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Abstract

Under mixed stocking, both intra- and inter-species associations exist. Sheep normally do not associate with cattle when the two species are grazed together. However, sheep can be made to consistently stay close to (bond) and follow cattle if forced in close association with cattle at an early age for a period of time. The cohesiveness of this inter-species association under free-ranging conditions varies due to many factors, including sheep gender. Bonded wethers stay nearer to cattle than do bonded ewes. However, the distance of separation between bonded sheep groups and cattle groups during grazing increases over time. Though the mechanism(s) for these phenomena are not presently understood, keeping a few bonded wethers with bonded ewes may enhance the establishment and maintenance of consistently coherent range flerds (flocks + herds).

Keywords: Sheep; Cattle; Grazing; Social grouping; Predation

1. Introduction

It is unusual to see sheep and cattle grazing together in the same paddock (Arnold and Dudzinski, 1978). Though sheep are highly gregarious, they may not readily associate with unfamiliar groups or individuals (Winfield et al., 1981). However, if a few sheep are trained the whole flock may be affected (Lynch et al., 1992). Trained sheep have been successfully used as leaders to facilitate movement of untrained sheep in abattoirs and on farms (Bremner et al., 1980).

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With early life experiences later life behaviors can be affected in both man (Hill et al., 1994) and animals (Beach and Jaynes, 1954; Creel and Albright, 1987). In general, associations developed in early life produce stronger bonds than those developed in later life (Arnold, 1985).

Even though social bonds between young animals and peers are difficult to quantify and the mechanism(s) that maintains the bonds, other than those between mother and young (Arnold et al., 1979), are not well understood, these associations are visible and have been measured (Arnold, 1985). It is possible to alter sheep behavior through an associative conditioning process involving close proximity, especially of animate objects, to form interspecies attachments (Cairns, 1966a).

Lambs will form cross-specific attachments with a wide range of animate and inanimate objects (Cairns, 1966b; Hulet et al., 1975). Through close association (socialization) of young sheep with cattle, an enduring affinity of sheep for cattle developed (Anderson et al., 1987). This group of sheep and cattle that consistently remained together and acted as a unit under free-ranging conditions, we term a flerd (Anderson et al., 1988). A flerd offers several management options for livestock producers including reduced sheep losses from coyote predation (Hulet et al., 1987) and the need for only minimal wire fencing in order to hold sheep on a pasture (Anderson et al., 1994).

In a flerd the closeness of the association that develops between sheep and cattle can be highly variable among individuals (Anderson et al., 1992; Hulet et al., 1992). Older lambs may stay closer to cattle than younger lambs (Hulet et al., 1991). Ewes and wethers mix freely with one another (Arnold and Pahl, 1967). Yet, we have observed that bonded wether sheep consistently stayed closer to cattle compared with bonded ewes under free-ranging conditions (Anderson et al., 1993). On arid rangeland in Australia, ewes with lambs were observed to be more dispersed than wethers under similar conditions (Dudzinski and Arnold, 1967).

Bond et al. (1967) found a similar phenomenon with wether–steer pairs compared with ewe–steer pairs. In particular, one wether lamb–steer pair remained in close proximity for 4 years while in a 4-ha paddock. The wether never left the steer or showed interest in 20 other sheep in the same paddock. Because sheep gender appears to influence the closeness of association with cattle, this study was initiated to monitor the dispersion or aggregation of ewes, wethers and cattle over time in free-ranging flerds.

2. Material and methods

A narrative description of moisture and atmospheric conditions including wind direction was recorded each day animal data were recorded. In addition, meteorological equipment was used to sample ambient wet and dry air temperatures and wind speed.

Fall born Polypay and Polypay × Rambouillet, 65 to 86 days of age ewe–ram sib pairs ($n = 42$ lambs) were selected and penned with 220-kg heifers ($n = 18$) beginning January 14, 1992. Ram lambs were castrated using elastic bands 7 days before being penned. Six randomly assigned groups consisting of seven lambs of the same sex and three heifers were put in rectangular pens approximately 63 m^2 in size. Each pen had a

creep area of 4 m^2, and ad libitum access to water. Alfalfa hay was fed to satiety each evening in a common feed bunk while milo (*Sorghum vulgare*) was provided at a rate of 1.45 kg day^{-1} per pen in the creep area for the growing lambs. Cost details associated with this period of confinement for bond formation have been previously published (Anderson et al., 1994).

On February 13 and 14, 1992 (Days 30 and 31 post-penning) the first of four similar 2-day field trials was conducted. Three of the six groups were evaluated each day. The day before field testing, three of the six groups were randomly chosen and hauled to corrals adjacent to the test paddocks 14B (131 ha), 11B (185 ha) and 7D (87 ha). The individual groups were penned separately in the corral with ad libitum access to water and given a minimal amount of alfalfa hay to encourage active grazing the following morning. The three groups were randomly assigned to one of the three paddocks and observed over 5 consecutive hours by one of three randomly assigned observers. Following testing, the groups were returned to their respective pens for an additional 16 or 18 days of pen confinement.

Measurements were recorded every 15 min following release of the livestock groups from the corral. This frequency of recording followed that used by Walser and Williams (1986) to record the distance of a lamb from its dam. The procedure involved holding a measuring tape at arm's length and measuring the diameter of two imaginary circles, (one enclosing all sheep the other enclosing all the cattle) the shortest distance between the perimeter of the two circles and the length of one animal of each species. Actual animal lengths (front shoulder to back legs) were taken before the field observations so accurate distances in the field could be calculated from the distances measured using the tape. If a sheep or sheep group were observed to be within the circle enclosing all of the cattle the distance of separation between the sheep or sheep group and the cattle group was recorded as 0.

Similar 2-day field testing was repeated during the mornings of March 3 and 4, 1992, May 26 and 27, 1993 and November 1 and 2, 1994. However, the original heifers penned with the sheep were used only during the first two 2-day field trials. During field trials three and four the sheep that had originally been penned together were again brought together into six groups and randomly assigned three cows from a preexisting flerd to evaluate cohesiveness. All of our studies to date indicate the bond sheep have to the cattle is species not individual specific. However, bonding strength differences between specific ovine–bovine pairs has not been experimentally evaluated. To reduce time and labor during each of the final three 2-day field evaluations, trials lasted only 4 h. In addition, during the last three field trials each sheep's separation from the perimeter of the smallest imaginary circle enclosing all cattle was measured seven times in a random sequence along with group data recorded every 15 min as in the February 1992 field trial. As in the first 2-day field trial, the livestock groups and observers were randomly assigned to paddocks 14B, 11B and 7D.

Immediately following the second 4-h 2-day field trial (March 3 and 4, 1992), the association of the ewes and wethers with cattle was monitored for 4 consecutive weeks. Two male and two female sheep groups were formed from the initial six pen groups and randomly assigned among paddocks 14B, 11B, 11D (333 ha) and 7B (300 ha). The gender specific groups consisted of either nine or ten lambs and four heifers or 11 lambs

and five heifers all randomly assigned. The heifers comprising each of the four groups were randomly assigned to the sheep groups based on prior associations with sheep. Heifers that had previously been penned with ewes were now assigned to wethers and visa versa. The minimum diameter circles enclosing each species group was recorded along with the separation distance between the perimeter of these two groups. Data were recorded twice each day (morning and afternoon) Monday through Friday between March 11 and April 8, 1992 (two observations $day^{-1} \times 5$ days $week^{-1} \times 4$ weeks $\times$ no. of distinctly separate livestock groups). Those sheep within the bovine group and the sheep closest and furthest away from the bovine group were recorded in addition to data collected during the 2-day field trials. After 5 days of data were collected, the four mini-flerds were rotated among paddocks. At the end of the 4 weeks, sheep from all four mini-flerds were combined into the preexisting flerd while the heifers were returned to the replacement heifer herd.

2.1. Statistical analyses

Over the 3-year study, a total of six sheep died (five ewes and one wether). The wether became ill and died during the period of pen confinement while all ewes died under free-ranging conditions (one from confirmed coyote predation). Because of these six deaths it was not possible to statistically evaluate six sib pairs in the statistical model across years due to the inordinate amount of missing experimental units ($n = 12$ lambs).

2.1.1. Two-day field trials

Data from the four 2-day field trials were analyzed using analysis of variance. For group measurements (cattle group diameter, sheep group diameter, group separation and proportion of time at least one sheep was within the cattle group), the experimental design was a split-plot in time with a completely randomized design on the whole plot. The whole plot treatment factor was gender and the whole plot experimental error was pen within gender. Two measurements made on individual sheep (individual sheep distance from cattle and proportion of time an individual sheep was within the cattle group) were analyzed similarly to group variables except that a subsampling term for animal within pen and gender was included in the whole plot analysis and individual measurements were not taken during the first 2-day field trial (February 1992). Analysis of variance was conducted with SAS Proc GLM (SAS, 1989). Least square means and standard errors were calculated and the PDIFF option (a procedure similar to LSD's) was used for means separation when the corresponding F-test was significant at $P \leq 0.05$. Because of some imbalance in sample sizes, for some tests it was necessary to synthesize F statistics using Satterthwaite's approximation (Milliken and Johnson, 1984).

2.1.2. Four-week field trial

For group measurements (cattle group diameter, sheep group diameter, group separation and proportion of time at least one sheep was within the cattle group), the experimental design was similar to that for the 2-day field trials. However, neither parametric nor non-parametric statistics could be used to differentiate gender differences

because of the high frequency of zeros (range = 92.5 to 97.5%). A zero indicated at least one sheep was within the cattle group during an observation. Categorizing the distances into groups also was unsuccessful for comparison purposes. Therefore, means and standard errors are reported for these data.

3. Results and discussion

3.1. Two-day field trials

Across the four 2-day field trials conducted in 1992, 1993 and 1994, wether groups tended ($P = 0.1005$) to stay closer (0.7 ± 2.8 m) to the bovine groups than did ewe groups (9.2 ± 2.8 m). There was a gender by trial interaction ($P = 0.0296$). The mean distance of separation between bovine and ovine groups was similar yet closer for wether groups across trials compared with ewe groups, which remained at a further distance from the group of bovines but not at a consistently similar distance (Fig. 1).

This same trend in sheep gender association with bovine groups was also observed for individual sheep. The mean distance individual sheep separated from the various groups of bovines differed ($P = 0.0562$) based on gender. Wethers maintained a mean distance of 2.8 ± 2.6 m from a bovine group compared with 12.8 ± 2.9 m for ewes.

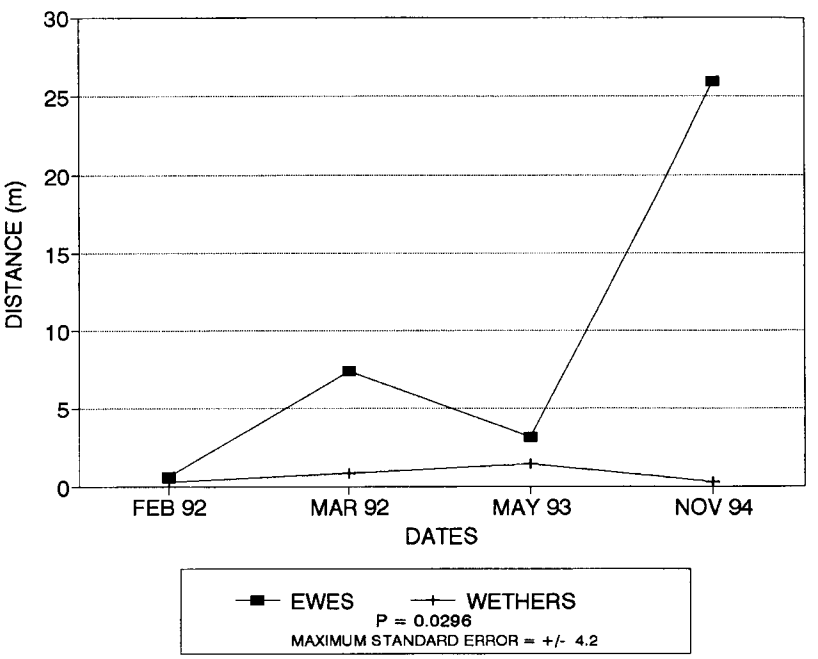

Fig. 1. LS mean separation (m) between cattle groups and sheep groups under free-ranging conditions during morning observations in February 1992, March 1992, May 1993 and November 1994.

Table 1
Cattle and sheep group diameters (m) and separations (m) between cattle and sheep groups under free-ranging conditions over 2-day field trials lasting 4 to 5 h on four dates expressed as least square means (LSM) with associated standard errors (SE)

Date	Group diameter		Group separation LSM ± SE
	Cattle LSM ± SE	Sheep LSM ± SE	
Feb. 1992	6.2 [a] ± 3.6	4.5 [a] ± 1.6	0.4 [a] ± 2.6
March 1992	6.6 [a] ± 2.3	6.1 [a] ± 1.6	4.1 [a] ± 2.9
May 1993	36.9 [b] ± 2.4	19.5 [b] ± 1.8	2.3 [a] ± 2.9
Nov. 1994	35.2 [b] ± 2.4	23.8 [b] ± 1.8	13.1 [b] ± 2.9

[a,b] Means in the same column with different letters differ ($P < 0.05$).

Based on a one sample t-test 2.8 was not distinguishable from zero while 12.8 m was different from zero; indicating wethers stayed closer than ewes to bovine groups.

Though sheep gender affected the closeness of association between species under free-ranging conditions, it did not ($P = 0.4209$) affect the imaginary bovine group diameters which were larger (23.5 m) than ovine group diameters (11.9 m). Sheep groups consisted of four to seven animals compared with only three animals per bovine group. Ewe group diameters tended ($P = 0.1473$) to be larger (15.2 ± 1.3 m) than those of wether groups (11.8 ± 1.3 m). Averaged over both genders, the mean diameter of both bovine and ovine groups increased ($P = 0.0001$) over the four 2-day field trials, as did the distance ($P = 0.0362$) the two species separated from each other (Table 1). This trend in increasing distance of separation over time is similar to that observed between mother and young as the young mature (Morgan and Arnold, 1974; Arnold, 1985). Several explanations should be considered in attempting to understand the spatial distribution of the flerds between 1992 and 1994. Seasonal differences, that affect distribution of free-ranging livestock, may be due to weather and standing crop changes (Arnold and Dudzinski, 1978; Lynch et al., 1992). Also bond cohesiveness may have been breaking down or the flerds may have matured into a more open free-ranging flerd configuration. It is the opinion of the authors that seasonal biotic and abiotic factors coupled with flerd maturation to free-ranging conditions are more likely to provide the correct interpretation for the decrease in flerd cohesiveness during the four 2-day field trials. Furthermore, when a trained dog was used to move the flerd among pastures between 1992 and 1994 the sheep were observed to coalesce among the cattle. This cohesive configuration of the flerd when approached by the dog was also observed and reported by Hulet et al. (1987) to be the proposed mechanism by which bonded sheep receive protection from coyote predation.

During the four 2-day field trials at least one sheep was within the bovine group approximately 72% of the time. Yet this association of sheep with bovines was not related to sheep gender ($P = 0.1399$), date of observation ($P = 0.2267$) or gender by trial date interaction ($P = 0.9685$).

The mean proportion of times a sheep was observed among the cattle was 47%. However, it appeared more likely ($P = 0.0966$) that the sheep would be a wether (59%) compared with a ewe (47%). Yet trial date ($P = 0.5500$) and the gender by trial date

Table 2
Cattle and sheep group diameters (m), separation distance (m) between cattle and sheep groups and distance (m) between the perimeter of the cattle group and the closest and furthest sheep under free-ranging conditions during 4 weeks beginning March 11, 1992 expressed as means with associated standard errors (SE)

Flerds (No. of sheep/cattle)	Group diameter		Group separation mean ± SE	Sheep separation	
	Cattle mean ± SE	Sheep mean ± SE		Closest mean ± SE	Furthest mean ± SE
Wethers					
A = (9/4)	$14.8^{40} \pm 2.7$	$11.7^{40} \pm 2.1$	$0.23^{40} \pm 0.21$	$0.23^{40} \pm 0.21$	$2.28^{40} \pm 0.61$
B = (11/5)	$23.3^{40} \pm 2.6$	$14.7^{40} \pm 1.8$	$0.16^{40} \pm 0.16$	$0.00^{40} \pm 0.00$	$1.12^{39} \pm 0.40$
Ewes					
C = (10/4)	$11.5^{40} \pm 1.2$	$9.0^{40} \pm 1.1$	$0.24^{40} \pm 0.21$	$0.24^{40} \pm 0.21$	$3.11^{39} \pm 0.96$
D = (11/5)	$13.5^{42} \pm 1.7$	$79.2^{42} \pm 48.1$	$0.03^{42} \pm 0.03$	$0.03^{42} \pm 0.03$	$70.82^{42} \pm 48.42$

Superscript = range in sample size, 39 to 42.

interaction ($P = 0.8595$) did not influence individual sheep location with respect to the bovine group.

3.2. Four-week field trial

The data obtained over 4 consecutive weeks support the supposition that bonded sheep stay near (< 161 m; Anderson et al., 1987) cattle under free-ranging conditions (Table 2). Frequently one or more sheep were observed within the cattle group during the 4-week test that began March 11, 1992. This reduced the mean separation between sheep groups and cattle groups to ≤ 0.24 m. In contrast, the mean distance of separation was greater (4.1 m) between sheep groups and cattle groups during the March 3 and 4, 1992, 2-day field trial.

It appears that among the four mini-flerds, ewes were more variable in the distance they stayed from the cattle (3 to 71 m). In contrast, the mean distance wethers stayed from cattle groups never exceeded 2 m during periods of observation. As in the 2-day field trials, cattle group ($n = 4$ or 5) diameters were generally larger (12 to 23 m) compared with sheep group ($n = 9$ to 11) diameters (9 to 15 m). However, 11 ewes comprising mini-flerd D had a mean group diameter of 79 m. Variability associated with these means indicated tremendous among animal variability in cohesiveness during each morning and afternoon observation.

It is unlikely weather was responsible for the high variability among observations. Except for the afternoon of March 17 and the day of April 2, no rain was received during the 4-week study. Wind speed ranged between 0 and 26 km h^{-1} and wet and dry bulb ambient air temperatures ranged between 2°C and 14°C, and 6°C and 26°C, respectively. The daily midrange (maximum + minimum/2) ambient air temperatures were 0.2 and 0.8°C above the 1951 to 1980 mean ambient dry bulb temperatures recorded at Jornada Experimental Range headquarters for March (9.4°C) and April (13.9°C), respectively.

4. Conclusion

Animal spacing under free-ranging conditions is quite variable due in part to individual animal variability. The data gathered during the 2-day field trials indicate cohesiveness between bonded sheep and cattle tended to be influenced by sheep gender while the data gathered over 4 consecutive weeks was too variable to statistically analyze even though similar trends were observed. Wethers consistently stayed closer to cattle than did ewes under free-ranging conditions. The basis for this closer association is yet to be discovered. Furthermore, it appears that flerd cohesiveness during grazing decreases over time based on 2-day field trials lasting 4 to 5 h. The explanation for this increase has not been demonstrated experimentally but is probably not due to a break down in bond cohesiveness.

Based on these data, bonded wethers appear to stay closer to cattle than do ewes under free-ranging conditions. Since ewes and wethers freely flock together (Arnold and Pahl, 1967) and because it is desirable for bonded sheep to stay near cattle to insure protection from coyote predation (Hulet et al., 1987) adding a few bonded wethers to bonded ewes may enhance flerd cohesiveness thus promoting the use of grazing/browsing flerds.

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