

EXTRAORDINARY LEVELS OF PRODUCTION OF PYRROLIZIDINE
ALKALOIDS IN *SENECIO RIDDELLII*

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Senecio riddellii Torr. & Gray (Riddell's groundsel) is a suffruticose perennial of the family Compositae that grows in sandy, waste areas throughout the Great Plains (1). As long ago as 1929, the plant was shown to be responsible for "walking horse disease" in Nebraska (2), and efforts have been made to eliminate it because of its reputation as a toxic forage for cattle. *S. riddellii* has been shown to contain the hepatotoxic pyrrolizidine alkaloid, riddelliine, together with traces of the closely related retrorsine (3,4). In range animals pyrrolizidine alkaloid (PA) toxicosis is insidious, irreversible, generally chronic, and characterized by a cirrhotic condition of the liver, with signs of poisoning and fatalities occurring often weeks or months after consumption of the offending plant.

In an attempt to identify the periods and conditions when animals are at greatest risk from PA-containing *Senecio* species growing on Western rangelands,

a survey was carried out over a three-year period at a number of different collection sites, to analyze for PA content of these plants. In accord with previous results (4), it was found that of the three major species of concern, *S. riddellii* produced the highest PA levels, with a mean content over all locations and collection periods of 6.42% leaf material dry weight, while *Senecio douglasii* var. *longilobus* and *Senecio jacobaea* had corresponding levels of 2.20% and 0.31%, respectively. However, it was found that at one collection site for *S. riddellii* the PA content attained exceptionally high levels, and for this reason the site was surveyed for a five-year period from 1979 to 1983. This particular location, near Woodward, OK, produced *S. riddellii* in which the maximum total PA content (free base plus N-oxide) of the air-dried leaves exceeded 10% for each one of the years surveyed. Table 1 shows the respective collection dates and maximum PA levels attained, together with the

TABLE 1. Maximum Pyrrolizidine Alkaloid Content and Composition for *Senecio riddellii* from Woodward, OK

Sample no.	Collection date	Total PA Content (%) ^a	Composition of total PA	
			free base (%)	N-oxide (%)
SR 1-4	8/1/79	10.04	15.3	84.7
SR 1-10	8/1/80	17.99	13.3	86.7
SR 1-15	7/1/81	12.82	13.0	87.0
SR 1-22	8/4/82	10.81	16.8	83.2
SR 1-27	8/1/83	14.46	10.9	89.1
	Mean	13.22	13.9	86.1

^aCalculated as percent riddelliine in dry weight of leaves.

relative proportions of free base and *N*-oxide as a percentage of total alkaloid.

In four of the years surveyed, the maximum PA content recorded corresponded with an early August collection date and in one year with early July. However, in all cases, the peak of PA production correlated to the mature plant stage of growth, immediately preceding flower-bud formation. The relative proportions of the free base and *N*-oxide were reasonably constant, averaging 14% and 86%, respectively.

Although *S. riddellii*, in general, appears to be a potent producer of alkaloids (4,5), the values recorded for samples from the Woodward location are exceptional. The PA content of 17.99% appears to be the highest recorded level for any type of alkaloid from any plant part. High production of alkaloids is typically associated with seeds or fruits, but in this case the alkaloid occurred in leaf material. The previous highest recorded PA level is 9.28% in seed from a strain of *Crotalaria retusa* specially selected for its alkaloid-producing ability (6). Levels recorded for other alkaloids specifically cultivated for their medicinal properties rarely exceed 7% (7).

The exceptionally high levels of alkaloids recorded for *S. riddellii* from this site raise interesting questions regarding the role of PAs in the plant. Because sampling was conducted on a monthly basis only, it would be extremely fortuitous if the record value of 17.99% was actually the highest level reached during that particular growing period, and the true maximum may well have been higher. It has been postulated that high levels of alkaloids in plants are produced in response to stresses such as drought, deprived soils, and attack by herbivores (8). The general association of *S. riddellii* with sandy wasteland suggests that such infertile soils may account, at least in part, for the common occurrence of high PA levels in this species. In addition, the 1980 season was characterized by very high tempera-

tures and low rainfall, which may have influenced the alkaloid level. However, there was no obvious evidence of grazing pressure upon the plants, by either insects or livestock, which might have stimulated alkaloid production.

EXPERIMENTAL

PLANT MATERIAL.—Collections of *S. riddellii* were made at Woodward, OK, and consisted of the filiform leaves only. Collections were generally made on the first day of each month, and individual plants were not sampled twice in the same season. The samples were air-dried in the shade and shipped to the Poisonous Plant Research Laboratory together with a data sheet indicating the approximate number of plants sampled, general atmospheric conditions, and plant growth stage. A voucher specimen from the location was filed in the Intermountain Herbarium at Utah State University, Logan, UT. Plant samples were given an accession number when received, further dried at room temperature if necessary, and ground in a Wiley mill to pass a 1 mm screen. Soil type at the collection site was classified as Pratt loamy, fine sand of very low natural fertility.

EXTRACTION AND ANALYSIS.—Ground plant material was extracted overnight in a Soxhlet apparatus with MeOH, and the total PA and free base PA content were determined for each sample by the previously described ¹H-nmr method¹ (4). PA *N*-oxide content was calculated from the difference between total PA and free base PA content. The alkaloid was shown by hplc (9) and tlc (10) to consist almost entirely of riddelliine with traces of retrorsine.

ACKNOWLEDGMENTS

The authors are grateful to Jack Engleman for collecting *S. riddellii* samples and to Felicula M. Porcuna and Sue C. Witt for technical assistance in carrying out the alkaloid analyses.

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¹In all cases, the quantity of alkaloid obtained from small samples (5-10 g) of plant material was so large that the ¹H-nmr results could be verified approximately by weighing the isolated material.

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Received 2 April 1984