Forage allowance and daily gain relationships on rye-ryegrass pastures at different stocking rates with continuous and rotational stocking

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Keywords
Cereal rye; annual ryegrass; rotational stocking; forage allowance; daily gain

Abstract
'Maton' cereal rye (*Secale cereale* L.) and 'TAM-90' annual ryegrass (*Lolium multiflorum* Lam.) are used for winter annual pastures to background stocker cattle in the southeastern US. Rye and ryegrass were sod-seeded into bermudagrass [*Cynodon dactylon* (L.) Pers.] pastures and fixed-stocked at different rates under continuous and 8-paddock rotation methods during each of 7 years to: 1) compare stocking methods for daily gain per animal (ADG) and gain/ha; and 2) quantify relationships of ADG with forage mass and forage allowance. Each of 3 levels of stocking rate, 4.9, 6.4, and 8.6 hd/ha, significantly affected ADG at 1.24, 1.04, and 0.74 kg/d, and gain/ha at 821, 991, and 794 kg/ha, respectively. There were no effects of stocking method on ADG at 1 kg/ha or gain/ha at 870 kg/ha. There was a 2-stage linear relationship for ADG and forage mass with the join point for maximum gain at 1850 kg/ha forage mass and 16 cm forage height. The 2-stage join point for forage allowance was 1.0 forage dry matter : animal body weight. The primary management strategy for rye + annual ryegrass pastures is that of stocking rate. During this 7-year period, stocker ADG ranged from 0.33 kg/d to 1.38 kg/d with gain/ha ranging from 388 kg/ha to 1291 kg/ha. Stocking strategies must be flexible with climatic changes to obtain optimum economic returns per unit land area. Rotational stocking method becomes a management choice to adjust forage mass options without expectations for increased ADG or gain/ha.

Introduction
The southeastern US has climatic conditions conducive for sod-seeding cool-season annual grasses and legumes into warm-season perennial grasses, such as bermudagrass, to extend the grazing season for cows and calves and/or backgrounding stocker cattle (Mullenix and Rouquette, 2018). Stocking strategies for cool-season annual forages such as cereal rye-ryegrass have been primarily concerned with stocking rate and secondarily with stocking method (Rouquette, 2015). Forage mass and forage allowance are the primary factors controlling gain per animal and gain per ha (Rouquette, 2016). A comprehensive review of 57 peer-reviewed papers showed no conclusive evidence for selection of stocking method (Sollenberger et al., 2012). In our stocking rate x stocking method research, we wanted to document the relationship of ADG with forage mass and forage allowance for rye-ryegrass, and to compare continuous stocking with an 8-paddock 2-day graze and 14-day rest system.

Methods
'Maton' cereal rye (*Secale cereale* L.) and 'TAM-90' annual ryegrass (*Lolium multiflorum* Lam.) were sod-seeded into bermudagrass [*Cynodon dactylon* (L.) Pers.] pastures at the Texas A&M AgriLife Research & Extension Center at Overton, TX (32º 17´ N, 94º 58´ W; elevation 147m) in the Pineywoods ecoregion. Winter-born steers and heifers were weaned in October and stocked on rye + ryegrass pastures (RRG) from December/January until May during 7 consecutive years. Rye was drill-seeded at 110 kg/ha and ryegrass broadcast at 33 kg/ha in the same operation. Four split applications of 226-22-48 kg/ha (N - P_2O_5- K_2O) was applied each year. Two to 3 stocking rates were used with 2 to 3 replicates each of continuous (CONT) and 8-paddock rotational (ROTN) stocking methods with 6 stockers per replicate

pasture (1 stocker = 250 kg). All ROTN pastures had a 2-d stocking residence and a 14-d rest period. Three steers and 3 heifers per replicate pasture were weighed on the same day at 28-d intervals. Forage mass was hand-clipped to ground level at time of pre- and post-stocking on ROTN paddocks and at 28-d intervals on CONT pastures. Forage allowance was calculated on a 28-d basis to align with weigh periods to document the relationship of forage dry matter (DM) : animal body weight (BW). Rouquette (2015) provided additional descriptions for using a series of monthly forage allowances that can be calculated for an entire grazing season. Sollenberger et al. (2005) suggested an approach for measuring forage allowance from both continuous and rotational stocking studies. That approach was incorporated in this 7-year study to represent forage allowance for each grazing season for this CONT and ROTN stocking study.

Statistical Analyses and Linear Plateau

Average daily gain (ADG) and gain/ha were analyzed via SAS PROC GLIMMIX (SAS 9.4; SAS Institute, Cary, NC.) with stocking rate, stocking method, and year as fixed, and replicates as random variables. Pastures were the experimental unit. The change in ADG relative to total forage mass or forage allowance was documented with a model in SAS PROC NLMIXED (SAS/STAT 15.1; SAS Institute, Cary, NC.) using a linear plateau model of ADG = $\mathbf{b_o} + \mathbf{b_1}$*X for X ≤ **a**, and ADG = $\mathbf{b_o}$ + **a***X for X > **a**, where ADG is average daily gain, $\mathbf{b_o}$ equals the intercept, $\mathbf{b_1}$ the slope, **x** the independent variable (forage mass or forage allowance) and **a** equals the join point where the slope response changes to a plateau. The intercept was forced to be equal to zero for biological reasons.

Results and Discussion

Table 1. Differences for stocking rate (SR) and stocking method (SM) on continuous vs rotational stocking of rye + ryegrass during 7 years.

	Average Daily Gain	Gain / Ha
Variable	**P Value**	
Stocking Rate	<.0001	0.0150
Stocking Method	0.7495	0.8762
SR x SM	0.6824	0.5840
Year	<.0001	0.0004

Table 2. Average daily gain (ADG) and gain per ha (Gain/Ha) from rye + ryegrass pastures stocked at three rates with continuous vs rotational stocking methods during 7 years.

	ADG		Gain/Ha	
Management Strategy	**kg/d**	**SE**	**kg/ha**	**SE**
Stocking Rate (animal/ha)†				
Low (4.9)	1.24 a*	0.042	821 b*	50.32
Medium (6.4)	1.04 b	0.048	991 a	60.97
High (8.6)	0.74 c	0.042	794 b	50.32
Stocking Method				
Continuous	1.02	0.040	873	46.26
Rotational	1.00	0.040	865	45.79

† One stocker = 250 kg bodyweight.

* Different letters within columns indicate a difference (P <0.01) between stocking rates

Stocking rate and year effects were significant factors affecting stocker ADG and gain/ha (Table 1). There were no effects on performance related to stocking method nor interactions of stocking rate and stocking method. Stocking rate decisions are the primary controlling factors for inputs and outputs of pasture-animal systems (Rouquette, 2015). Stocking rates of 4.9, 6.4, and 8.6 stockers per ha resulted in different ADG for each rate at 1.24, 1.04, and 0.74 kg/d, respectively (Table 2). Gain/ha was greatest at the medium stocking rate with 991 kg/ha and was similar for both low and high stocking rates at 821 and 794 kg/ha, respectively. The 7-year average performance for CONT and ROTN stocking method showed nearly identical ADG (1.02 and 1.00 kg/d) and gain/ha (873 and 865 kg/ha).

2 – plane linear plateau and join point

For every unit increase in total forage mass, ADG increased by 0.64 [0.55; 0.72] kg/d up to the join point of 1850 kg [1580; 2120] kg/ha (Fig. 1). The 95% confidence intervals shown in brackets reflect the inherent variability in the data during the 7 RRG growing seasons. For other cool season forages, Willoughby (1959) stocked sheep on *Phalaris sp* and subterranean clover (*Trifolium subterraneum* L.) and reported maximum ADG at 1568 kg/ha forage mass.

For every unit increase in total forage allowance, ADG increased by 1.34 [1.19; 1.50] kg/d up to the join point of 0.99 [0.79; 1.08] DM:BW and rounded to 1.0 (Fig 2). The 95% confidence intervals shown in brackets reflect the inherent variability in forage allowance data taken over 7 RRG seasons. Several stocking experiments on C-3 and C-4 forages have projected curvilinear vs linear relationships of ADG and forage mass and/or forage allowance. McCartor and Rouquette (1977) reported a 2-plane linear model with stockers grazing hybrid pearl millet [*Pennisetum typhoides* (Burm.) Stapf and E. C. Hubbard]. This C-4 forage produced a maximum ADG of 1.01 kg/d at the forage allowance join point of 3.31. With higher nutritive value C-3 forages, the join point would be expected to have lower values for forage allowance (DM: BW) such as 1.0 found in our 7-year study.

Figure 1. Forage mass and join point of rye + ryegrass for maximum daily gain (ADG) for 250kg stockers.

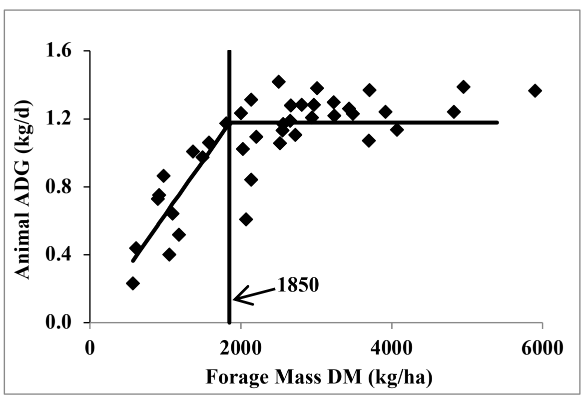
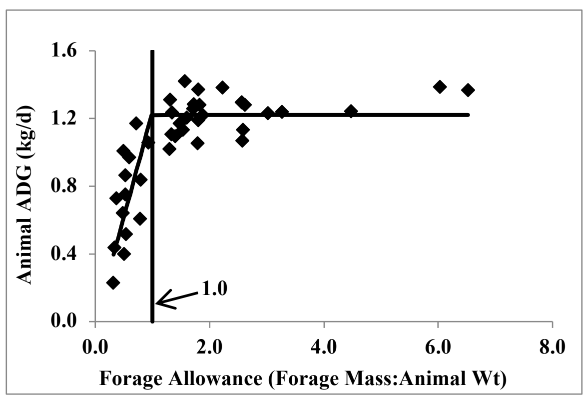


Figure 2. Forage allowance and join point of rye + ryegrass for maximum daily gain (ADG) for 250kg stockers.



Gain per animal vs gain per ha

Stocking rates and resultant ADG are controlled and determined primarily by management strategies and climatic conditions within a specific Hardiness Zone and Vegetation Region. Beck et al., (2013) summarized a 6-yr sod-seeded small grain experiment that showed maximum steer ADG of 1.24 kg/d. The relationship of ADG and gain/ha with stocking rates during our 7-year RRG study showed a linear decrease in ADG and curvilinear response in gain/ha (Fig 3). The 7-year average body weight growth of stockers stocked at three rates on RRG showed differences in growth rate and final body weight (Fig 4). Management strategies for stocking rate determine the economy of gain per unit land area and the value of stockers. Final body weights on our RRG pastures ranged from about 425 kg for low stocked to 325 kg for high stocked.

Figure 3. Relationship of average daily gain (ADG) with gain per ha at different stocking rates of 250kg stockers.

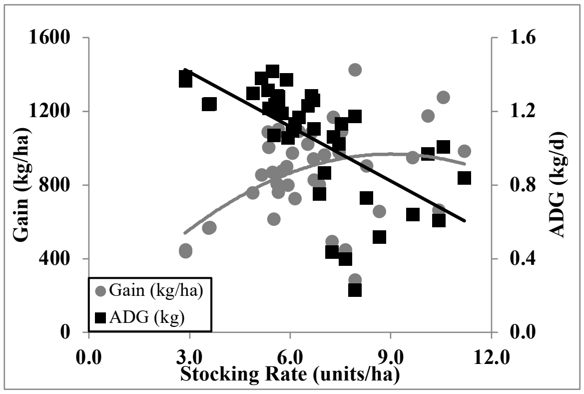
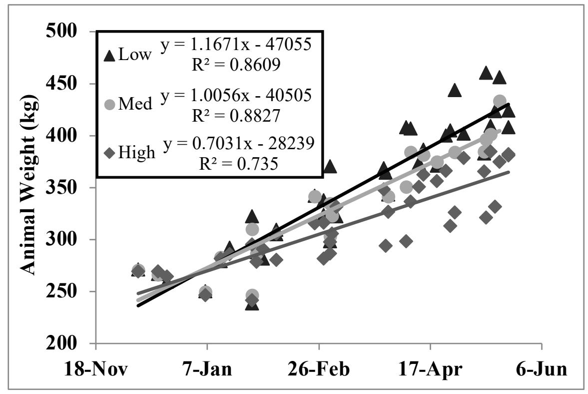


Figure 4. Average growth and body weight of steers and heifers stocked at three rates on rye + ryegrass.



Conclusions and Implications

Sod-seeded RRG pastures in the southeastern US offer excellent opportunities to background stocker cattle from weaning to feedlot entry with acceptable daily gains at stocking rates for positive economic returns. Stocking strategies should be directed more toward management for forage production and implementation of desired stocking rate rather than stocking method. Management for forage growth and mass during fall-winter-spring will allow for more successful opportunities for stocking rates to match the join point for optimum-maximum stocker performance. Rotational stocking using any rest-defer system may allow for desired utilization strategies; however, increased performance per animal or per unit land area would not likely be different than CONT stocking.

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