Relationship of Soils to Seasonal Deer Forage Quality

WILLIAM C. KRUEGER AND GARY B. DONART

Highlight: *Blue wildrye, sheep sorrel, Oregon white oak, and arroyo willow were studied on Yorkville and Tyson soils in northern California to determine the effects of soil series and season on relative concentrations of protein, acid-insoluble lignin, and total sugars in the forage. Production of protein and sugars, but not lignin, was found to be related to soil series. Differences in levels of three chemical constituents varied among plant species with season on two soil series.*

Studies of Columbian black-tailed deer (*Odocoileus hemionus columbianus*) indicated these animals graze vegetation on some soil series more frequently than others (Hooper, 1960; Whitaker, 1965; and Bonn, 1967). This study was undertaken to identify relationships between protein, lignin, and sugar levels of deer forage and the soil series that produced this forage. Comparisons were made for dry and rainy seasons. Differences in these chemical constituents among plant species were also examined.

Bonn (1967) found the tyson soil series, dominated by Oregon white oak (*Quercus garryana*), supported range most heavily used by black-tailed deer in northwestern California; the Yorkville soil series supported the range with heaviest use by deer of the grassland soils. Deer use on the Tyson soil series was more than four times greater than deer use on the Yorkville soil series.

In the current study, perennial plants known to be used by deer were chosen for chemical analysis. Blue wildrye (*Elymus glaucus*) and sheep sorrel (*Rumex acetosella*) were collected on Tyson and Yorkville soil series. No browse species were common to these soils in sufficient quantity to insure collection throughout the year, so the most abundant browse species was chosen from each soil. Oregon white oak was collected on the Tyson soil series and arroyo willow (*Salix lasiolepis*) was sampled on the Yorkville soil series.

Study Area

The range areas of Humboldt County, Calif., consist of open grasslands bordered by Douglas fir (*Pseudotsuga menziesii*) and oaks (*Quercus* spp.), with a good understory of herbaceous plants.

The Tyson soil series has been described by the Soil Conservation Service (1951). It was derived from sandstone, shale, and related metamorphic rock of the Franciscan geologic formation. The vegetation is characteristically a fairly dense cover of Oregon white oak and an herbaceous understory with scattered shrubs. The Tyson soil series will be subsequently referred to as Tyson soil in this paper.

The Yorkville soil series has been described by Gardner (1958). This hilly, rolling soil has a strong tendency to slip and in many places slips a little almost every winter. The Yorkville soil series was formed in well-weathered material of metamorphic, basic rock with glaucophane shist common. The vegetation is a mixture of annual and perennial grasses and forbs with a few shrubs interspersed throughout. The Yorkville soil series will subsequently be referred to as Yorkville soil in this paper.

The area has high annual precipitation occurring primarily from November through May. Annual rainfall averages between 35 and 85 inches (Cooper and Heady, 1964). Bridgeville, Calif., which is adjacent to the ranch at 700-ft elevation averaged 61.18 inches annual precipitation from 1939-1952 (U. S. Commerce Dep., 1958). The area of the ranch involved in this study was about 1700 ft in elevation and about 5 miles from Bridgeville. During this study (June 1, 1966, to June 7, 1967), the total precipitation at Bridgeville was 67.37 inches (U. S. Commerce Dep., 1966 and 1967). Precipitation would be slightly higher at the site of plant collection because of increased elevation. During the study the dry season extended from June through late October, 1966. The rainy season began in late October, 1966, and extended to early June, 1967.

Methods

A minimum of ten plants each of blue wildrye and sheep sorrel were chosen at random for each collection and all aerial portions were collected to yield a composite sample of approximately 200 g dry weight. Only ungrazed plants or portions of plants were collected, except in the middle of the rainy season when there was not enough ungrazed sheep sorrel available to obtain an adequate sample. Only leaves in the lower crown of Oregon white oak and arroyo willow were collected, and no samples were collected while the browse was dormant. Phenological stages were recorded at the time of collection.

The plant samples were analyzed for crude protein by the micro-kjeldahl method (Association of Official Agricultural Chemists, 1950). The method of Sullivan (1959) was used to determine the percentage concentration of acid-insoluble lignin. Sugars were extracted in a Waring blender, using hot 80% ethyl alcohol (Thomas et al., 1949). Total sugars were determined by a modification of Forsee's photocolorimetric method (Morrell, 1941).

Statistical comparisons of differences in levels of each chemical component as influenced by soil series were con-

The authors are assistant professor, Rangeland Resources Program, Oregon State University, Corvallis, and associate professor, Department of Animal, Range, and Wildlife Sciences, New Mexico State University, Las Cruces. They were formerly of the School of Natural Resources, Humboldt State College, Arcata, California.

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ducted separately for blue wildrye and sheep sorrel in each season, using paired comparisons and Student's *t* test. Effects of soil series on Oregon white oak and arroyo willow were not statistically evaluated since neither species grew on both series. Differences in concentration of chemical factors within a soil series over seasons for all four species were tested with the Student's *t* test.

Differences for each chemical component among plant species were tested for each soil series and season, using analysis of variance with a completely randomized design. Differences among means were examined with Scheffe's test. Throughout the paper the term *significant* refers to significant difference between means at $P<.05$.

Results and Discussion

Phenology

Humboldt County has a mild climate and many plants never become dormant. There are two seasons, dry and rainy. Different species of plants begin their annual cycle at different times of the year. The phenological condition of the plants studied reflected this pattern in different months of observation.

Blue wildrye began its annual cycle with the beginning of the rainy season. Vegetative development progressed through the boot stage during the rainy season on both soil series. During the dry season grass matured more rapidly on Yorkville soil than on Tyson soil. By the second month of the dry season, blue wildrye was quiescent on Yorkville soil. Rangelands on Tyson soil with its oak overstory maintained a cool, moist environment, and wildrye never became quiescent.

Sheep sorrel began its annual cycle on both soil series by late September which corresponded with light precipitation (1.1 inches) near the end of the dry season. Sheep sorrel followed the same pattern of vegetative growth on both soil series through most of the rainy season. In May, sheep sorrel on Yorkville soil began to produce seed, while sorrel on Tyson soil remained vegetative. At the end of the rainy season in June, sheep sorrel on Tyson soil began to produce seed. Total seed production on shaded Tyson soil was far below that on open Yorkville soil. Sorrel continued seed production on both soil series throughout the dry season.

Arroyo willow was collected only from Yorkville soil. It began growth in April and leaves had reached full size by the end of the rainy season. Shoots matured and became woody in the middle of the dry season. Leaf abscission began at the end of the dry season and continued for 3 months.

Oregon white oak, growing on Tyson soil, began to produce leaves at the end of the rainy season. Leaves matured early in the dry season, and stems became woody 1 month after the leaves had attained full growth. Acorn production began when the stems matured and continued for 2 months. Leaf abscission began at the end of the dry season in late October and continued for the first 2 months of the rainy season.

Grazing

Utilization was noted while forage samples were being collected. No quantitative measurements of utilization were taken. Observations of utilization consisted of recording whether or not the herbaceous species were being used by cattle and deer grazing in common.

Blue wildrye was utilized primarily from November to June, which corresponded with the entire rainy season. No further use was noted on wildrye, which had become mature and dry on Yorkville soil and mature but still green on Tyson soil.

During the rainy season, forage production of most species was minimal and grazing on sheep sorrel was heavy. Regrowth of sheep sorrel maintained a 0.5-inch leaf length, while sorrel protected by rocks and logs maintained a 2-inch leaf length throughout the rainy season.

Protein

During the rainy season there were no significant differences in protein levels for blue wildrye or sheep sorrel in response to the soils on which they were growing. In the dry season differences became more pronounced. Blue wildrye had a significantly higher concentration of protein (5.4%) from Tyson soil when compared to blue wildrye (3.7%) from Yorkville soil. Sheep sorrel on Yorkville soil was significantly higher in protein (12.7%) when compared to sheep sorrel (8.4%) from Tyson soil.

Differences in responses of blue wildrye and sheep sorrel were related to phenology. In the rainy season there was little difference in phenology for each species when grown on different soils, and no significant differences in protein concentration were found. In the dry season blue wildrye matured more slowly and remained more succulent in the shaded habitat on Tyson soil when compared to open Yorkville soil. As a result, wildrye growing in shade maintained higher protein levels. Sheep sorrel responded differently to shading. Protein levels were higher in plants from Yorkville soil compared to those from Tyson soil. The higher seed/stem ratio of sheep sorrel on Yorkville soil when compared to that on Tyson soil probably accounted for the difference in levels of protein.

Comparison of protein concentrations between dry and rainy seasons for each species on either Yorkville or Tyson soil indicated blue wildrye had significantly higher levels of protein on both soils in the rainy season (Table 1). Sheep sorrel contained a significantly higher level of protein on Tyson soil in the rainy season when compared to the dry season. Both forb and browse plants maintained a high level of protein throughout the dry season, when protein levels of blue wildrye were comparatively low.

Differences in protein concentration among plant species varied with season and soil series. In the rainy season there were no significant differences among species. In the dry season all plant species studied from Yorkville soil were significantly different (Table 1). Sheep sorrel had the highest concentration of protein (12.7%) and blue wildrye the lowest (3.7%). On Tyson soil in the dry season, Oregon white oak contained significantly more protein than blue wildrye (11.4% and 5.4%, respectively). Sheep sorrel was intermediate in protein concentration with 8.4%.

Einarsen (1946) reported 5% as the critical protein level needed in deer forage. Dasmann (1964) indicated 7% protein

Table 1. Average protein concentration in percent of four plant species for dry and rainy seasons on two soils.[1]

Species	Yorkville soil		Tyson soil	
	Dry season	Rainy season	Dry season	Rainy season
Blue wildrye	3.7^{a}	15.8^{*a}	5.4^{a}	17.7^{*a}
Sheep sorrel	12.7^{b}	11.0^{a}	8.4^{ab}	13.1^{*a}
Arroyo willow	8.5^{c}	13.2^{a}	–	–
Oregon white oak	–	–	11.4^{b}	12.0^{a}

[1] *Across columns within a soil indicates a significant difference at $P < .05$.
Different letters within a column indicates a significant difference at $P < .05$.

was the minimum level to maintain deer. In the rainy season, all plant species studied on both soils were well above required protein concentrations. Both Oregon white oak and arroyo willow leaves were not available during parts of the rainy season as a result of abscission. In the dry season, forbs and browse on both soil series exceeded protein requirements for deer and, except for sheep sorrel on Tyson soil, were not significantly lower in protein when compared to the rainy season. While protein concentration in blue wildrye was significantly lower for both soils during the dry season when compared to the rainy season, only blue wildrye on Yorkville soil was below 5%. The grass on both soils was below 7%. Because of low levels of protein in the grass during the dry season, it would be desirable to maintain forbs and browse present in these plant communities to prevent a protein deficiency occurring in the dry season.

Acid-insoluble Lignin

There were no significant differences in concentrations of lignin for the herbaceous species in response to soils on which they were growing during either the dry or rainy season. The greatest difference in lignin concentration in response to soils was for sheep sorrel in the rainy season. Percentage lignin concentration of sheep sorrel produced on Yorkville and Tyson soils was 16.6 and 12.6, respectively. Grazing of sheep sorrel in the rainy season may account for variability of lignin levels during this period.

Comparison of acid-insoluble lignin levels in plants for the dry versus the rainy season on Yorkville and Tyson soils indicated that only blue wildrye differed significantly (Table 2). High levels of lignin for the grass in the dry as compared to the rainy season reflected a considerable change in phenology over seasons, from a leafy plant in the rainy season to a stemmy plant in the dry season. Sheep sorrel did change a great deal in phenological appearance over the seasons but was primarily a leafy plant in both seasons. Oregon white oak exhibited a steady increase in lignin over time, but phenology of this deep rooted plant was not as rapidly influenced by climate as the herbaceous vegetation. As a result, lignin values for the rainy season reflected impacts of both very early and very late phenological development. Arroyo willow had no identifiable seasonal trends in concentration of lignin.

A number of differences in concentration of lignin were found among species on different soils in different seasons (Table 2). In the dry season arroyo willow had significantly more lignin (30.4%) than sheep sorrel and blue wildrye (16.2% and 9.4%, respectively) on Yorkville soil. On Tyson soil for the dry season, wildrye (9.0%) had significantly less lignin than sheep sorrel (15.1%) and Oregon white oak (15.1%). In the rainy season there were no significant differences in lignin concentration among plants growing on Tyson soil. However, on Yorkville soil lignin concentration of all species studied was significantly different.

Lignin has been widely used to evaluate the quality of feeds. Lignin is primarily related to digestibility of cellulose and other structural carbohydrates of plants (Dietz, 1970). Arroyo willow and Oregon white oak were generally higher in lignin than the other species studied and thus would be expected to be lower in digestibility of structural carbohydrates and probably lower in usable energy. Blue wildrye would provide the most digestible structural carbohydrates of all species studied, as inferred from its lower lignin concentration, and would probably provide the highest level of usable energy.

Sugars

Levels of total sugars in blue wildrye and sheep sorrel showed no significant relationship to the soil on which these plants grew in the dry season. In the rainy season both blue wildrye and sheep sorrel had significantly less total sugars when growing on shaded Tyson soil than on open Yorkville soil. The magnitude of these differences was not great being 9.0% versus 7.2% for wildrye and 8.7% versus 7.0% for sheep sorrel on Yorkville and Tyson soils, respectively.

Soil fertility might also have had some effect on sugar concentration in these plants. High nitrogen concentrations in soils have been shown to depress levels of sugar concentration in plants (Plice, 1952). Cooper and Heady (1964) found Tyson soil contained 8.4 tons of nitrogen per acre in the first 4 ft of soil, while Yorkville soil contained 6.0 tons of nitrogen per acre for the same depth. The higher nitrogen content of Tyson soil might be partially related to the lowered sugar content of plants on this soil series.

Comparison of total sugar concentrations in plants for the dry versus the rainy season on Yorkville and Tyson soils indicated that only sheep sorrel on Yorkville soil exhibited seasonal effects (Table 3). In the dry season on Yorkville soil, the sugar concentration of 5.9% for sheep sorrel, when compared to 8.7% in the rainy season, may be closely related to phenology. Plants with extensive seed production in the dry season had depressed sugar levels when compared to plants with no seed production, in the rainy season, on Yorkville soil. No differences in sugar were noted on Tyson soil over seasons, and sheep sorrel on Tyson soil did not set a heavy seed crop.

The only statistically significant difference in level of total sugars among plant species occurred in the dry season (Table 3). Oregon white oak had significantly less sugar than blue wildrye on Tyson soil (4.6% and 6.8%, respectively).

Crawford and Church (1971) reported that black-tailed deer demonstrated strong preferences for sweet solutions. Dasmann et al. (1967) found preference by deer for conifer

Table 2. Average acid-insoluble lignin concentration in percent of four plant species for dry and rainy seasons on two soils.[1]

Species	Yorkville soil: Dry season	Yorkville soil: Rainy season	Tyson soil: Dry season	Tyson soil: Rainy season
Blue wildrye	9.4[a]	4.6*[a]	9.0[a]	6.5*[a]
Sheep sorrel	16.2[a]	16.6[b]	15.1[b]	12.6[a]
Arroyo willow	30.4[b]	29.8[c]	–	–
Oregon white oak	–	–	15.1[b]	21.1[a]

[1] *Across columns within a soil indicates a significant difference at $P < .05$.
Different letters within a column indicates a significant difference at $P < .05$.

Table 3. Average total sugar concentration in percent of four plant species for dry and rainy seasons on two soils.[1]

Species	Yorkville soil: Dry season	Yorkville soil: Rainy season	Tyson soil: Dry season	Tyson soil: Rainy season
Blue wildrye	6.0[a]	9.0[a]	6.8[a]	7.2[a]
Sheep sorrel	5.9[a]	8.7*[a]	6.1[a]	7.0[a]
Arroyo willow	6.4[a]	7.3[a]	–	–
Oregon white oak	–	–	4.6[b]	4.5[a]

[1] *Across columns within a soil indicates a significant difference at $P < .05$.
Different letters within a column indicates a significant difference at $P < .05$.

seedlings in northern California was increased when seedlings were sprayed with molasses and other sweeteners.

Although a great many factors influence animal preference for specific forages, the taste of a plant is certainly an important factor to consider when evaluating palatability. If sugar concentration in forage is positively related to palatability of that forage for deer, then plants growing on open Yorkville soil should be preferred over those on Tyson soil during the rainy season.

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