d 243) than for cattle alone. Grazing pressure in pastures with sheep alone reflected the high AU/hectare and the trend for lower forage mass during this period (Figure 2c, d, and e). This occurred even though total weight of animals (kilogram/hectare) was actually lower ($P < .05$) throughout most of the grazing season in pastures occupied by sheep than in those occupied by cattle alone (Figure 2a). As lambs were weaned, stocking rate and grazing pressure decreased in pastures where sheep grazed alone, but overall, ewes lost weight in this system (Table 1). This lost BW was not recovered by the ewes during the last 30 d (Figure 2c).

In the mixed-grazed pastures, forage mass, stocking rate, and grazing pressure were more stable over the entire grazing season than in pastures occupied by the single species (Figure 2). Lambs from mixed-grazed pastures reached their target weight earlier in the season when forage mass was greater, which should have allowed more selective grazing by lambs. Furthermore, this early removal from pasture helped to avoid late-summer stress on the lambs. Our results agree with those of Brelin (1979), who reported faster growth by lambs grazing with cattle than by lambs grazed alone. Removal of lambs at weaning in mixed-grazed pastures increased ($P < .01$) forage available for grazing by the remaining calves, ewes, and cows compared with pastures grazed by the single-animal species (Figure 2). Thus, in pastures where a single species grazed, maximal animal needs for forage came at points when the natural productivity of cool-season forage was low, causing a further decrease in pasture quality and growth. Combined grazing of sheep and cattle matched forage growth with animal needs.

Ewes in mixed-grazed pastures also gained more weight by October than those grazed alone, which probably reflected increased forage mass. Although not measured in our study, greater gain by ewes may further increase benefits of mixed grazing through increased conception rates and subsequent lamb crops. The increased performance per animal achieved from the mixed-species grazing also could be attributed to sheep grazing forages growing near dung (as was visually observed) that were avoided by cattle, thereby increasing total feed available to sheep compared with cattle. Similar observations were made by Brelin (1979).

The greater gain by ewes in mixed-grazed pastures than by ewes grazing alone also may have reflected greater forage intake, as suggested by the greater time that mixed-grazed ewes spent grazing. However, Krysl and Hess (1993) suggested that measurement of grazing time alone is unlikely to predict animal performance. The increased ($P < .001$) night grazing by sheep when they grazed with cattle increased ($P < .001$) the total time spent grazing per 24 h. The increased ($P < .001$) night grazing by cows when they grazed with sheep was not great enough to affect total time spent grazing by cows. Stobbs (1970) observed that nonlactating and lactating Jersey cows grazing both tropical legumes ($Desmodium intortum$, $Dolichos lab lab$, $Phascolus atropurpureus$, and $Leucaena leucocephala$) and grasses ($Setaria sphacelata$, $Digitaria decumbens$, and $Chloris gayana$) spent more time grazing during the day than during the night. However, Stobbs (1970) suggested that during the night, cows grazing tropical forage behaved more as individuals than as a group and high-producing cows increased night grazing. In our experiment, animal species that grazed together were perhaps better able to maintain individuality. Their grazing behavior at night was perhaps less affected by the presence of another group, allowing them to compensate for less grazing time during the day.

Visual observations of animal grazing patterns and behavior indicated that during hot summer days, sheep spent more time resting during the day,
whereas cattle grazed intermittently. In mixed-species grazing, where only one animal from each animal species was involved (one cow and one sheep), a very strong social relationship has been shown to develop, and time strengthened this relationship (Bond et al., 1967). However, when more than one animal from each species was used, as in our experiment, animals tended to stay within their own species group (Bond et al., 1967). In our experiment, in mixed-species pastures, cattle and sheep were separated, often at opposite ends of the pasture. However, as the day progressed, cattle and sheep traveled as separate groups in opposite directions, and by late afternoon, sheep and cattle were observed to be in close proximity, occasionally mixing. An occasional accidental mixing of species seemed to frighten sheep more than cattle, whereas calves frequently mixed with sheep. Hafez and Bouissou (1975) suggested that in domestic cattle, especially under intensive management systems, the natural organization of a strong bond between cows and calves is modified, with lessening of the maternal bond. However, as reported by Winfield and Mullaney (1973), sheep form a strong social group early in life, and will maintain that social group even when previously formed groups are forced into close association; our results support these observations. Social relationships among grazing animals are important because once such relationships are established, certain response patterns such as grazing behavior of two animals become mutually dependent, in that the behavior of one animal will affect the behavior of the other (Hulet et al., 1975).

In our experiment, forage-animal relationships were described by stocking rates, grazing pressure, animal number and weight, and forage mass. Stocking rate expressed as animal number/hectare did not account for differences in animal species, age, or effect of production stage. Expressing stocking rate as AU/hectare more nearly equated sheep with cattle and reflected changes in body condition. Animal BW/hectare suggested the least difference in stocking among the three systems until after midseason and was the only measure that suggested equality between one cow and five ewes. However, by d 186, animal BW/hectare was greater in pastures occupied by both animal species, yet there also was more ($P < .05$) forage mass in these pastures compared with pastures grazed by a single species. Furthermore, animal BW/hectare in sheep pastures tended ($P < .10$) to be lower than that in cattle pastures until August (d 243), but sheep pastures had numerically lower forage mass during this time period. Only grazing pressure took into account both the animal and the plant in providing a unit for comparison among the systems.

The advantage of mixed grazing was observed primarily in increased rate of gain and earlier weaning of lambs, as well as in increased BW of ewes in autumn at the beginning of the breeding season. Total animal production per unit of land area was similar, whether the land unit was grazed by both animal species or was divided and grazed separately by cattle and sheep. At the stocking rates used in our experiment, sheep produced more kilograms/hectare of weaned offspring than cattle within their separate areas, whereas production from pastures occupied by both animal species approximated the average of production by cattle and sheep grazed alone.

**Implications**

Mixed grazing of cattle and sheep should increase daily gain, total gain, and weaning weights of lambs and allow target weaning weights of lambs to be reached earlier in the grazing season. Combining cows and ewes with their offspring improved ewe condition at the start of the breeding season and provided a better season-long balance among forage growth and quality and nutritional needs of animals grazing bluegrass-white clover pastures. Stocking rate, animal number and weight, forage mass, and grazing pressure have been used to describe forage-animal relationships. Grazing pressure best described the forage-animal balance because it reflected variation in animals (animal units) and forage mass.

**Literature Cited**


