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ABSTRACTS

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**Panjab Singh
Vinod Shankar
A.K. Srivastava**



**Range Management Society of India
Indian Grassland & Fodder Research Institute
Jhansi - 284003, India**

clip. The effect of age on fleece yield was also significant ($P < 0.05$). The yield increased with advancement of age gradually. The hair yield in Marwari goat was also affected by the sex and age of the animal. The weight of hair per clip was significantly higher ($P < 0.01$) in bucks. The older animals yielded higher amount of hairs than respective younger animals.

Comparative economic potential of sheep and goats was also calculated at the end of this study which revealed that a net income of Rs. 231.00 can be derived from a single goat per year. A single sheep can provide a net income of Rs. 62.00 only. Thus goat in a mixed flock on desert rangelands is more economical than sheep. In our earlier studies (Mittal and Ghosh 1980) goat was found to be 120 percent more economical than sheep. According to Acharya and Patnayak (1977) in mixed flock, goat is most economical followed by sheep and cattle on semi-arid lands. Studies conducted at Hissar indicated that goat is more economical than cattle.

The results of this study clearly indicated that both desert sheep and goats can be reared exclusively on rangelands and there is no need for providing any supplementary feed at any stage. It is also clear that these two species can be reared together on desert rangelands. By raising them together the carrying capacity of rangelands can be doubled. Sheep being chiefly foraging animal and goat being a browsing animal, they complement each other for utilization of range resources. During present study while sheep remained only on pasture grasses, the goats used *Zizyphus nummularia* bushes as browsing material till spring season and then they were kept on loppings of *Prosopis cineraria* trees. Thus the goats received better nutrition than the sheep on desert rangelands. This was the reason that reduction in body weights during summer season was higher in sheep. Milk yield of ewes was positively correlated with availability of nutrition. Since does received good nutrition in all the seasons its milk yield was not affected by the season.

One very interesting fact became evident from study was that while all productive characteris-

tics of both sheep and goat showed a seasonal trend which were related to nutrient availability, none of the reproductive traits were affected by the season. It means that sheep and goat breeds inhabiting in Indian desert are non-seasonal in their reproductive behaviour. This fact is of special practical significance to the farmers of desert region. They can plan and implement the breeding programme of sheep and goats according to resource availability and market demands.

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Behaviour Modification in Sheep to Reduce Canine Predation and Facilitate Grazing with Cattle

D.M. Anderson, C.V. Hulet, J.N. Smith,
W.L. Shupe & L.W. Murray

U.S. Department of Agriculture, Agricultural
Research Service, Jornada Experimental Range,
Las Cruces, New Mexico 88003-0003, U.S.A.

Department of Experimental Statistics,
New Mexico State University, Las Cruces,
New Mexico 88003-0003, U.S.A.

Benefits of multispecies grazing are often overshadowed by ineffective predator control programs (Baker 1985). The coyote (*Canis latrans*) is probably one of north America's most versatile predators and continues to present one of the greatest challenges to United States sheep and goat producers (Green 1987). These producers have had varying degrees of success using steel traps, poisoned baits, calling and shooting, aerial gunning, guarding animals (primarily dogs) and electrified fences, used singly or in combination. During 1983, 63 of 144 sheep died

while managed under free-ranging conditions on the Jornada Experimental Range, most were killed by coyotes (Hulet *et al.* 1987b).

To our knowledge, no healthy adult or juvenile cattle have ever been lost to coyotes on the Jornada Experimental Range. In contrast, sheep were being lost and this stimulated the question: If sheep would stay close to cattle under free ranging conditions, could coyote predation be reduced? Research by Cairns (1966) demonstrated that young animals will form cross-specific attachments (i.e. bonds) to animate or inanimate objects. Bond *et al.* (1967) demonstrated such attachments between bovines and ovines. Therefore, the objectives of this research were to 1) determine if young sheep could be bonded to cattle 2) if a bond developed, would it be effective against coyote predation under free ranging conditions and (3) what mechanism might be operating to render bonding effective against coyote predation on sheep.

The Jornada Experimental Range (78,206 ha) is in Dona Ana County New Mexico, U.S.A. 37 km northeast of Las Cruces (106° 55.3' W, 32° 17.4' N). Elevations range between 1,260 and 2,822 m above sea level. Intense, convective, highly localized thunderstorms of short duration occur during June, July and August and provide 52 percent of the average annual precipitation of 230 mm. Yearly evaporation averages 225 cm from a free water surface. The average maximum ambient air temperature is highest (36° C) in June and lowest (13° C) in January. The average frost free period for this arid climate is 200 days.

Grasses, forbs and shrubs form a heterogeneous plant cover. This vegetation mosaic has been described as a semidesert grass-shrub complex (Paulsen and Ares 1962). Grasses form the predominant nutritional base for grazing livestock, with diet quality being substantially improved when forbs are avail-

able. Desirable and undesirable shrubs provide a vegetative overstory with no areas virtually free of brush in 1988.

The initial study was conducted between 16 December 1985 and 28 March 1986 (Anderson *et al.* 1987a). Rambouillet x Polypay lambs averaging 45, 62, and 90 days of age were confined in pens (139 m²) for 60 consecutive days with 8-9-month-old crossbred Hereford x Angus and Brangus heifers. The largest treatment group consisted of penning seven lambs, all the same age, together with three heifers. Control lambs and heifers were kept visually isolated from each other in pens 10 m from the treated lambs. Following 30 and 60 days of pen confinement, treated and control lambs along with heifers were evaluated separately before being combined and tested together. Each test took place in a 122-ha paddock for consecutive hours. At 15-minute intervals, data were recorded, which consisted of estimating the smallest diameter circle that would enclose all animals of the same species, and estimating the shortest distance between the perimeter of each of these two circles. The maximum distance animals could be separated while in the paddock was approximately 1.6 km. Diameters and distances were combined into frequency classes, and analyzed using X² procedures with age of lamb and length of penning as independent variables.

In the second study, under free-ranging conditions, survival of lambs that had bonded during the 60 days of pen confinement were compared to sheep that had not been with heifers and were not bonded (Hulet *et al.* 1987a). Livestock groups were rotated among paddocks ranging in size between 122 and 689 ha beginning 13 March and ending 22 August 1986. Initially, nine bonded lambs were released with seven heifers for 50 days. During the remaining 113 days, non-bonded sheep were maintained in a separate, but similar paddock. Following confirmation of a sheep kill, livestock were rotated between the two paddocks

to give equal exposure of bonded and non-bonded sheep to predation. The study was terminated when half of the non-bonded sheep had been lost. After all sheep were removed from the area, the bonded sheep were rotated between the two paddocks at weekly intervals for an additional 3 weeks. Data collected consisted of numbers of surviving sheep in the bonded and non-bonded groups.

The final study conducted between 2 and 9 December 1986 consisted of evaluating the response of free-ranging bonded sheep and cattle, and non-bonded sheep and cattle, separately and together, to the presence of a canine (Anderson *et al.* in Press). A border collie dog, trained to respond to voice and hand signals was used to simulate a coyote. Several livestock combinations were tested. The data consisted of distance estimates as made in the initial study. These data were taken immediately before, during and after sending the dog into the livestock groups. Data were largely descriptive.

Control lambs within each age class, penned in visual isolation from heifers and heifers not previously exposed to sheep, were evaluated under field conditions after 30 and 60 days of pen confinement. Each species maintained distinct intraspecific groups, often separated by ≥ 700 m. In contrast, the 45 and 90-day old lambs that had been penned together with heifers followed the heifers during both the 30 and 60 day evaluations. The lambs would mingle with the heifers during grazing and resting. However, during walking lambs normally walked behind or to the side of the heifers. These two age classes of lambs did not differ ($P > 0.05$) in the distance (50 to 161 m) the sheep and cattle were from each other. Following separate testing of control and treated lamb heifer groups, treated and control sheep, within each age class, were combined in a 1:1 ratio (14 sheep). The treated lambs showed no preference to stay with the heifers they had been penned with over the control heifers. Control lambs followed the

bonded lambs, but tended to stay on the outer perimeter of the group. The heifers did not appear to have developed an attachment to lambs, as evidenced by their independent movement with respect to the lambs.

Testing of the 62-day old lambs penned with heifers gave results different from the other two ages of lambs. Bonded lambs separated (≥ 161 m) from the heifers indicating bonding was poor. When control and exposed lambs were put together, they did not stay together. Cattle formed one group separate and independent of the sheep in another, with a separation of > 900 m. Lack of bonding within the 62-day old lamb group was attributed to physical abusiveness displayed towards the lambs by two heifers during the 60 days of pen confinement. This physical abusiveness was confirmed through subsequent experimental testing (Anderson *et al.* 1987b).

During the second study, lasting 163 days, no bonded sheep were lost to coyote predation. In contrast, 13 of 23 control sheep were killed during 62 days.

In the third study, bonded yearling ewes and cattle were always found together before applying the treatment (dog). In contrast, the non-bonded yearling ewes were never closer than 150m before application of the treatment and often had to be brought together within 75 m before the treatment could be applied. Upon sending the dog into the cattle-sheep groups, the area occupied by the sheep would decrease while cattle behaviour was less definitive. Non-bonded sheep would run away from the cattle, but bonded sheep would run among the cattle so cattle were between the sheep and the dog. Within minutes after removal of the dog from the livestock, activities as observed before testing started again. When bonded and control lambs were combined in a 1:1 ratio (24 sheep), bonded animals influenced the movement of control animals.

Arbitrarily and a priori, we established that a strong bond had been established when interspecific distances of ≤ 161 m were maintained between lambs and heifers during grazing, walking and resting. These criteria were met by lambs that had been penned with tolerant heifers, but not in lambs penned with physically abusive heifers. The propensity for lambs to bond was not different between 45 and 9 day old lambs. The bond appears to be unidirectional with the heifers showing no bond, but only tolerance for lambs. Although a bond was apparent following 30 days of penning, unpublished work by Anderson and Hulet suggest, for the bond to endure under field conditions, pen confinement for 30 days is not adequate. When bonded and non-bonded lambs are combined in a 1:1 ratio, activity of the non-bonded lambs is controlled by the bonded lambs that follow the cattle.

When bonded and non-bonded lambs were maintained under free ranging conditions, no bonded lambs were lost. In contrast, control sheep were killed at an average rate of one sheep every 5 days.

Sheep bonded to cattle remain together as one interspecific group. When threatened by the dog, the sheep positioned themselves among the cattle away from the dog. Cattle aggression toward the dog was only observed when the dog approached the heifers. Non-bonded sheep and cattle reacted as two distinct intraspecific groups. However, as in the initial study when bonded and non-bonded sheep were maintained in a 1:1 ratio, the 12 bonded sheep controlled the movement and location of the 12 non-bonded sheep. Therefore, the protection that bonded sheep receive from cattle appears to result from close association with cattle that pose a threat to predators.

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Augmentation of Native Pastures for Commercial Beef Production in Northern Australia

John H. Wildin
Queensland Department of Primary Industries
Rockhampton, Australia

Northern Australia has a tropical climate characterised by a summer dominant rainfall with the dry season being most prolonged in the north-west. The area is extensive and sparsely populated. The vegetation type is predominantly savanna of open woodland communities of native trees and grasses. Throughout the region beef production is the most important rural industry. Most of the beef cattle are raised on the natural savannas or on derived native grasslands. However the low quality native pasture in the dry season has always been a serious constraint to beef production in northern Australia. The initial priorities of management on pastoral holdings, which are generally very extensive, are to provide permanent stock, drinking water and fencing for cattle control. On