

Terms

Endophyte - an endosymbiont, often a bacteria or fungus, that lives within a plant or at least part of its life cycle without causing apparent disease. Endophytes are ubiquitous and have been found in all the species of plants studied to date; however, most of these endophyte/plant relationships are not well understood.

Vertical transmission - endophytes that are asexually transmitted via fungal hyphae penetrating the host's seeds (e.g. *Neotyphodium*). Since their reproductive fitness is intimately tied to that of their host plant, these fungi are often mutualistic

Horizontal transmission - endophytes are sexual and transmit via spores that can be spread by wind and/or insect vectors. Since they spread in a similar way to pathogens, horizontally transmitted endophytes are often closely related to pathogenic fungi.

Locoweed Endophyte



Figs 1–2. Endophyte isolate L12. **Fig. 1.** Mycelia and conidia. **Fig. 2.** Conidia. Bars= 10 μ m.

Correlation between endophyte infection and mean swainsonine content

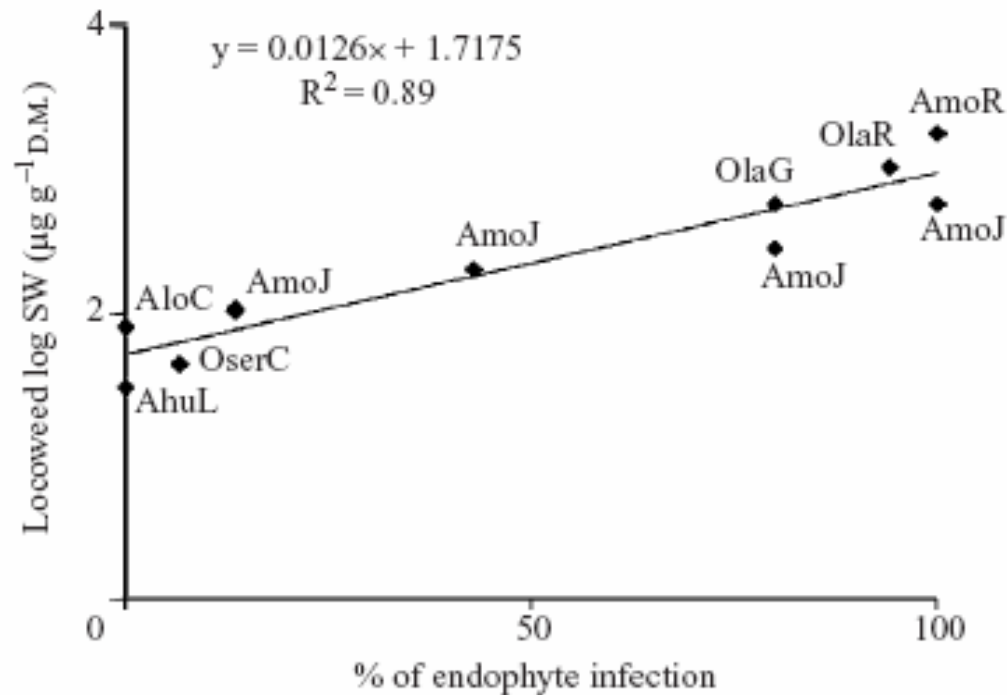


Fig. 3. Endophyte infection and mean swainsonine content in locoweed populations. Regression of mean swainsonine (SW) content against percentage of endophyte infection in 10 locoweed populations. Ahu, *Astragalus humistratus*; Alo, *A. lonchocarpus*; Amoj, *A. mollissimus*; Ola, *Oxytropis lambertii*; Ose, *O. sericea*; C, Colfax; G, Gila; J, Jornada; L, Lincoln; and R, Raton.

Correlation between swainsonine production of endophyte strains compared to the locoweed populations from which they were isolated

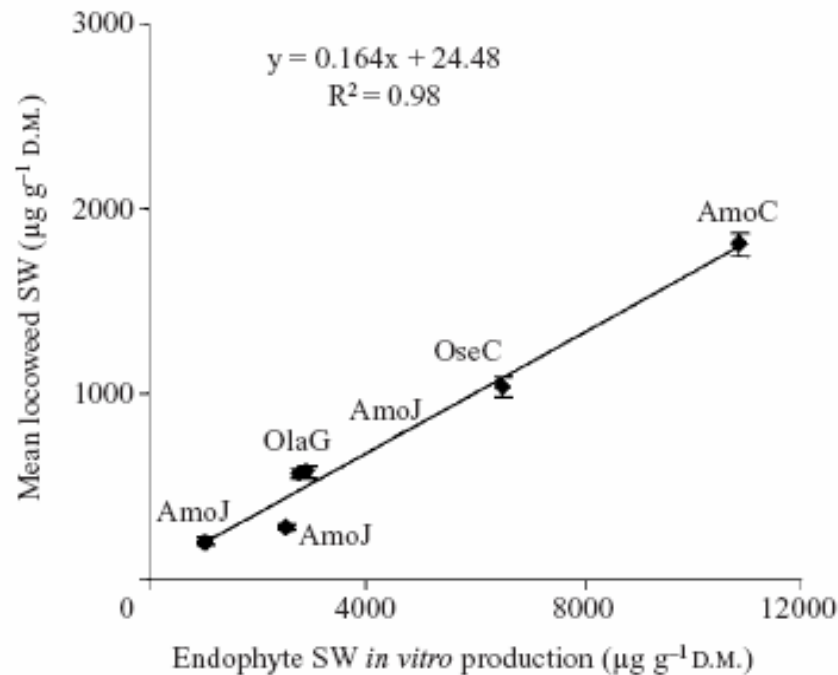


Fig. 4. *In vitro* swainsonine production of endophyte strains compared to the locoweed populations from which they were isolated. Regression of mean swainsonine (SW) content ($\mu\text{g/g}$ D.M.) (D.M. = dry matter) of 6 locoweed populations against the *in vitro* SW production of their associated isolated endophyte strains. Error bars are the standard error of the raw data. Abbreviations as Fig. 3.

Mean swainsonine concentrations for the major *Astragalus* and *Oxytropis* locoweeds

Species	Variety	N	Swainsonine	SE	Min	Max
			-----%-----			
<i>A. wootoni</i>		11	0.37	0.06	0.25	0.43
<i>A. pubentissimus</i>		10	0.21	0.012	0.16	0.27
<i>A. mollissimus</i>	<i>earleii</i>	30	0.22	0.012	0.01	0.38
	<i>mollissimus</i>	15	0.14	0.007	0.11	0.21
	<i>thompsonii</i>	25	0.002		0	0.008
<i>A. lentiginosus</i>	<i>diphysus</i>	10	0.23	0.018	0.18	0.39
	<i>lentiginosus</i>	5	0.15	0.016	0.11	0.19
	<i>wahweapensis</i>	10	0.15	0.019	0.002	0.20
	<i>araneosus</i>	15	0.11	0.011	0.001	0.14
<i>O. sericea</i>	<i>sericea</i>	26	0.04	0.005	0	0.09

Mean swainsonine concentrations and variance for some *Astragalus* and *Oxytropis* non-locoweeds

Species	Variety	N	Swainsonine	SE	Min	Max
Non - locoweed species						
<i>A. alpinus</i>		1	0			
<i>A. amphioxys</i>		8	0.001		0	0.005
<i>A. cibarius</i>		5	0			
<i>A. coltonii</i>		5	0			
<i>A. filipes</i>		2	0			
<i>O. campestris</i>		1	0			

Correlation between swainsonine and the presence of the endophyte as detected by culturing methods and PCR in the major locoweed species

Species	Variety	Swainsonine			Endophyte		PCR
		+	-	Low	Culture +	-	
<i>A. wootoni</i>		11	0	0	11	0	11
<i>A. pubentissimus</i>		10	0	0	9	1	10
<i>A. mollissimus</i>	<i>earleii</i>	30	0	0	27	3	30
	<i>mollissimus</i>	15	0	0	12	3	15
<i>A. lentiginosus</i>	<i>diphysus</i>	10	0	0	8	2	10
	<i>lentiginosus</i>	5	0	0	5	0	5
	<i>wahweapensis</i>	9	0	1 ^a	8	2	10
	<i>araneosus</i>	13	0	2 ^a	14	1	15
<i>O. sericea</i>	<i>sericea</i>	22	1 ^a	3 ^a	22	4	26
Total		125	1 ^a	6 ^a	116	16	132

Correlation between swainsonine and the presence of the endophyte as detected by culturing methods and PCR in other Astragalus species

Species	Variety	Swainsonine			Endophyte		PCR
		+	-	Low	Culture	-	
^a Swainsonine at	or below detection level (0.001)						
<i>A. mollissimus</i>	<i>thompsonii</i>	0	16 ^a	9 ^a	1	24	25
<i>A. amphioxys</i>		0	6 ^a	1 ^a	0	7	7

***O. Lambertii* populations representing three varieties and their mean swainsonine concentrations**

Table 3. *O. lambertii* Populations and Mean Swainsonine Concentration

location	<i>O. lambertii</i> var.	stage ^a	GPS coordinates	voucher no. ^b	mean ^c (% dry wt ± SD)	range
Meade, KS	<i>articulata</i>	pod	37° 10' 09 N; 100° 23' 03 W	27698	<0.0001	
Knowles, OK	<i>articulata</i>	early pod	36° 55' 15 N; 100° 18' 23 W	27689	<0.0001	
Buffalo, OK	<i>articulata</i>	pod	30° 48' 44 N; 99° 46' 22 W	27697	<0.0001	
Flagstaff, AZ	<i>bigelovii</i>	vegetative	35° 23' 41 N; 111° 34' 46 W	27665	0.054 ± 0.027	0.022–0.106
Springerville, AZ	<i>bigelovii</i>	vegetative	34° 00' 49 N; 109° 10' 48 W	27667	0.026 ± 0.021	0.0–0.065
Kingston, NM	<i>bigelovii</i>	vegetative	32° 52' 51 N; 107° 51' 55 W	27668	0.016 ± 0.013	0.0–0.043
Winston, NM	<i>bigelovii</i>	flower	33° 21' 43 N; 107° 34' 41 W	27669	0.038 ± 0.035	0.0–0.068
Kanab, UT	<i>bigelovii</i>	vegetative	37° 06' 19 N; 111° 51' 28 W	27661	0.008 ± 0.016	0.0–0.047
Ferron, UT	<i>bigelovii</i>	flower	39° 06' 57 N; 111° 17' 36 W	440983	<0.0001	
Fort Collins, CO	<i>bigelovii</i>	flower	40° 56' 39 N; 105° 15' 33 W	440980	0.0002	
Ocate, NM	<i>bigelovii</i>	pod	36° 15' 11 N; 105° 02' 32 W	27672	0.0006	
Capulin, NM	<i>bigelovii</i>	flower	36° 41' 25 N; 104° 08' 35 W	440981	0.0001	
Sophia, NM	<i>bigelovii</i>	flower	36° 28' 06 N; 103° 59' 54 W	440982	<0.0001	
Sidney, NE	<i>lambertii</i>	flower	41° 09' 18 N; 103° 05' 27 W	27704	0.0007	
Hot Springs, SD	<i>lambertii</i>	flower	43° 24' 35 N; 103° 26' 23 W	27717	0.0001	
Lusk, WY	<i>lambertii</i>	flower	43° 05' 12 N; 104° 19' 36 W	27721	<0.0001	

^a Phenological growth stages. ^b Voucher specimens deposited in Monte L. Bean Herbarium, Brigham Young University, Provo, UT.

^c For those samples with initial swainsonine levels at <0.001%, a separate bulk sample was analyzed with quantitation down to 0.0001% (1 ppm) and the presence of swainsonine confirmed by GC-MS.

Map of *O. Lambertii* populations

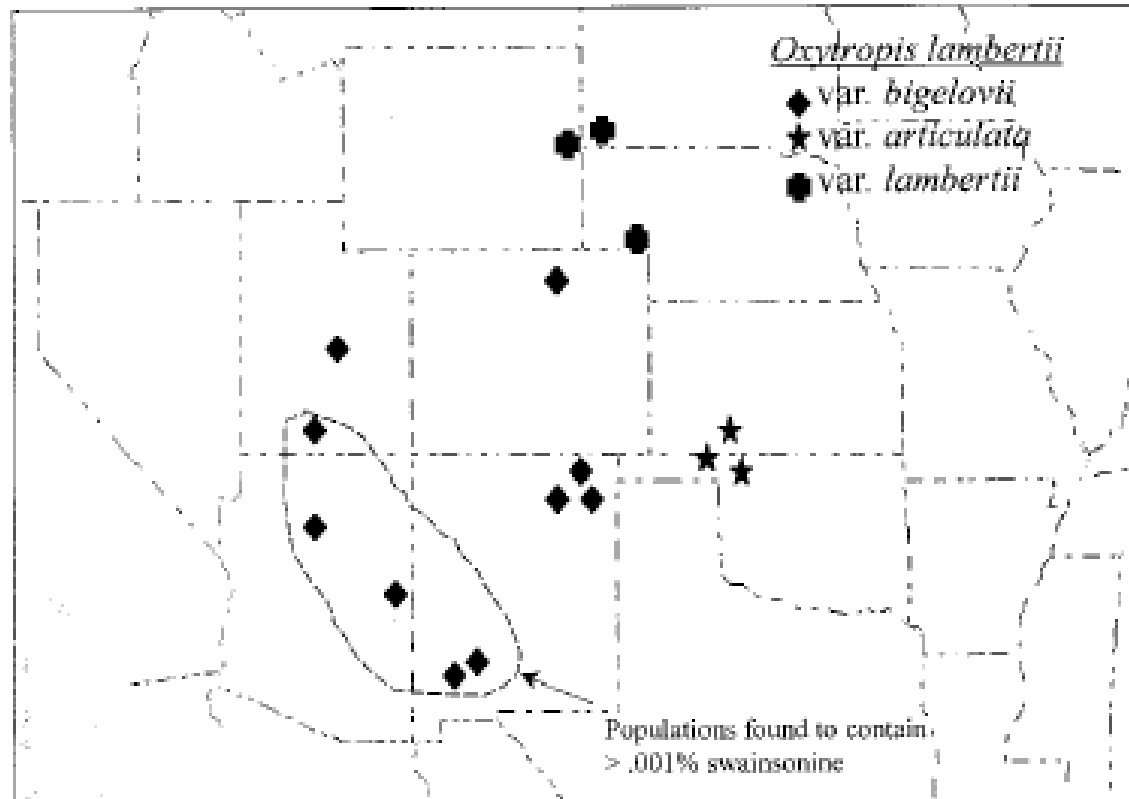


Figure 3. Map showing the 16 locations for collection of *O. lambertii* var. *lambertii*, *articulata*, and *bigelovii* from western United States.

Conclusions

- A fungal endophyte is responsible for swainsonine biosynthesis
- *Astragalus* species generally have higher swainsonine concentrations than do *Oxytropis* species
- Not all plants that contain the endophyte produce detectable levels of swainsonine
- Not all populations of the same species contain swainsonine at detectable levels

Required Reading

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