# Monensin and mineral supplementation economically increase yearling cattle weight gain on California annual rangeland

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**ABSTRACT:** Stocker operators generally graze cattle on California annual rangelands from November to May. The profit margins of these operators is low as cattle sell for less per unit at the end of the season when compared with the beginning. This creates a need for methods to economically increase weight gain, which can help to mitigate market volatility. The use of monensin is common in much of the United States but has not been researched in the unique winter annual rangelands of California. Likewise, research that formally documents weight gain from the correction of selenium deficiency on these rangelands is also lacking. Trials were conducted over 2 years to determine weight gain differences with treatments of salt only (control), salt with monensin, mineral supplement, and mineral supplement with monensin. All three treatments increased weight gain by 12%, 9%, and 15% over feeding straight salt, respectively. It appears that selenium deficiency correction and supplemental monensin should be considered economical weight gain improvement tools for yearling cattle grazing California annual rangeland.

**Key words:** California annual rangeland, cattle, ionophore, monensin, selenium mineral, weight gain

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## INTRODUCTION

The annual rangeland of California uniquely produces forage from late fall through spring. This winter forage is frequently grazed by yearling cattle. These cattle are typically spring-born calves that are weaned in the fall and sold to stocker operators who graze them through the winter and spring. At the end of the green feed season (November–late May), stockers have reached a weight of approximately 380 kg. At this time, they are typically shipped to a feedlot to be finished on grain. It's estimated that over half a million of these weaned calves winter on the rainfed annual grasslands of California. The inverse price differential between weaned calves and the end of stocker phase contributes to narrow profit margins. Cattle marketed at the end of the yearling phase sell for 16% less on average when compared with per unit price at weaning (Saitone et al., 2016). The economic reality of growing cattle has stocker operators seeking opportunities to increase weight gain to help mitigate the economic volatility of the stocker phase.

Producers in other areas of the United States have improved cattle gains by feeding monensin. One Oklahoma study found cattle grazing wheat

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pasture had 0.08 kg/d higher gains when fed monensin with a pelleted supplement compared with animals fed the nonmonensin pelleted product (Horn et al., 1981). Subsequent winter wheat grazing trials found similar daily gain increases could be achieved with monensin fed through a mineral supplement (Fieser et al., 2007) and also provided evidence that mineral deficiency correction may also interact with monensin in increasing weight gain. Trials in California's summer-irrigated pasture showed a 16% increase in daily gain when cattle were supplemented barley with monensin (Hull et al., 1981). A meta-analysis of cattle mostly receiving a total mixed ration found a much lower daily gain increase of only 0.03 kg/d over control cattle (Duffield et al., 2012). To date, no trials have considered the use of monensin supplementation for cattle grazing California annual rangeland.

Previous work demonstrates the potential for the economical application of monensin in California. Yet these results cannot be extrapolated to the uniqueness of California's Mediterranean annual grasslands. This study addresses this research need and is the first conducted that establishes performance increases associated with the use of an ionophore on growing beef cattle pastured on annual grassland in California. Because previous work hints that mineral deficiency correction may have interactive effects with monensin in weight gain, the use of monensin with and without mineral supplementation is explored. The results provide an opportunity for stocker operators to evaluate the use of monensin and mineral supplementation as economic tools for added weight gain.

## MATERIALS AND METHODS

### *Site*

This project was conducted at the University of California Sierra Foothill Research and Extension Center. The facility is located near Browns Valley, CA, at an elevation of about 200 m. The climate is Mediterranean, characterized as having moist cool winters and hot dry summers. Mean average precipitation during the rainfall season is 99 cm (PRISM, 2019), generally occurring from October to May. Most of the forage is annual and typically grazed during the winter and spring when forage quality and quantity are adequate to meet the requirements of maintenance and growth for beef cattle.

### *Treatments*

Salt and a salt-based loose mineral supplement that included grain byproducts were used as carriers for monensin. Separate treatments that contained only mineral supplement and only salt without monensin were used to appropriate the variation of any potential gain differences attributed to mineral supplementation and not the monensin treatment. The addition of the mineral without monensin allowed evaluation of weight gain benefits of mineral deficient versus adequate cattle. The four treatments were a control ("salt"), salt with monensin ("salt+"), mineral only ("mineral"), and mineral with monensin ("mineral+").

The experiment was initiated in late December and ceased in late May both years. One hundred and forty weaned steer calves were randomly assigned to four treatments in 2017 and 2018. Steers averaged approximately 300 kg per head onto the trial both years. Cattle were stratified into four groups by weight, and treatments were randomly assigned to each group. Pastures were then randomly assigned to each treatment group. Cattle and their treatments moved four times throughout growing season so that each treatment spent roughly the same amount of time in each pasture to account for pasture and season effect (crossover design). Cattle were weighed five times each year. Weights were taken at the onset of the trial, quarterly, and at the end of the trial. Cattle were held off feed and water overnight prior to weighing.

Treatments were provided free choice in weatherproof feeders. Consumption was estimated by removing and weighing the residual product at the end of each quarter. The residual weight was subtracted from the amount provided to give a per head estimate of daily consumption. Blood samples to determine mineral levels were taken from a subset of the group each year at the beginning and conclusion of the trial each year.

The four pastures average about 46 hectares (114 acres) and are stocked at an average of 1.3 hectares/steer (3.25 acres/steer) for the grazing season.

### *Statistical Analysis*

To evaluate the contribution of mineral treatment to overall gain and average daily gain (ADG), we ran a multifactor analysis of variance including variables of mineral treatment, year (2017/2018), and their interaction. Likewise, mineral levels were run using treatment, year, and their interaction. The model for period ADGs included the variables pasture (4; Table 3), period (4; Table 3), mineral treatment, year, an interaction of period and year, and an interaction of pasture and year. The mineral treatments included salt (control), salt+, mineral, and mineral+. Least square means (LSM) and mean separation were conducted using Fisher's least significant difference

**Table 1.** Mean mineral, salt, and monensin consumption per day by treatment

| | 2017 | | 2018 | | Mean consumption | |
|---|---|---|---|---|---|---|
| | Product, g/d | Monensin, mg/d | Product, g/d | Monensin, mg/d | Product, g/d | Monensin, mg/d |
| Salt | 23 | 0 | 26 | 0 | 24.5 | 0 |
| Salt+* | 28 | 48 | 23 | 39 | 25.5 | 43 |
| Mineral | 147 | 0 | 117 | 0 | 132 | 0 |
| Mineral+[†] | 57 | 50 | 57 | 50 | 57 | 50 |

*Monensin in the salt treatment was added at 1.7 mg/g.
[†]Monensin in the mineral treatment was added at 0.88 mg/g.

**Table 2.** Least Square Means (LSM) for season and average daily gain (ADG) with cost by treatment

| Treatment | Total gain kg/d | ADG Kg/d | Mean cost/hd/season |
|---|---|---|---|
| Salt | 131a | 0.85a | $1.01 |
| Mineral | 144b | 0.94b | $16.28 |
| Salt+ | 148bc | 0.97bc | $2.02 |
| Mineral+ | 154c | 1.01c | $8.08 |

a,b,c $P < 0.05$.

procedure at the 0.05 level. All statistics were run using Statgraphics (StatPoint, 2009).

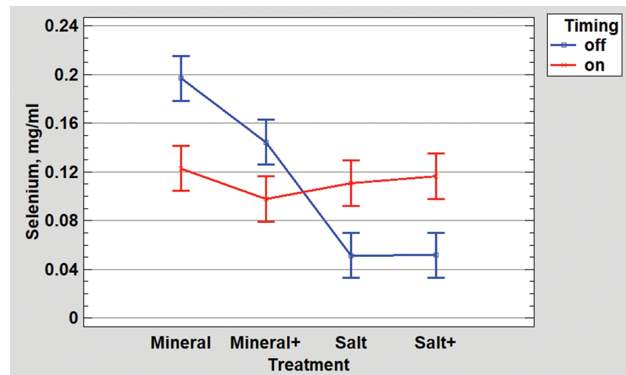


**Figure 1.** Whole blood selenium least significant differences by treatment on and off trial.

## RESULTS

The mineral and monensin treatments significantly affected overall ($P < 0.01$; Table 2) and total average daily steer gain ($P < 0.01$; Table 2). Over the season, the mineral+ treatment yielded 22 more kg of gain over the salt treatment and 10 kg over the mineral treatment. Though the mineral+ group gained 6 kg more than the salt+ treatment, the difference was not significant ($P > 0.05$) nor was the difference between the salt+ and mineral group ($P > 0.05$).

Year itself did not significantly affect total ($P = 0.08$) or ADG ($P = 0.55$) but its interaction with treatment did ($P = 0.01$, both). The only difference between years in gain was seen solely in the salt treatment, which had a 17-kg higher gain in 2018 than 2017. The other treatments were relatively uniform between years. It appears the ionophore and mineral treatments may have the potential to create more consistent gains compared with only feeding salt.

Mineral treatment did not affect copper ($P = 0.74$), only tended to affect zinc ($P = 0.06$), but did affect selenium ($P < 0.01$). Consumption (Table 1) may have affected zinc levels as the only difference seen was between the mineral and salt+ treatments (LSM 0.80 vs. 0.71 mg/ml, respectively), which also had the greatest spread in daily consumption. Selenium (Figure 1) shown to be the most limiting mineral and the most affected by supplementation. The two salt treatments that did not include a selenium supplement had significantly lowered levels after the growing season, while those supplemented increased over levels seen at trial initiation.

Period ADG was affected by mineral treatment ($P < 0.01$), pasture ($P < 0.01$), and period ($P < 0.01$) but not by year ($P = 0.08$). Both interactions of pasture and year ($P < 0.01$) as well as period and year ($P < 0.01$) were significant. The salt group had significantly lower period ADG than the other treatments, but differences between the other treatments were not evident. Probably, a larger sample size or more years would be needed to significantly separate their means.

The study design proved prudent due to the significant differences between period and pasture (Table 3). The latter two periods did not differ from each other, but produced nearly double the ADG of the earlier periods. A significant ADG difference occurred between the first two periods but the difference was small. As with season, pasture had two higher and equal performing pastures compared with the bottom two, with small differences seen between the lesser yielding pastures.

## DISCUSSION

This is the first formal research evaluating the weight gain potential of monensin for yearling

**Table 3.** Least square average daily gain (ADG) means by period (season) and pasture

| Period | ADG Kg/d | Pasture name | ADG kg/d |
|---|---|---|---|
| 1. December–January | 0.49a | Hawthorn | 0.76a |
| 2. February–March | 0.78b | Slicks | 0.84b |
| 4. April–May | 1.25c | Lower forbes | 1.10c |
| 3. March–April | 1.28c | Upper forbes | 1.12c |

cattle on California's Mediterranean annual rangeland. The results align with the meta-analysis findings of Duffield et al. (2012) who showed greater benefit of monensin when ADGs in control cattle were under 1.17 kg/d. In this trial, the LSM ADG of all cattle was below 1.17 kg/d over the entire growing season (Table 2), but was higher than this during the two March to May spring periods (1.25 and 1.28 kg/d; Table 3).

Potter et al. (1986) compiled 24 mostly summer pasture trials in 12 states and found a 16% mean increase in ADG by feeding monensin. In this trial cattle fed monensin through a mineral mix had a 16% increase in ADG over those fed solely salt (control). Those fed monensin through salt saw a 13% increase over those with salt and no ionophore. Though the Potter et al. (1986) forage sources were very different from California annual winter rangeland, their mean increase in ADG due to the addition of monensin was very similar. A mineral program that incorporates monensin appears to be an economical method of increasing weight gain in yearling cattle grazing California rangelands.

The difficulty in a rangeland setting is that consumption cannot be individually controlled, which Duffield et al. (2012) also found to be linear with increased weight gain. Use of a mineral mix allows an opportunity to add small amounts of distillers grain and rice bran to increase consumption, where straight salt is limited in intake. The inclusion of monensin reduced palatability, dropping consumption of the mineral+ treatment to 43% of the mineral consumption that lacked the ionophore (Table 1). This was not seen with straight salt. Still, the mineral+ group consumed more product and subsequently slightly more monensin (50 mg/d) than the salt+ group (43 mg/d), even though its concentration was less (0.88 vs. 1.7 mg/g, respectively). The slightly higher consumption may explain why gain differences of the mineral+, but not the salt+, were significantly higher than the mineral only cattle (Table 2). It is not definitive that a cumulative effect exists in including both mineral and monensin as no significant difference existed between the two ionophore treatments, but the mineral+ group did tend to be higher. Doses of both monensin treatments were relatively low compared with those recommended in other trials (200 mg/d; Kunkle et al., 2000) but were high enough to still have a significant response in weight gain.

The mineral most effected by supplementation, and a lack thereof, was selenium (Figure 1). Cattle not supplemented had levels drop below the critical level of 0.08 mg/ml (Davy et al., 2018), while supplemented cattle did not. Though the positive influence of adequate selenium in terms of immunity are well documented (Spears et al., 1986; Arthur et al., 2003), recent work on California summer-irrigated pasture has not yielded a difference in weight gain between selenium deficient and adequate yearling cattle (Davy et al., 2016). In this trial, yearling cattle on dryland range that attained adequate selenium through a mineral supplement alone outgained deficient control (salt only) cattle by 10%. It is not understood why differences in gain based on supplementation are seen in cattle on winter annual range when they were not seen for cattle on summer-irrigated pasture, but additional gains in cattle grazing winter annual California rangeland have been seen previously in less formal trials (Johnson et al., 1979; Nelson and Miller, 1987). The results indicate that selenium deficiency correction should be considered a practice that not only enhances immune response but may also increase weight gain for cattle grazing California's foothill annual rangelands.

The inclusion of low-dose monensin and a correction of selenium deficiency appear to have the positive effect of increasing weight gain in yearling cattle grazing annual rangeland by a mean of 15% over feeding salt alone. This was at an added cost of \$7.07/head/season or \$0.31/kg (Table 2). The inclusion of monensin in salt increased gains by roughly 12% at a cost of \$0.06/kg over feeding salt alone, which was the most economical treatment. Though higher in cost, the inclusion of mineral supplementation with monensin is potentially beneficial beyond weight gain due to the improved immune response of cattle with adequate selenium (Nicholson et al., 1993; Salles et al., 2014). Although costs may vary, it appears that the inclusion of monensin in either mineral or salt is likely an economical practice for stocker operators on California annual rangelands. Alternatively, if operator's marketing programs do not allow the inclusion of monensin in cattle diets, correction of selenium through mineral supplementation increased gains by 9% over feeding salt alone at a cost of \$1.17/kg, which still appeared to be an economical practice.

Feeding monensin through either a mineral mix or straight salt does create an opportunity for increasing ADG, with the salt-based mix being the lesser cost option. Despite higher cost, including monensin in a mineral mix allows for the added benefits of manipulation of ingredients to influence consumption as straight salt appears relatively constant in intake, at the same time, providing the potential to correct mineral deficiency when necessary. Future studies that incorporate higher doses of monensin would be beneficial in determining the applicability and economic benefits on California's winter annual rangeland.

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