Effect of Sheep and Rabbit Digestion on the Viability of Some Range Plant Seeds[1]

W. P. LEHRER JR. AND E. W. TISDALE

Associate Professor of Animal Husbandry and Professor of Range Management, respectively, University of Idaho, Moscow, Idaho

The role that animals play in the dissemination of seeds has been the subject of speculation and limited study for many years. It has been established that animals may spread plants when seeds become attached to their bodies or by ingestion of seeds at one location and discharge at another. In many areas grazed by livestock, or used for trailing, plants formerly not common to the region have been introduced. It seems logical to assume that in many cases these plants may have been introduced by livestock coming from areas where these species were present or by the use of imported feeds containing seeds of these species. Today, livestock, in addition to being trailed, are often carried great distances to grazing areas by railroads or trucks. Consequently, seeds of various species could be spread over distant areas by livestock in a short period of time. In addition, rabbits and rodents may act as carriers of seed for shorter distances.

In view of these possibilities, the present study was undertaken to determine the viability of certain range plant seeds after passing through the digestive tract of sheep and rabbits and to ascertain how long viable seeds would remain in the digestive system before being

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excreted. Such information would be valuable in planning programs aimed to prevent the spreading of undesirable plant species and possibly as an aid in the revegetation of ranges with acceptible species.

In selecting the plants for this study, an attempt was made to use representative species found in the sagebrush-grass and salt-desert shrub types of the intermountain region. Seeds of seven species, including two shrubs, two annual forbs, two annual grasses and one perennial grass were selected.

The species[2] studied were: Nuttall saltbush (*Atriplex nuttallii*); shadscale (*Atriplex confertifolia*); halogeton (*Halogeton glomeratus*); Russian thistle (*Salsola kali tenuifolia*); cheatgrass (*Bromus tectorum*); Medusa-head (*Elymus caput-medusae*); and fairway crested wheatgrass (*Agropyron cristatum*).

Saltbush and shadscale were chosen for study because of their importance as browse plants and the need for further knowledge concerning their reproduction and spread. Halogeton was selected because of its importance as a toxic range weed; Russian thistle because of its relationship to halogeton and its abundance on depleted ranges; cheatgrass because of its status as an invader of former perennial ranges and medusa-head as a recent and less desirable invader. Crested wheatgrass was chosen as the principal species for range reseeding in Idaho and other western states.

Literature Review

Many papers dealing with the relationship of animals to the dissemination of ingested seeds have been published. In the following review only papers concerned with mammalian seed ingestion and having an experimental basis are considered.

Oswald (1908) fed 2,000 seeds each of 21 different species of plants to yearling calves. An average germination of 12.8 percent was obtained after the seeds had passed through the digestive tract. Beach (1908) fed 6 pounds daily of flax feed containing 212,912 weed seeds per pound to a Jersey cow. Germination percentage of the check lot seeds was 26 percent; 4 to 5 percent of recovered seeds were found to be viable.

Harmon and Keim (1934) used several species of domestic animals in seed viability studies. In respect to percentage of whole seeds passed, test animals were ranked in the following order: hogs 24.1, calves 23.1, horses 12.9, sheep 10.7, and chickens 0.3. The effect of digestion on the viability of weed seeds was sufficiently different for each kind of animal so that the order was changed when consideration was given to the percentage of viabile seeds passed. The percentages of viable seeds passed by test animals were: calves 9.6, hogs 8.8, horses 8.7, sheep 6.4 and chickens 0.2. These workers state that, "an average of 14.2 percent uninjured seeds was recovered from calves, horses, sheep, hogs and chickens fed various weed seeds; an average of 6.7 percent viable seeds was recovered from each 1,000 seeds fed to all the animals." Working with dairy cows, Atkeson, Hulbert and Warren (1934) recovered several species of weed seeds after 47, 59, 73 and 93 hours in the bovine digestive tract. Germination tests showed that apparently the longer the seeds remained in the animal's digestive tract, the greater was the reduction in germination. Of 19 samples, representing 13 different species studied, reduction in germination due to digestive processes was more than 90 percent in 6 samples and 80 percent or more in 11 samples.

Fisher (1947) has observed that mesquite infestation may be due to livestock grazing on brush-infested land and spreading the seed through fecal droppings. Germination studies of mesquite seed fed to mules, steer calves and lambs showed viability of 54, 45 and 12 percent, respectively, after having passed through the digestive tracts.

Working with Macartney rose hips, McCully (1951) found that slightly more than 50 percent of the seed was recovered and of this approximately 90 percent suffered no apparent damage from passing through the digestive system of mature cows. More than 90 percent of the seed recovered was passed by the fourth day.

In a California study using cattle as the disseminators of eight range forage species, Jones and Carroll (1953) observed little difference in the controlled and reclaimed germination. These germination percentages averaged 88.8 and 85.7, respectively, for the eight species studied. No attempt was made to determine the percentage of ingested seeds which passed through the digestive tract.

In a Georgia study, Burton and Andrews (1948) used Jersey cows to study the rate of elimination and germination of seeds of lespedeza and various grass species. Although the bulk of seed was passed in 72 hours, the time required varied from 24 hours to 10 days depending on the plant species. Recovery of seeds varied from one-half to one-eighth of the amount fed in a 10-day collection period. Passage through the digestive tract reduced the viability of most seeds fed.

In west-central Kansas, Timmons (1942) observed jack rabbits eating prickly-pear cactus fruit and disseminating the seed in their fecal pellets. Germination of seeds found in the jack rabbit droppings was 62 percent in comparison to 44 percent in hand picked seeds. Extensive eating of cactus fruit by jack rabbits was reported by Riegel (1941, 1942). Most of the seeds passed unharmed through the digestive tracts of the rabbits. Brown (1947), in Kansas, found numerous seeds in fecal pellets of jack rabbits. Germination tests showed that many of the seeds were viable and that passage through the digestive tract increased the germination percentage in buffalo grass, cactus and smooth sumac, whereas sand dropseed was affected very little.

Glendening and Paulsen (1950) fed 5,950 seeds of velvet mesquite to two sheep in six tests and found that 68 percent of the seeds were destroyed beyond recognition by mastication and digestive processes. The greatest elimination of seeds occurred the second day after ingestion, and approximately 95 percent of the seeds were eliminated by the fifth day. Of the total seeds fed, 27.3 percent were found to be immediately or potentially viable.

Cook and Stoddart (1953) collected feces of sheep and jack rabbits on halogeton-infested ranges in Utah. These workers found that for every 500 grams of dry sheep feces and each 500 grams of dry jack rabbit feces, 14 and 18 halogeton seedlings were produced, respectively. Two wether sheep, consum-

[2] *Nomenclature follows that of R. J. Davis: Flora of Idaho, William C. Brown Co., Dubuque, Iowa, 1952.*

ing two quarts of halogeton seeds (42,690 winged seeds) per day were equipped with fecal bags. The average germination of halogeton seeds after passing through the sheep was only 1.02 percent. Calculations showed, however, that 435 potential seedlings were excreted by each animal each day and seeds were completely eliminated from the digestive tract in 3 days.

In studying fecal pellets obtained from the colons of domestic sheep and deer, Heady (1954) stated that "a portion of the seeds consumed pass through these animals in viable condition; the portion being dependent on the nature of the seed and characteristics of the animal—."

Experimental Procedure

Seeds of six range plant species were collected in southern Idaho during 1953 or 1954. The crested wheatgrass sample was of a 1953 commercial seed lot. The seeds were fed to domestic sheep and domestic rabbits to ascertain the effect of animal digestion on viability.

All seeds were cleaned by hand or mechanical means to remove foreign material. Nuttall saltbush was cleaned by hand to remove leaves and twigs. Shadscale was first run through a laboratory hammermill to remove bracts and then through a Clipper seed cleaner to separate foreign material. Halogeton was processed by rolling with a rubber roller to loosen seed from bracts; manual fanning was used to remove chaffy bracts and the seed sifted through a 2 mm. soil screen to separate seed from foreign material. No attempt was made to separate the "black" and "brown" forms of seeds (Tisdale and Zappettini, 1953). Seeds of Russian thistle and cheatgrass were rolled with a rubber roller and then passed through the Clipper seed cleaner to separate seeds from foreign material. Medusa-head seeds were merely separated by hand from the spikes and given no further treatment.

The average number of seeds per gram was obtained for each species from three 1-gram samples. Computation of the number of seeds in the 25-gram and 5-gram samples fed to sheep and rabbits, respectively, was made by means of these conversion factors.

The Hampshire and Rambouillet ewe lambs and New Zealand rabbits used as experimental animals had free access to water and were fed constant, predetermined quantities of chopped alfalfa hay for 14 days prior to and throughout each trial. Animals were kept and fed in individual feeding cages which facilitated fecal collections.

The amount of feces excreted over a 24-hour period was determined prior to each trial when the animals were fed at a constant level. Fecal collections made over three 24-hour periods immediately prior to the feeding of the seeds under study served as a basis for calculated daily fecal excretions.

On the first day of each trial, the experimental animals were fed two portions of seeds, in the morning (7 a.m.) and the afternoon (4 p.m.). Sheep were fed two 25-gram portions of seeds and rabbits two 5-gram portions. Animals were fed pre-determined quantities of alfalfa hay and continued to receive this amount daily throughout each trial.

The number of viable seeds recovered in sheep feces was determined on 100-gram fecal collections made daily for 10 days after the seed were fed. Similar 40-gram fecal collections were made with the rabbits for a 5-day period. The total number of viable seeds excreted daily was computed from the daily fecal collections on the basis of the previously determined total daily fecal excretion.

Germination studies were conducted with the control seed, fecal samples, and chopped alfalfa hay. The control samples consisting of 4 replicates of 100 seeds of each species were counted and spread on uncontaminated blotters in petri dishes. In addition three duplicate samples of 100 seeds each of the shadscale and Nuttall salt-

Table 1. Germination tests of seeds before and after passing through the digestive tracts of sheep.

Plant species	Daily feed intake	Daily fecal excr.	Control seed germin.	No. seeds fed	No. of fecal seed germinating — Collection days after feeding											Recovered seed germination
					1	2	3	4	5	6	7	8	9	10	Total	
	gms.	*gms.*	%													%
Nuttall saltbush	1362	1120	6.5	16,000	0	67	45	45	34	11	11	22	0	0	235	1.47
	1135	967			0	48	48	39	29	29	19	19	10	0	241	1.51
Shadscale	908	787	0	13,000	0	24	31	24	24	16	16	8	0	0	143	1.10
	1362	1256			0	25	25	38	25	25	13	0	0	0	151	1.16
Halogeton	1362	1059	60.1	74,950	0	135	254	143	127	72	40	16	16	0	803	1.07
	1816	1483			0	133	356	208	178	89	59	15	15	0	1053	1.40
Cheatgrass	1816	1650	90	13,700	0	33	83	66	50	33	17	17	0	0	299	2.18
	1816	1559			0	47	62	78	31	47	31	16	0	0	312	2.28
Medusa-head	1362	1301	98.5	9,350	0	26	52	39	26	26	26	13	13	0	221	2.36
	1135	1090			0	33	44	44	44	33	22	11	0	0	231	2.47
Fairway crested wheatgrass	908	787	97.5	18,000	0	31	47	47	31	24	24	8	8	0	220	1.22
	1362	1301			0	91	78	52	39	26	26	0	0	0	312	1.73

Table 2. Germination tests of seeds before and after passing through the digestive tracts of rabbits.

Plant species	Daily feed intake	Daily fecal excr.	Control seed germin.	No. seeds fed.	No. of fecal seed germinating: Collection days after feeding 1	2	3	4	5	Total	Recovered seed germination
	gms.	*gms.*	*%*								*%*
Nuttall saltbush	60	42	6.5	3,200	0	6	3	0	0	9	.28
	60	42			0	5	4	2	0	11	.34
Shadscale	60	41	0	2,600	0	0	0	0	0	0	0
	60	42			0	0	0	0	0	0	0
Halogeton	60	44	60.1	14,900	0	2	3	2	0	7	.05
	60	42			0	3	4	2	0	9	.06
Russian thistle	60	40	73	7,970	0	6	7	0	0	13	.16
	60	43			0	9	6	0	0	15	.19
Cheatgrass	60	44	90	2,740	0	3	2	0	0	5	.18
	60	43			0	4	2	0	0	6	.22
Medusa-head	60	42	98.5	1,870	0	5	6	0	0	11	.59
	60	44			0	7	5	0	0	12	.64
Fairway crested wheatgrass	60	46	97.5	3,600	0	1	5	2	0	8	.22
	60	42			0	2	6	3	0	11	.31

bush were treated with 10 percent hydrochloric acid for 5 minutes and an additional three samples of 100 seeds each of these two species were refrigerated at 25° F. for 6 days in an attempt to break seed dormancy. Seed from a single source was used in each study.

Fecal pellet samples and alfalfa hay samples were spread on and covered with large clean blotters in metal trays. Fecal pellets were broken apart with a putty knife prior to placing on the blotters. All samples were germinated in a room where daily temperatures alternated between 72 and 80° F. The humidity of the blotters was kept as high as possible. Seeds were considered to have germinated when definite seedlings developed. The germination period for the control lots varied from 14 days to a maximum of 30 days. Seeds in the fecal samples were allowed 35 days to germinate.

Experimental Results

The data for the trials with sheep (Table 1) indicate a considerable period following each feeding during which appreciable numbers of viable seeds were excreted. In most cases this period was from the 2nd through the 8th day after feeding. Numbers of seeds excreted were generally greatest on the 2nd through the 5th day.

The percentage of viable seeds passed by the sheep was similar for all species, despite marked differences in seed size, shape and nature of seed coat. The two annual grasses yielded the greatest germination of total seeds fed. The two browse species gave the highest germination in relation to the laboratory germination of the control seed samples.

Results of the trials with rabbits (Table 2) were distinguished by the shorter period during which seeds were excreted following a feeding, and the lower percentage recovery of viable seeds of all species. No viable seeds of shadscale were recovered and recovery of halogeton seed was extremely limited.

Special Seed Treatment

The poor laboratory germination of the two browse species suggested further study to determine to what extent seed dormancy might be involved. Three 100-seed samples of Nuttall saltbush were treated with 10 percent hydrochloric acid for 5 minutes prior to testing for germination but with no apparent effect on seed dormancy. Seeds receiving this prior treatment had an average germination of 6 percent as compared to 6.5 for untreated seed. Three additional samples of this species were subjected to 6 days of refrigeration (25° F.) prior to germination. This treatment had an adverse effect on germination, as no seeds germinated during a 35-day test period. Examination of ungerminated seeds in these two studies showed that 21 percent had no embryos.

Treatment of three seed samples of shadscale for 5 minutes with 10 percent hydrochloric acid prior to germination studies apparently aided in reducing seed dormancy. Five percent germination was obtained for seeds thus treated. However, refrigeration treatment—25° F. for 6 days—had no beneficial effects in increasing germination as seeds thus treated failed to germinate. An average of 23 percent of the ungerminated seeds in these two treatments were found to have no embryos.

The low germination of halogeton noted for the control samples is apparenty due to the use of a mixture of "black" and "brown" forms of seed as collected in the field. Laboratory tests of the latter form of seed have shown consistently low germination without

special treatment such as scarification of the seed coat (Tisdale, 1955).

Feed Intake and Fecal Excretion

The relationship of average daily feed intake to the average daily fecal excretion is of interest to those concerned with livestock-land use relationships. Table 3 presents a summary of the average daily feed intake and average fecal excretion of experimental animals under the conditions of this study.

Table 3. Average daily feed intake and fecal excretion of sheep and rabbits.

Feed intake	Fecal excretion (oven dry wt.) Range	Average
gms.	*gms.*	*gms.*
	Sheep	
908	545- 999	787
1,135	635-1,180	1,078
1,362	908-1,407	1,207
1,816	1,408-1,771	1,566
	Rabbits	
60	40-46	44

Discussion and Conclusions

These studies indicate that domestic sheep and domestic rabbits have the ability to carry viable seeds in their digestive tracts for comparatively long periods of time and, hence, could distribute these seeds. Although most of the viable seeds were passed by sheep during the third and fourth days (Table 1) and by rabbits on the second and third days (Table 2), it is significant that a few viable seeds were still being passed by sheep 9 days and by rabbits 4 days after they were fed. However, the quantities of viable seeds passed by sheep and recovered on the 8th and 9th days were so small as to suggest that practically all the other seeds fed had been destroyed by mastication and digestive processes and contributed to the nutritional needs of the animals.

The viability of most seeds was greatly reduced by their passage through the digestive tracts of both sheep and rabbits. Seed viability was reduced more consistently by rabbits than by sheep. In tests with both animals, differences in viability of excreted seed among the seven plant species were small, despite the fact that the species tested varied greatly in the amount and rapidity of laboratory germination.

In the case of shadscale, germination was actually increased after passage through the digestive tract of sheep. Apparently the digestive processes of the ruminant are such as to partially overcome the seed dormancy of this species. The fact that the ruminant does not masticate, as do rabbits, at the time of initial feed intake may have a bearing on this phenomenon. Some seeds may perhaps settle out in rumination and thus are not subjected to regurgitation and subsequent mastication, and passed from the rumen into the reticulum, omasum and abomasum without complete disintegration.

Germination of 5 percent was obtained for shadscale seed treated with acid and presumedly this indicates that seed dormancy can be partially overcome by such treatment or by ruminant digestion.

Summary

The effects of sheep and rabbit digestion on the viability of seeds of seven western range plants are reported.

Under the conditions of the study viable seeds remained in the digestive tracts of sheep for as long as 9 days and in that of rabbits for 4 days. The proportion of viable seeds recovered was relatively small for all species studied.

These data indicate that it is entirely feasible for sheep or rabbits to transport viable seed via their digestive systems for great distances and, consequently, to contribute materially to the spread of various plants in relatively short periods of time. This fact may partially explain the rapid spread of certain weedy plant species on western ranges.

This knowledge could perhaps be used to advantage by utilizing sheep as disseminators of seeds of preferred range forage species into inaccessible areas.

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