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Stocking Rates on Cultivated Winter Pastures for Meat Goats

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Summary

Cultivated cool-season pastures are needed to complement rangeland-based goat production in warmer regions of North America, but optimum stocking rates have yet to be determined. To address this question, growing Spanish X Boer doe kids (average 25 kg) were stocked at 0-12.5 head ha^{-1} from 14 January to 22 April 2002 (366 mm rainfall from October 2001 to April 2002) and 8 January to 23 April 2003 (494 mm rainfall over the same months) on cultivated pastures seeded with annual, cool-season grasses and legumes in north-central Texas, United States. Legumes comprised only 10 percent of the herbage and were less affected by stocking rates than were grasses. Grass biomass increased during the growing season and declined with stocking rate. Herbage fiber concentrations increased and N concentrations decreased with both grass and legume maturity and were not strongly affected by stocking rates. There was an inverse relationship between average daily gains per animal and per area, with the best gains (132 g) per animal at low stocking rates and greatest production (463 g) ha^{-1} at high stocking rates. Stocking rates indicated that herbage availability appeared to be a greater determinant to animal weight gain than did herbage nutritive value.

Key words: Forage Selectivity, Average Daily Gain, Silvopastoral, Cultivated Forages.

Introduction

There are numerous naturalized, self-reseeding annual cool-season legumes with proven adaptation to south-central United States (Diggs et al., 1999) whose productivity and stand regeneration from year-to-year (Muir et al., 2005) may be ideal components of cultivated pastures designed specifically for goats. Mixing well-adapted, self-reseeding native or naturalized grasses, such as *Bromus* spp. and *Lolium multiflorum* L., with self-reseeding legumes that have proven adaptation and nutritive value could benefit the mid-winter period during which rangeland-browse species are dormant. Goat selectivity in these pasture systems, both among species and plant parts, depends on many factors including climate, plant maturity and pasture management (Muir, 2003).

The ideal stocking rates for goats grazing winter-cultivated pastures in south-central North America, however, have not been studied. These stocking rates are important to modify inter-specific, annual-plant competition in pastures where self-reseeding in subsequent years is totally dependent on adequate seed production in late spring (Muir et al., 2005). Research has shown that increasing sward height (negatively correlated to stocking rate) benefits daily gain in kids (Osoro and Martinez, 1995). Lack of stocking- rate studies for cultivated, cool-season pasture systems for goats has managers dependent on data collected from cattle and sheep systems, for which a large body of animal performance vis-à-vis herbage availability exists (Wu and Rykiel, 1986), including complementary rangeland and improved pasture systems (Hart et al., 1988). Studies with sheep on Mediterranean-type pastures, for example, have shown that heavier stocking rates may favor persistence of palatable herbage species but undermine seed production, while lighter stocking rates may result in better animal performance (Ovalle et al., 1987) but also favor domination of more aggressive, less palatable grasses (Torres et al., 1987). The extent to which knowledge from cattle and sheep stocking trials can be transferred to goat production systems is not known. Discerning where the ideal balance between gain-per-animal versus gain-per-area will contribute to our understanding of cool-season pasture managed specifically for goats. The objective of this study was to compare daily gain in Boer X Spanish doe kids and per ha productivity of a mixture of cool-season, annual grasses and legumes at various stocking rates. A further objective was to determine pasture productivity and nutritive value under a range of stocking rates.

Materials and Methods

The trial was conducted at the Texas Agricultural Experiment Station in Stephenville, Texas (32° 13'N / 9° 12'W at 399 m elevation), on 3.2 ha exposed to full sun and 1.6 ha under a pecan orchard with a density of 68.5 trees ha^{-1}. This area was divided into 16 0.4-ha paddocks separated by 6-strand, electrified wire. The soil was a Windthorst fine, sandy loam (fine, mixed thermic Udic Paleustalf) with low phosphorus (10 mg kg^{-1} soil), low nitrate N (4 mg kg^{-1} soil), high K (316 mg kg^{-1} soil), and a pH of 6.4. Pasture planting in the autumn of both 2001 and 2002 was followed by introduction of the animals in January to allow adequate forage accumulation (14 January through 22 April in 2002; 8 January through 23 April in 2003). Animals were removed in April to allow the annual forage species an opportunity to set seed in May of each year. In both years, the pasture was lightly disced (but not completely tilled), seed was broadcast and seedbeds packed with a roller in late September or early October, depending on soil moisture. Arrowleaf clover (*Trifolium vesiculosum* cv. 'Yuchi'), button medic (*Medicago orbicularis* cv. 'Estes'), burr medic (*Medicago polymorpha* cv. 'Armadillo'), crimson clover (*Trifolium incarnatum* cv. 'Dixie'), and annual ryegrass (*Lolium multiflorum* cv. 'Tam90') were seeded, each at 20 percent of the recommended rate for pure stands (2, 2, 2, 6 and 8 kg seed ha^{-1}, respectively) after inoculation of the legumes with specific rhizobia. Bromes (*Bromus* spp.) and black medic (*Medicago lupulina*) germinated naturally in all pastures. Before the trial began, 85 kg P ha^{-1} was applied as triple-superphosphate to all pastures. Following germination, paddocks received 30 kg N ha^{-1}, a low fertilizer application rate meant to avoid making grasses too competitive with legumes.

Thirty-eight 5- to 7-month old Boer X Spanish cross doe kids averaging 25 kg were placed in the 16 paddocks at stocking rates of 5, 7.5, 10 and 12.5 goats ha^{-1}. Two replications of each treatment were placed in the open pasture and a third replication was placed in the pecan grove. Free-choice water and salt was available in each paddock. Precipitation from October to April was 91 percent of the 30-year average (402 mm) during 2001-2002 and 123 percent of the 30-year average in 2002-2003, affecting the duration of the grazing period each year and providing an ideal range in which to test stocking rates. Goats in each system were allowed at least five days before initial weighing to adapt to their respective paddocks and initial weight was used as a reference point to determine changes in subsequent weight. Following the adjustment period, individual goats were weighed at 28-day intervals and data obtained was used to estimate monthly and season-long average daily gain as g weight change per goat per day. Each paddock was considered an experimental unit and average daily gain was obtained per paddock and used in data analyses.

Forage biomass, nutrient concentrations and species composition for each paddock were estimated on a monthly basis by hand-clipping five 1 m^2 samples, cut at 5 cm above the soil surface, randomly taken along a diagonal transect in each pasture. Two permanent 5 by 5 m wire exclosures were placed in each paddock and 1 m^2 samples within each of these were taken at 28-day intervals as well. These exclosures were considered the zero stocking rate treatments (check) for forage data purposes and samples represented forage accumulation to date since a previously unharvested m^2 was used at each sampling date. Forage samples were separated into grass and legume components to provide an estimate of species composition and herbage components over time. All forage samples were dried at 55°C in a forced-air oven to a constant DM prior to final weighing. Forage sub-samples were then ground in a sheer mill through a 1-mm screen and batched by paddock, harvest period, and grass or legume for use in bromotological analyses.

Plant nutritive value measured as percentage of DM in these subsamples included acid detergent fiber (ADF), acid detergent lignin (lignin) and nitrogen [N; these values can be converted to crude protein (CP) by multiplying by 6.25;

A.O.A.C., 1990]. Total N concentrations were measured by using a modification of the aluminum block digestion procedure of Gallaher et al. (1975). Sample weight was 1.0 g, digest used was 5 g of 33:1:1 K_2SO_4:$CuSO_4$:TiO_2 and digestion was conducted for 2 h at 400° C using 17 ml of H_2SO_4. Nitrogen concentration in the digestate was determined by semiautomated colorimetry (Hambleton, 1977) using a Technicon Autoanalyzer II (Technicon Industrial Systems, Tarrytown, New York). Lignin and ADF were estimated using a modified method as reported by Van Soest and Robertson (1980) and described by the A.O.A.C. (1990).

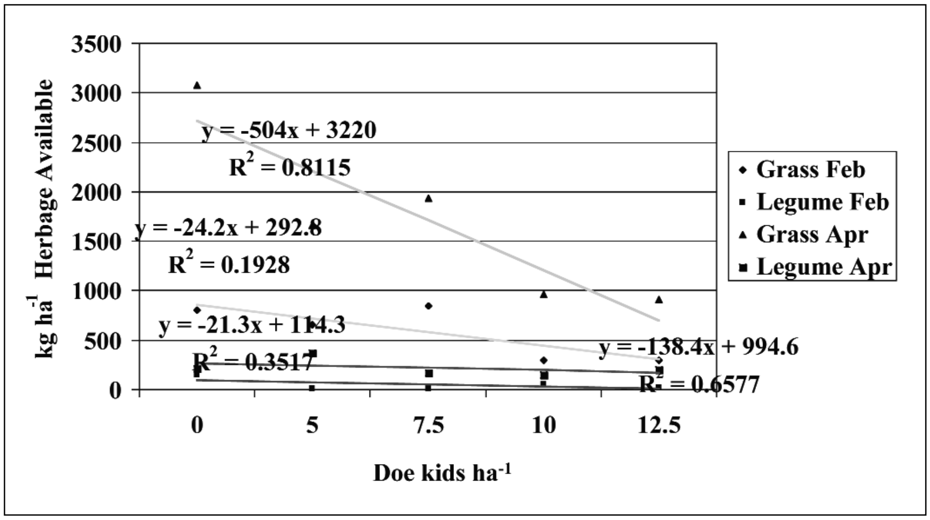
The mathematical model included fixed effects due to stocking rates and years with three replications arranged in a completely randomized, block design to exclude potential variability due to soils. Animal daily gain, herbage on offer, and forage ADF, lignin and N concentrations were submitted to analysis of variance, as well as best fit correlation with the treatment levels. Differences among means were based on a least significant difference considered significant at 0.05 or less (SAS Institute, 1991).

Results and Discussion

The relative effect of stocking rate on herbage availability and daily gain was similar between years ($P > 0.05$), despite the large differences in rainfall, and were therefore pooled over years. This was also true for the herbage fiber components and N concentrations, indicating that the 91 percent to 123 percent variation in 30-year average rainfall did not change relationships among stocking rates. No differences were measured between paddocks with and without trees ($P > 0.05$), so these values were also pooled.

Perhaps because of low plant populations, especially in 2002, there was no ($P > 0.05$) correlation between legume herbage biomass and stocking rates (Figure 1). Njwe et al. (1995), using a tropical pasture, determined that goats selected legume over grass, a finding the present study cannot confirm since legume biomass never exceeded 200 kg ha^{-1} in any samples. Previous research in north-central Texas determined goats tend to favor grasses early in the cool season but, as grasses matured, favored legumes (Muir, 2003). In the present study, doe kids at the heavier stocking rates eliminated nearly all legume herbage in February and March with only a slight recovery in April. These plant populations would likely not be sustainable without prior soil seed bank buildup, similar to those reported for burr medic by Muir et al. (2005).

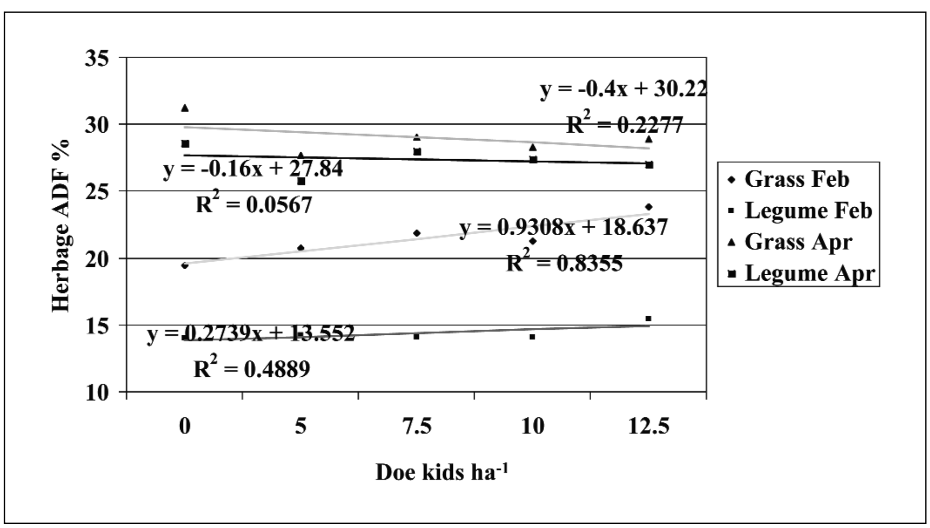
Figure 1. February and April herbage available to doe kids in pastures stocked at 0-12.5 kids ha^{-1} at Stephenville, TX (pooled over two seasons; grass $P < 0.05$ both months; legume $P > 0.05$ both months).



Grass herbage biomass showed a stronger negative correlation ($P < 0.05$) to stocking rate (Figure 1). Grass biomass in exclosures started near 800 kg ha^{-1} in February and rose steadily to approximately 3000 kg ha^{-1} in April. The two heaviest stocking rates reduced this biomass over 60 percent in February, after only one month of grazing, and further reduced it to over 70 percent in April after three months of continuous stocking at either 10 or 12.5 doe kids ha^{-1}.

Correlations between stocking rates and legume herbage ADF (Figure 2) or lignin (Figure 3) concentrations were negligible ($P > 0.05$), indicating that doe kids were not selecting for or against these components. Njwe et al. (1995), examining neutral detergent fiber in tropical legumes, reported similar results. In the present study, legume ADF for all treatments was approximately 15 percent in February, increasing gradually to over 25 percent in April as plants matured. Increases in lignin concentration were more gradual from February to March

Figure 2. February and April herbage acid detergent fiber (ADF) in paddocks stocked at five different rates (pooled over two years; grass $P > 0.05$ both months; legume $P > 0.05$ both months).



(around 2.5 percent) but rose sharply as legumes entered reproductive stages, reaching nearly 4.5 percent for plants sampled in exclosures during April.

Grass herbage ADF (Figure 2) and lignin (Figure 3) concentrations were positively correlated ($P < 0.05$) to stocking rate even after only one month of grazing. In subsequent months, both fiber components had weak negative correlations to stocking rates, a reflection of grass maturation in exclosures and regrowth following grazing in the paddocks. Relative to the legumes, grass ADF was generally greater while lignin was either similar or, by the end of the season, less concentrated.

Paralleling the findings of Njwe et al. (1995) in a tropical pasture, no relation ($P > 0.05$) between stocking rates and legume herbage N concentration was detected (Figure 4). From February to March, little change in N concentration occurred, but average values during these months (generally over 3.5 percent or the equivalent of 22 percent CP) declined to 2.5 percent in plants protected from grazing in April.

Grass N concentrations were fairly high when rate of fertilizer applied was low (Figure 4). February values around 3.0 percent (approximately 19 percent CP equivalent) reflect young, growing plants. These values remained fairly stable for heavily stocked paddocks through March but declined in the ungrazed exclosures ($P < 0.05$), especially by April when concentrations reached as low as 1.7 percent. An analysis of April grass N concentrations indicated that only grass in paddocks stocked at 10 and 12.5 goats ha^{-1} had greater concentrations than the exclosures and that grass N concentrations were much greater in 2002 than in 2003.

Daily gain at the lowest stocking rate exceeded 130 g day^{-1} and was greater than the two heaviest stocking rates (Figure 5). There was a strong quadratic relationship ($P< 0.05$) between stocking rate and doe ADG (Figure 6) although more stocking rates, especially on the high end, are needed to confirm this trend. Herbage biomass (Figure 1) would indicate that these greater gains were due to greater herbage availability at the lower stocking rate which allowed for greater goat selectivity, in agreement with Osoro and Martinez (1995) that greater sward height improves kid gains. These results contrast with other trials in which goat performance was not affected by 15 to 26 stocking units ha^{-1} on temperate pastures (Thomson and Power, 1993). However, sheep-stocking-rate studies of 1.0 to 4.0 ewes ha^{-1} show that animal performance suffers if stocking rates exceed sustainable carrying capacity (Ovalle et al., 1987).

Figure 3. February and April herbage lignin concentration in paddocks stocked at five different rates (pooled over two years; grass $P \leq 0.05$ both months; legume $P > 0.05$ both months).

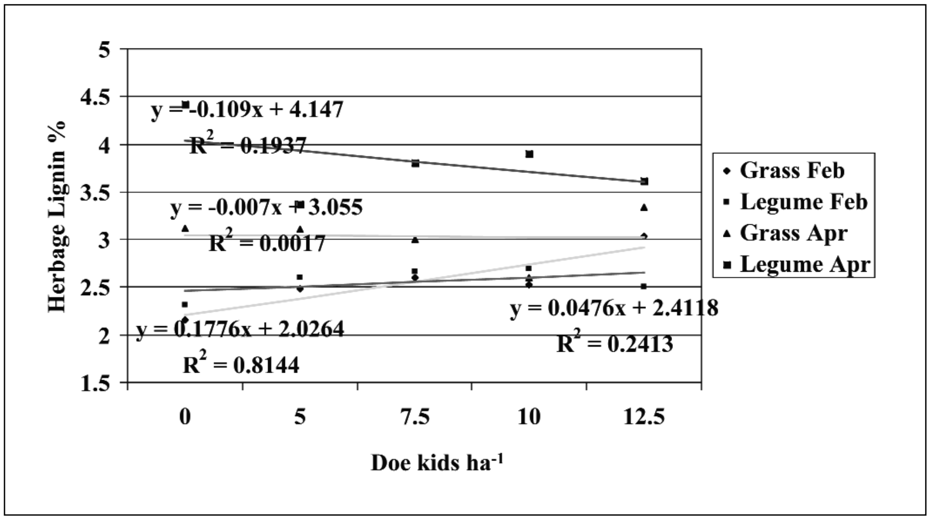
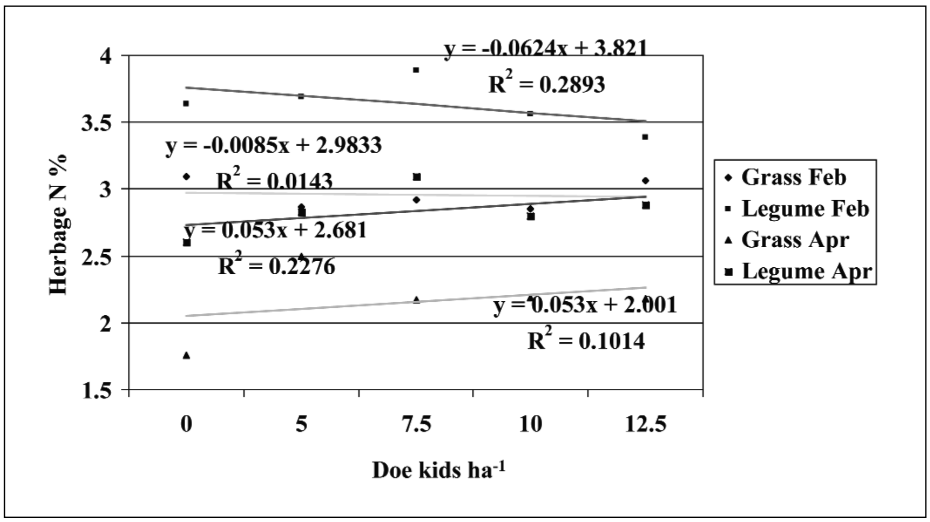


Figure 4. February and April herbage N concentration in paddocks stocked at five different rates (pooled over two years; grass $P > 0.05$ both months; legume $P > 0.05$ both months).



Late in the trial period, herbage fiber (Figures 2 and 3) and N (Figure 4) concentrations across stocking rates increased or remained stable, so the greater animal performance at the lower stocking rates cannot be explained by superior, total-plant, herbage-nutritive value. Analysis of hand-plucked samples or doe-ingested material would provide clearer indications of this, since forage in this trial was clipped to include stems that goats do not normally ingest. Daily-gain trend lines over time and pooled for both years (Figure 7) parallel herbage availability, confirming that herbage quantity rather than total-plant nutritive value was likely the principal factor determining weight gains in the does. Greater biomass at lower stocking rates may have allowed greater selectivity or reduced grazing effort (canopy density) by the goats, as has been shown in cattle and sheep (Torres et al., 1987) and in goat hay trials (da Silva et al., 1999). There is some indication, however, that canopy height does not always affect apparent intake rates in goats despite a decrease in bite mass as canopy heights

Figure 5. Winter pasture average daily gain (ADG) per animal and per area stocked at 5, 7.5, 10 or 12.5 doe kids ha^{-1} pooled over two seasons. Columns within groupings headed by different letters differ (P < 0.05) according to Least Significant Difference Separation Test.

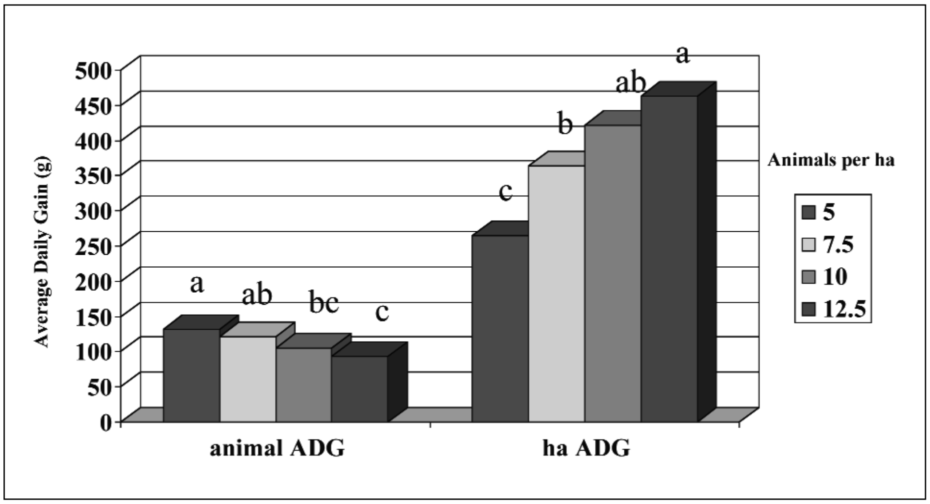


Figure 6. Average daily gains (ADG) of doe kids stocked at 5-12.5 head ha^{-1} on winter legume/grass pasture in north central Texas (pooled over two years).

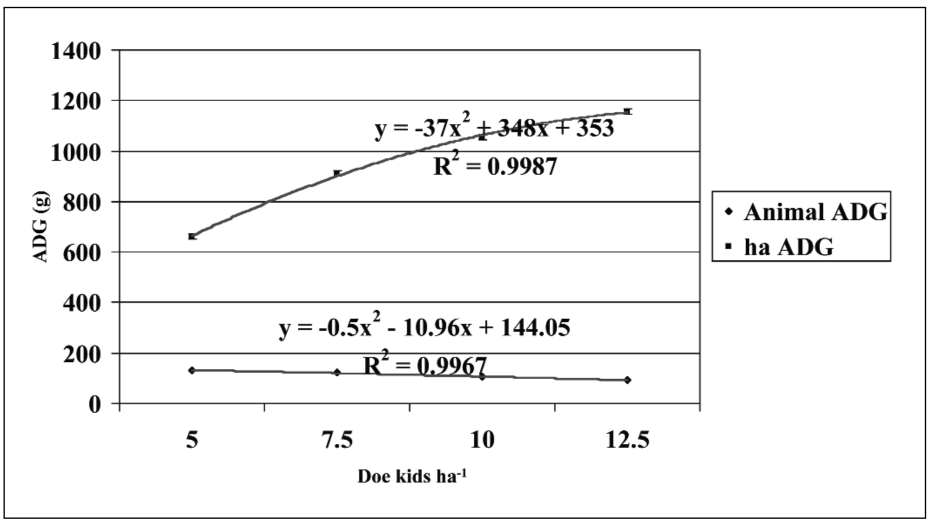
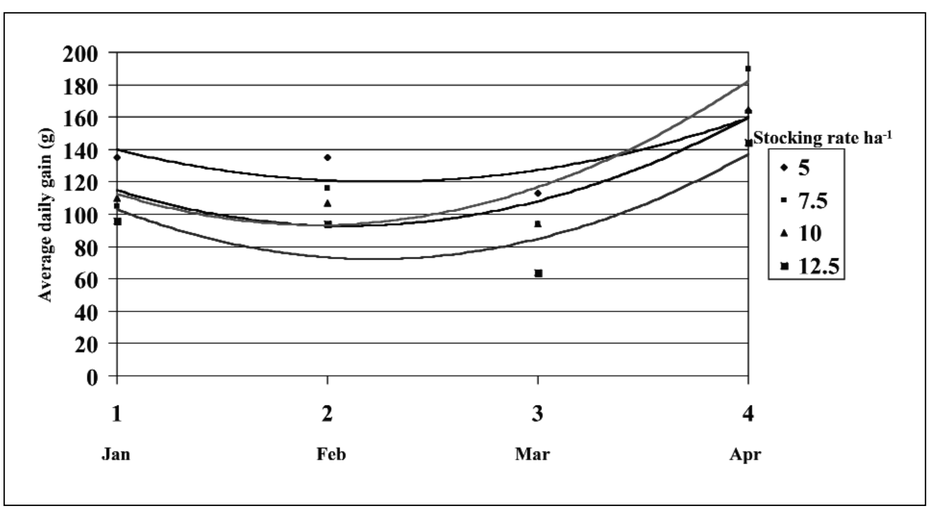


Figure 7. Trend lines of average daily gain (ADG) per animal stocked at 5, 7.5, 10 or 12.5 doe kids ha^{-1} (pooled over two years).



decrease (Concha and Nicol, 2000). Goat dietary (extrusa) neutral detergent fiber on tropical pastures can be independent of stocking rate, indicating goats will maintain selectivity at the expense of intake (Njwe et al., 1995).

Daily gains per area were greatest at the heavier stocking rates, over 450 g ha^{-1} day^{-1} at the 12.5 rate (Figure 5). These values were positively correlated to stocking rates, showing a close quadratic fit (Figure 6). Additional heavy stocking rates are needed to determine where peak-per-area productivity lies. Detrimental effects on plant seed production at stocking rates greater than the 12.5 ha^{-1} could affect long-term persistence of the pasture, although timing rather than stocking rate may be more important (Muir et al., 2005).

There was an obvious trade-off in daily gain per-animal versus per-area (Figure 5), much as has been observed for cattle and sheep in other studies (Peterson et al., 1965). A low stocking rate of 5 does ha^{-1} resulted in 43 percent greater gain/doe than the 12.5 doe ha^{-1} stocking rate. Conversely, the heavier stocking rate gave 75 percent greater gains/ha than the lightest stocking rate in the study. Long- and short-term animal production goals, favoring per animal or per area production, will determine which stocking rates should be applied. In addition, the effects of the various stocking rates on herbage seed set and subsequent stand persistence should also figure into management decisions. In drier regions, annual, self-reseeding grasses and forbs dominate cool-season, annual pastures and adequate seed set will determine seedling counts in subsequent seasons (Muir et al., 2005).

Conclusions

At the heaviest stocking rates, improved nutritive value of forage regrowth cannot compensate for the lack of herbage quantity that favors animal weight gains at low stocking rates and may also deleteriously affect reseeding potential of annual pasture species. The trade-off is that greater stocking rates produce greater doe kid gain per area, with further research needed to determine just how high stocking rates can go without negatively affecting both animal production and self-reseeding capabilities of these cultivated annual winter pastures.

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