Nitrates in Forage Cause Cattle Deaths: A Common Weed and Uncommon Circumstances

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Introduction

Annual death losses of about 1.2 animals per herd are typical of United States cattle herds with 100 to 200 head. Poisoning causes 3.7% of all deaths (NAHMS, 1997). Nitrate toxicosis resulting in cattle loss is commonly associated with stem or stalk portions of sorghum, sorghum–sudangrass hybrids, corn, oats, Johnsongrass, pigweed, thistle, lamb's-quarter, and nightshade. Environmental factors such as drought stress and excessive nitrogen fertilization are usually considered causal conditions for nitrate accumulation in forages. In late 1997, a Jefferson County cattleman lost 35 cattle from a herd of 123. The cause of death appears to have been nitrate poisoning from cudweed, a common late-winter weed not widely recognized as a hazard.

Nitrate Poisoning of Cattle

Factors that contribute to livestock poisoning by nitrates (NO_3^-) are presented comprehensively by Wright and Davison (1964) and summarized in Table 1. National Research Council survey of nitrates presents some of the factors that lead to the accumulation of nitrate in plants (NRC, 1972). It includes dry hot seasons, heavy manure treatments, and insufficient levels of phosphorus or other plant nutrients required for normal plant metabolism. Other factors are sudden changes in temperature, frost, shading of plants, insect infestation, lack of balance among nutrients in soil, and certain herbicides. The plant's stage of maturity also affects its nitrate content. The amount of nitrate in plants increases when too much nitrogen is supplied. Livestock losses depend not only on nitrate accumulation, but also on the prior condition of the exposed animals and the management practices of the livestock producer. Suggested feeding levels for forages with various levels of NO_3^- are included in Table 2 from Faulkner and Hutjens (1989).

Nitrate Toxicosis Case Study

Two cows died on December 17, 1997, in a pasture in Jefferson County, Florida. The local veterinarian pulled samples that afternoon and sent them to the diagnostic lab, but the chocolate-brown blood sample and signs of labored breathing strongly indicated nitrate poisoning. An animal was sent to the lab, but it was apparently mishandled and was not autopsied until the following morning. Their diagnosis was blackleg (*Clostridium chauvoei*). The literature indicates rapid diminishing of nitrate toxicosis signs over time. The lab failed to make a nitrate poisoning diagnosis. Additional animals died in a second pasture a mile distant from the first.

The cattleman called on the morning of December 18 to report 28 dead animals and to seek help in identifying the cause of death. Eventually mortality totaled 35 head. No cattle were lost in a field where hay from a later cutting was being fed, and only mature animals were lost. Calves and yearlings were not apparently affected. Table 3 shows that 50% of mature animals in 2 fields were lost.

[1] The author acknowledges the very quick and competent assistance of Dr. Ed Richey, Dr. Bill Kunkle, and cattleman Jed Dillard in targeting nitrate poisoning on the basis of description of signs by telephone, December 18, 1997. The willingness of the cattleman to share his loss in the hope that other losses would be prevented is appreciated.

We checked the 2 fields, including water sources, where deaths occurred. Cherry and oak trees in fence rows, acorns, open bags of fertilizer or containers of pesticides, toxic plants in pastures, and other sources of poisoning were sought; none were found. We made a similar survey of the third pasture. Cattle in fields with weedy hay showed signs quickly—within an hour or two. Cattle on hay from a different cutting were unaffected. Everything pointed to weedy bales of bahiagrass (*Paspalum notatum)* hay. The hay was removed from the field.

The suspected hay was from 2 adjacent 8-acre fields (16 total acres) of newly planted Tifton-9 Pensacola bahiagrass. The fields had been planted in winter-annual small grains for many years. In late March, 1996, the prepared fields were seeded to Tifton-9 at 10 lb per acre, and cultipacked. Fields were not fertilized. A modest cutting was made in late summer, 1996, with about 1 bale per acre harvested (round bales, about 1,100 lb per bale). The 15 bales from the late 1996 cut were fed to the herd with no adverse effect. The field was cut in late April, 1997, making 12 bales from the 16 acres. The hay from this first cut was extremely weedy. Following first cut, the fields were fertilized with 90 lb N per acre from 19% liquid N, applied by a custom operator. No other input applications were made. The fields were cut 3 additional times throughout the 1997 season: late July (3 bales/acre), early October (3 bales/acre), and in November before first frost (1 bale/acre). All hay was stored on pallets along the edge of the field. In all, 135 bales were harvested on the 16 acres during 1997 for an approximate yield of 4.5 tons/acre.

Gnaphalium purpureum: Nitrate Accumulator

Grab samples of the hay were taken and delivered to Water's Laboratory in Camilla, Georgia. Nitrate levels in 3 bales ranged from 1.32% to 2.11%. A retained portion of the sample lowest in nitrate was separated, segregating the identifiable bahiagrass within the sample from identifiable weeds. This analysis showed 33.4% of the sample was bahiagrass, 36.3% appeared to be cudweed, 8.1% was wild radish (*Raphanus raphanistrum*, more commonly called wild turnip or wild mustard by local cattlemen), and the balance was unidentifiable parts and fines. Dr. Fred Rhoads (North Florida Research and Education Center, Quincy) ran a quick test for NO_3^- using the Cardy ion meter, measuring the cudweed fraction at 34,000 ppm (3.4%) NO_3^-. A sample was submitted to UF/IFAS Ona Research and Education Center for forage analysis. The University of Florida Herbarium confirmed the weed to be purple cudweed, *Gnaphalium purpureum*, a close relative of "rabbit tobacco." Table 4 gives forage analysis of the 3 bales sampled.

A review of literature found a citation of cudweed as a suspected nitrate accumulator in a single California source (Tucker et al., 1961) and a notation in Kingsbury (1964). Table 5 lists nitrate accumulator plants from Kingsbury.

Weather conditions in early 1997 were unusually cloudy and rainy through late February. Modest drop in rainfall with signs of moisture stress occurred in March and early April. Rainfall was 2.25″ below normal in March. January, February, and March were warmer than normal. April average temperature was 3°F below normal and cooler than the average temperature for March. The hay was cut before two intense rainfall events in late April. In January 1998, the 2 hay fields were sampled for soil analysis. Phosphorus (P_2O_5) and potassium (K_2O) levels were very low in each field.

Within a given species, crude protein content and nitrate content are often correlated. Owens and Dubeski (1989) recommend caution when feeding grasses containing more than 15.7% crude protein. Intuitively unreasonable levels of crude protein in both wet-lab forage test and NIR assay were found in the high-nitrate samples. Florida's forage-testing program (UF/IFAS, 1976) reports average crude protein levels for bahiagrass (dry-matter basis) at 7.3%, and 6.4% for Pensacola bahiagrass. The 3 bales fed and analyzed by Water's Lab were 21.23%, 22.53%, and 26.08%. The Ona REC Near Infrared (NIR) analysis of the same forage was reported as 25.6% CP (dry).

Conclusions: Lessons Learned

In spite of its near-ubiquitous and common-place presence, cudweed was not known locally as a potential hazard. Nonetheless, it seems to have been the cause of substantial cattle losses. The combination of circumstances such as modest drought stress and overcast skies giving lower-than-normal light intensities, low P_2O_5 and K_2O levels, and the high cudweed concentration in bales led to a tragic and costly loss. The primary lesson learned is that hazards are present but often unrecognized, and vigilance is necessary. We have come to the following conclusions:

- Extremely weedy hay fields should be burned or mowed and the low forage value sacrificed rather than risking livestock loss by baling very low-quality, toxic forage.
- Suspect, low-quality, and very weedy forage should be tested for feed value including nitrate analysis.
- At first sign of a suspected poisoning, cattle should be taken off low-quality feed and put on high-energy feeds with superior-quality forage until the source of poisoning is determined.
- Some high-nitrate hay may be fed to yearling cattle or monogastric livestock, or else blended and fed at safe total nitrate levels.
- The Cardy nitrate ion meter appears to provide a credible yet simple assay as a "quick test" that may indicate need for additional forage analysis. The Jefferson County Extension Service office has purchased a Cardy meter and has a Penn State forage sampler for use by county cattlemen as a result of the experiences reported here.
- Minimum levels of fertility and weed control are essential to produce high quality-forage.

A growing collection of information, which can be used for emergency reference, is available on the World Wide Web. We benefited from very quick access to a number of files in gaining a greater understanding of nitrates and nitrate accumulation. Table 6 lists some of the more helpful sites visited.

References

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Table 1. Summary of factors that contribute to nitrate toxicosis in livestock[a]

Plant Characteristics	Environmental Factors	Livestock Conditions
Familial, genetic, specific and varietal diferences	External source and rates of nutrient nitrogen	Monogastric animals are not easily poisoned by nitrate; ruminants are especially susceptible
Families: *Amaranthaceae, Chenopodiaceae, Cruciferae, Compositae, Gramineae, Solanaceae*	Timing of nitrogen fertilization	Rate and quantity of consumption
Stems usually contain more than leaves, and leaves more than floral parts	Strong positive relationship between nitrate and potassium levels in soil solution	Energy level or adequacy of diet
Lower portions of stems tend to be higher than upper portions	Phosphorus fertilization has raised the nitrate content in plants in some experiments, lowered it, or had no or variable effect in others	Adaptation and health of the animal
A progressive diminution of concentration with height above the roots is assumed	Plants that have been in dormancy state due to drought	Pregnancy status of the animal
Content first rises and then, after reaching a peak about the pre-bloom stage, declines as plant matures	Light intensity, duration and quality, including day-to-day and diurnal variations	Methemogoblin in young animals may be more rapidly reduced than in older animals
Level of nitrate reductase activity	Herbicide treatments, with the possibility that weeds may become more attractive (more succulent) following application	
	Method of harvesting and post-harvest handling	

[a]Wright & Davison, 1964.

Table 2. Guidelines for nitrate in feedstuffs (% dry-matter basis) complete ration[a]

Nitrate Content[b]	Comments
.0 – .44	This level is considered safe to feed under all conditions.
.44 – .66	This level should be safe to feed to non-pregnant animals under all conditions. It may be best to limit its use for pregnant animals to 50% of the total ration on a dry-matter basis.
.66 – .88	Feeds safely fed if limited to 50% of the total dry matter in the ration.
.88 – 1.54	Feeds should be limited to about 35% to 40% of the total dry matter in the ration. Feeds containing over .88% nitrate should not be used for pregnant animals.
1.54 – 1.76	Feeds should be limited to 25% of the total dry matter in the ration. Do not use for pregnant animals.
> 1.76	These feeds are potentially toxic. Do *NOT* feed.

[a](Faulkner & Hutjens, 1989).
[b](% NO_3^-)

Table 3. Losses attributed to nitrates; case study, 1997

Head	Deaths	Type of Animal
Home field (deaths)		
0	0	bulls
20	2	cows and mature heifers
15	0	calves and yearlings
35	2	TOTAL
Home field (no deaths)		
1	0	bulls
12	0	cows and mature heifers
5	0	calves and yearlings
18	0	TOTAL
Parrish field (deaths)		
4	2	bulls
46	31	cows and mature heifers
20	0	calves and yearlings
70	33	TOTAL
123	35	28% loss of total herd
70	35	50% loss of mature animals exposed to toxic bales

- All fields had free-choice mineral blocks.
- All herds were fed with Argentine bahiagrass hay prior to the affected hay.
- Herds on home (no deaths) and Parrish fields supplemented with Prolix.
- Herd on home field had some grazing of residual feed and no Prolix.
- All herds were watered from well-supplied troughs, each from different wells.

Table 4. Forage analyses of samples of hay, 1997

Nutrient	Home (weedy)	Parrish (less weedy)	Parrish (weedy)	Average of 3
Analysis by Water's Lab, 12/22/97[a]				
Nitrate (NO_3^-)	1.32	1.67	2.11	1.70
Crude protein	21.23	22.53	26.08	23.28
Digestible protein	14.82	15.73	18.21	16.25
Crude fat	.95	.85	1.15	.98
Crude fiber	26.55	28.60	48.20	34.45
Nitrogen-free extract (NFE)	38.07	37.32	12.17	29.19
Total digestible nutrients (TDN)	64.60	64.41	58.56	62.52
Ash	13.20	10.70	12.40	12.10
Analysis by Ona REC, 01/13/98[b]				
	Submitted		Dry-Matter Basis	
Moisture	13.4		13.4	
Crude protein	22.1		22.1	
Neutral detergent fiber	57.5		57.5	
Total digestible nutrient (TDN)	44.2		44.2	
Quality index (.6 – 2.2)	1.2		1.2	

[a]Results = % on dry-matter basis.
[b]Near infrared (NIR)

Table 5. Nitrate accumulator plants

Botanical	Common	Family
Weeds		
))))))))))))	bluegreen algae	(Cyanophyta)
Amaranthus spp.	pigweeds	Amaranthaceae
Amsinckia sp.	tarweed	Boraginaceae
Plagiobothrys sp.	popcorn flower	Boraginaceae
Cleome serrulasa	Rocky Mt. bee plant	Capparidanceae
Sambucus pubens	elder	Caprifoliaceae
Stellaria media	chickweed	Caryophyllaceae
Salsola pestifer	Russian thistle	Chenopodiace
Chenopodium spp.	pigweed, lamb's quarters	Chenopodiaceae
Kochia scoparia	fireball	Chenopodiaceae
Bidens frondosa	beggar-tick	Compositae
Carduus sp.	plumeless thistle	Compositae
Cirsium arvense	Canada thistle	Compositae
Eupatorium perfoliaium	joe-pye weed	Compositae
Eupatorium purpureum	thoroughwort	Compositae
Franseria discolor	white ragweed	Compositae
Gnaphalium purpureum	purple cudweed	Compositae
Haplopappus venetus	coast goldenbush	Compositae
Helianthus annuus	wild sunflower	Compositae
Lactuca scariola	prickly lettuce	Compositae
Rafinesquia californica	California chicory	Compositae

Botanical	Common	Family
Silybum marianum	variegated thistle	Compositae
Solidago spp.	goldenrods	Compositae
Sonchus spp.	sow thistles	Compositae
Verbesina encelioides	crownbeard	Compositae
Convolvulus sp.	bindweed	Convolvulaceae
Thelypodium lasiophyllum	mustard	Cruciferae
Euphorbia maculata	milk purslane	Euphorbiaceae
Bromus catharticus	rescue grass	Gramineae
Echinochloa crusgalli	barnyard grass	Gramineae
Eleusine indica	goose grass	Gramineae
Panicum capillare	witchgrass	Gramineae
Sorghum halepense	Johnsongrass	Gramineae
Salvia reflexa	annual sage	Labiatae
Melilotus officinalis	sweetclover	Leguminosae
Parkinsonia aculeata	horsebean	Leguminosae
Malva parviflora	cheeseweed	Malvaceae
Polygonum spp.	smartweeds	Polygonacaea
Rumex spp.	dock	Polygonacaea
Montia perfoliata	miner's lettuce	Portulacaceae
Solanum spp.	nightshades	Solanaceae
Datura sp.	jimson weed	Solanazceae
Ammi majus	bishop's weed	Umbelliferae
Conium maculatum	poison hemlock	Umbelliferae
Tribulus terrestris	nettle	Urticaceae
Tribulus terrestris	puncture vine	Zygophyllaceae
Crop Plants		
Beta vulgaris	beet and mangold	Chenopodiaceae
Lactuca sativa	lettuce	Compositae
Ipomoea batatas	sweet potato vines	Convolvulaceae
Brassica napobrassica	rutabaga	Cruciferae
Brassica napus	rape	Cruciferae
Brassica oleracea	broccoli, kale, etc.	Cruciferae
Brassica rapa	turnip	Cruciferae
Raphanus sativus	radish	Cruciferae
Cucurbita maxima	squash	Cucurbitaceae
Triticum aestivum	wheat	Graminaea
Avena sativa	oat hay	Gramineae
Hordeum vulgare	barley	Gramineae
Secale cereale	rye	Gramineae
Sorghum vulgare	sudangrass	Gramineae
Zea mays	corn	Gramineae
Glycine max	soybean	Leguminosae
Medicago sativa	alfalfa	Leguminosae
Linum usitatissimum	flax	Linaceae
Apium graveolens	celery	Umbelliferae
Daucus carota	carrot	Umbelliferae

[a]Kingsbury, 1961.

Table 6. Websites related to nitrate toxicosis in livestock

Website	**URL**[a]
Nitrate Poisoning and Feeding Nitrate Feeds to Livestock	www.agric.gov.ab.ca/agdex/400/0006001.html
Minimizing the Risks from Nitrate Toxicity and Prussic Acid Poisoning	www.ansi.okstate.edu/exten/nl960506/selk.htm
Nitrate Toxicity	hubcap.clemson.ecu/forages/foragefacts/nitrate.htm
Nitrates in Livestock Feeding	www.inar.unl.edu/pubs/Beef/g170.htm#causes
Poisonous Plant Database (PLANTOX)	vm.cfsan.fda.gov/~djw/readme.html
Plants Poisonous to Livestock	www.mes.umn.edu/Documents/D/I/Di5655.htm

[a]URL = universal resource locator; precede URL with *http://*, if necessary.

NOTES: