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Do most livestock losses to poisonous plants result from "poor" range management?

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Abstract

In recent years livestock death losses from poisonous plants in the western United States have averaged about 2–3% annually. A review of 36 grazing studies in North America shows poisonous plant availability and death losses of livestock from poisonous plants are closely associated with grazing intensity. Across studies, livestock death losses to poisonous plants average about 2.0% under moderate grazing compared with 4.8% under heavy grazing intensities. Sheep and goat losses from poisonous plants appear to be increased more by heavy stocking than those from cattle. Impacts of poisonous plants on livestock reproductive success are difficult to quantify, but probably reduce calf and lamb crops, even when grazing intensities are conservative. Increased poisonous plant consumption may explain in part why calf and lamb crops average about 7% lower under heavy compared to moderate grazing. With the exception of 1 Texas study, rotation and continuous/season long grazing systems show little differences in livestock death losses under comparable stocking rates. Certain plants, such as locoweeds (*Astragalus* sp.) and larkspur (*Delphinium* sp.), can elevate livestock death losses, even when grazing intensities are moderate or conservative. Special management programs that involve careful timing of grazing, aversive conditioning, and creation of locoweed (or larkspur)-free pastures can reduce problems with these plants. Use of adapted livestock is a critical part of minimizing poisonous plant problems. However, on some rangelands, such as those with infestations of locoweed and larkspurs, naive livestock may be less affected by poisonous plants than familiar livestock. Knowledge of poisonous plant identification, conditions of toxicity, and affects on the animal, in conjunction with conservative grazing, will in most cases avoid excessive death and productivity losses from poisonous plants. In some cases livestock can be conditioned or trained to not consume poisonous plants. It can be concluded that most livestock losses from poisonous plants are caused by poor management.

Key Words: Cattle, sheep, goats, grazing, poisonous plants, economics

Resumen

En años recientes, en el oeste de Estados Unidos las perdidas por muerte de ganado debido a plantas tóxicas ocurridas promedian anualmente del 2–3%. Una revisión de 36 estudios de apacentamiento realizados en Norte América muestran que la disponibilidad de plantas tóxicas y las perdidas por muerte de ganado a causa de este tipo de plantas están estrechamente asociadas con la intensidad de apacentamiento. Los estudios revisados muestran que bajo apacentamiento moderado las perdidas por muerte de ganado debido a plantas tóxicas promedian aproximadamente 2.0%, comparado con 4.8% bajo intensidades de apacentamiento fuerte. El apacentamiento fuerte parece incrementar mas las perdidas por plantas tóxicas de caprinos y ovinos que de bovinos. Los impactos de las plantas tóxicas en el éxito reproductivo del ganado es difícil de cuantificar, pero probablemente reducen la cosecha de becerros y corderos, aun bajo intensidades de apacentamiento conservadoras. El aumento en el consumo de plantas tóxicas puede explicar en parte porque la cosecha de becerros y corderos es aproximadamente 7% menos bajo el apacentamiento fuerte que bajo el apacentamiento moderado. Con excepción de 1 estudio en Texas, los sistemas de apacentamiento rotacionales y continuo/estación larga, con cargas animal comparables, presentaron pocas diferencias en las perdidas por muerte de ganado por plantas tóxicas Ciertas plantas como "Locoweeds" (*Astragalus* sp.) y "Larkspur" (*Delphinium* sp.) pueden aumentar las perdidas por muerte de ganado, aun en intensidades de apacentamiento que son moderadas o conservadoras. Programas especiales de manejo que involucran el apacentar en el tiempo correcto, el acondicionamiento aversivo y la creación de potreros libres de "Locoweed" o "Larkspur" pueden reducir los problemas con estas plantas. El uso de ganado adaptado es una parte critica para minimizar los problemas de plantas tóxicas. Sin embargo, en algunos pastizales, tales como aquellos con infestaciones de "Locoweed" y "Larkspur", el ganado no familiarizado puede ser menos afectado por las plantas toxicas que el familiarizado. El conocimiento en la identificación de las plantas tóxicas, condiciones de toxicidad y los efectos en el animal en conjunto con un apacentamiento conservador, evitara, en muchos casos, perdidas excesivas de productividad y muertes por plantas tóxicas. En algunos casos el ganado puede ser acondicionado o entrenado para no consumir plantas tóxicas. Se puede concluir que la mayoría de las perdidas de ganado por plantas tóxicas son causadas por un manejo pobre.

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Poisonous plants have been an important problem for livestock producers using rangelands in the United States since the first pioneers from Europe began settlement of the country in the 1600's (James et al. 1992). Through the early history of range management, beginning in the late 1800's to the present, grazing practices have been closely linked with the magnitude of livestock losses from poisonous plants (Smith 1899, Stoddert and Smith 1943, Holechek et al. 2001). Presently poisonous plants are considered to be important impediments to profitable ranching on roughly 400 million hectares of rangeland in the United States (James et al. 1992).

The issue of whether or not economically significant livestock losses from poisonous plants are a result of "poor" range management practices has long been a point of controversy among ranchers and range scientists. Some 30 long term grazing studies reviewed by Vallentine (1990), Heady and Child (1994), and Holechek et al. (2001) provide insight into this issue. More recently, several studies have evaluated how timing and intensity of livestock grazing can be manipulated to minimize losses from poisonous plants such as larkspurs and locoweeds.

In this review consideration will be given to what the various long term studies on grazing intensities and grazing systems have shown regarding poisonous plant losses. Personal observations regarding livestock losses from poisonous plants on Oregon and New Mexico rangelands will be incorporated into the discussion. Consideration will also be given to special grazing approaches to deal with poisonous plants such as locoweeds and larkspurs that may be readily consumed by livestock even when non-poisonous forage species are available. Finally, the practicality of conditioning livestock to avoid poisonous plants will be examined.

Magnitude of Poison Plant Losses

Economic losses due to livestock poisoning can be divided into 2 parts: (1) direct losses and (2) indirect losses (James 1978). Direct losses of livestock involve the effects of poison plants on livestock productivity and health. Indirect losses include those activities or costs that are incurred by a livestock operation to prevent losses or costs from poisonous plants (James et al. 1992).

It has always been difficult to quantify actual dollar losses to livestock operations from poisonous plants. This is because separation of disease, accident, and predator losses from poisonous plant losses can be difficult. Low reproductive performance and weight gains can be caused by disease and inadequate nutrition as well as poisonous plants. Some adverse effects of poisonous plants such as birth defects occur long after poisonous plant ingestion. Nevertheless, various attempts have been made to quantify economic impacts of poisonous plants on the range livestock industry.

Based on a 1% death loss in cattle, a 3.5% death loss in sheep, and a 1% decrease in calf and lamb crops due to poisonous plants, Nielsen and James (1991) estimated total annual economic losses at $340,000,000 in the 17 western states. They used 1989 livestock numbers and prices. Based on 1999 livestock prices and livestock numbers, the estimate would be $503,000,000. In New Mexico annual experiment station reports based on rancher interviews have shown cattle death losses to average 3–4% and sheep death losses to average 4–6% for the 1987 to 1996 period (Torell et al. 1998). At least half of these losses are believed to be caused by poisonous plants. Gay and Dwyer (1967) suggested that over the entire western range, death losses were 2 to 3%. The USDA (1968) estimated countable death losses in the western United States were 3-5%. It is believed that losses in reproduction and weight gains from animals poisoned that do not die exceed those from death loss (Gay and Dwyer 1967).

Regardless of how estimates of livestock losses from poisonous plants are derived, poisonous plants are one of the most important causes of economic loss to the livestock industry. However, averages are somewhat misleading in that they do not take into account management. An important question is how much could economic losses from poisonous plants be reduced with improved grazing management? This issue will be explored.

Grazing Management and Poisonous Plant Availability

Grazing Intensity

Poisonous plant abundance on rangelands has been linked with overgrazing from the beginning of scientific range management in the late 1800's. Smith (1895, 1899) in west Texas, Colville (1898) in Oregon, Nelson (1898) in Wyoming, and Wooton (1915) in New Mexico all commented that overstocking caused a decline in palatable forage plants and an increase in unpalatable poisonous plants. Through the years various papers have described how and why retrogression from palatable to unpalatable plant species occurs under heavy or severe grazing pressure (Ellison 1960, Cronin et al. 1978, Laycock 1978, Molyneuax and Ralphs 1992). The processes were summarized by Holechek et al. (2001) as follows:

> "Under moderate or light grazing levels the poisonous, unpalatable plants are at a competitive disadvantage because they invest part of their products from photosynthesis in poisonous compounds (alkaloids, oxalates, glycosides, etc.) and appendages (spines, thorns, stickers, etc.) that discourage defoliation rather than contribute to growth...In contrast the palatable plants use their photosynthetic products mainly for growth in the form of roots, leaves, stems, rhizomes, stolons, seeds, and so forth. Under heavy defoliation levels the photosynthetic capacity of the palatable plants is reduced to the point that they are unable to produce enough carbon compounds for maintaining root systems, regeneration of leaves, respiration and reproduction. Over time, they shrink and die, and gradually are replaced with the unpalatable plants that are able to defend themselves against defoliation."

Various long-term grazing studies in North America support the above statement (Table 1). The concept advanced by Dyksterhuis (1949) that the more palatable species increase and least palatable species decrease under light to moderate grazing pressure is well supported by the literature (Table 1). On the other hand, the literature consistently shows species that are unpalatable or low in palatability tend to increase under heavy grazing pressure. The only major exception was the California annual grassland type where vegetation compositional changes were not greatly affected by grazing pressure.

Another minor exception was the study by Burzlaff and Harris (1969) in the shortgrass prairie of Nebraska. However, Vallentine (1990) noted that this study was conducted under favorable precipitation conditions. After the study was reported, 2 years of severe drought occurred that reduced the tallgrasses and midgrasses under all grazing intensities. However, the deleterious effects of the drought on the forage stand, including wind erosion, were much more severe under the heaviest stocking rate.

Table 1. Summary of studies evaluating influence of grazing intensities and grazing systems on long-term trend in palatable, unpalatable, and poisonous plant levels on North American rangelands.

			Grazing Intensities				
Range Type/ Location	Livestock Type	Number of Years	Grazing Intensity	Forage Use Level	Change in Proportion of Palatable Plants	Relative Poison Plant Availability	Reference
				(%)			
Deserts							
Salt Desert (Utah)	Ewe-Lamb	13	Heavy	60	No Change	Highest	Hutchings and Stewart 1953
			Moderate	35	Large Increase	Intermediate	
			Light	25	Large Increase	Lowest	
Chihuahuan Desert (New Mexico)	Cow-Calf	22	Heavy	60	Decrease	Highest	Holechek et al. 1994
			Moderate	35	Large Increase	Lowest	
Grasslands							
Shortgrass (Colorado)	Yearling-Cattle	55	Heavy	54	Decrease	No definite difference	Klipple and Costello 1960, Hart and Ashby 1998
			Moderate	37	Increase		
			Light	21	Increase		
Tallgrass (Kansas)	Yearling-Cattle	5	Heavy	Not Given	Decrease	Not Evaluated	Gillen et al. 1998
			Moderate		Increase		
			Light		Increase		
Sandhills (Colorado)	Yearling-Cattle	12	Heavy	64	Decrease	No definite differences	Sims et. al. 1976
			Moderate	44	Decrease		
			Light	30	Stable		
Shortgrass (Wyoming)	Yearling-Cattle	13	Heavy	45	Decrease	No definite differences	Manley et al. 1997
			Moderate	36	Stable		
			Light	25	Increase		
Mixed Prairie (South Dakota)	Cow-Calf	9	Heavy	63	Decrease	No definite differences	Johnson et al. 1951
			Moderate	46	Stable		
			Light	37	Increase		
Mixed Prairie (Montana)	Cow-Calf	10	Heavy	51	Decrease	Highest	Houston and Woodward 1966
			Moderate	38	Stable	Intermediate	
			Light	29	Increase	Lowest	
Mixed Prairie (Texas)	Cow-Calf	16	Heavy	50	Decrease	No definite differences	Kothmann et al. 1978
			Moderate	40	Increase		
Mixed Prairie (Alberta)	Ewe-Lamb	19	Heavy	68	Decrease	No definite differences	Smoliak 1974
			Moderate	53	Stable		
			Light	45	Increase		
Tallgrass Prairie (Kansas)	Yearling-Cattle	7	Heavy	58	Decrease	No definite differences	Herbel and Anderson 1959
			Moderate	52	Decrease		
			Light	29	Increase		
Shortgrass (Nebraska)	Yearling-Cattle	10	Heavy	74	Stable	No definite differences	Burzlaff and Harris 1969
			Moderate	58	Stable		
			Light	53	Stable		
Shortgrass (Wyoming)	Ewe-Lamb	10	Heavy	Not Given	Decrease	No definite differences	Lang et al. 1956
			Moderate		Small Decrease		
			Light		Increase		
Shortgrass (Kansas)	Yearling-Cattle	20	Heavy	66	Decrease	No definite differences	Launchbaugh 1967
			Moderate	48	Increase		
			Light	39	Large Increase		
Annual Grassland (California)	Cow-Calf	14	Heavy	Not Given	No definite changes	No definite differences	Bently and Talbot 1951
			Moderate				
			Light				
Bunchgrass (Oregon)	Cow-Calf	12	Heavy	53	Decrease	Highest	Skovlin et al. 1976
			Moderate	35	Small Increse	Intermediate	
			Light	20	Large Increase	Lowest	
Woodland							
Pinyon-Juniper (New Mexico)	Cow-Calf	10	Heavy	60	Decrease	Highest	Pieper et. al. 1991
			Moderate	40	Increase	Lowest	
Coniferous Forest (Colorado)	Yearling-Cattle	16	Heavy	58	Decrease	Highest	Smith 1967
			Moderate	33	No Change	Intermediate	
			Light	16	No Change	Lowest	
Coniferous Forest (Oregon)	Cow-Calf	12	Heavy	34	Most Decrease	Highest	Skovlin et al. 1976
			Moderate	25	Intermediate Decrease	Intermediate	
			Light	10	Least Decrease	Lowest	
Chaparral (Texas)	Cattle-Sheep-Goats	20	Heavy	Not Given	Decrease	Highest	Reardon and Merrill 1976
			Moderate		Large Increase	Lowest	
			Light		Increase	Lowest	
Southern Pine Forest (Louisiana)	Cow-Calf	10	Heavy	57	Decrease	Not Evaluated	Pearson and Whitaker 1974
			Moderate	40	Decrease		
			Light	35	Increase		
Southern Pine Forest (Georgia)	Yearling-Cattle	4	Heavy	65	Decrease	Not Evaluated	Halls et al. 1956
			Moderate	44	Increase		
			Light	30	Increase		

Table 1. Continued.

Range Type/ Location	Livestock Type	Number of Years	Grazing Systems	Forage Use Level	Change in Proportion of Palatable Plants	Relative Poison Plant Availability	Reference
			Grazing Systems	(%)			
Deserts							
Sonoran Desert (Arizona)	Cow-Calf	10	Yearlong	52	No Change	No	Martin and
			Rotation	48	No Change	Difference	Severson 1988
Grasslands							
Mid-grass Prairie (Texas)	Cow-Calf	16	Yearlong	35	Increase	No	Kothmann et
			Rotation	35	Increase	Difference	al. 1978
Tall-grass Prairie (Kansas)	Yearling-Cattle	16	Season-Long	52	Most Decrease	No Definite	Owensby et
			Rotation	45	Least Decrease	Difference	al. 1973
Tall-grass Prairie (Texas)	Cow-Calf	6	Yearlong	43	No Change	No	Drawe 1988
			Rotation	41	No Change	Difference	
Shortgrass Prairie (Wyoming)	Yearling-Cattle	13	Season-Long	40	No Definite Change	Lowest	Manley et.
			Rotation	40	Decrease	Highest	al. 1997
Tall-grass Prairie (Oklahoma)	Yearling-Cattle	5	Season-Long	Not	No Change	No	Gillen et
			Rotation	Given	No Change	Difference	al. 1998
Mid-grass Prairie (Alberta, Canada)	Yearling-Cattle	9	Season-Long	44	Increase	No	Smoliak 1960
			Rotation	46	Increase	Difference	
Bunchgrass (Oregon)	Cow-Calf	10	Season-Long	30	Most Increase	No	Skovlin et
			Rotation	27	Least Increase	Difference	al. 1976
Woodland							
Chaparral (Texas)	Cattle-Sheep-Goats	20	Yearlong	Not	Least Increase	Highest	Reardon and
			Rotation	Given	Most Increase	Lowest	Merrill 1976
Pinyon-Juniper (New Mexico)	Cow-Calf	10	Yearlong	40	No Definite Change	No Definite	Pieper et
			Rotation	55	No Definite Change	Difference	al. 1991
Coniferous Forest (Oregon)	Cow-Calf	12	Season-Long	21	Most Decrease	No	Skovlin et
			Rotation	23	Least decrease	Difference	al. 1976

Evidence that heavy grazing increases poisonous plant availability is more limited than that for plants of low palatability. However, 7 of the 22 grazing studies reviewed in Table 1 showed poisonous plants were definitely more available under heavy grazing on a biomass basis than under moderate to light grazing. These studies supported the theory that heavy grazing causes vegetational composition shifts towards poisonous plants. Desert and woodland studies showed more tendency for poisonous plants to increase under heavy grazing than those from grasslands.

Two important reasons why 12 of the 22 studies reviewed showed no definite increase in poisonous plants under heavy grazing may have to do with the relatively short time frame of the studies and lack of severity in the heavy grazing treatment. Fusco et al. (1995), on Chihuahuan Desert grassland rangeland in New Mexico, found that poisonous plants totally dominated areas within 1,000 meters of permanent waters on rangelands with a 50 year history of heavy grazing. However, on rangelands with a 50 year history of conservative grazing, the zone of poisonous plant domination extended only 500 meters from water. Across the entire study areas, poisonous plant biomass levels were 57% higher on the long term heavy compared to conservative grazed range.

Grazing Systems

Generally, rotation and year-long or season-long grazing systems have shown little difference in their effects on proportions of decreaser and poisonous plants (Table 1). An exception is chaparral range type of south Texas where the Merrill 3-herd/4-pasture system has definitely favored decreaser plants and reduced poisonous plants (Reardon and Merrill 1976, Merrill and Schuster 1978, Taylor and Ralphs 1992). A modification of the Merrill 3-herd/4-pasture system may have reduced white loco (*Oxytropis sericea* Nutt.) availability on mountain range in Utah (Taylor and Ralphs 1992). The literature convincingly shows grazing intensity has far more impact on vegetation composition changes through time than system of grazing.

Poison Plant Availability and Livestock Food Habits

Research is restricted on how range condition and grazing management affect poisonous plant levels in livestock diets. One study from the Chihuahuan Desert of south-central New Mexico evaluated poisonous plant levels in cattle diets over a 3 year period on rangelands in late-seral and mid-seral ecological condition (Daniel et al. 1993). Both areas were stocked conservatively, but poisonous plant biomass levels were about 60% higher on the mid-seral compared to late-seral range. Across the 3 year study period poisonous plants comprised 14% and 10% of cattle diets by weight and late- and mid-seral ranges, respectively. Total poisonous plant consumption never exceeded 20% of the diet on either range. Over a 3 year period no death losses from poisonous plants (220 cattle/year) were observed on either range (Fusco et al. 1995). Results from this study indicated that poisonous plant consumption by livestock is more related to grazing intensity than rangeland condition.

Grazing Management and Livestock Losses to Poisonous Plants

Grazing Intensity

Several range researchers and managers through the years have noted that elevated livestock death losses from poisonous plants were associated with heavy grazing intensities (Smith 1899, Stoddart and Smith 1943, Shoop and McIlvain 1971, Merrill and Schuster 1978, Taylor and Ralphs 1992). Various grazing studies generally supported by actual research show this observation (Table 2). Based on the author's review, sheep and goat death

losses from poisonous plants are more elevated by heavy grazing than those from cattle. Generally, grazing intensities must involve more than 50% use of palatable forage species for elevated poisonous plant losses to occur. The author has had opportunity to evaluate cattle death losses from poisonous plants on several rangelands in Oregon and New Mexico. On mountain rangeland (the Starkey Experimental Range) in northeastern Oregon 100 yearling cattle per year over a 3 year period for a 120 day grazing season (20 June to 20 October) have been observed by the author. These rangelands were generally in high ecological condition and conservatively stocked. Only 2 animals died from poisonous plants over the 3 year period (Holechek 1980).

In south-central New Mexico, over the past 11 years, cattle death losses on the Chihuahuan Desert Rangeland Research Center and several surrounding rangelands under the control of the Bureau of Land Management have been monitored by the author. On the Chihuahuan Desert Rangeland Research Center, death losses to poisonous plants have been no more than 1% per year (1,100 observations). This area is generally in high ecological condition and pastures are conservatively or moderately stocked. On surrounding rangelands in lower ecological condition low death losses (1–2%) have been observed when grazing intensities were conservative to moderate (Fusco et al. 1995). However, when grazing intensities reached heavy to severe levels (over 60% use of forage) death losses in the spring were elevated to 4–8%.

On 2 occasions the author investigated cases where cattle death losses from poisonous plants took 10 to 25% of the herd. In these situations, grazing intensity was so severe (over 70% use of forage) that livestock had little choice other than to consume unpalatable/poisonous plants or starve. Based on these experiences, along with a review of the literature, the author concludes that heavy to severe livestock grazing pressure is generally the cause of excessive death losses to poisonous plants.

Holechek et al. (1999, 2001) review several long term grazing studies that show calf and lamb crops are closely associated with grazing intensity. Calf crops under heavy, moderate, and light grazing averaged 72%, 79%, and 82%, respectively, across all studies (Holechek et al. 1999). Lamb crops averaged 78%, 82%, and 87% across heavy, moderate, and light grazing intensities. Part of the depressed calf and lamb crops under the heavily grazed treatment in several of these studies was probably due to poisonous plant consumption. However, separation of poisonous plant from nutritional influences has not been done.

Grazing Systems

Livestock death losses under continuous and rotation grazing systems have shown little to no difference with 1 exception (Table 2). On chaparral rangeland in south-central Texas the Merrill 3-herd/4-pasture system has reduced livestock (cattle-sheep-goats) death losses compared to continuous grazing (Merrill and Schuster 1978, Taylor and Ralphs 1992). Lower poisonous plant availability (Table 1) appears to explain why livestock death losses have been almost nil under the Merrill system (Reardon and Merrill 1976).

Application of the Merrill 3-herd/4-pasture system on mountain range in Utah reduced the number of sick calves from poisoning by white locoweed (*Oxytropis sericea* Nutt) from 20 to 3% compared to rest-rest rotation grazing (Taylor and Ralphs 1992). Under rest-rotation grazing, the entire herd was concentrated into 1 pasture to force even use of all forage, including locoweed. In the Merrill 3-herd/4-pasture system, the grazing pressure was distributed over 3 pastures, and cattle were not forced to eat locoweed. A shortened grazing season also contributed to reduction in losses by removing all the animals before intoxication became serious or irreversible.

Table 2. Summary of studies evaluating influence of grazing intensities and grazing systems on livestock death losses from poisonous plants.

Grazing Intensities					
Range Type/ Location	Livestock Type	Number of Years	Forage Use Level (%)	Death Loss (%)	Reference
Deserts					
Salt Desert (Utah)	Ewe-Lamb	13	Heavy - 60	8.1	Hutchings and
			Moderate - 35	3.1	Stewart 1953
Chihuahuan Desert (New) (Mexico)	Cow-Calf	20	Heavy - 50	3.5	Holechek 1992
			Conservative - 35	1.0	
Grasslands					
Shortgrass (Colorado)	Yearling-Steer	13	Heavy - 54	1.43	Klipple and
			Moderate - 37	0.33	Costello 1960
			Light - 21	0.14	
Annual Grassland (California)	Ewe - Lamb	5	Heavy - 63	9 ewes	Rosiere and
			Moderate - 49	13 ewes	Torell 1996
			Light - 44	6 ewes	
Bunchgrass (Oregon)	Cow-Calf	12	Heavy - 53	< 2	Skovlin et
			Moderate - 35	< 2	al. 1976
			Light - 20	< 2	
Mixed Prairie (Texas)	Cow-Calf	6	Heavy - 50	2.6 cows	Heitschmidt
			Moderate - 40	2.6 cows	et al. 1990
			Heavy - 50	8.3 calve	
			Moderate - 40	8.3 calves	
			Heavy - 50	No	Heitschmidt
			Moderate - 40	Difference	et al. 1982
Mixed Prairie	Cow-Calf	10	Heavy - 51	<2 Highest	Houston and
			Moderate - 38	<2 Lowest	
			Light - 20	<2 Lowest	1966
Woodward					
Pinyon-Juniper (New Mexico)	Cow-Calf	10	Heavy - 55	< 2	Holechek
			Moderate - 40	< 2	1994
Coniferous Forest (Oregon)	Cow-Calf	12	Moderate - 34	< 2	Skovlin et
			Heavy - 28	< 2	al. 1976
			Light - 17	< 2	
Chaparral	Cattle-Sheep-Goats	21	Heavy	6.3 Bitterweed	Merrill and
			Moderate	3.3 Bitterweed	Schuster
			Light	0.7 Bitterweed	1978
	Goats	21	Heavy	4.0 Sachuista	Taylor and
			Moderate	3.3 Sachuista	Ralphs 1992
			Light	1.7 Sachuista	
	Goats	21	Heavy	3.1 Oak	Taylor and
			Moderate	2.6 Oak	Ralphs 1992
			Light	0.4 Oak	

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Table 2. Continued.

Grazing Systems						
Range Type/ Location	Livestock Type	Number of Years	Grazing System	Forage Use Level (%)	Death Loss (%)	Reference
Deserts						
Chihuahuan Desert (New Mexico)	Cow-Calf	20	Yearlong	30	< 2	Beck and McNeely 1993
			Rotation	30	< 2	
Grasslands						
Mixed Prairie (Texas)	Cow-Calf	6	Yearlong	40	2.6 cows	Heitschmidt et al. 1990
			Rotation	40-50	2.6 cows	
			Yearlong	40	8.3 calves	
			Rotation	40-50	8.3 calves	
Bunchgrass (Oregon)	Cow-Calf	12	Season-long	30	< 2	Skovlin et al. 1976
			Rotation	27	< 2	
Bunchgrass	Yearling Cattle (Oregon)	3	Season-long	30-35	< 1	Holechek et al. 1981
			Rotation	30-35	< 1	
Woodland						
Coniferous Forest (Oregon)	Yearling Cattle	3	Season-long	30-35	< 1	Holechek et al. 1981
			Rotation	30-35	< 1	
Coniferous Forest (Oregon)	Cow-Calf	12	Season-long	21	< 2	Skovlin et al. 1976
			Rotation	23	< 2	
Coniferous Forest (Oregon)	Yearling Cattle	5	Season-long	30-35	0	Holechek et al. 1987
			Rotation	30-40	0	
Pinyon-Juniper	Cow-Calf	10	Yearlong	40	< 2	Holechek 1994
			Rotation	50	< 2	
Chaparral (Texas)	Cattle-Sheep-Goats	21	Yearlong Rotation	Not Given	Lowest Under Merrill Grazing System	Merrill and Schuster 1978, Taylor and Ralphs 1992

Multi-Species Grazing

Multi-species grazing involving cattle-sheep and goats has reduced livestock death losses from poisonous plants on chaparral ranges in south-central Texas (Merrill and Schuster 1978, Taylor and Ralphs 1992). Sheep death losses to bitterweed (*Hymenoxys odorata* D.C.) were greatest on pastures stocked with sheep only and least with a combination of multi-species grazing (cattle-sheep-goats), moderate stocking, and Merrill 3-herd/4-pasture grazing. Goat losses to sacahuista (*Nolina texana* wats.) were reduced by multi-species grazing. However, goat losses due to oak (*Quercus* spp.) consumption were little affected by stocking rate, multi-species grazing, or grazing system. Taylor and Ralphs (1992) concluded that grazing management alone will not eliminate livestock death losses caused by consumption of poisonous plants. However, livestock losses can be reduced through proper grazing management.

Special Poisonous Plant Problems

Certain poisonous plants have caused inordinate problems to livestock producers because of their widespread distribution and/or palatability to livestock under certain conditions. Considerable research has been directed towards management of livestock and rangelands to minimize losses from these plants. A more detailed discussion is presented by other papers in this symposium. Readers are also referred to Kingbury (1964), James and Johnson (1976), Keeler et al. (1978), James et al. (1988), Taylor and Ralphs (1992), and James et al. (1992) for overviews of specific management strategies to deal with various poisonous plants.

Summary and Conclusions

In this review of livestock poisonous plant losses and grazing management, 3 issues were addressed in some detail. These include the influence of grazing management on poisonous plant availability, poisonous plant consumption, and livestock death losses from poisonous plants. Long term studies were quite consistent in showing heavy grazing intensities increased proportions of unpalatable plants on most rangelands. This same relationship also occurred for poisonous plants but fewer studies confirmed it. Generally, poisonous plant levels on rangelands showed few differences among continuous and rotation grazing systems. However, there was evidence the Merrill 3 herd/4 pasture system in South Texas lowered poisonous plant levels compared to continuous grazing. Research regarding poisonous plant levels in livestock diets under different ecological condition levels and grazing management strategies is somewhat restricted. Available studies indicate poisonous plant consumption is much more related to grazing intensity than rangeland ecological condition. Actual death losses from poisonous plants were strongly related to grazing intensity and, to a much lesser extent, grazing system. The Merrill 3 herd/4 pasture system has lowered cattle, sheep, and goat death losses from poisonous plants in south Texas compared to continuous grazing. Carefully timed grazing can be used to minimize cattle losses from larkspur and locoweed. Aversive conditioning and herbicidal control of dense stands can be effective in reducing livestock losses to these plants. Proper stocking and careful timing of grazing are critical management practices in minimizing livestock losses from poisonous plants. In conclusion most livestock losses from poisonous plants do result from "poor" range management.

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