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Benefits and costs in controlling sheep bonded to cattle without wire fencing*

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Abstract

Mixed grazing groups of 15 bonded ewes and five cows consistently (100%) remained together in one of two adjoining arid rangeland paddocks during each of three seasons beginning in September 1991. The paddocks were separated with only two strands of wire fence, the bottom wire being 0.7 m off the ground. In contrast, non-bonded ewes (controls) were found in the adjoining paddock without cattle 54% of the time. This created a mean separation distance between non-bonded ewes and cattle of 977 m. Locating ewes in the non-bonded treatment required additional time, thus reducing management efficiency and increasing costs by approx. $0.10/hd/d. In a separate study begun in January 1992 an enduring bond between sheep and cattle was produced by confining 65 to 86 day-old lambs with cattle in pens for 55 d at a cost of approx. $0.51/hd/d. Bonding may provide an economically viable alternative to conventional wire fencing on many properties as a means of controlling the spatial distribution of sheep under mixed grazing.

Keywords: Free-ranging livestock; Ranch economics; Sheep behavior; Distribution; Pen feeding

1. Introduction

Management of western rangelands was changed with the introduction of barbed wire in the 1870s (Youngblood, 1922). Except for weaving wire into various geometrical patterns, removing barbs, electrifying the metal, or combining metal and plastic into an electroplastic twine (Jepson et al., 1983), wire fencing has been the norm for over 120 years. However, within the past few years bioinstrumentation has offered new alternatives to wire fences for controlling livestock (Rose, 1991). By combining electronics and training, goat (Fay et al., 1989) and cattle (Quigley et al., 1990) movement can be restricted without conventional wire fencing.

Fencing has been the accepted tool to enhance proper animal distribution (Stoddard and Smith, 1955) and provide small ruminants protection from predators such as coyotes (Thompson, 1979). Economics frequently limit where and when wire fencing is used. If mean

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annual forage production is less than 500 kg/ha, as in many arid areas, fencing may not be a cost–effective way to enhance forage utilization (Holechek et al., 1989).

Topography and vegetation significantly affect fence construction costs. In 1970 the total cost (skilled and unskilled labor, equipment and materials) for a barbed wire fence constructed with steel posts to last 30 years in the desert shrub, southwestern shrubsteppe and desert grasslands ranges was between $528 and $746 per km (Duran and Kaiser, 1972). In 1990, barbed wire fencing costs of $1243 per km were estimated for the southwestern portion of New Mexico, while $1864 per km was estimated for net wire fencing on combination sheep and cattle ranches in the Southeast and the central subregions of the state (Torell and Word, 1991).

Construction costs in forested ecosystems can be 60% higher than for similar type fences in non-forested ecosystems (Quigley and Sanderson, 1989). Materials to construct a woven or barbed wire fence can cost 20% (Stoddard and Smith, 1955) to 50% (Gates et al., 1978) more than a properly constructed electric fence.

Net-wire fences are generally preferable to restrain sheep (US Government Printing Office, 1961) and goats (Ragsdale et al., 1971). However, net-wire fencing may be a barrier to wildlife species such as antelope and should be discouraged. Balancing wildlife needs to livestock requirements can be challenging. Studman (1991) has demonstrated that sheep with a mean brisket size of 32.2 cm can escape under a bar that is only 29.0 cm off the ground. Since antelope generally go under fences, Yoakum (1978) recommends barbed wire fences be constructed with the bottom wire, preferably smooth, being 41 cm off the ground.

High-tensile electric fences may last longer and cost less to maintain than traditional barbed wire or woven wire fences (Broussard and Gates, 1988). In addition, electric fences appear to be satisfactory for controlling cattle (Mc Donald et al., 1981) and sheep (Hulet et al., 1987b).

The spatial distribution and relationship among individuals within a group of livestock is not random under free-ranging conditions (Arnold, 1985; Lynch et al., 1992). Under mixed grazing (Allen, 1991), cattle will normally dominate sheep when the two species are together under free-ranging conditions; therefore, it is not common for cattle and sheep to graze together when they are in the same paddock (Squires, 1981).

Sheep not bonded to cattle characteristically do not associate with cattle on rangeland. However, sheep (Anderson et al., 1987) and goats (Hulet et al., 1989) that have had their behavior modified when young and consistently remain in close association with cattle under free-ranging conditions have been termed a 'flerd' (Anderson et al., 1988).

Reduction in predation losses from coyotes (Hulet et al., 1987a) and improved animal distribution during grazing (Nakamatsu, 1989) have been demonstrated with flerds grazing arid rangeland. The objective of this research was to evaluate the spatial distribution of mixed grazing groups of cattle and bonded and non-bonded ewes under minimal wire fencing.

2. Materials and methods

Flerd behavior was evaluated as an alternative to wire fencing for confining bonded ewes to one of two adjoining paddocks (7B, 122 ha and 11D, 333 ha) across three seasons. The study was conducted during growth of perennial herbage (September 16, 1991 to October 7, 1991), plant dormancy (January 6, 1992 to January 31, 1992) and spring growth (April 20 to May 18, 1992).

The triangular shaped paddock (7B) in which the mixed grazing groups were evaluated had been fenced on the east and west sides with six and seven strands of smooth and barbed wire, respectively. All wires were approx. equally spaced to a height of 1.5 m with the bottom wire approx. 10 cm off the ground. The third fence separating paddock 7B from 11D was 1.3 km in length and was constructed with two strands of wire. The bottom wire was smooth and 0.7 m off the ground while the top wire was barbed and 1 m off the ground. This configuration gave the ewes ample opportunity to leave paddock 7B and move into paddock 11D. Water and minerals, in the form of blocks, were provided ad libitum on the two-wire fence line. This location was chosen to add extra pressure to the test for non-wire animal control.

A total of 180 ewes were evaluated across the three seasons. The bonded treatment consisted of 90 adult (3–7 yr old) Polypay or Polypay × Rambouillet flerd ewes, previously bonded as lambs to cattle using either pen (Anderson et al., 1987) or field (Hulet et al., 1992) bonding. The 90 remaining 2–9-yr-old ewes of similar breeding, had not been socialized (bonded) to cattle and served as controls. The 30 gentle crossbred beef cattle used throughout the study were at least 2 years old and of Hereford, Angus, and Brangus breeding. Dry cows were used during dormancy, while dry cows and cow–calf pairs were used during growth.

Each season, a total of 60 ewes (30 ewes/treatment) and ten cows were randomly evaluated over four consecutive weeks. Each of the two groups of five randomly assigned cows were used to test cohesiveness of both 15 randomly assigned bonded and 15 randomly assigned non-bonded ewes. Each Monday morning a mixed grazing group consisting of 20 animals (five cows and 15 ewes) was assigned to paddock 7B. Beginning Monday afternoon and following consecutively throughout the remaining four days, data were collected during five morning (AM) and five afternoon (PM) periods to include ambient air temperatures, wind speed, direction, and atmospheric conditions in addition to the spatial distribution data and distance of the animals within the group from the two-wire fence. The following Monday morning the last AM data were recorded before a new mixed grazing group was put into paddock 7B.

Bonded and control livestock not being evaluated during the week were maintained in two separate 8 to 16 ha paddocks built in paddock 11D, 0.2 km south of the two-wire fence. The 'holding' paddocks were separated by at least 0.6 km to minimize control ewes from having visual contact with cattle. Both paddocks had similar vegetation to that found in 7B.

Substantial time was required to locate non-bonded ewes in paddock 11 D, especially if they had moved into the brush which was approx. 91 cm tall. Therefore, beginning September 11, 1991 and continuing through the remaining seasons, a radio collar manufactured by Telonics® was attached to one ewe in each group of 15 sheep being evaluated.

Standing crop was evaluated in twelve (six/paddock) 5.8 m × 50.8 cm plots laid out perpendicular to the two-wire fence prior to each Monday morning when a new mixed grazing group was released into paddock 7B. Mowing was done to a stubble height of 7.6 cm with a rotary powered mower equipped with a grass catcher. Mowed samples were put into paper sacks and oven dried at 60°C. Dried contents in the bags were dumped on a sieve with 1 mm openings to remove sand and soil immediately before samples were weighed.

Short distances between cattle and sheep were associated with high affinity or a good bond. The shorter the distance between the perimeter of the circle enclosing cattle and the circle enclosing the ewes, the more cohesive (bonded) to the cattle the ewes were assumed to be. This spatial distribution of animals was documented by holding a measuring tape at arm's length to estimate distance. The minimum length or width of a ewe and/or cow, the minimum diameter of two circles, one encircling all ewes and one encircling all cows, and the minimum distance between the perimeters of these two circles was measured. Also the minimum distance from the perimeter of each animal-species-circle to the two-wire fence was measured.

Ewe groups when in 7B were recorded as having a positive distance from the two-wire fence, while ewes in 11D were recorded as having a negative distance. All measurements were made before ewes were returned to paddock 7D to within line of sight (approx. 30 m) of the cattle. Ewes and cows were measured for length and width before field observations in order that ratios between actual animal measurements and lengths read from the measuring tape in the field could be used to calculate accurate field distances.

2.1. Bonding costs

A separate study to bond 21 ewe and 21 wether lambs of Polypay and Rambouillet × Polypay breeding to cattle was begun January 14, 1992. Bonding was done in groups of ten. Each group consisted of seven randomly assigned lambs of the same gender and three randomly assigned heifers. Six pens located at Jornada Experimental Range Headquarters were used to hold the 60 animals until March 10, 1992 (55 consecutive days). Each pen had a mean area of 63 m^2 with a creep area of 4 m^2, ad libitum water and a common feed bunk. The lambs ranged between 65 and 86 d of age when penning began and the beef heifers initially weighed 220 kg/hd.

Approx. 40.7 kg/d/pen of alfalfa hay (*Medicago sativa*; 1.35 bales/d/pen) was fed each evening. A mean of 1.45 kg/d/pen of milo (*Sorghum vulgare*) was provided to all lambs in the creep area. The growing heifers were fed a cottonseed/alfalfa based 25% CP range cube manufactured by Alderman-Cave Milling and Grain Co. Roswell, NM, at a mean rate of approx. 5.12 kg/pen every 3 d.

Mean time required to administer feed and check animals was 30 min/d. Labor was charged at a rate of $5.26/h (NM Agric. Stat. Serv., 1992). Feed costs at FOB Jornada Experimental Range were as follows: baled top quality alfalfa hay $0.10/kg ($3.03/bale at 30 bales/ton), milo at $0.13/kg and range cubes at $0.20/kg (25% CP).

2.2. Management costs

Throughout the study in which we evaluated the spatial association of ewes and cattle in paddocks 7B and 11D, we estimated our cost in locating animals. We assumed use of a pickup truck at 24 km/h (15 m/h) during the searching time required to locate animals. Cost to operate the pickup was calculated at a rate of $0.17/km ($0.27/mile) (J. Fowler, personal communication, 1992).

2.3. Statistical analyses

Animal group measurements (cow group diameter, ewe group diameter, separation distance between cow and ewe groups, and separation distance of either animal group from the two-wire fence) were analyzed using analysis of variance. The analysis was a split plot with time of day (AM, PM) as the split factor. The whole plot was a completely randomized design with treatments in a 3 (season) by 2 (bonding condition) factorial with replication within season and bonding condition as the whole plot error. Day within replication, season, and bonding condition was the whole plot subsample. Analyses were conducted using the SAS GLM procedure (SAS, 1985). Least-square means and standard errors were calculated.

Means and standard errors were calculated for standing crop but formal statistical tests were not performed. The cost of producing a bonded sheep and the cost in locating animals are given in 1992 US $.

3. Results

Bonded ewes with cattle were never (100% of the time) found outside of paddock 7B. However, non-bonded ewes were found in paddock 11D 54% of the time, while the cattle consistently remained in 7B. Non-bonded ewes showed a tendency to separate from cattle and move into paddock 11D more often during dormancy and perennial growth compared to the season of spring growth (Table 1).

Finding the two livestock groups required varying amounts of time. The cattle were never found outside of paddock 7B; therefore, paddock 7B was always entered initially to begin the search for the ewes. Since ewes in the flerd were always found with the cattle all animals were accounted for simultaneously. However, the flock of non-bonded ewes was not with the cattle in paddock 7B 54% of the time. Therefore, the mean additional time required each day to locate both livestock species in the control treatment was 5 ± 1 min (Table 2).

Weather throughout the three seasons was similar to the 30 year (1951–1980) season means for the area (NOAA, 1991/92). Ambient air temperatures ranged between $-1°$ and 33°C with lowest temperatures in January and highest temperatures at the end of April. Atmospheric conditions ranged from bright clear sunny days to foggy mornings when visibility was minimal. Relative humidities ranged between 6 and 100% with a mean of $51 \pm 22\%$.

The herbaceous standing crop was similar between paddocks 7B and 11D within each season. The highest standing crop occurred during the season of perennial plant growth with 155 ± 25 and 178 ± 43 kg/ha in paddocks 7B and 11D, respectively. During dormancy the mean standing crop in 7B and 11D was 70 ± 16 and 79 ± 17 kg/ha, respectively. Mean standing crop during spring growth was similar to that mowed during dormancy and was essentially the same (89 ± 28 and 88 ± 22 kg/ha) between paddocks 7B and 11D, respectively.

Frequently additional time was required to locate the control ewes since they did not consistently stay near the cattle. If the ewes moved into paddock 11D, which was 211 ha larger and contained noticeably more brush than paddock 7B, it took more than twice as long to locate them (Table 2).

Time of day did not ($P > 0.05$) influence the diameter of livestock groups, separation of ewe groups from the cattle, or distance either livestock species was from the division fence between paddocks 7B and 11D. Cattle dispersion was not influenced ($P = 0.5679$) by the presence of sheep since cattle with the flerd and with

Table 1
Mean percentage of times non-bonded ewes were observed in paddocks 7B (122 ha) and 11D (333 ha) and LS mean[a] ± SE[b] of group diameters and separation between groups of free-ranging non-bonded ewes and ewes bonded to cattle during perennial plant growth, dormancy and spring growth in semi-arid rangeland paddocks on the Jornada Experimental Range

Season	Times observed in paddock		LS means[a] ± SE[b]							
			Diameters						Separation of sheep and cattle groups	
	non-bonded group						bonded group		non-bonded	bonded
	sheep					cattle	sheep	cattle		
	7B	11D	7B	11D	overall	7B	7B	7B		
	%		meters							
Perennial growth	37	63	35 ± 30	15 ± 5	24 ± 11	86 ± 19	28 ± 11	98 ± 19	1214 ± 126	0 ± 121
Dormancy	45	55	49 ± 28	62 ± 44	58 ± 11	94 ± 19	56 ± 11	78 ± 19	1063 ± 121	0 ± 121
Spring growth	55	45	19 ± 11	10 ± 4	15 ± 11	53 ± 19	68 ± 11	85 ± 19	653 ± 121	0 ± 121
Overall	46	54	33 ± 26	30 ± 35	32 ± 6	78 ± 11	51 ± 6	87 ± 11	977 ± 71	0 ± 70

[a]Least-square means (LS means) generated using the GLM procedure (SAS, 1985).
[b]Standard errors (SE).

Table 2
Mean daily additional time in minutes ± SE[a] required to locate cattle and non-bonded ewes once one species was found and mean maximum marginal costs[a] (US$/d) above those associated with finding the flerd (cattle and sheep together) when non-bonded ewes and cattle were not together under rangeland conditions

Season	Additional time (min)			Marginal costs (US$/d)		
	overall	7B	11D	overall	7B	11D
Perennial growth	5 ± 1[c]	5 ± 2	6 ± 2	1.55	1.55	1.86
Dormancy	7 ± 3	2 ± 1	11 ± 4	2.79	0.62	3.88
Spring growth	4 ± 1	3 ± 1	6 ± 1	1.24	1.09	1.55
Overall	5 ± 1	3 ± 1	7 ± 2	2.02	1.09	2.48

[a]Standard errors (SE).
[b]The following conditions are assumed: vehicle costs of $0.0675/min; pickup traveling approx. 24 km/h (15 miles/h); vehicle costs of $0.17/km ($0.27/mile). Labor costs of $0.0877/min ($5.26/h).
[c]The ewes were not found on 9-10-91 during a search from a pick up truck which lasted 90 min.

Table 3
Cost[a] (US$) per head to create bonded sheep through pen confinement of 42 lambs and 18 heifers over 55 consecutive days

Item	Unit cost	First 30 days		Following 25 days		Overall 55 days	
		$/hd/d	total	$/hd/d	total	$/hd/d	total
Labor	$5.26/h	0.045	15.54 h	0.044	12.5 h	0.045	28.04 h
Baled alfalfa hay[b]	$0.10/kg	0.392	232.8 bales	0.418	207 bales	0.408	444.3 bales
Range cubes[b,c] (cattle)	$0.20/kg	0.039	351.08 kg	0.028	212.28 kg	0.034	563.36 kg
Milo (sheep)[b]	$0.13/kg	0.013	178.26 kg	0.026	292.11 kg	0.019	477.63 kg
Total		0.489		0.516		0.506	

[a]Does not include construction or capitalization costs.
[b]Prices are in 1991/92 dollars at FOB Jornada Experimental Range.
[c]The range cubes contained 25% crude protein.

the non-bonded flock ewes were found in groups having mean diameters of 87 and 78 m, respectively. However, bonded ewes tended ($P = 0.0772$) to be more dispersed than non-bonded ewes as reflected in groups having mean diameters of 51 and 32 m, respectively. In all three seasons ewes formed smaller intraspecific diameter groups compared to cattle regardless of treatment (Table 1). During the three seasons bonded ewes were never found ($P = 0.0001$) separated from the cattle while the distance non-bonded ewes ranged from cattle varied between 0 to 4758 m. Bonded ewes were always found in paddock 7B. This resulted in a positive mean distance of 561 ± 157 m from the two-wire fence in contrast to the non-bonded ewes that were frequently found (54%) in paddock 11D thus resulting in a negative mean distance of −34 ± 159 m ($P = 0.0372$) from the two-wire fence. Overall, cattle stayed more than 500 m from the two-wire fence regardless of sheep group ($P = 0.5052$); however, during perennial plant growth cattle tended to stay further ($P = 0.0523$) from the two-wire fence (650 ± 41 m) than during dormancy (516 ± 41 m) or during annual growth (472 ± 41 m).

3.1. Savings and costs in managing flerds

Bonded ewes were always found with the cattle and therefore costs associated with locating livestock could be allocated evenly between the two species. In contrast, non-bonded ewes were only found in the same paddock with cattle 46% of the time. Even though the control ewes and cows had a mean separation of 977 ± 71 m (Table 1) in 13 (22%) of the 60 observations, the control ewes were within ≤ 322 m of the cows. Based on previous research (Anderson et al.,

1987) this amount of separation would have been considered within that allowable for a bonded group of ewes. However, in four (31%) of these 13 observations the control ewes were in paddock 11D. In only one of these four separations did the control ewes return to paddock 7B by the time the next data were recorded.

Therefore, locating and returning control ewes from 11D back to 7B required additional travel. This can be translated into a mean marginal cost above the time required to locate the flerd of $2.02 per day (Table 2). This additional cost is a very conservative estimate compared to most commercial production systems since radio telemetry equipment was used to locate the ewes if they were not immediately seen to be associated with the cattle.

The cost to create a bonded ewe and wether lambs under pen confinement was $0.49/hd/d during the first 30 d of pen confinement and $0.52/hd/d during the additional 25 d of pen confinement. The mean cost per day was $0.51/hd/d for 55 d (Table 3). If supplement is not provided the cost drops to approx. $0.45/hd/d for a 55 d period of pen confinement.

4. Discussion

Weather patterns differed across seasons, yet patterns within a season were similar during each of the 4 weeks. Therefore, it was not obvious that weather per se influenced the spatial distribution of non-bonded or bonded ewes within a season. Likewise, plant species, phenological stage of maturity (quality) and quantity of standing crop were similar in paddocks 7B and 11D within seasons. Therefore, distribution of the non-bonded ewes between paddocks 7B and 11D was not likely related to herbaceous vegetation differences between paddocks.

Locating livestock, especially small ruminants, on large brush infested areas can be challenging. On September 10, 1991, two technicians were unsuccessful in locating the flock of 15 ewes after searching from a pickup for 90 min. The ewes were not found until the following day in paddock 11D. Following this event, radio collars were attached to one sheep in each group of bonded and non-bonded ewes to aid in locating sheep that were not close to the cattle or readily visible. This substantially reduced the time required to locate animals. Therefore, it is almost certain that had radio telemetry not been used during each of the remaining tests, the time required in locating the non-bonded flock ewes would have been substantially longer and probably would have been recorded in hours rather than in minutes.

On the morning of January 27, 1992 dense fog covered paddocks 7B and 11D. After driving the three fence lines and searching from a pickup for 15 min, without relying on radio telemetry, the cattle were located approx. 161 m into paddock 7B near the east fence line. As the two observers walked towards the cattle the ewes were found in among the cattle. If these ewes had not been bonded to cattle it is highly probable the sheep would not have been located until the fog lifted or until the radio telemetry equipment would have been used.

The two-wire fence separating paddocks 7B and 11D was adequate to consistently hold the gentle cattle in paddock 7B through the three seasons. However, the two-wire fence between paddock 7B and 11D did not provide a deterrent to the free movement of the ewes. Fencing of minimal construction using a single wire about 1 m above the ground was reported by Heady (1975) to hold mature cattle yet permit calves to cross underneath to better feed. Furthermore, the non-bonded (control) ewes appeared to distribute themselves in both paddocks 7B and 11D without regard to the cattle in contrast to the bonded ewes which consistently stayed near the cattle.

5. Conclusions

These data support previous research that indicates bonded sheep consistently stay with cattle under free-ranging conditions while non-bonded sheep do not consistently associate with cattle. We demonstrated that a flerd can be contained in a paddock which has minimal fencing, adequate only to control gentle cattle. Creating a bonded sheep will require additional expenses not usually incurred on ranches stocking both cattle and sheep. However, creating a bonded animal may be a practical means of controlling sheep especially if fencing adequate to manage sheep is not in place. We determined the cost of pen confining 42 lambs for 55 d to cost approx. $0.51/hd/d. In addition, the bonded sheep are protected from coyote predation due to their association with cattle, this further reduces the cost associated with creating a bonded animal. Furthermore, the time and vehicle costs ($0.10/hd/d) required in locating our groups of 15 non-bonded free-ranging ewes were higher compared to locating ewes bonded to cattle that stayed near cattle. Therefore, it appears reasonable to conclude that the cost of managing mixed grazing groups of cattle and sheep may be enhanced by modifying and using animal behavior to create bonded sheep.

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