TOXICITY OF SOME COMPOSITE (*SENECIO*) WEEDS

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Summary

The pyrrolizidine alkaloid status of many *Senecio* spp. growing in New Zealand has been investigated. The nature and level of alkaloids present gives a good indication of their potential toxicity. Three species, *Senecio jacobaea* (ragwort), *S. bipinnatisectus* (Australian fireweed) and *S. spathulatus*, available in quantity, were dosed to calves in identical manner and they showed similar levels of toxicity. All produced photosensitization, jaundice and wasting, with severe liver fibrosis and atrophy. Sheep given daily doses of 3 g dried *S. jacobaea*/kg bodyweight for 16 weeks suffered impaired liver function, usually unaccompanied by clinical signs. However there was a 70% mortality rate over the ensuing six months.

INTRODUCTION

Pyrrolizidine alkaloid poisoning of livestock, usually arising from ingestion of *Senecio* spp., causes serious economic losses in many countries. It was held (Forsyth 1954) that *S. jacobaea* (ragwort) alone probably caused more annual loss of livestock in Britain than all other poisonous plants together. This is probably still valid and it is also probably the major cause of plant poisoning in New Zealand.

Noteworthy, the first known records of experimental feeding of *Senecio* material to farm animals are attributed to Gilruth (1903) at Ruakura, New Zealand, where the experimental reproduction of previously suspected poisoning of horses by *S. jacobaea* was accomplished. Encouraged by this, Pethick (1906) reproduced Pictou disease in cattle in Canada by feeding *S. jacobaea*. Sheep, at first reported resistant, were later reported by Gilruth (1905) to have definite, but lower, susceptibility, but the finding has received little attention since that time.

In a continuing investigation our broad objectives are (1) to test the toxicity of available *Senecio* spp., indicated as being toxic from the structure of alkaloids isolated, by dosing dried plant materials to calves in strict comparison with *S. jacobaea*. (2) in view of the results of investigations into the serious and chronic nature of pyrrolizidine alkaloid poisoning of sheep by *Heliotropium europaeum* (Boraginaceae) in Australia (Bull *et al.* 1968), and irrespective of the popular view that *S. jacobaea* is harmless to sheep, to appraise the effects of experimental long-term and repeated intakes of *S. jacobaea* in sheep, commonly used for 'control' of this persistent pasture weed.

PLANTS IN NEW ZEALAND AND THEIR PYRROLIZIDINE ALKALOIDS

Senecio species growing in New Zealand vary greatly in their known or potential toxicity to farm animals. We are concerned here with the liver damage caused with a commonly occurring type of pyrrolizidine alkaloid which contains a double bond in its pyrrolizidine structure (see Figure). These alkaloids usually occur partly as their amine oxides, but this does not alter the toxicity.

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Some of the findings reported in this paper have been published in detail (White 1969; White and Warren 1972).

The main source of these alkaloids in New Zealand is *S. jacobaea* which contains 0.2 to 0.4% alkaloid (on a dry weight basis) in the softer green material. Similar alkaloids in similar level are in *S. bipinnatisectus* (previously *Erechtites atkinsoniae*, Australian fireweed), which is often nibbled by stock, and in *S. spathulatus* which is to be found around the harbours, rail tracks and goods yards. We have no evidence that the latter is eaten by animals. Also in this group is *S. vulgaris* (groundsel).

Several of the herbaceous species contain up to 1% of the alkaloid sarracine mainly as its N-oxide. It is saturated, i.e. does not contain the important double bond, and is not liver-damaging. These species include *S. sylvaticus* (wood groundsel), *S. mikanioides* (German ivy) and *S. glastifolius* (large senecio), a species occurring about Gisborne.

Several other plants, some of garden origin contain lower levels of toxic pyrrolizidine alkaloids, e.g. a *S. cruentus* derivative (garden cineraria), *S. quadridentatus* (cotton fireweed), which occurs rarely about Auckland, and the cultivated shrub *S. petasites*, occasionally seen about the countryside. *S. cineraria* (dusty miller) is reported to contain much the same alkaloids as *S. jacobaea* but in our experience the alkaloid concentration is low, e.g. 0.02%.

Most of the remaining *Senecio* species in New Zealand appear to contain very low levels of alkaloid. These include most of the shrubby endemic species (of Allan's Flora of New Zealand, Vol. 1), and other herbaceous fireweeds often placed in the *Erechtites* genus. These include *S. minimus*, *S. hispidulus* var. *scaberulus* and *S. glomeratus*, the only representatives we have examined. *S. elegans* (purple groundsel, of the beaches) contains very little alkaloid, also *S. crassiflorus* a horticultural ground cover.

S. lautus ssp. *lautus* (shore groundsel), found around the coast, contains very little alkaloid and is very different in this respect from the only other plant of this complex we have examined, *S. spathulatus*.

It is of interest that the alkaloid senkirkine which is slightly modified in structure from the basic pyrrolizidine nucleus, but still contains the double bond, is found by us to be liver-damaging. It is found (up to 0.1%) in the flower parts of *Brachyglottis repanda* (rangiora), closely allied to *Senecio*, and in *S. kirkii*. Green parts of *B. repanda* contain at least two alkaloids, one of which is toxic, but the concentration is only about 1 in 100,000.

The two species of the related genus *Eupatorium* found here contain low levels of toxic pyrrolizidine alkaloids, but some boraginaceous plants are moderately toxic due to these alkaloids. *Echium lycopsis* (Paterson's curse) is the worst offender, while *E. vulgare* (viper's bugloss) common in the South Island contains much lower levels of these alkaloids.

Our observations are based on plant material we have been able to obtain in the northern part of the country. Some of these plants which

Poisonous Plants

we regard as harmless may however contain other non-alkaloidal toxic agents.

TOXIC EFFECTS OF *SENECIO* SPP. TO CALVES

Since the animal toxicity of *S. bipinnatisectus* and *S. spathulatus* has not previously been reported we compared their toxicities with that of *S. jacobaea*, which is well documented. Comparison was by oral dosing of dried leaf and stem materials to two groups of calves at two levels, 34 g and 68 g daily. Unless death supervened dosing was continued for 11 weeks.

The high toxicity of all three *Senecio* spp. is apparent from Table 1 where the doses given and the gross effects are summarised. In most instances weight losses were recorded two to three weeks before death and diarrhoea was common. Most animals showed jaundice and photosensitization and typical alkaloidal liver injury was found in all animals at autopsy. Liver fibrosis and atrophy was apparent from the diminished liver weight/bodyweight ratios compared with controls.

TABLE 1: COMPARISON OF TOXICITY OF THREE *SENECIO* SPP. TO CALVES

Daily dose Rate (g)	No. of calves	Aver. wt. (kg)	Mean total dose (DM) kg g/kg b.wt.		Mean survival time (days)	Liver wt. as % of Body wt.
<i>S. jacobaea</i>						
68	3	56	2.92	55	50 (44 to 55)	1.3
34	3	48	1.22	26	42 (33 to 49)	1.3
<i>S. bipinnatisectus</i>						
68	3	56	3.15	57	55 (37 to 78)	1.6
34	3	48	3.00	42	86 (52 to 120)	1.5
<i>S. spathulatus</i>						
68	2	48	1.33	28	23 (15 and 31)	1.4
34	2	46	1.17	27	40 (37 and 43)	1.4
<i>Controls</i>						
—	5	51	—	—	—	2.2

TOXICITY OF *S. JACOBAEA* TO SHEEP

In a pilot experiment four sheep (30 to 35 kg b.wt.) were orally dosed with 100 g of dried *S. jacobaea* leaves daily for a maximum of 20 weeks. One death resulted after 11 weeks (total dose 264 g/kg), another after 18 weeks (420 g/kg) and a third at 46 weeks (460 g/kg), i.e. 26 weeks after cessation of dosing. Typical clinical signs were wasting, jaundice and photosensitization, and autopsy revealed progressive liver fibrosis and atrophy. The fourth animal, killed 18 months post dosing (460 g/kg), showed only an abnormally pigmented liver.

Subsequently two further groups of four sheep were identically dosed for four and eight weeks when they were killed to study progression of histological liver changes. Liver cell changes were apparent after both four and eight weeks of dosing with *S. jacobaea*. Noteworthy, one sheep became jaundiced and died after only 5 weeks dosing (total dose 3.0 kg or 88 g/kg).

Next we compared age susceptibility of sheep by orally dosing 10 lambs (24 kg b.wt.) and 8 hoggets (40 kg b.wt) with dried *S. jacobaea* leaves. Dosage was at 3 g/kg daily, the dose being adjusted upwards weekly according to individual weight gain. All but one animal survived the 16 week dosing period and each received a total dose of 288 g/kg.

The results showed no difference in susceptibility in relation to age or weight. Six hoggets (75%) died at a mean interval of 11.9 weeks after cessation of dosing (range -2.6 to +24 weeks). Seven lambs (70%) died

at a mean interval of 13.7 weeks after dosing (range 8 to 23 weeks). Tests made at the termination of dosing on serum of all dosed sheep revealed marked liver dysfunction. All sheep which succumbed to *S. jacobaea* showed jaundice and weight loss over the terminal three to six weeks. Liver fibrosis and atrophy were found in all autopsied sheep but these changes were not so pronounced as in calves. The mean liver weight/bodyweight ratio for the dosed hogget group was 1.00% (range 0.73 to 1.10; 6 animals); for controls 1.22% (range 1.10 to 1.28; 4 animals).

DISCUSSION

The toxicity of *Senecio* and other plants which contain pyrrolizidine alkaloids can be largely predicted by isolation and determination of the structure of alkaloids present.

Cattle are particularly susceptible to toxic *Senecio* spp., and *S. jacobaea*, *S. bipinnatisectus* and *S. spathulatus*, when dosed to calves, showed similar levels of toxicity. The higher dose rate employed (68 g daily) proved to be far greater than required to produce disease and death, and it is likely that lesser amounts than the lower dose rate used (34 g daily), if fed over a longer period, would have produced similar disease and death.

The chronic nature of pyrrolizidine alkaloid poisoning was well illustrated in the sheep experiments with *S. jacobaea* in which deaths occurred many weeks after cessation of dosing. Lambs and hoggets proved equally susceptible and smaller daily doses than the 3 g/kg given are likely to produce significant loss of production and deaths over many months. On evidence available from these experiments, sheep appear to be about 10 times less susceptible than calves. In spite of the lower susceptibility of sheep, the use of adult sheep to graze out *S. jacobaea* is a dangerous policy. Because of the chronic nature of the liver changes it may be prudent where possible to use lambs destined for early slaughter for this purpose.

The dangers attendant in grazing sheep on *S. jacobaea* for a second season requires to be investigated for, with sheep grazing *Heliotropium europaeum* in Australia, no effects are seen in the first year but losses can be serious many weeks after grazing the weed for a second season.

Because of its chronicity, the disease is rarely associated in time with grazing of *S. jacobaea* infested pastures. Deaths from poisoning with *S. jacobaea* are likely to be attributed to out-of-season deaths from facial eczema, particularly in the North Island. On clinical and on gross liver appearances the two diseases present a similar picture, although on histological appearances they are quite distinct.

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