Comparison of chicory and annual ryegrass for spring stockering of beef steers

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ABSTRACT

The perennial forage herb, ‘Puna II’ chicory (Cichorium intybus L.; CHY) was evaluated as an alternative to ‘Marshall’ annual ryegrass (Lolium multiflorum Lam.; ARG) for spring stocker cattle grazing. Replicated (n = 4) 0.81-ha ARG and CHY pastures were established in September 2004 in a randomized complete block design. British-Continental crossbred steers (mean BW = 215 kg; 5 testers/paddock) were rotationally stocked (14-d grazing, 14-d rest) for a 56-d period starting in mid-April, for 3 yr. Forage IVDMD and ADF concentrations were not different between ARG and CHY pastures in April or May, but were lesser (P < 0.01) or greater (P < 0.01), respectively, in ARG compared with CHY pastures in June. Forage NDF concentrations were greater (P < 0.01) in ARG than CHY pastures in all months. Forage CP concentration was greater (P < 0.05) in CHY than ARG pastures on 6 out of the 9 sampling date and year combinations. The difference of least squares means revealed a nutritive value advantage for CHY as large as 11.3% CP in June 2006. Steer ADG was not different (P = 0.73) between pastures (ARG: 1.17 ± 0.03 kg; CHY: 1.16 ± 0.03 kg). Steer BW gain/ha was also not different (P = 0.50) between pastures (ARG: 452 ± 14.8 kg/ha; CHY: 436 ± 15.5 kg/ha). Cattle growth performance on CHY is comparable with that on ARG in the spring.

Key words: annual ryegrass, beef cattle, chicory, grazing, stocker

INTRODUCTION

The forage forb, chicory (Cichorium intybus L.), may be a viable high-quality forage option during the spring months in the Southeast region of the United States (Collins and McCoy, 1997; Foster et al., 2002). It is a drought-tolerant, high-yielding perennial forage crop that is palatable to a wide range of livestock, including cattle, goats, sheep, and deer (Fraser et al., 1988; Clark et al., 1990; Niezen et al., 1993). Chicory maintains its high nutritional quality (85 to 95% digestibility and 10 to 32% CP) throughout the growing season (Kusmartono et al., 1996). High intake rates of chicory by cattle combined with its high and uniform forage quality make chicory a useful forage for grazing livestock with high nutrient and DMI requirements (McCoy et al., 1997). Although chicory is a C₃ plant, it is very drought tolerant and continues to grow through the summer months. Cattle grazing pure crops of chicory can maintain BW gains above 1 kg/d throughout the summer because of the high nutritional quality, yield, and forage intake achieved with chicory (Fraser et al., 1988). Chicory is very responsive to N fertilizer up to 200 kg of N/ha and can yield in excess of 14 Mg/ha when N is not limiting (Hare et al., 1987). Chicory is also a suitable companion genus for annual and perennial clovers, which can reduce the requirement for N fertilizer applications.

‘Puna II’ chicory is marketed as Oasis chicory (Ampac Seed Company, Tangent, OR). It was bred out of the first forage chicory cultivar, ‘Grasslands Puna’, for improved cool-season production with a more uniform leaf and greater concentration of sesquiterpene lactones (Rumball, 1986; Rumball et al., 2003). There is a dearth of
information regarding stocker cattle production on chicory in direct comparison with annual ryegrass (Lolium multiflorum Lam.), the most widely used cool-season annual forage in the Southeast region of the United States (Evers et al., 1997). The objective of this experiment was to compare grazing steer growth performance and forage nutritive value of ‘Puna II’ chicory (CHY) and ‘Marshall’ annual ryegrass (ARG) in the Southeast of the United States.

**MATERIALS AND METHODS**

**Pasture Establishment and Management**

Two forage systems, ‘Marshall’ ARG and ‘Puna II’ CHY, were compared for stocker steer growth performance for 3 yr at the Mississippi Agricultural and Forestry Experiment Station, North Mississippi Branch Experiment Station at Holly Springs, Mississippi (latitude 34.8223°N; longitude 89.4348°W; elevation 147.5 m). This grazing experiment was a randomized complete block design with 4 blocks (replications) of each forage system. Pastures were blocked according to soil type. Soil types were Loring, Grenada, and Calloway silt loams. The 0.81-ha paddocks were monocultures of either ARG, established in September each year, or CHY, established in September 2004. The pastures were prepared by conventional tillage in late August 2004. In September 2004, after volunteer grass seedlings emerged and 7 d before planting, an application of glyphosate (1.5 L/ha of 41% vol/vol) was applied to eradicate the existing pasture plants (predominantly annual ryegrass). In late September 2004, CHY seed supplied by the Ampac Seed Company was precision drilled with a 15.2-cm Tye drill (AGCO Corporation, Duluth, GA) into well-prepared seedbeds at a seeding rate of 8 kg/ha. Annual ARG seed supplied by the Wax Seed Company (Amory, MS) was precision drilled with a 15.2-cm Tye drill (AGCO Corporation) into well-prepared seedbeds at a seeding rate of 30 kg/ha in late September 2004 and again following the same establishment protocol in the subsequent 2 yr. Nitrogen fertilizer (33 kg of N/ha) was applied uniformly after establishment in October as ammonium nitrate (NH₄NO₃). The ARG and CHY pastures received 3 equal applications of N (33 kg of N/ha) fertilizer in the form of ammonium nitrate (NH₄NO₃) in April, May, and October of each subsequent year. All pastures received uniformed applications of lime, P, and K according to soil test results at establishment and in late February of each subsequent year. Broadleaf weeds were controlled in the CHY pastures with Poast herbicide (sethoxydim, BASF Corporation, Research Triangle Park, NC; 2.3 L/ha of 18% vol/vol) on an as-needed basis according to label recommendations in the experiment area after forage establishment. On the basis of visual assessments, weed control measures were effective, and weed encroachment in CHY paddocks was generally not deemed a problem over the duration of the experiment.

**Cattle and Grazing Management**

The cattle in this experiment were managed under a protocol approved by the Mississippi State University Institutional Animal Care and Use Committee. British-Continental crossbred steers (mean BW = 215 kg) were randomly assigned to the pastures. Five tester steers per paddock were used each grazing season. In each paddock, cattle were supplied at all times with fresh water and free-choice loose mineral supplement (Bova Mag Breeder 5, Furst-McNess Co., Freeport, IL) containing 8.1% Ca, 5.0% P, 9.1% NaCl, 13.0% Mg, 0.5% K, 0.3% S, 9,000 mg/kg of Zn, 6,500 mg/kg of Mn, 3,000 mg/kg of Cu, 184 mg/kg of I, 45 mg/kg of Co, and 39 mg/kg of Se. The supplement was labeled to contain 661,380 IU of vitamin A/kg, 66.138 IU of vitamin D/kg, and 1,323 IU of vitamin E/kg. Before each grazing season, steers were vaccinated against respiratory diseases with Master Guard 10 (Agri Laboratories Ltd., St. Joseph, MO), against clostridial diseases with Vision 7 (Intervet Inc., Millsboro, DE), and against Mannheimia diseases with Prespone SQ (Fort Dodge Laboratories Inc., Fort Dodge, IA). Cattle were also treated for internal and external parasites with Cydectin pour-on (Fort Dodge Animal Health, Overland Park, KS).

Spring grazing seasons were 56 d each. Grazing was initiated when there was adequate herbage mass, approximately 3,500 kg of DM/ha, at the start of each grazing season. Early spring grazing management of the ARG paddocks by weaned calves was used to provide comparable initial forage mass between forage genera at the initiation of each grazing period. Grazing periods for the experiment were as follows: April 15 to June 10, 2005; April 13 to June 8, 2006; and April 11 to June 6, 2007. Between grazing periods during summer and early autumn each year, the CHY pastures were grazed by weaned calves beginning when it reached a mean forage height of 25 cm tall, as determined by visual appraisal, to a residual forage height of 10 cm. Cattle were then removed to allow regrowth. In addition, the ARG pastures were grazed by weaned calves during the winter and allowed to accumulate herbage mass each year before grazing initiation for the experiment.

In an attempt to maintain similar forage availability among paddocks, put-and-take grazing management was used. Stocking rate was adjusted by removing or adding grazer animals if determined appropriate, based on visual appraisal of herbage mass at 14-d intervals. Tester animals were defined as calves that remained on their original assigned paddocks for the duration of the grazing season.

Weaned calves less than 1 yr of age were acquired from the resident Mississippi Agricultural and Forestry Experiment Station herds and purchased from preconditioning operations. These cattle were stocked on ARG for at least 14 d before being stratified by BW and estimated breed composi-
tion to paddocks at the beginning of each grazing season. Paddocks were restocked with new animals at the beginning of each grazing season. Because it has been shown that continuous stocking of chicory pastures will cause the stand to decrease rapidly (Lancashire and Brock, 1983; Labreveux et al., 2004), rotational grazing management was used for CHY and also for ARG paddocks. Each 0.81-ha paddock was subdivided into 2 grazing cells equal in area. Within a paddock, calves were rotated between the two 0.40-ha grazing cells every 14 d so that each half of the paddock alternated between 14-d grazing and rest periods.

**Pasture Data Collection**

Pasture herbage mass was determined every 14 d, beginning at d 0 through the end of each grazing season. Herbage from ten 0.12-m² quadrats within each grazing cell within paddock was harvested at 2.5 cm above the soil surface at randomly selected sites. The quadrat cuts from each pasture were weighed fresh and then pooled within grazing cell within pasture replicate. From each pooled sample, a 1-kg subsample was taken, dried in a forced-air oven at 60°C for 72 h, and then weighed to determine DM concentration and to estimate paddock herbage mass. From the pregrazing cells, herbage samples from d 0, 28, and 56 of the grazing period were lyophilized, ground through a 1-mm screen in a Wiley mill (Arthur A. Thomas, Philadelphia, PA), and analyzed for nutritive value, including DM, IVDM (Cherney et al., 1997), NDF, ADF (Van Soest et al., 1991), and total N (AOAC, 1990). Crude protein concentration was determined by multiplying total N concentration by 6.25.

**Stocker Animal Data Collection**

Animal BW were collected at the beginning of the experimental period and then at 28-d intervals thereafter during each grazing season. Initial and final unshrunk steer BW were collected on 2 consecutive days and averaged. Animal days for each paddock were calculated as the sum of the days each animal (tester or grazer) spent grazing the paddock during a given grazing season. Animal ADG was computed by dividing mean tester animal BW gain in a particular paddock by the number of days in the grazing season. Mean stocking rate was computed by dividing annual days by the duration of the grazing season in days and then multiplying by the average steer BW. Mean forage allowance was calculated as the quotient of mean herbage mass divided by mean stocking rate. Body weight gain per hectare was calculated as the number of animal days multiplied by tester animal ADG.

**Statistical Analysis**

The PROC GLIMMIX of SAS (SAS Inst. Inc., Cary, NC) was used to analyze the continuous and percentage dependent data, respectively, from the experiment. With the GLIMMIX procedure, a default logit link function with a binomial distribution was assumed. A randomized complete block experimental design was used, with paddock as the experimental unit. Main effects were pasture (forage genera), block (replication), and grazing year. Forage sampling and grazing periods were analyzed as repeated measures. The model included main effects and their interactions. Pasture effects were tested using paddock within pasture as the error term. Period effects and period × pasture were tested using period × paddock within pasture as the error term. Because block was not a significant source of variation and no significant interactions were involving block, means were pooled within treatment across blocks. Means were separated using the PDIFF function of SAS with the Tukey-Kramer adjustment. Significant differences were defined as $P < 0.05$.

**RESULTS AND DISCUSSION**

**Climatology**

Climatic information was obtained from the environmental monitoring center reporting data to the National Climatic Data Center located at the experimental site (Table 1). In general, mean monthly temperatures in all years during the experimental period were numerically close to 30-yr means. Exceptions included slightly elevated mean temperatures in October and November 2004; January, February, and November 2005; and January, April, and August 2006; with the greatest departure above the mean historical temperatures occurring in March 2007. The greatest monthly mean temperature departure below the 30-yr means happened in December 2005. Monthly precipitation in late autumn and early winter 2004 tended to exceed the 30-yr means, whereas in late autumn and early winter 2005, it was much less than the 30-yr means. However, following the droughty autumn and early winter of 2005, January 2006 was a relatively wet month in terms of precipitation compared with the 30-yr means. In 2005, mid-late winter precipitation was on par with the 30-yr means, but March rainfall tended to be depressed compared with these means. Also in 2005, April precipitation greatly surpassed the historical means, followed by late spring through mid-summer rainfall that was notably less than these means. Late winter through early summer precipitation was depressed in comparison with the 30-yr means in 2006 and even more so in 2007.

**Nutrient Composition**

Forage nutritive values appear in Tables 2, 3, and 4. There were pasture × year effects for IVDM (P = 0.05) and ADF (P < 0.01; Table 2). Forage IVMD concentrations were not different between pastures in 2005 (P = 0.66) and 2007 (P = 0.17) but were greater (P < 0.01) in CHY pastures versus ARG pastures in 2006. Similarly, ADF concentrations were not different between pastures in 2005 (P = 0.78) and 2007 (P = 0.07) but were greater (P < 0.01) in ARG pastures versus CHY pastures in 2006. This pasture × year interaction for ADF
likely contributed to the same interaction noted for IVDMD.

Pasture × date interactions were significant \((P \leq 0.01)\) for IVDMD, NDF, and ADF (Table 3). As expected going from early to late spring, forage IVDMD concentration decreased and NDF and ADF concentrations increased progressively for both ARG and CHY pastures. However, the magnitude of these changes differed between the pastures. Forage IVDMD and ADF concentrations were not different between ARG and CHY pastures in April and May but were lesser \((P < 0.01)\) and greater \((P < 0.01)\), respectively, in ARG compared with CHY pastures by June. Forage NDF concentrations were greater \((P < 0.01)\) in ARG than CHY pastures in all these months. Parish (2006) further observed a decrease in IVDMD concentration from spring to summer in the first year, but no differences were noted between these seasons in the second year.

A pasture × date × year interaction \((P < 0.01)\) was present for CP concentration (Table 4). Forage CP concentration was greater \((P < 0.05)\) in CHY than ARG pastures on 6 out of the 9 sampling date and year combinations, including all the June dates (Table 4). The difference in least squares means revealed a nutritive value advantage for CHY as large as 11.3% CP in June 2006 and was noticeably large in other months as well. Had May precipitation been closer to the 30-yr means in 2005 and 2007 instead of being relatively droughty, the large CP difference observed in June 2006 might have been seen in these other years. Jung et al. (1996) reported that chicory maturity and CP concentration are inversely related. Parish (2006) suggested that the high CP concentration of chicory could

### Table 1. Temperature and precipitation at the experimental site during the period in which the grazing experiment was conducted

<table>
<thead>
<tr>
<th>Month</th>
<th>Mean temperature, °C</th>
<th>Precipitation, cm</th>
</tr>
</thead>
<tbody>
<tr>
<td>September</td>
<td>21.1</td>
<td>22.2</td>
</tr>
<tr>
<td>October</td>
<td>18.0</td>
<td>13.4</td>
</tr>
<tr>
<td>November</td>
<td>12.6</td>
<td>11.2</td>
</tr>
<tr>
<td>December</td>
<td>4.0</td>
<td>3.0</td>
</tr>
<tr>
<td>January</td>
<td>6.5</td>
<td>7.7</td>
</tr>
<tr>
<td>February</td>
<td>7.1</td>
<td>3.7</td>
</tr>
<tr>
<td>March</td>
<td>8.8</td>
<td>10.7</td>
</tr>
<tr>
<td>April</td>
<td>14.6</td>
<td>18.5</td>
</tr>
<tr>
<td>May</td>
<td>18.0</td>
<td>20.3</td>
</tr>
<tr>
<td>June</td>
<td>23.4</td>
<td>23.8</td>
</tr>
<tr>
<td>July</td>
<td>25.3</td>
<td>26.5</td>
</tr>
<tr>
<td>August</td>
<td>26.4</td>
<td>27.3</td>
</tr>
</tbody>
</table>

\(^1\)Average monthly climatological data at the experimental site (National Climatic Data Center, Holly Springs, MS).

\(^2\)Data for 30-yr means are from 1971 through 2000.

### Table 2. Mean paddock forage IVDMD, NDF, and ADF as affected by forage genera and grazing year

<table>
<thead>
<tr>
<th>Item, %</th>
<th>Treatment(^1),(^2)</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>SEM</th>
<th>Pasture</th>
<th>Year</th>
<th>Pasture × year</th>
</tr>
</thead>
<tbody>
<tr>
<td>IVDMD</td>
<td>ARG</td>
<td>CHY</td>
<td>ARG</td>
<td>CHY</td>
<td>ARG</td>
<td>CHY</td>
<td>SEM</td>
<td>Pasture</td>
</tr>
<tr>
<td>65.8(^a)</td>
<td>66.6(^a)</td>
<td>66.3(^b)</td>
<td>73.3(^a)</td>
<td>72.2(^a)</td>
<td>74.6(^a)</td>
<td>1.1</td>
<td>0.01</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>NDF</td>
<td>52.5</td>
<td>39.6</td>
<td>57.0</td>
<td>40.0</td>
<td>57.1</td>
<td>41.8</td>
<td>0.9</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>ADF</td>
<td>28.6(^a)</td>
<td>28.3(^b)</td>
<td>30.6(^a)</td>
<td>25.5(^b)</td>
<td>30.4(^a)</td>
<td>28.6(^a)</td>
<td>0.6</td>
<td>&lt;0.01</td>
</tr>
</tbody>
</table>

\(^a\)Within a row, means without a common superscript letter differ \((P < 0.05)\).

\(^1\)Year: Grazing years were April 15 to June 10, 2005; April 13 to June 8, 2006; and April 11 to June 6, 2007.

Chicory versus annual ryegrass for beef steer grazing

make chicory an excellent grazing protein supplement for cattle during the summer and autumn months when the CP concentrations of warm-season grasses are typically low. Thus, results from the present experiment indicate that in addition to chicory being a good source of CP for grazing livestock during summer and autumn, it is also an excellent CP source during spring and is comparable with or better than annual ryegrass in terms of CP concentration during spring. This is important because most stocker cattle grazing acreage during spring in Mississippi currently use annual ryegrass.

The results of this experiment confirm what others have reported, namely, that chicory is a high-quality forage (Jung et al., 1996; Kusmartono et al., 1996; Neel et al., 2002). The high CP of chicory may be attributed to the high uptake of N from the soil (Neel et al., 2002). The lesser ADF and NDF and increased IVDMD of chicory likely result from the high ratio of readily fermentable carbohydrates to structural carbohydrates, and low silica content (Kusmartono et al., 1997).

Although other direct comparisons of chicory and annual ryegrass were not found, information is available on the nutritive value of chicory compared with other winter-annual grasses. Chicory had lower NDF and greater CP in spring than the cereal grains, wheat (Triticum aestivum L.), triticale (Triticum × secale), and oats (Avena sativa L.; Fulkerson et al., 2008). In addition, the ADF content of chicory during spring was less than that of oats but was greater than those of triticale and wheat. In comparisons with cool-season perennial forages, chicory also tended to have less fiber and greater CP content. Collins and McCoy (1997) reported that chicory had higher IVDMD values than tall fescue [Lolium arundinaceum (Schreb.) S. J. Darbyshire]. Holden et al. (2000) found that chicory contained less NDF and ADF than orchardgrass (Dactylis glomerata L.). Other experiments reported that chicory contained less NDF and more CP than monocultures of perennial ryegrass (Lolium perenne L.; Sun et al., 2011) or mixed swards of perennial ryegrass and white clover (Trifolium repens L.; Athanasiadou et al., 2007; Nielsen et al., 2009). The results are not as clear for ADF content.

### Table 3. Mean paddock forage IVDMD, NDF, and ADF as affected by forage genera and date within the grazing period

<table>
<thead>
<tr>
<th>Item, %</th>
<th>Treatment</th>
<th>Date</th>
<th>Pasture</th>
<th>Date × Pasture</th>
<th>SEM</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>April</td>
<td>May</td>
<td>June</td>
<td>April</td>
<td>May</td>
<td>June</td>
</tr>
<tr>
<td>IVDMD</td>
<td>ARG</td>
<td>CHY</td>
<td>ARG</td>
<td>CHY</td>
<td>ARG</td>
<td>CHY</td>
</tr>
<tr>
<td></td>
<td>79.1a</td>
<td>79.9a</td>
<td>70.7b</td>
<td>69.6c</td>
<td>54.6d</td>
<td>65.0f</td>
</tr>
<tr>
<td>NDF</td>
<td>48.2c</td>
<td>39.2d</td>
<td>53.1b</td>
<td>39.9e</td>
<td>65.2a</td>
<td>42.2d</td>
</tr>
<tr>
<td>ADF</td>
<td>25.1d</td>
<td>25.1d</td>
<td>29.3c</td>
<td>27.4d</td>
<td>35.1a</td>
<td>29.9d</td>
</tr>
</tbody>
</table>

a–eWithin a row, means without a common superscript letter differ (P < 0.05).

1Date: Collection dates were April (April 15, 2005; April 13, 2006; and April 11, 2007), May (May 13, 2005; May 11, 2006; and May 9, 2007), and June (June 10, 2005; June 8, 2006; and June 6, 2007).


### Table 4. Mean paddock forage CP (%) as affected by forage genera, grazing year, and date within the grazing period

<table>
<thead>
<tr>
<th>Year</th>
<th>Treatment</th>
<th>Date</th>
<th>Pasture</th>
<th>Date × Year</th>
<th>SEM</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ARG</td>
<td>CHY</td>
<td>ARG</td>
<td>CHY</td>
<td>ARG</td>
<td>CHY</td>
</tr>
<tr>
<td></td>
<td>April</td>
<td>May</td>
<td>June</td>
<td>April</td>
<td>May</td>
<td>June</td>
</tr>
<tr>
<td>2005</td>
<td>14.9g</td>
<td>16.0h</td>
<td>16.5h</td>
<td>24.3e</td>
<td>14.7g</td>
<td>20.3hde</td>
</tr>
<tr>
<td>2006</td>
<td>13.0g</td>
<td>22.3h</td>
<td>17.6g</td>
<td>20.0d</td>
<td>11.2</td>
<td>22.5e</td>
</tr>
<tr>
<td>2007</td>
<td>17.4h</td>
<td>23.3h</td>
<td>20.9h</td>
<td>20.2d</td>
<td>12.0</td>
<td>16.8h</td>
</tr>
</tbody>
</table>

a–iMeans without a common superscript letter differ (P < 0.05).

1Year: Grazing years were April 15 to June 10, 2005; April 13 to June 8, 2006; and April 11 to June 6, 2007.

2Date: Collection dates were April (April 15, 2005; April 13, 2006; and April 11, 2007), May (May 13, 2005; May 11, 2006; and May 9, 2007), and June (June 10, 2005; June 8, 2006; and June 6, 2007).


4Pasture × date × year: P < 0.01; SEM = 1.3.
Nielsen et al. (2009) reported both greater and similar ADF content in chicory relative to mixed swards of perennial ryegrass and white clover. Likewise, Athanasiadou et al. (2007) reported the ADF content of chicory was greater than that of a mixture of perennial ryegrass and white clover in spring but less in summer. Yet Sun et al. (2011) noted lower ADF content in chicory compared with perennial ryegrass and white clover in 2011. This fact, along with the relatively droughty conditions experienced in the spring of 2006 and spring of 2007, helps explain the progressively reduced stocking rates supported by the pastures in this experiment over the 3 yr. This suggests that there is room for further improvement in chicory breeding and selection for the environment of the US Southeast.

**Herbage Mass**

Chicory stands were visually estimated at 95% throughout the duration of the experiment, consistent with the findings of Parish (2006). A pasture × year interaction (P < 0.01) was present for mean herbage mass (Table 5). In 2005, mean herbage mass was greater (P < 0.01) on CHY than ARG pastures. However, this trend was reversed in 2006 and 2007, with the herbage mass being greatest (P < 0.01) on the ARG pastures. Herbage mass increased from 2005 to 2006 (P < 0.01) and then again from 2006 to 2007 (P < 0.01) for ARG and from 2006 to 2007 for CHY (P < 0.01). The different growth rates and maturities between the 2 forages could explain this finding.

A year × grazing period interaction (P < 0.01) was observed for mean herbage mass (Table 6). In 2005, mean herbage mass was not different (P = 0.53) between grazing periods. However, in 2006 and 2007, mean herbage mass was greater (P < 0.01) from d 0 to 28 than from d 28 to 56. The relatively droughty conditions experienced during the spring of 2006 and the spring of 2007 may have contributed to this interaction.

**Mean Stocking Rate**

No interactions (P > 0.12) were detected for mean stocking rate, but a year effect (P < 0.01) was present (Tables 5 and 6). Stocking rate was greatest in 2005 (1,562 ± 51 kg of BW/ha), intermediate in 2006 (1,372 ± 48 kg of BW/ha), and least in 2007 (1,149 ± 48 kg of BW/ha). As a short-lived perennial in the Southeast region of the United States, chicory stands may decline over time (Collins and McCoy, 1997; Hoveland and Durham, 1998; Ball, 2003). This fact, along with the relatively droughty conditions experienced in the spring of 2006 and spring of 2007, helps explain the progressively reduced stocking rates supported by the pastures in this experiment over the 3 yr. This suggests that there is room for further improvement in chicory breeding and selection for the environment of the US Southeast.

**Mean Forage Allowance**

A pasture × year interaction (P < 0.01) was found for mean forage allowance (Table 5). In 2005, mean forage allowance was greater (P < 0.03) on CHY than ARG pastures, but the relationship was reversed (P < 0.01) in both 2006 and 2007. Mean forage allowance increased (P < 0.01) from 2005 to 2006 and then again from 2006 to 2007 for ARG and from 2006 to 2007 for CHY. This followed the same trend observed for herbage mass, indicating that herbage mass changes over the course of the experiment contributed to the mean forage allowance pasture × year interaction.

A year × grazing period interaction (P < 0.01) was observed for mean forage allowance (Table 6). This interaction mirrored the same interaction for mean herbage mass. In 2005, mean forage allowance was not different (P = 0.50) between grazing periods. However, in 2006 and 2007, mean forage allowance was greater (P < 0.01) from d 0 to 28 than from d 28 to 56. Mean forage allowance values revealed that stocking rates were managed to achieve initial target ranges such that adequate forage allowance was provided to calves throughout the experiment so as not to limit their DMI (NRC, 1987). Redmon et al. (1995) defined the forage allowance at which or less than which it becomes limiting to calf growth as 20 to 24 kg of DM/100 kg of BW for cool-season grasses.

**Average Daily Gain**

As shown in Table 5, steer ADG was not different (P = 0.73) between pastures (ARG: 1.17 ± 0.03 kg; CHY: 1.16 ± 0.03 kg). These results are similar to those of research in New Zealand, where high BW gains were achieved in steers grazing monocultures of chicory (Fraser et al., 1988). Limited information is available on the performance of cattle grazing chicory in the United States. Much of what is available compares chicory grown in mixed swards with other forages (Sanderson et al., 2006; Soder et al., 2006). A forage finishing experiment using crossbred beef steers in South Carolina demonstrated greater ADG on chicory pastures compared with 2 warm-season forages, Bermuda grass ([Cynodon dactylon L.] and pearl millet [Pennisetum glaucum (L.) R. Br.] (Schmidt, 2009). The information presented here provides a basis for studying monocultures of chicory in relation to cool-season forages for cattle grazing performance in the United States in the future.

A significant year × grazing period interaction (P < 0.01) was observed for ADG (Table 6). Steer ADG was greater (P < 0.01) from d 0 to 28 than from d 28 to 56 in all years. This is not surprising, given the lower digestibility and increased fiber content of the forage as the grazing season progressed each year. The differences in least squares means showed an ADG advantage in the first 28-d grazing period of 0.60, 0.73, and 0.34 kg/d, in 2005, 2006, and 2007, respectively.

**Steer Body Weight Gain per Hectare**

As with ADG, steer BW gain per hectare was not different (P = 0.50) between pastures (ARG: 452 ± 14.8 kg/ha; CHY: 436 ± 15.5 kg/ha; Table 5). A year effect was detected (P < 0.01) for steer BW gain per hectare.
Steer BW gain per hectare was greatest ($P < 0.03$) in 2005 ($510 \pm 18$ kg/ha), intermediate in 2007 ($446 \pm 16$ kg/ha), and least ($P < 0.02$) in 2006 ($376 \pm 16$ kg/ha). The progressive decline in stocking rate over the course of the experimental years was likely a major determining factor in the year effect for steer BW gain per hectare.

It should be noted that this experiment compared ARG and CHY pastures in only a spring grazing period. Both forage genera provide adequate grazing for cattle during other months of the year (Parish, 2006). The ARG pastures can provide winter grazing, and the CHY pastures can be productively grazed in summer and autumn. Therefore, it may be worthwhile to compare the 2 forages for steer BW gain per hectare over the entire production year to better determine their usefulness as pasture in cattle production systems.

Although the greater nutritive value of chicory did not translate to better animal growth performance, the comparable growth rate of calves grazing CHY and ARG should be of interest to stocker operators and other cattle producers desiring forages to support high rates of animal BW gain. With ARG dominating much of the pastureland area planted to cool-season grazing in the Southeast region of the United States, finding a potential substitute for ARG in CHY could mean that potential exists for widespread adoption of this forage for cattle grazing. When these ADG results are combined with 1) the growth patterns of CHY allowing for summer grazing (Volesky, 1996), 2) the forage nutritive value advantages of CHY versus traditional warm-season forages (Parish, 2006), 3) the drought tolerance of CHY provided by a deep taproot on the plant (Barry, 1998), and 4) the fact that it is a perennial that does not require annual establishment, CHY may fit very well into cattle grazing systems.

**IMPLICATIONS**

These results indicate that chicory is a viable alternative to annual
ryegrass, producing comparable BW gains in stocker cattle during the spring. Forage chicory is also superior to annual ryegrass in CP content and has less NDF. Thus, chicory appears to be a high-quality perennial forage option for spring grazing of stocker calves in the Southeast region of the United States. Further studies are warranted to compare chicory with other forages commonly used in this region and during other times of the year in which it can be productively used as pasture.

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**LITERATURE CITED**


