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Evaluation of a positive conditioning technique for influencing big sagebrush (*Artemisia tridentata* subspp. *wyomingensis*) consumption by goats

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Abstract

Diets of angora goats (*Capra hircus*) positively conditioned to eat big sagebrush (*Artemisia tridentata* subspp. *wyomingensis*) were contrasted with control groups to assess the effects of positive conditioning. Goats were conditioned by including ever-increasing amounts of sagebrush in the daily ration, to a maximum of 25% by weight as fed. Conditioning effects were evaluated by comparing relative consumption of big sagebrush in a rangeland setting. Field trials were conducted at the Squaw Butte Experimental Range, a shrub steppe rangeland in eastern Oregon. Our results indicate that neither conditioned does nor kids had significantly different intake of sagebrush when compared with control animals. Young animals consumed shrub species sooner than adults and ate significantly more shrubs throughout all seasons until the second summer when diets did not differ between age groups.

Keywords: Goat; Diet selection; Sagebrush; Learning; Positive conditioning

1. Introduction

Relationships between grazing animals and the forage they consume are often difficult to quantify. Some interrelated factors include: plants present, relative availability of plants, plant phenology, herbivore body size, rumen volume-to-

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body ratio, mouth size, and behavioral components related to the ecological hierarchy of the area (Hanley, 1982; Senft et al., 1987). In spite of the complexity, knowledge of dietary traits and behaviors can be extremely useful for accomplishing specific management objectives. One objective that is likely to be increasingly beneficial in rangeland settings is to modify plant communities by controlled livestock grazing.

The psychology of animal learning can be a valuable resource for ecologists interested in the potential roles of learning and memory in foraging behavior (Kamil, 1983). In particular, it is possible that through manipulation of dietary experience, a manager may create a foraging group better suited to specific management goals. Young livestock might be trained to increase consumption of less palatable and weedy species, ultimately increasing the value and decreasing the abundance of plants normally considered undesirable. Of particular interest to this study are the possibilities that exist for manipulating vegetation on sagebrush–bunchgrass rangelands, to improve the ecological status of areas in less than optimal condition.

To forage effectively, animals must acquire information about resources through learning. Learning may serve to adapt herbivores to forages available within their environment, and may help to counter physical and chemical defenses of plants. Manipulation of learning might make diet training possible (Provenza and Balph, 1987). Diet training in this sense is the manipulation of livestock foraging behavior to meet a management objective (Provenza and Balph, 1987).

It is believed that dietary learning is most pronounced early in life and that there may be a sensitive period that coincides with weaning, when learning is most efficient (Provenza and Balph, 1987). The most favorable learning period is generally considered to be early in the individual's life, while the young animal is still a member of the family group (Immelman, 1975). Only a few studies have looked qualitatively at age and its relation to learning (Arnold and Maller, 1977; Squibb et al., 1987; Ortega-Reyes and Provenza, 1993).

Whereas the vast majority of diet conditioning studies have focused on aversive conditioning methods (Zahorik and Houpt, 1981; Kamil and Yoerg, 1982; Braverman and Bronstein, 1985; Burritt and Provenza, 1989), positive or motivational conditioning remains relatively unexplored. Our objective for this research was to examine how diet training through the use of positive or motivational conditioning affects future consumption of plant species to which the animals have been positively conditioned.

This research evaluated the effects of pre-conditioning mature, pregnant angora does to a diet that included ever-increasing amounts of sagebrush. After parturition their kids were also exposed to sagebrush. Effects of that diet learning experience were expressed by the relative amounts of sagebrush later consumed by both does and kids under free-ranging conditions.

Dietary habits of adults are apparently more stable than those of young herbivores (Provenza and Balph, 1988). This leads to an interesting question. Once a group of animals is trained for a specific management purpose, will that training persist, build upon itself and provide a framework for future generations to learn

from their familial social group and facilitate farther adaptation to that setting, or is the effect transient?

As very little goat research has focused specifically on the sagebrush–bunchgrass system, we investigated what role these animals might have in management of problem shrubs, and in particular, if diet training may give goats the incentive and experience to utilize sagebrush forage significantly.

2. Animals, materials and methods

2.1. Animals

Thirty (30) mature female angora goats, ranging from 3 to 10 years of age, were bred beginning 15 September 1989. The animals were housed at Oregon State University for 8 months, undergoing breeding, pre-conditioning and kidding. The does were randomly assigned to either the treatment or control group shortly after breeding. Both groups were fed a diet of high-quality alfalfa hay and grain supplement (as required), but the treatment feed included sagebrush. The groups were kept in separate paddocks to avoid social interactions during the conditioning period and throughout the range field trials.

2.2. Conditioning

Before feeding, the sagebrush had been harvested and quickly frozen to preserve the volatile oil component. It was presented to the goats after being ground through a shredder–mulcher and mixed with their hay. The sagebrush component was gradually increased throughout the 226 day preconditioning period (15 November 1989–30 June 1990) to a maximum of 25% of the goat's diet on an as-fed basis. The conditioning schedule was: 4% of diet for 33 days; 10% of diet for 30 days; 14% of diet for 73 days; 18% of diet for 45 days; 25% of diet for 30 days; 20% of diet for 15 days. During the last conditioning period, sagebrush was reduced to 20% of diet because animal intake declined. Feed offered was adjusted to insure total consumption. Daily hay intake by does averaged 1.35 kg as fed. The does began to kid on 15 February 1990. The kids became part of the group of their dam and received the same treatment. This resulted in four groups of animals—conditioned does, conditioned kids, control does, and control kids (COND DOES, COND KIDS, CTRL DOES, CTRL KIDS). Dietary treatments were maintained until the animals began foraging in their rangeland paddocks. Kids were weaned on 21 May 1990.

2.3. Study site

All the goats were moved on 15 June 1990 to the Eastern Oregon Agricultural Research Center, Squaw Butte Experimental Range, 56 km west of Burns, Oregon, where the remainder of this study took place. The Squaw Butte site is in the

high-elevation intermountain region of eastern Oregon, in the sagebrush–grassland vegetation type. Diet studies were conducted in a 40 ha pasture, divided into four 10 ha paddocks. Dominant species include Wyoming big sagebrush (*Artemisia tridentata* subspp. *wyomingensis* Nutt.), green rabbitbrush (*Chrysothamnus viscidiflores* (Hook.) Nutt.), Idaho fescue (*Festuca idahoensis* Elmer), Thurber's needlegrass (*Stipa thurberiana* Piper), bluebunch wheatgrass (*Agropyron spicatum* (Purch.) Scribn. & J.G. Smith) and various other grasses and forbs.

The animals required confinement at night to prevent losses owing to predators. In addition, a Great Pyrenees guarding dog provided constant protection for the goats. A large holding area (32 m × 32 m) was constructed at the junction of the four 10 ha paddocks with a centrally placed shed–handling facility for conducting weighing and management operations (worming, hoof trimming, etc.). Shade shelters were constructed for the animals, which also served as winter shelters after the addition of sides.

2.4. Diet evaluation

Upon introduction to the experimental paddocks at the Squaw Butte Experimental Range, diets selected by goats were monitored daily for the initial 35 day period, using focal animal sampling (Altmann, 1974). For each 2 day sampling period, 12 individuals from each of the four groups were randomly chosen for observation. During continuous 20 min periods of observation, bite counts by plant species were recorded for each animal. During each observation session, bite equivalents were hand collected for each plant species. Samples were dried and weighed to provide a biomass equivalent per bite. Given 2 h in the morning and 2 h in the afternoon of actual foraging time, observations were made on 24 animals one day and the other 24 were observed the next day. This schedule provided 13 observation periods per goat over the initial 35 days. The order of observations on individuals was randomly assigned to avoid bias. Animals were weighed before introduction to the paddock and every 10 days thereafter to document changes in their condition. Animals were penned except during observation periods.

Fecal collections were made seasonally on randomly selected goats in each group. Total fecal output combined with hand-collected diet samples and bite count observations were used to provide an estimate of total forage consumption and pasture utilization.

Before introducing the animals to the paddocks, forage availability was assessed using permanent line and belt transects as well as randomly located plots. Vegetation measurements assessed include biomass, per cent foliar cover, density and frequency.

Information pertaining to the diets selected by conditioned and unconditioned goats was monitored throughout the following four seasons (until 29 July 1991). Studies using sheep by Arnold and Maller (1977) suggested that differences in acceptability of generally disliked species (such as big sagebrush) between groups with differing previous experience will persist until animals are forced to graze

on that species for at least a month. Therefore, we monitored diet intensively for the initial 35 day period and then every phenological plant season for the following year to quantify persistence and change.

2.5. Data analysis

The dietary data were summarized by converting bites to a biomass basis and averaging each of the four groups (COND DOES, COND KIDS, CTRL DOES, CTRL KIDS) by 2 day sampling period. Grams of forage (by species) consumed per hour per kilogram of body weight averaged by group were then analyzed using a general linear model (GLM) procedure, and a Fisher's protected least significant difference (LSD) test was performed to identify significant differences. All statistical analyses were performed using SAS procedures (Statistical Analysis Systems Institute, Inc., 1988).

3. Results and discussion

3.1. Initial 35 day period

Live sagebrush consumption was very low for all groups (0.23 g h^{-1} kg^{-1} of weight) during the initial 35 day period (Fig. 1). Conditioning treatment had no effect ($P=0.9768$) on consumption of live sagebrush during this period. Dead

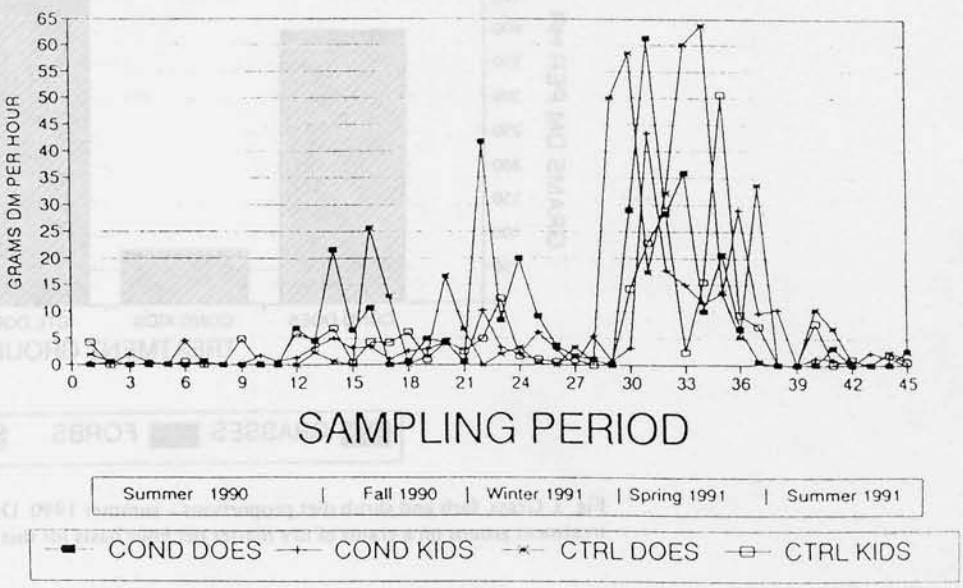

Fig. 1. Live sagebrush intake. Values are presented on a grams of dry matter per hour basis. Intake was assessed seasonally and averaged by treatment group.

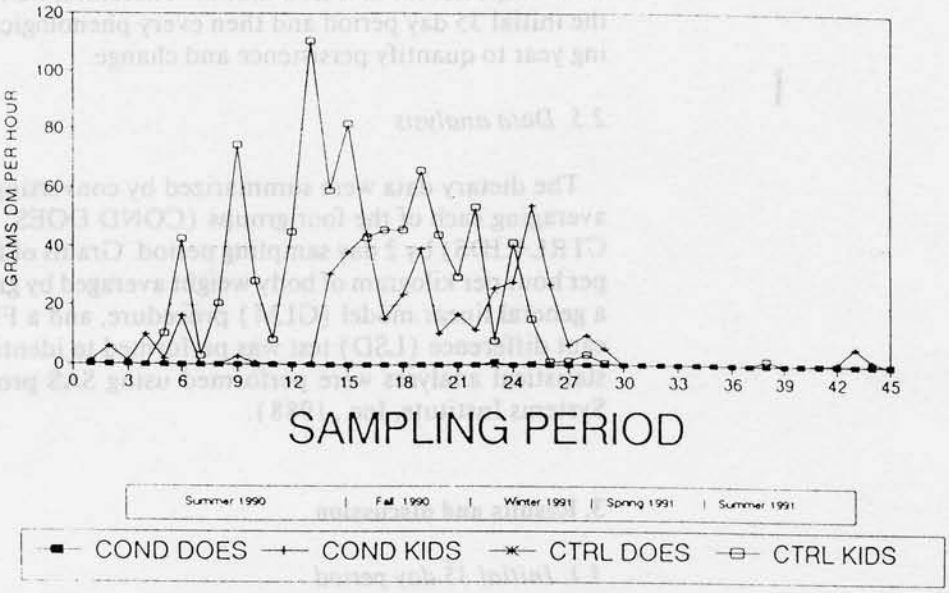

Fig. 2. Dead sagebrush intake. Values are presented on a grams of dry matter per hour basis. Intake was assessed seasonally and averaged by treatment group.

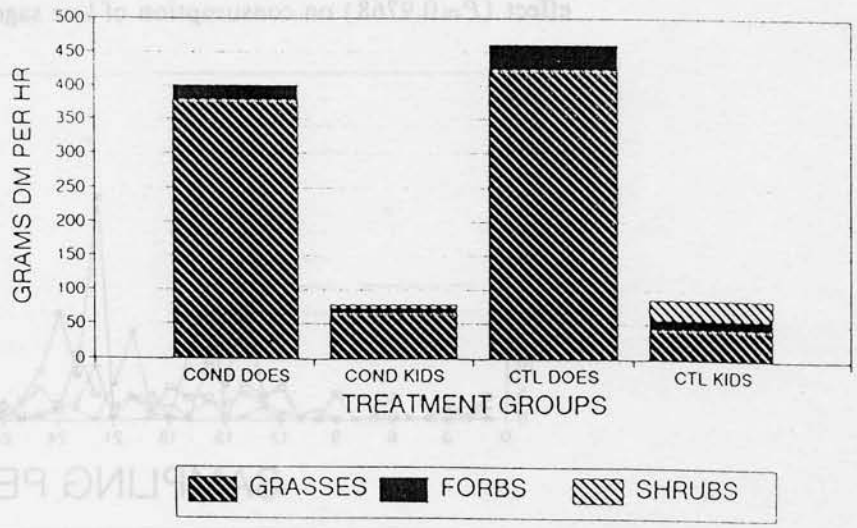

Fig. 3. Grass, forb and shrub diet proportions – summer 1990. Dietary proportions were averaged by treatment groups on a grams of dry matter per hour basis for this season.

sagebrush twig consumption, although not affected by conditioning ($P=0.2328$), tended to be higher ($P=0.1285$) for kids than for does (Fig. 2). Control kids ate more than 375 bites h^{-1} of dead sagebrush, but these bites translate to only 1 g

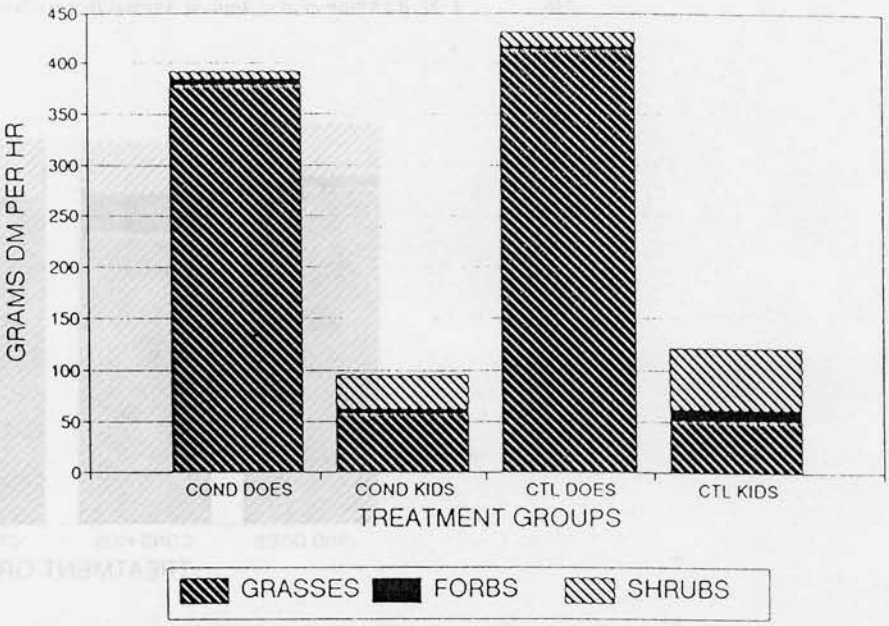

Fig. 4. Grass, forb and shrub diet proportions – fall 1990. Dietary proportions were averaged by treatment groups on a grams of dry matter per hour basis for this season.

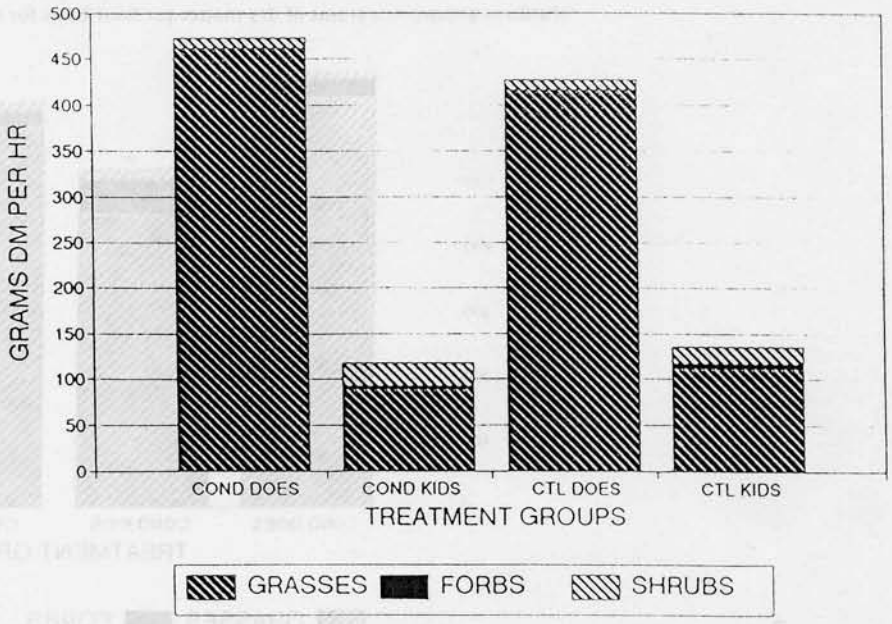

Fig. 5. Grass, forb and shrub diet proportions – winter 1991. Dietary proportions were averaged by treatment groups on a grams of dry matter per hour basis for this season

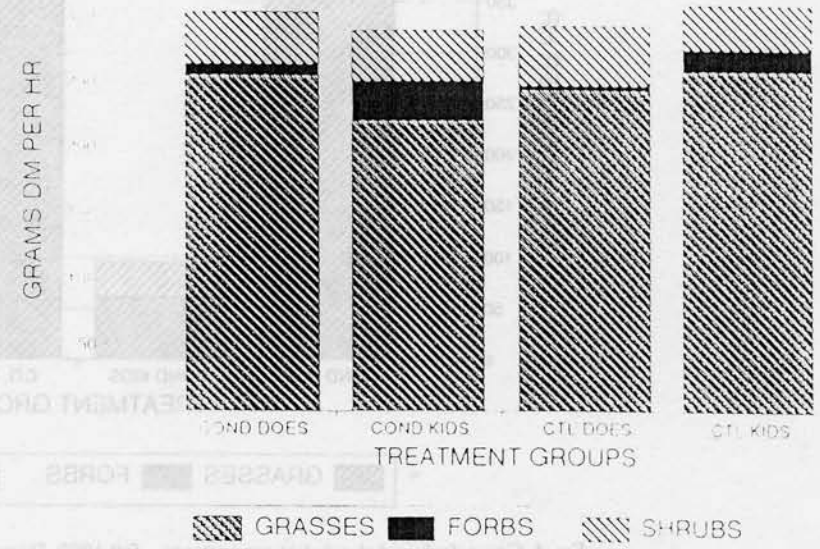

Fig. 6. Grass, forb and shrub diet proportions – spring 1991. Dietary proportions were averaged for treatment groups on a grams of dry matter per hour basis for this season.

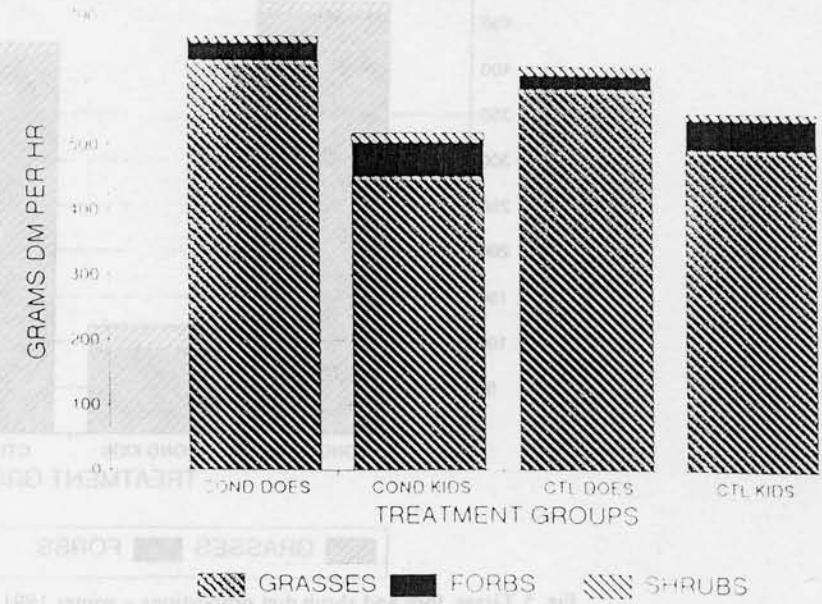

Fig. 7. Grass, forb and shrub diet proportions – summer 1991. Dietary proportions were averaged for treatment groups on a grams of dry matter per hour basis for this season.

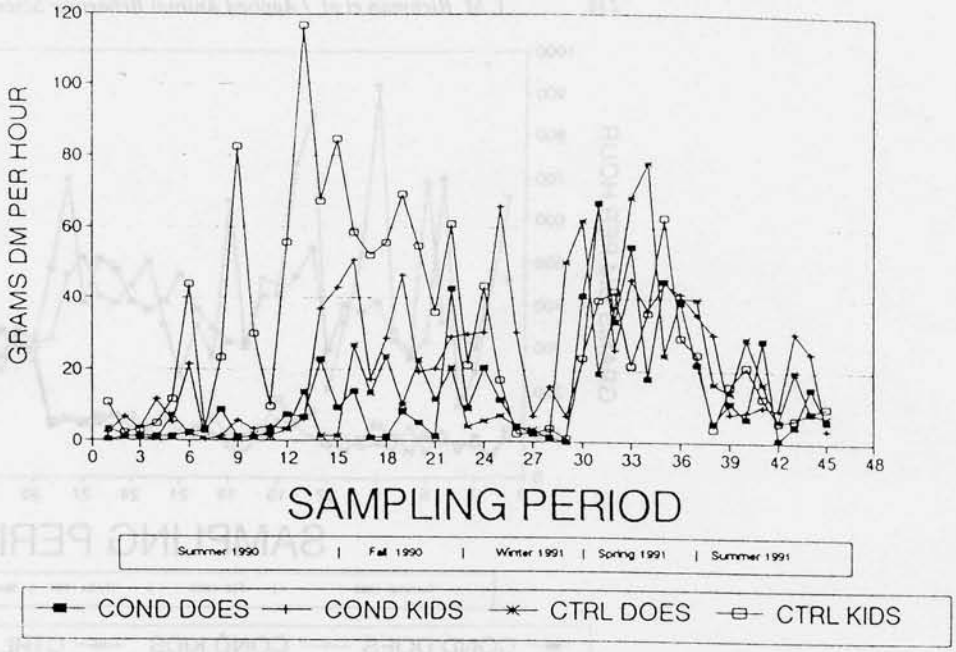

Fig. 8. Total shrub intake. Values were averaged on a grams of dry matter per hour basis. Intake was collected seasonally and averaged by treatment group.

Table 1
Number of plant species that made up 1% or more of doe and kid diets and Shannon's diversity index of dietary components. Dietary diversity was calculated using Shannon's diversity index by group and by season. Because *Poa*, *Koeleria*, and *Sitanion* could not always be distinguished from one another during the winter, the Shannon index was not calculated for this season

Season	Dietary diversity			
	Number of plant species		Shannon index	
	Does	Kids	Does	Kids
Summer 1990	9	10	1.79	1.93
Fall 1990	9	9	1.81	1.51
Winter 1991	8	7	–	–
Spring 1991	9	10	1.82	2.01
Summer 1991	11	12	1.79	2.07

dry matter h^{-1} kg^{-1} of body weight. Total shrub consumption accounted for approximately one-third of the control kid's total diet for this time period.

Upon more detailed analysis of dietary trend during the initial 35 day period, we found that kids tended to eat more live sagebrush ($P=0.114$) than does. Live sagebrush consumption by does increased in the last 4 days of this observation period ($P=0.006$) across both treatment groups. This change could be because

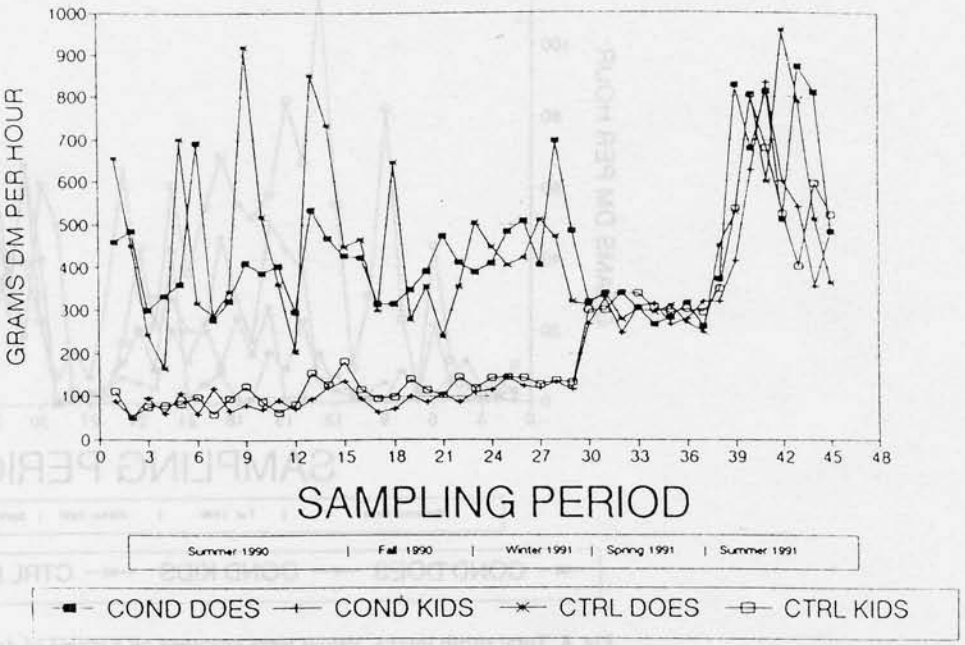

Fig. 9. Total biomass intake. Values were averaged on a grams of dry matter per hour basis. Intake was collected seasonally and averaged by treatment group.

of either phenology of sagebrush, which had begun to flower, or changes in availability and phenology of preferred species.

3.2. Seasonal observations

The conditioning treatment had no effect on sagebrush consumption across all five observation seasons (Fig. 1). Total shrub consumption was similar between control and conditioned groups ($P=0.172$); however, kids ate significantly greater amounts of shrubs than did does ($P=0.0001$). Shrubs include live sagebrush, dead sagebrush, green rabbitbrush, rubber rabbitbrush (*Chrysothamnus nauseosus* (Pallas ex Pursh.) Britton), gray horsebrush (*Tetradymia canescens* DC.), granitegilia (*Leptodactylon pungens* (Torr.) Torr. ex Nutt.), and western juniper (*Juniperus occidentalis* Hook.).

Overall, the kid groups exhibited a tendency to explore more, especially in their consumption of the various life-forms (Figs. 3–8). The kids compiled less focused diets than adults. Kid diets contained larger proportions of minor species. For each of the six shrub species monitored, kids consumed an equivalent proportion to does in all seasons, or a greater proportion. Of the 11 grass species monitored, does consumed more than kids of ten species. Kid diets remained more diverse except during dormant seasons (autumn and winter) as demonstrated by the number of plant species that made up 1% or more of the diet and Shannon's diversity index (Table 1).

To determine whether dietary change had occurred, we compared the diets from summer 1990 to summer 1991. In summer 1991 we found greater consumption of green rabbitbrush ($P=0.0001$), crested wheatgrass (*Agropyron desertorum* (Fisch. ex Link) J.A. Shultes) ($P=0.0009$), bluebunch wheatgrass ($P=0.0001$), Basin wild rye (*Elymuscinereus* Scribn. & Merrill) ($P=0.007$), bottle-brush squirreltail (*Sitanion hystrix* (Nutt.) J.G. Smith) ($P=0.0001$), needle-and-thread (*Stipa comata* Trin. & Rupr.) ($P=0.0017$), and Thurber's needlegrass ($P=0.0002$). The two species that decreased in consumption were junegrass (*Koelaria pyramidata* (Lam.) Beauv.) ($P=0.0013$) and the bluegrasses (*Poa* spp. L.) ($P=0.0005$). The other species were unchanged. Both kids and does ingested more per kilogram of body weight the second summer, which may indicate improved foraging skills and a broader acceptability of plant species (Fig. 9). This increase affected both treatment groups equally; however, increase in grams of intake per kilogram of body weight was greatest for kids.

Because the kids used in this study were weaned before grazing in a rangeland setting, they did not have the social training from their mothers that is often considered to be critical for developing effective foraging skills. Additional research should address the role of social training.

4. Conclusions

Our conditioning treatment did not significantly alter dietary choices in either kids or does. Substantial changes in the diets of all groups occurred seasonally, indicating that as plant phenologies and nutritional status change, goat diets will shift as well. All our goat groups had significantly different diets in the second summer compared with the first summer.

There are many more questions to address concerning the potential for goat grazing in the sagebrush–bunchgrass region. We see the need to investigate farther what the differences are between kids that learn to forage with their mothers compared with kids that must learn without mothers, both in new settings and in settings to which the does are acclimated. We also need to investigate the impact that grazing by goats, with their unique grazing preferences and habits, will subsequently have on the vegetation and on the health and stability of the overall ecosystem.

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