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SESQUITERPENE LACTONE COMPOSITION OF FORAGE CHICORY CULTIVARS GROWN IN WEST VIRGINIA AND PENNSYLVANIA

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Abstract Center Abstract heading

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'Grasslands Puna' (Puna) chicory (*Cichorium intybus* L.) is a promising pasture component in Pennsylvania (PA). In southern West Virginia (WV), Puna is not relished by sheep, and other forage chicory cultivars vary in acceptability. Chicory contains bitter sesquiterpene lactones; therefore, this study was undertaken to determine whether sesquiterpene lactone composition might be related to observed animal feeding behaviors. Investigations included the cultivars Puna, 'INIA le Lacerta' (Lacerta), and 'Forage Feast'. Vegetative herbage was collected during the summer of 1998 from each of the three cultivars at a PA State University research farm near State College, PA and a USDA, ARS research farm in southern WV. Dried tissues were extracted with methanol, and sesquiterpene lactones were determined chromatographically. Total concentration of sesquiterpene lactones ranged from 1.03 (Lacerta) to 1.52% (dry matter [DM] basis) (Forage Feast) in cultivars grown in WV. Forage Feast contained the highest concentrations of the sesquiterpene lactones lactucin (0.37%) and lactucopicrin (0.94%) and the lowest concentration of 8-deoxylactucin (0.22%). This was also the trend in PA-grown herbage, but the concentrations of total sesquiterpene lactones (0.32 to 0.55%), and particularly lactucopicrin (0.09 to 0.18%) were dramatically lower in PA samples. Data suggest that environmental factors influence the sesquiterpene lactone composition of chicory and thereby impact palatability of the herbage.

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Introduction: Forage chicory is a potentially valuable pasture species because it can enhance seasonal distribution of herbage (Kusmartono et al., 1996). The New Zealand cultivar, Puna, has been used successfully in many parts of the world (Barry, 1998), including PA (Jung et al., 1996); however, sheep (*Ovis aries*) are reluctant to eat herbage produced on the Appalachian Plateau in southern WV (Belesky et al., 1996). Comparisons of Puna with the cultivars Lacerta and Forage Feast, showed that Forage Feast was even less palatable than Puna for both whitetail deer (*Odocoileus virginianus*) and sheep (Foster et al., 2001). In PA, Labreuveux et al. (2001) used all three cultivars in a summer grazing experiment with beef cow-calf pairs without noting differences in forage preference.

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Chicory contains bitter sesquiterpene lactones (Rees and Harborne, 1985). Burnett et al. (1978) observed that cattle avoid *Vernonia* species that contain high concentrations (0.5 to 1.0% DM) of sesquiterpene lactones. They also noted that eastern cottontail rabbits (*Sylvilagus floridanus*) selected *Vernonia* species that lacked sesquiterpene lactones and that the bitterness of a sesquiterpene lactone (glaucolide-A) influences feeding preferences of whitetail deer. We have analyzed the sesquiterpene lactone composition of herbage from each forage chicory cultivar grown in WV and in PA to determine whether it might be linked to observed feeding behaviors of grazers in the two locations.

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Materials and Methods: Puna, Lacerta, and Forage Feast were established at the PA State University Haller Beef Research Center at State College, PA (40°N, 77°W; 1170 ft above sea level), in May 1997 and at the ARS research farm in Raleigh County, WV (38°N, 81°W; 2790 ft above sea level), in May 1998 using a seeding rate of 5 lb/ac. Leaf tissue from vegetative plants was collected from two replicated plots at each site twice during the summer of 1998 (WV: 7/16, 7/30; PA: 6/8, 8/24). Samples from WV were freeze dried. Samples from PA were oven dried at 150 F. Dried tissues were pulverized; subsamples were extracted with methanol; and extracts were passed through solid-phase extraction cartridges to prepare sesquiterpene lactone fractions (Tamaki et al., 1995). These fractions were analyzed by gradient reversed-phase (C₁₈) high performance liquid chromatography following the protocol of Sessa et al. (2000). Sample peaks were identified by comparison of retention times, UV spectra, and wavelength ratios with those for the pure sesquiterpene lactones, lactucin, 8-deoxylactucin, and lactucopicrin. Standards were generously provided by Dr. Mark Henry Bennett, Wye College, University of London, Ashford, Kent (lactucin and lactucopicrin) and Dr. Toshio Miyase, University of Shizaoka, Japan (8-deoxylactucin). Dry matter determinations were made using AOAC (1990) procedures, and sesquiterpene lactone data were converted to this basis.

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Results and Discussion: All forage chicory cultivars contained lactucin, 8-deoxylactucin, and lactucopicrin. Total concentration of sesquiterpene lactones, determined as the sum of the individual constituents, on each harvest date is depicted in Figure 1. Forage Feast consistently had a higher concentration of sesquiterpene lactones than Lacerta. Concentrations of sesquiterpene lactones in Puna varied between those in Lacerta and those in Forage Feast. For each cultivar, herbage produced in WV contained more sesquiterpene lactones than PA-grown herbage. Sesquiterpene lactone concentrations in all PA-grown cultivars were less than or equal to that present in WV Lacerta. Variations among harvest dates were greater in WV samples than PA samples. Differences in sample drying procedures are not responsible for observed differences in the sesquiterpene lactone composition of WV and PA samples. Subsamples of WV herbage dried by the two procedures had similar sesquiterpene lactone composition (data not shown). High sesquiterpene lactone concentrations in WV-grown forage chicory are also not unique to 1998 or to first-year plants (data not shown).

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Concentrations of individual sesquiterpene lactones are given in Table 1. For each cultivar and cultivation site, sesquiterpene lactone concentrations reported are means for two replicate plots and two harvest dates. Lactucin concentrations in Lacerta and Puna were

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similar for the two cultivation sites. The concentration of lactucin in Forage Feast was slightly higher in herbage from WV. Concentrations of 8-deoxylactucin and lactucopicrin in WV samples were approximately three and five times those in corresponding PA samples, respectively. Total sesquiterpene lactone concentrations in WV samples were also approximately three times those in their PA counterparts. Concentrations of lactucin and lactucopicrin were highest in Forage Feast while concentrations of 8-deoxylactucin were lowest in Forage Feast, regardless of cultivation site.

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These results suggest that total sesquiterpene lactone concentration in general, and lactucopicrin concentration in particular, are associated with the reduced palatability of WV-grown forage chicory. All WV-grown cultivars contain more sesquiterpene lactones than *Vernonia* species which cattle avoid (Burnett et al., 1978). Moreover, concentrations of lactucopicrin, the most bitter of the chicory sesquiterpene lactones (van Beek et al., 1990), are greater than the highest total concentration of sesquiterpene lactones (0.45% DM) found in a variety of chicory plants grown in the United Kingdom (Rees and Harborne, 1985). Both lactucopicrin and 8-deoxylactucin inhibit herbivory by insects (Rees and Harborne, 1985); lactucin effects on insect feeding have not been evaluated. Among the PA-grown cultivars, only Forage Feast has a sesquiterpene lactone concentration that exceeds the range observed by Rees and Harborne (1985), and lactucopicrin is not the dominant constituent in any of the PA-grown cultivars. Concentrations of sesquiterpene lactones in cultivars grown in their country of origin have not been published.

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Differences in the chemical composition of different cultivars grown at a specific site are indicative of genetic variations. Differences in the chemical composition of cultivars grown at different sites (PA and WV) suggest regulation of sesquiterpene lactones by environmental factors. Data show that individual sesquiterpene lactones are regulated independently. Investigations of specific environmental factors that influence the sesquiterpene lactone composition of chicory herbage are underway. Results will provide fundamental information needed for development of management strategies that will enable livestock producers with site limitations to take advantage of the positive attributes of forage chicory.

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Acknowledgment: The technical assistance of Jared Robertson and David Bligh are gratefully acknowledged.

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Table 1. Sesquiterpene lactone composition of herbage of forage chicory cultivars grown in West Virginia and Pennsylvania. Center title

Sesquiterpene lactone	Lacerta		Puna		Forage Feast	
	WV	PA	WV	PA	WV	PA
	% (DM basis) ^a					
Lactucin	0.09	0.09	0.12	0.14	0.37	0.29
8-Deoxylactucin	0.40	0.13	0.38	0.11	0.22	0.09
Lactucopicrin	0.55	0.09	0.75	0.14	0.94	0.18
Total	1.03	0.32	1.25	0.38	1.52	0.55

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^aValues are means for two replicate plots and two harvest dates (WV: 7/16/98, 7/30/98; PA: 6/8/98, 8/24/98).

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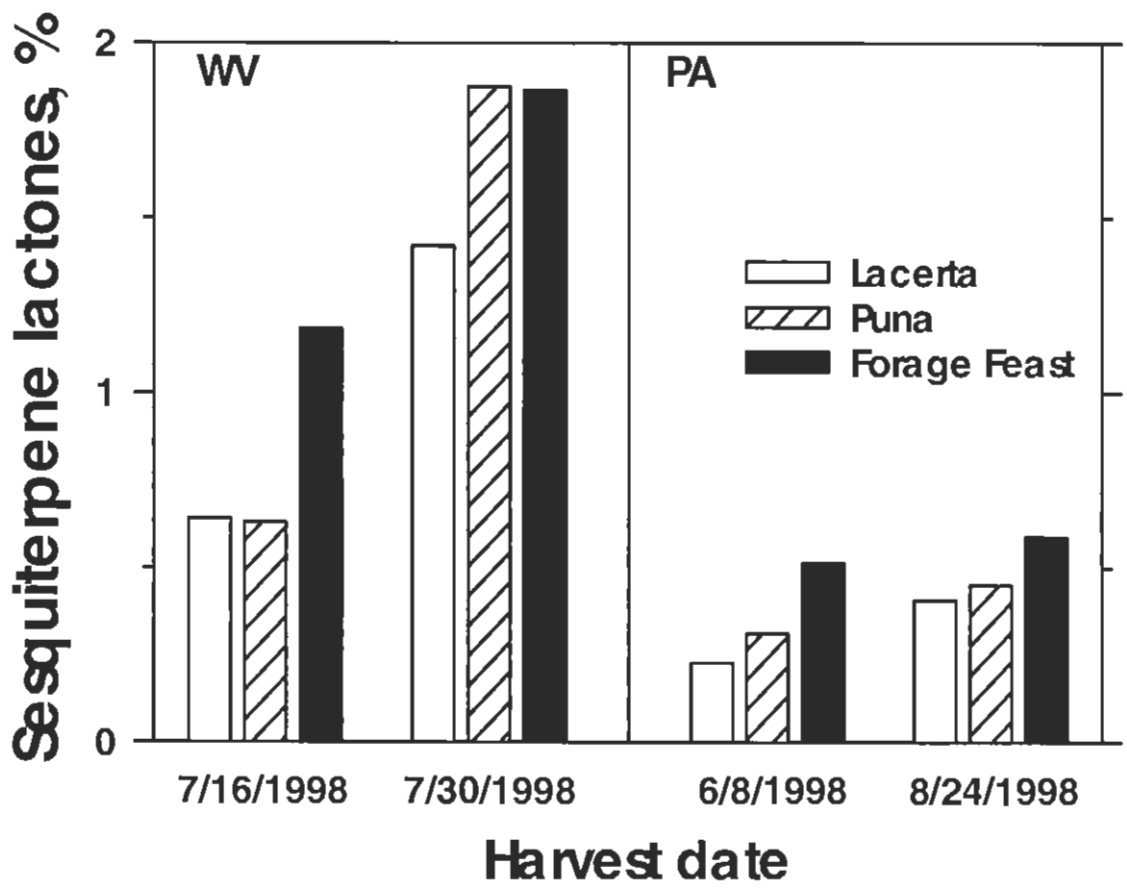


Figure 1. Total sesquiterpene lactones (dry matter basis) in herbage of forage chicory cultivars grown in West Virginia and Pennsylvania.

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