UNIVERSITY OF CALIFORNIA
HOPLAND RESEARCH & EXTENSION CENTER

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THREE-YEAR REVIEW REPORT

Title of Research Project: Comparative analysis of responses of sheep and goats to California Chaparral brows plants
Center Project No.: 46-00

AES or CEFS Project No. and Title: CA-D*-ASC-6740-H

Project Leader: Wolfgang Pittroff, Assistant Professor
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Project Cooperators:
(Name & Title)

Attach a detailed 2-4-page narrative addressing the following items:

1. **Justification and Problem Statement** (Describe the original or modified problem and justification).
2. **Objectives:** (Describe the specific original or modified objectives of the project).
3. **Procedures:** (Include experimental design, data collected, and methods of data analysis).
4. **Summary of Research Results:** (Provide a summary of research conducted on this problem. Include statement of how original or modified objectives were met, and relevance of research results to California)
5. **Extension of Results:** (Explain how research results were shared, including publications, field days, seminars, etc.).
6. **Description of Research Planned for the Next Three-Year Period:** (Include objectives and procedures).
7. **Publications:** (Also include unpublished reports to industry or funding agencies, in press and in presentation papers. List and provide single copies).
8. **Attach a completed Land, Labor and Facilities Form.**

Project Leader Signature:______________________ Date:______________

I have reviewed this proposal and approve it as appropriate research for the Project Leader and the Center.

Authorizing Signature:______________________ Date:______________

The following authorizing signatures are required:

1.	For Faculty and Campus Specialists:	Department Chair
2.	For Farm Advisors:	County Director
3.	For other State and U.S. agencies:	Admin. Unit Head and Cooperating Department Chair

Comparative analysis of responses of sheep and goats to California Chaparral browse plants.

Justification and Problem Statement.

There is strong interest in the use of domestic ruminants as tools in vegetation management in areas prone to brush fire hazards and exotic weed species invasions (Sverson and Debano, 1991). Indeed, in Europe there are breeds of ruminants specifically selected for the management of characteristic vegetation associations (Haring, 1975).California Chaparral vegetation is composed of plants with generally high levels of plant secondary compounds (PSC) (Sampson and Jespersen, 1963). Some of these compounds lead to very low palatability even in ruminant species capable of consuming relatively high levels of PSC. While there is considerable information about the palatability ranking of key browse species of California Chaparral, little is known about specific animal responses in terms of intake levels, intra-ruminal or post-absorptive detoxification processes, and potential strategies for mitigation of deleterious effects of PSC. Previous work pertinent to the study of ruminant grazing of California Chaparral (Wilson et al., 1970; Longhurst et al., 1979; Sidahmed et al., 1981) focused on dietary overlap of domestic and wildlife herbivores and nutritional properties of selected plant species.

The effective use of ruminants in vegetation management requires knowledge about animal responses to PSC. This information is needed in order to select the most effective species (for example, sheep vs. goat) and breed for desired vegetation management goals. It is further essential for flock management planning, i.e. selection of animal categories in terms of growth stage and physiological stage for specified vegetation management tasks. For example, a producer engaged in vegetation control must know if grazing a specific plant community will increase the risk of permanent metabolic damage in his or her animals due to PSC. Some of this information is empirically available, but little mechanistic understanding is present. Studies aiming at the understanding of the physiological basis of animal tolerance to PSC are extremely rare (Foley et al., 1999). The future use of ruminant grazing in vegetation management will, due to deleterious effects of PSC on animals, undoubtedly invoke animal welfare concerns. It is, therefore, mandatory to study possible mitigation schemes and establish guidelines of animal use in vegetation control related to potentially toxic effects of PSC. In addition, it will be needed to quantify the *lost animal performance* cost component of vegetation control. Lost performance may be due to both direct effects of chaparral vegetation on nutrient acquisition of animals, as well as long term morbidity effects incurred by recurrent sub-clinical damage to metabolically significant organs. The significance of this work is exemplified by the need of public land managers and utility companies in California to consider controlled ruminant grazing as possibly the most effective tool in vegetation management of watersheds subject to extreme fire hazards. An example is the peninsula watershed of the San Francisco Water Department (Ciardi, pers. comm.).

Objectives

The project will research the following hypotheses:

1. Liver parameters are effective in monitoring toxic effects of PSC on sheep and goats.
2. Goats and sheep differ in intake levels per unit of body mass of key browse species of California Chaparral
3. Supplementary nitrogen changes intake of browse containing PSC in accordance with specific biochemical properties of PSC. For example, intake of species containing predominantly tannins will respond positively to nitrogen supplementation.
4. Supplementation of sheep and goats with polyethylene-glycol with a molecular weight of 4000 (PEG 4000) significantly increases intake of browse containing predominantly tannins (such as *Quercus* spp. and *Arctostaphylos* spp) in both sheep and goats. This mitigation effect of PEG 4000 varies between sheep and goats.

Procedures

The project will use a mixed flock of sheep and goats (whethers > 1 yr). Animals will be housed indoors in facilities which allow the collection of feces and urine and the accurate measurement of intake.

The following plant species (groups) will be evaluated in feeding trials:

Arctostaphylos spp.

Adenostoma fasciculatum

Rhamnus californica

These species groups were either identified by Longhurst et al. (1979) as important components in the diet of sheep and deer, or present specific vegetation management problems. The exact species of *Arctostaphylos* will depend on results of the vegetation survey. The deer data of Longhurst et al. (1979) are assumed to be relevant to predicted diet selection of goats, which are, like deer, concentrate selectors favoring browse.

Experiment 1. Liver parameters and mitigation schemes for tannin-rich browse (Hypotheses 1,2,3,4).

A 2 x 2 x 2 factorial experiment will be conducted examining the effects of livestock species (sheep vs. goats), PEG, and urea supplementation on the voluntary intake of tannin-rich feed (*Arctostaphylos* spp). Urea supplementation is tested as a factor because of the N-binding effects of tannins. Experimental animals (three per factor-level combination, n= 24) will be maintained on hay and small amounts of concentrates until gradual adaptation to the experimental diet over a 2 week period. The experimental diet (one species of *Arctostaphylos*, as determined by site abundance) will be fed for one week before start of plasma collection. Three blood samples will be collected by jugular venipuncture in week 2 after reaching full experimental diet. Blood samples will be analyzed for leucocyte count, erythrocyte count, albumin, cholesterol, and specific enzymes: alkaline phosphatase, oxoglutarate amino transferase, creatine phosphokinase, glutamic oxaloacetic transaminase, glutamic pyruvate transaminase, gamma-glutamin transferase and lactate dehydrogenase. During the experiment, intake will be recorded for individual animals.

Fecal samples will be collected for determination of fecal N. The design of Experiment 1 is based on the assumption that the above plasma parameters suffice to indicate damage to liver, and such indicators trace systemic morbidity caused by toxic effects of PSC. It is realized that the study of liver parameters can only provide a partial view of potentially harmful systemic effects of PSC. The measurement of liver weights of animals under long-term exposure to California Chaparral would add considerable information and will be subject of subsequent experiments. Further, the selected plant species may not provide a complete picture of potentially effective mitigation schemes aimed to increase the consumption of plants containing PSC. However, literature review suggests general paucity of such data.

Experiment 2. Liver parameters and protein supplementation effects for flavonoid/phenolics rich browse (Hypotheses 1,2). The feed adaptation regime will be as in Experiment 1. *Adenostoma fasciculatum* contains hydrophilic flavonol glycosides (for example, kaempferol, quercetin and isorhamnetin (Proksch et al., 1985). Energy levels of *Adenostoma fasciculatum* browse appear to be sufficient for maintenance (Sampson and Jesperson, 1963) but Wilson et al. (1971) pointed out the dependence of level of intake of *Adenostoma fasciculatum* on supplementation. Therefore, the effects of protein supplementation with cottonseed meal and the effect of PEG supplementation on voluntary intake of *Adenostoma fasciculatum* will be tested. Cottonseed meal was chosen because the chemical properties of flavonol glycosides and their metabolites suggest a possible mitigation effect of both protein and energy supplementation. In addition to protein, cottonseed meal also supplies energy. A 2 x 2 x 2 factorial experiment (animal species, protein, and PEG supplementation) with three experimental animals per factor-level combination will be conducted. In addition to the intake effects of species and supplementation, liver parameters of experimental animals will be monitored. The same procedure as in Experiment 1 will be applied. Toxic effects of PSC of *Adenostoma fasciculatum* have been described in insects (Harborne, 1991), but the metabolism of these PSC is unknown for ruminants. In monogastric animals, some flavonoid metabolites are conjugated to glucoronic acid for excretion, an energy consuming process (Palo and Robbins, 1991). Palo and Robbins (1991) suggested that microbial degradation reduces absorption of flavonoids and thus the need for conjugation in foregut fermenters. These authors pointed out that additional studies on liver function of animals with specific gut structures are needed. Therefore, blood parameters will be determined as in Experiment 1. Rumen liquid samples will be collected by stomach tube 1 and 4 hours after feed administration on three days during the second week of feeding. The samples will be analyzed for flavonoid metabolites by HPLC. Feed intake will be monitored for individual animals during the experimental period. Urine samples will be collected on three days in Week 2 for the analysis of presence of flavonol glycoside metabolites.

Experiment 3 (Hypotheses 1,2).

No specific information about the biochemistry of *Rhamnus californica* was found; however, the literature on chemosystematics of Rhamnacea suggests the presence of flavonoids (Umadevi and Daniel, 1990). Thus, voluntary intake metabolic effects and rumen metabolites of major PSC of *Rhamnus californica* will be evaluated in the same design.

Summary of Research Results

Total collection (digestibility trials) were conducted with sheep and goats using three Chaparral brush species: Quercus wislenzii var. frutescens (scrub interior live oak), Adenostoma fasciculatum (chamise), and Arctostaphylos manzanita (common manzanita). Experiments with manzanita were designed as a factorial with PEG supplementation.

Intake levels were significantly higher for goats than for sheep for all plants and supplementation levels. Goats generally maintained liveweight (animals were supplemented with a small amount of alfalfa). The supplementation of PEG significantly increased consumption of manzanita. However, there were environmental effects (increase in temperature) that may have contributed to the observed decrease in intake with decreasing PEG supplementation. Data analysis is in progress.

Plant Species	Goats	Sheep
Oak	0.49	0.52
Chamise	0.50	0.53
Manzanita (High PEG)		
Manzanita (Medium PEG)		
Manzanita (Low PEG)		
Manzanita (No PEG)		

DM Digestibility values for select Chaparral species

AVG VALUES FOR	INTAKE(gDM/day/kgBW)	
	Goats	Sheep
Oak	47.95	29.43
Chamise	24.08	12.09
MANZANITA		
PEG PHASE 1 (High PEG)	36.95	29.05
PEG PHASE 2 (Medium PEG)	35.54	29.72
PEG PHASE 3 (Low PEG)	28.86	25.27
PEG PHASE 4 (No PEG)	28.36	23.98

Research planned for the next Three-Year Period

Due to funding limitations, it has not been possible to conduct the blood work detailed in the description of planned experiments above. Once more suitable animal facilities become available in Hopland, we expect to conduct these experiments starting in 2003. We are currently attempting to detect an influence of weather conditions in the manzanita data. Because the conditions in the facility were the experiments were conducted did not preclude undue weather influence, we decided that a major upgrade of existing facilities is essential to conduct the more detailed animal work. It may be required to repeat some of the supplementation trials. In the meantime, we will complete the laboratory analysis.

Publications

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