Toxic Plant Research Updates

Dr. Daniel Cook
USDA-ARS Poisonous Plant Research Laboratory
1150 E 1400 N
Logan, UT
(435) 752-2941
Daniel.Cook@ars.usda.gov
The mission of the Poisonous Plant Research Laboratory is to identify poisonous plants and their toxins, determine how the plants poison animals, develop diagnostic and prognostic procedures, identify the conditions under which poisoning occurs, and develop management strategies and treatments for ranchers to reduce livestock losses.

USDA-ARS Poisonous Plant Research Laboratory
1150 E. 1400 N.
Logan, Utah 84341
Phone: 435-752-2941
Fax: 435-753-5681
Email Contact: Dr. Kip Panter, Research Leader
Kip.Panter@ars.usda.gov
Losses to Toxic Plants

- Death
- Impaired gains
- Abortions, birth defects
- Indirect losses:
  - vet costs
  - increased risk
  - changes in management

Total annual losses in U.S. exceed $300 million
Common cause of problems

No groceryosis = toxic plant problems

Body condition score=1  Body condition score=4
Some current research:

- Larkspurs (Delphinium):
  - Tall, Low, Plains
- Hepato and Neuro Toxins:
  - pyrrolizidine alkaloids
- Teratogenic or abortifacient plants
  - pine needles; lupines
- Locoweeds
  - Oxytropis & Astragalus
- Selenium toxicity
- Rayless goldenrod and white snakeroot toxicity
Distribution of the Major Locoweed Species

Rank Order of toxicity:
A. wootoni > A. mollissimus = A. lentiginosus > O. sericea
(garbancillo) (wooly loco) (spotted loco) (white point loco)
Locoweed Endophyte

- Fungal endophyte isolated from toxic locoweeds
- Produces swainsonine in culture
- Cultured from stems, leaves, seeds, and flowers of toxic field plants
- Localized to seed coat
Update on Swainsonine–containing locoweeds in Arizona

- Some species thought to be toxic (i.e., contain swainsonine) are not, and other Astragalus species were found to contain swainsonine, and thus are toxic
Previously Known Swainsonine-containing locoweeds

- Astragalus amphioxys (across northern Arizona)
- A. lentiginosus vars. araneousus, diphysus, lentiginosus, and wahweapensis;
- A. mollissimus vars. bigelovii, earlei, matthewsii, mollissimus, and thompsonae;
- A. wootoni (found across Arizona)
- Oxytropis lambertii
- (northern and southern Arizona);
Arizona Astragalus species said to cause locoism

- A. praelongus
- A. emoryanus
- A. bisulcatus
- A. didymocarpus
- A. humistratus
- A. lonchocarpus
- A. nothoxys
- A. tephrodes
Arizona Astragalus species said to cause locoism

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- A. emoryanus
- A. bisulcatus
- A. didymocarpus
- A. humistratus
- A. lonchocarpus
- A. nothoxys
- A. tephrodes

None of these species contain swainsonine, therefore they are not toxic to livestock (unless they contain another toxin like A. bisulcatus (selenium accumulator).

- Astragalus allochrous and thurberi have not been previously shown to contain swainsonine, but they do, so they are definitely toxic.

Proper identification can be very difficult with locoweeds, so it is important to consult a competent taxonomist.
Locoweed effects on livestock

- Four principal effects on livestock: (1) neurological damage; (2) emaciation; (3) reproductive dysfunction and abortion; and (4) congestive right heart failure when grazed at high elevations.
Clinical Signs of Locoweed Poisoning

- Depression; Dull dry hair coat; Eyes dull and staring
- Irregular gait or some loss of muscular control
- Weakness; Some animals show extreme nervousness; Loss of sense of direction; Animal may become violent if stressed
- Withdrawal from other animals; Some animals unable to eat or drink
- Recumbency and death may follow prolonged consumption of locoweed
Female Reproduction

- Abortion/fetal resorption
- Embryo loss
- Reduced maternal responsiveness
- Developmentally impaired lambs/ lack of nursing at birth
Male Reproduction

- Inhibits Spermatogenesis; abnormal sperm
Behavioral Aspects of Locoweed Intoxication

- Addiction, habituation or learned preference?
- Social facilitation leads to greater consumption of locoweeds
- Mother infant behaviors at birth:
  - pregnant ewes given locoweed had weak lambs
  - ewes were nervous and poor mothers
  - lambs were unable to suckle etc. normally
  - lambs recovered rapidly within about 10 days
  - when lambs were 9 months old they had recovered completely from initial intoxication
Conclusions

- Avoid locoweed during pregnancy
- Use intermittent grazing patterns
- Provide clean pastures when animals start to eat locoweed
- Breeding males should be off locoweed for at least 90 days before breeding season
- Permanent neurological disorders may preclude keeping animals for reproduction
Larkspur (Delphinium species)
Clinical Signs of Poisoning

- Staggering gait.
- Muscle trembles.
- Collapse to sternal and then lateral recumbency (this can lead to death for various reasons).
- Death occurs from neuromuscular paralysis and/or bloat.
Methods of Avoiding Larkspur Death Losses

- Drug treatment.


- Future Management – select animals with decreased susceptibility to poisonous plants.
Delphinium species (larkspurs): proof of concept for selecting resistant cattle

- One solution to losses of grazing livestock from toxic plants involves the compatibility of animals to their environment. Genetic selection of livestock has the potential to reduce livestock losses.
- Cattle differ greatly in response to larkspur toxicity; the differing susceptibility and resistance appears to be highly heritable. Current work is focused on phenotyping cattle, and then determining the genetic basis for their response to larkspur alkaloids.
Grazing and the Toxic Window

Larkspur Breed Study

- Developed two quantitative measures of larkspur intoxication.
  - Heart rate.
  - Time to fatigue.
- Evaluating cattle breeds for susceptibility to larkspur intoxication.
Cattle responses to 8.0 mg/kg MSAL-type alkaloids.

# Average time to exercise-induced fatigue.

<table>
<thead>
<tr>
<th>Breed, (number of animals)</th>
<th>Time to muscle fatigue, (minutes)</th>
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<tbody>
<tr>
<td>Angus, 33</td>
<td>17.2 ± 2.7</td>
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<tr>
<td>Brahman, 13</td>
<td>9.4 ± 3.3</td>
</tr>
<tr>
<td>Line 1, Hereford, 48</td>
<td>7.4 ± 1.4</td>
</tr>
<tr>
<td>Holstein, 15</td>
<td>26.8 ± 3.4</td>
</tr>
<tr>
<td>Jersey, 14</td>
<td>29.3 ± 2.9</td>
</tr>
</tbody>
</table>

Genomic approaches (In Collaboration with MARC)

- Whole genome association study (GWAS)
  - Multiple testing requires stringent statistical threshold
  - More likely to test SNP that are truly associated but too many false positives if threshold is not stringent.
- Candidate gene approach
  - Hypothesis driven
  - Small number of loci tested
- Most studies utilize both approaches
- GWAS can be used to identify initial candidates
Illumina Bovine SNPHD genotyping array.

- Illumina Bovine SNPHD genotyping array.
  - 777,962 polymorphisms across the entire bovine genome.
  - Breed associations currently using the BovineSNP50 for the calculation of genome enhanced EPDs.
Current Work

- Phenotyping 20 bulls with larkspur to provide a basis for selecting animals tolerant of larkspur.
  - Collect semen and ship to MARC for AI.
- Progeny test for larkspur resistance.
- Testing Angus steers for resistance to larkspur.

- The larkspur selection research will be a model for work with other toxic plants such as lupine.
Abortions in cattle from pine needles

- Affects only cattle in mid to late gestation
- Cows often eat needles during cold, snowy weather
- Thin cows eat more than fatter cows
- Dead calves, retained placenta
Cattle eat substantial amounts of pine needles during winter.
Weather affects cattle consumption of pine needles

- At minimum temperatures > -5 °C, cattle in 5 winter grazing studies consumed no green needles from trees (MT, SD, OR).

Consumption (% of bites) of pine needles and other browse in Montana during winter*

<table>
<thead>
<tr>
<th>Average snow depth (cm)</th>
<th>&lt; 2.5</th>
<th>2.5-25.0</th>
<th>&gt; 25.0</th>
</tr>
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<tbody>
<tr>
<td>Pine litter</td>
<td>38</td>
<td>42</td>
<td>15</td>
</tr>
<tr>
<td>Green needles on tree</td>
<td>0</td>
<td>6</td>
<td>24</td>
</tr>
<tr>
<td>Other browse</td>
<td>0</td>
<td>16</td>
<td>35</td>
</tr>
</tbody>
</table>

*Does not include dried grass and forbs.
Effect of body condition on PN consumption by cattle

Low body condition increases PN intake

Low protein diets reduce PN intake
Juniper (*Juniperus spp.*)

- Over 30 type of junipers
- A variety of agents have been associated with toxicity of the needles including phytoestrogens, mycotoxins, resins, and lignols. However the main component is isocupressic acid
- Experimentally, results in abortion in cattle – sheep and goats are unaffected
Oak Poisoning in Livestock
Quercus turbinella
Shrub live oak -
Grows in semi-arid, lower
elevation shrub woodlands or
deserts from CA to TX.
Most common oak in Arizona
Toxins are Tannins - concentrations may be high in oakbrush, especially in spring (% of dry weight)

<table>
<thead>
<tr>
<th></th>
<th>Juvenile</th>
<th>Mature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gambel oak</td>
<td>11.1%</td>
<td>8.7%</td>
</tr>
<tr>
<td>Shinnery oak</td>
<td>15.1%</td>
<td>4.2%</td>
</tr>
</tbody>
</table>
Oak poisoning

- Ingestion of buds, leaves, stems and sometimes acorns
- Spring: buds and current seasons growth, and immature leaves.
- Consumption by cattle:
  - Data on Q. turbinella in AZ: 25-40% of diet in winter
- Generally animals must eat >50-75% of diet to be fatally intoxicated.
Toxicity to ruminants

- Clinical signs:
  - Anorexia, depression, loss of rumen motility, constipation changing to bloody diarrhea
  - Blood urea nitrogen (BUN) elevated from 10-20 mg/dl to >150 mg/dl
  - Acute cases die in 1-3 days
  - Chronic cases linger weeks or months
  - Animals that continue to eat other forage generally recover completely
  - Most prominent finding is typically kidney lesions. Renal lesions always present; may also have necrosis of GIT
  - May have liver lesions and elevated liver enzymes
Reducing losses to Oakbrush

- Good range management = diverse forage base
- Mechanical or fire treatment may reduce stands (risk of increasing problems from resprouting in subsequent years)
- Keep livestock off oak stands until plants mature (i.e. > 30 days)
Reducing losses to oakbrush

- Supplemental feeding may reduce oak consumption.
- TX researchers (Dolohite) recommended feeding calcium hydroxide (10-15%) as an antidote in feed. Counteracts metabolic acidosis from organic acids.
- 4 pounds per head per day containing
  - 10 percent hydrated lime (CaOH)
  - 6 percent fat
  - 30 percent alfalfa
  - 54 percent cottonseed meal starting before the buds are set in the spring
Isocoma – Rayless Goldenrod update

- Affects nervous system
- Depression; reluctant to move
- Muscle tremors when moved
- Tremetone suggested as the toxin
Toxicity of burroweed to livestock

- RGR was dosed to Spanish goats and Jersey calves at 2 % b.w. daily;
  - clinical signs after 5-9 days of dosage.
- RGR was dosed to horses at 3 % b.w. daily;
  - After 7 days they showed decreased appetite, exercise intolerance, reluctance to stand, muscle swelling, and tremors on standing & exercise.
- RGR was dosed to lactating goats for 14 days at 2% b.w. daily.
  - Mothers showed no clinical signs
  - Kids showed no or mild clinical signs but did have greatly increased serum CK activity, indicating muscle damage.
  - No tremetone was found in the milk of lactating dams.
Toxin(s) in Isocoma species (burroweed; rayless goldenrod; goldenbush)

- Tremetone and dehydrotremetone (benzofuran ketones [BFKs] have been suggested as the toxic compounds in I. pluriflora.
- We examined I. pluriflora, I. tenuisecta, I. azteca, I. acradenia, and I. rusbyi for tremetone, dehydrotremetone, and other compounds.
- We found tremetone, dehydrotremetone, and 3-oxyangeloyltremetone in I. tenuisecta, I. azteca, I. acradenia, I. rusbyi, and several other Isocoma spp.
Toxin(s) in Burroweed

- Tremetone, 3-oxyangeloyltremetone, and related BFK compounds were found for the first time in 8 other species:
  - Isocoma menziesii
  - I. coronoplofolia,
  - I. drummondi,
  - I. veneta,
  - I. hartwegii,
  - I. gypsophila,
  - I. tometosa,
  - I. arguta
Toxicity of Burroweed

- It is well established that I. pluriflora is poisonous causing a trembles and milksickness in livestock.
- Why is there an absence of reports of livestock poisoning due to I. tenuisecta, I. azteca, I. acradenia, and I. rusbyi?
- It may be that tremetone, dehydrotremetone, and other benzofuran ketones (BFKs) are not the compounds responsible for toxicity in I. pluriflora?
- In all studies, BFKs have been found in the plants when animal toxicity has been demonstrated.
- Further work needs to be done to verify if the BFKs are the toxic compounds or if other compounds are responsible for the toxicity of these plants.
Lupine (Lupinus spp.) – Crooked calf syndrome
Lupine consumed by pregnant cattle causes several birth defects: skeletal and cleft palate.
Defects/Susceptible Gestational Periods: Caused by alkaloid-induced reduction in fetal movement

- Multiple Congenital Contractures  40-70 days
  - Arthrogryposis
  - Scoliosis
  - Torticollis
  - Kyphosis
- Cleft Palate  40-50 days

Scoliosis
Management Recommendations

Management changes to reduce or eliminate crooked calves:

a) Intermittent grazing (clean vs. infested pastures)
b) Changing breeding program (avoid lupine during susceptible gestational period)
c) Intense management (cull lupine eaters or move them to clean pastures)
d) Graze steers or open heifers
e) Graze infested pastures after seed pods shatter
WHAT DOES YOUR DAD DO?

HE'S AN ENVIRONMENTAL ACTIVIST

ONE OF THOSE GUYS THAT CHAIN THEMSELVES TO TREES?

HE'S A FARMER
‘‘Don’t worry about those poison weeds, them coyotes will have yore sheep eat up before they git to this pasture!’’
Appendix: Other toxic plants
Halogeton

- Oxalate poisoning
- Muscle weakness and collapse
- Kidney failure
- Adapted animals can eat substantial amounts
Horsebrush

- Grows with sagebrush areas
- Primarily affects sheep - “bighead”
- Photosensitization
- Typically must eat black sage first
Milkweeds

- Contain cardiac glycosides (heart toxins)
- Not usually eaten unless forage v. scarce
Senecio

- Potent liver toxins
- Wasting disease and photosensitization
Broom snakeweed

- Abortions and sick cows
- Toxins probably terpenes – similar to pine needle abortions
Colorado rubberweed

- Irritate stomach
- Clinically -sneezing, vomiting, diarrhea
- Muscle weakness; weight loss
Selenium-containing plants

- Se toxic to cells
- Causes hair to fall out and hooves to fracture (lameness)
- Sometimes blindness and aimless wandering
Selenium indicator plants

- Princes plume indicates soils with high Se content
Cow Cockle

- **Saponaria officinalis**
- May cause liver problems
Mesquite

- **Prosopis spp.**
- **Pods and beans causes rumen impaction**
- **Long-term consumption can cause eating impairment; protruding tongue**
Nightshades

- Solanum spp.-several species
- Affect nervous system
- Loss of balance; tremors; seizures
Black Locust

- *Robinia pseudoacacia*
- Toxin similar to ricin; high in bark and seeds
- Severe GIT irritation; diarrhea; shock
- Sometimes heart problems
Puncture Vine

- Tribulus terrestris
- Saponins cause liver disease
- Photosensitization
Kochia weed

- Kochia scoparia
- Accumulates nitrates; other toxins
- Causes sudden death
- Blood chocolate brown
- Also photosensitization
Tree tobacco

- Nicotiana spp.
- Nicotine toxicity
- Affects nervous system
- Also causes birth defects (skeletal malformations) in pregnant animals
Sagewort and Sand sage

- Artemisia spp.
- Typically “saged horses”
- Nervous system - loss of balance and circling aimlessly
- Can recover on good diet
Russian knapweed

- Centauria repens
- Weedy plant
- Toxic to horses
- ‘Chewing disease’ after prolonged consumption
- Food cannot be eaten normally
Kallstroemia spp

Can form dense carpet of plants

Hind limb weakness; convulsions; sheep may walk on knees
Dock

- *Rumex spp.*
- Contain oxalates
- Muscle tremors; weakness; reluctant to move
- Coma; death
- Adapted animals not usually affected
<table>
<thead>
<tr>
<th>Isocoma spp. / Site</th>
<th>Average Compound Concentration ± SD (n=10)</th>
<th>µg/mg dry weight</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>I. pluriflora</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pecos</td>
<td>0.4 ± 0.3</td>
<td>2.6 ± 0.7</td>
</tr>
<tr>
<td>Carlsbad</td>
<td>0.16 ± 0.08</td>
<td>0.8 ± 0.2</td>
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<tr>
<td>I. tenuisecta</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tuscon</td>
<td>0.2 ± 0.1</td>
<td>1.7 ± 0.5</td>
</tr>
<tr>
<td>Red Rock</td>
<td>0.11 ±0.08</td>
<td>0.7 ± 0.5</td>
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<tr>
<td>I. azteca</td>
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<tr>
<td>Newcomb</td>
<td>6 ± 2</td>
<td>0.8 ± 1</td>
</tr>
<tr>
<td>Tsaya</td>
<td>8 ± 2</td>
<td>0.0004 ± 0.001</td>
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<tr>
<td>I. acradenia</td>
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<tr>
<td>Mesa</td>
<td>1.0 ± 0.2</td>
<td>1.0 ± 0.4</td>
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<td>Kingman</td>
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<td>4 ± 2</td>
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<tr>
<td>Wickenburg</td>
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<td>1.1 ± 0.5</td>
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<td>I. rusbyi</td>
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<td>Marble Canyon</td>
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<tr>
<td>Tuba City</td>
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<td>---</td>
</tr>
<tr>
<td>Holbrook</td>
<td>2 ± 1</td>
<td>2 ± 2</td>
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