

EFFECTS OF GROUP SIZE ON RATE OF LEARNING FOOD LOCATIONS BY CATTLE

Authors: Taoufik Ksiksi¹ and Emilio A. Laca²

¹ QDPI Charters Towers Q 4820, Australia.

Email: ksiksit@dpi.qld.gov.au

² Agronomy and Range Science, UC Davis, CA, USA.

Email: ealaca@ucdavis.edu

1. Abstract

The rate at which grazing animals learn the location of preferred food patches is important from two standpoints. First, animals that learn fast are more efficient foragers as individuals. Second, they may impose more uneven grazing distributions with potential reductions in grazing capacity. However, when food is scarce, e.g. arid and semiarid environment, grazing efficiency becomes the ability to revisit preferred food locations. As a result, the energy spent searching for food would be minimized. We tested if animals trained in groups learn food locations faster than those trained as individuals. Steers were trained to find 10 trays with food in a grid of 64 trays. The steers were trained in groups or as individuals in three 8-minute sessions on days 1, 3, 5, and 7 of the experiment. All steers were tested individually on days 2, 4, 6, and 8. We recorded the search path and the trays visited. No significant differences were found between treatments in any of the variables measured. This suggested that social interactions did not have a net effect on the ability of animals to find and learn location of food patches. Steers in both treatments (individual and group training) learned the locations of food over time. Covariance analysis showed that there was no significant interaction between days of experience and treatment. In other words, steers in both treatments did perform similarly over time. Steers in group treatment, however, did better than expected by chance after 5 days and those in solitary treatment after 7 days. This may suggest that individuals within a group of animals rely on the information available from other members, hence

a decrease in energy spent for feed searching. In drought and when food is scarce, cattle may increase their efficiency by minimizing energy expenditure.

2. Introduction

Social learning can be used to pass foraging information from experienced to inexperienced foragers (Provenza and Balph, 1987). For example, the trial of novel food by animals has been shown to be affected by social facilitation (Thorhallsdottir et al., 1990). Besides trying novel food, avoiding poisonous plants can be an advantage for animals in a herd (Scott et al., 1995). Finding food can be greatly affected by the social structure of the herd. Animals that are leaders choose where to graze and the rest of the herd follows (Bailey et al., 1996). The way a group of animals behaves is an important aspect that can crucially affect the success rate of survival.

Many factors can affect the location of food by grazing animals. In order to efficiently use the spatial characteristics of an area, animals may rely on observing their conspecifics. Green et al. (1984) concluded that lambs consumed more grain with the presence of their mothers than without. In a different study, Scott et al. (1995) found that where to forage was more affected when sheep (*Ovis aries*) grazed in the presence of companions than in the presence of strangers. To locate a food patch, animals use various means such as their spatial memory. Locating food patches based on spatial characteristics was the focus of this study. We hypothesized that group grazing may enhance the rate of learning of animals. Some members of a group may be more efficient than others in finding food. Howery et al. (1995) and Warren and Mysterud (1993) reported that the familiarity of individual animals within a herd affects the passage of information as to where to forage. This may be the case in quality as well as in quantity of search. In other words, some members of a herd may increase the overall success rate of other members by social facilitation. In this experiment, eight steers were used to test if spatial memory improves when feeding in a group. Increasing foraging efficiency may lead to concentrated search and therefore uneven grazing pattern.

3. Materials and Methods

3.1 Experimental Arena

The experimental arena consisted of two 55 by 55 meter-paddocks. They were established in an Old-World bluestems (*Bothriochloa spp.*) pasture. Each of the paddocks had an 8 row by 8 column grid of plastic containers 5 meters apart. The experiment was conducted from September 11, 1995 to January 30, 1996.

3.2 Animals

Eight steers were used to conduct this experiment. The average weight was 500 ± 53 kg. When not used for the experiment, they were grazing in an Old-World-bluestem dominated pasture. Water was available *ad libitum*. Animals were fed 12.5 kg of feed every day. The experimental protocol and animal handling and use were approved by the Texas Tech University Animal Care and Use Committee.

3.3 Treatments

Two treatments were tested to study the effect of group size on the rate of learning of food locations. In the solitary treatment steers were trained to locate 10 trays loaded with food. In the group treatment steers were trained to locate the loaded food trays as groups of three animals. Each group of animals in the latter treatment consisted of 3 steers. The combinations of loaded trays were randomly chosen for each of the treatments. Each treatment was replicated four times.

3.4 Training

During training, steers were allowed to locate 10 loaded trays out of 64 available. For convenience, each treatment was randomly assigned to one of the two available paddocks. In other words, steers within the same treatment were always trained and tested in the same paddock for the duration of the experiment. Training was done on days 1, 3, 5, and 7 of the experiment. Steers were allowed to locate the 10 loaded trays for 8 minutes. Steers in the solitary treatment, were trained individually. One training session was conducted for each steer on each training day. The amount of feed in each loaded tray was about 130 grams for the solitary treatment and about 400 grams for the group

treatment. This was done to minimize the effect of competition on finding food. Feed pellets were placed under each tray to control for smell. These pellets could not be seen or eaten by the animals.

3.5 Testing

Steers from both treatments were tested as individuals on days 2, 4, 6, and 8 of the experiment. Each steer was tested for 5 minutes. The reason behind shorter testing sessions was to minimize the impact of learning using other mechanisms such as spatial memory. The amount of feed in each loaded tray was about 130 grams for both treatments.

3.6 Measured Variables

All training and testing sessions were observed continuously. A map of each paddock was used to record data. The maps included the locations of loaded trays and trays that did not contain feed. Every time steers were tested, we drew the path that they followed. In addition to the path followed, we recorded starting time of each session, time of arrival at each loaded tray, time of departure from each loaded tray, time spent consuming food, and the ending time of each session.

3.7 Calculated Variables

New locations visited were referred to as NL, found loaded trays visited were referred to as FL, and total visits (including revisits) were referred to as TV. Two ratios were calculated to test working and reference memory as a possibility among animal searching mechanisms. Working memory was tested using the ratio of NL and TV (NL/TV). Reference memory was tested using the ratio of FL and NL (FL/NL). A Z test was used to investigate if searching for food by animals was random (Tillié et al., 1996).

3.8 Experimental Design and Analysis

A completely randomized design in a split-plot was used to analyze the data. Treatments were used as main-plots and days were used as sub-plots. Tests for normality and homogeneous variances were performed to assess the validity of using an F test to compare treatments. To test for normality, a Shapiro-Wilk procedure was performed using SAS computer software (SAS, 1985). To test for homogeneous

variances, a Levine's procedure was performed using SAS (SAS, 1985). When data were not normally distributed and/or their variances were not homogeneous, transformations were used. We used two different approaches to analyze the data in this experiment. First we used an analysis of variance procedure to compare treatments. An LSD test was performed to compare treatments within days and from one day to the next. A critical difference was calculated to do the comparison with a 5% significance level. Second, we used a covariance analysis to test for interactions between days and treatments. This would give an idea of the rate of learning by steers in each treatment.

4. Results and Discussion

In this experiment, we assessed the effect of social interaction from three standpoints. First, we compared the performance of steers in the group treatment in relation to steers in the solitary treatment. Second, we compared the average performance of each steer against the performance expected by random search. Standardized values were used to compare treatments. Comparing treatments using the original ratios (NL/TV and FL/NL) cannot be done because variances and means change as FL and NL changed. The standardized ratio NL/TV (Z_1) was calculated to test if NL/TV was better than expected by chance. The standardized ratio FL/NL (Z_2) was calculated to test if FL/NL was better than expected by chance. Third, we used a covariance analysis to study learning over time. This would give an idea if steers in one treatment learned faster than those in the second treatment as testing days passed.

The variable TV was transformed to its logarithm base 10 (LTV) because it did not meet the assumptions of analysis of variance procedures. When this value is high, animals may cover a wider area searching for, and locating preferred food. There was no interaction treatment by day $P > 0.05$ (Table 4.1). Covariance analysis revealed that there was no interaction treatment by day ($P = 0.747$; Table 4.1). Learning was not different in one treatment when compared to the other.

New locations or NL was transformed to its square root (SNL) and showed no interaction treatment by day $P > 0.05$ (Table 4.1). When animals do not know where the food is, they try to visit as many distinct locations as possible and avoid trays visited within the same session. As they gain

experience, animals tend to concentrate around those areas and SNL declines. Being trained in a group or trained individually did not affect the number of locations visited. Covariance analysis showed no interaction treatment by day ($P=0.743$; Table 4.1).

The analysis of variance using an F test did not show a treatment by day effect for FL $P>0.05$ (Table 4.1). A covariance analysis did not exhibit any treatment by day interaction ($P=0.876$; Table 4.1). Animals in both treatments learned at a comparable speed. The searching efficiency of animals was closely related to how successful they were in locating preferred food. Steers that find more loaded trays, tend to be more efficient foragers. However, this depends of how many locations they visit.

The ratio NL/TV was transformed to its angular sine (SINLTV). The purpose of calculating this ratio was to assess the impact of searching mechanisms on food finding. Working memory was the most important mechanism targeted by this variable. The closer this ratio to 1, the better animals used their working memory. The analysis showed that there was no interaction of treatment by day $P>0.05$ (Table 4.1). Covariance analysis also revealed no difference on the rate of learning to avoid recently visited locations ($P=0.569$; Table 4.1). Overall, steers succeeded in avoiding the previously located feed trays. This would help in increasing the success rate in a real world situation. Grazing animals would explore more new places, which leads to increasing intake rate. Exploring new locations would help toward achieving the goal of even grazing in rangelands.

The variable FLNL was transformed to its square root (SFLNL). It was one of the best means of analyzing spatial learning in my experimental protocol. At random, the value would be $10/64$ (its square root, in this case). Ten was the number of loaded trays available for steers to locate, and 64 was the total number of available containers. The purpose for calculating this ratio was to value the magnitude of reference memory on food searching. The analysis showed that there was no interaction treatment by day $P>0.05$ (Table 4.1; Figure 4.1). A significant increase was observed between day 2 and 8 of the experiment for both treatments. In both treatments, steers learned to find more loaded trays as testing days passed.

For Z1, there was no interaction between treatment and day $P > 0.05$ (Table 4.1). When this value is less than 1.64, the search was random; however, when it is greater than 1.64 steers used some behavioral mechanisms to avoid recently visited locations. Working memory can be one of these mechanisms. In both treatments, Z1 was not better than expected by chance in almost all days. Covariance analysis evinced no interaction treatment by day ($P = 0.461$; Table 4.1). No one treatment learned faster than the other to avoid previously located trays. If forage replenishes periodically, the use of working memory can be profitable (Bailey et al., 1996).

In order to study if animals were locating loaded food trays better than by chance, we calculated Z2. Covariance analysis showed no interaction day by treatment ($P = 0.794$; Table 4.1). Animals in both treatments learned comparably fast. There was no treatment by day interaction $P > 0.05$ (Table 4.1; Figure 4.2). In order to check if steers were performing better than a random search, we compared each Z2 to 1.64. Random search can be expected if Z2 was less than 1.64. Animals in the group treatment showed a clearly increasing trend over the study period. They started performing better than expected by chance after 5 training days. On the other hand, animals in the solitary treatment did not perform better than expected by chance until day 8 of the experiment, when they caught-up with the other treatment.

The searching efficiency of steers was assessed by calculating the ratio of time spent searching and FL (SRCHFL). A non-significant interaction of treatment by day was observed ($P > 0.05$). Covariance analysis did not show any differences in the rate of learning between treatments ($P = 0.780$; Table 4.1).

Individual animals may learn to forage more efficiently when around conspecifics. Foraging efficiently may lead to uneven grazing pattern. In drought, however, and when food is scarce, cattle may increase their grazing efficiency and minimize energy expenditure. The presence of social models such as mothers (Green et al., 1984) helped the feeding behavior of other animals. Rats transformed information about food by smelling other members of a group (Galef et al., 1984). Galef (1980) studied wild rats diving in water for food. When naive wild rats were trained in the presence of experienced ones, interaction with or observing a conspecific was not efficient to dive for food. This was not the case when

Galef et al. (1984) studied rats. The results were that observing rats were influenced by what conspecifics were consuming. However, the interactions with model animals may weaken when naive rats were deprived of food for 24 hours (Galef, 1984). The place to forage was affected by social interaction and efficiency of feeding was improved (Scott et al., 1995). Male bees (*Apis mellifera*) performed better in groups when locating female ones (Wcislo, 1992). The previous findings may be important when reporting social facilitation concerning feeding behavior, but not negative stimulus. Alpern and McIntyre (1985) reported that rats trained individually avoided shocks better than those trained as groups.

5. Conclusion

These results can be interpreted depending on the environment concerned. In arid environments, and where food resources are scarce, herbivores may have to waste precious energy to locate food patches. Relying on their group size seems to have no effect in minimizing energy expenditures when searching for food. In higher rainfall areas, and where food is more available, herbivores may have to search extended areas resulting to a better grazing distribution.

Table 4.1 Performance of Steers when Trained to Locate Food as Solitary and as Group (N=16) over the 4-day Testing Period

<i>Variable</i>	<i>Probability Levels¹</i>	<i>Treatment</i>	<i>DAY</i>			
			<i>2</i>	<i>4</i>	<i>6</i>	<i>8</i>
LTV	0.747	SOLITARY	1.38	1.32	1.35	1.18
		GROUP	1.24	1.22	1.17	1.10
SNL	0.743	SOLITARY	4.66	4.48	4.52	3.86
		GROUP	4.16	4.07	3.89	3.55
FL	0.876	SOLITARY	4.0	4.25	6.25	5.75
		GROUP	3.5	4.08	5.25	5.33
SINLTV	0.569	SOLITARY	0.78	0.81	0.78	0.81
		GROUP	0.82	0.82	0.83	0.82
SFLNL	0.979	SOLITARY	0.42	0.46	0.55	0.63
		GROUP	0.45	0.50	0.59	0.66
Z1	0.794	SOLITARY	2.17	1.37	1.24	1.43
		GROUP	1.34	1.16	1.28	0.98
Z2	0.461	SOLITARY	0.97	0.83	0.37	2.92
		GROUP	0.71	1.17	2.36	3.01
SRCHFL	0.780	SOLITARY	58.8	39.9	26.4	20.8
		GROUP	56.1	35.3	23.1	21.2

¹ Covariance Analysis

Means were not Significantly Different within the same Day and the same Variable

LTV: Logarithm base 10 of total visits (TV)

SNL: Square Root of New Locations (NL)

SINLTV: Angular Sine of ratio NL per TV

Z1: Z values to test Randomness of the ratio NL/TV

Z2: Z values to test Randomness of the ratio FL/NL

SRCHFL: ratio of Search Time (in seconds) per FL

Figure 4.1 Changes in Square Root of Found Locations per New Location (SFLNL) Over Time for

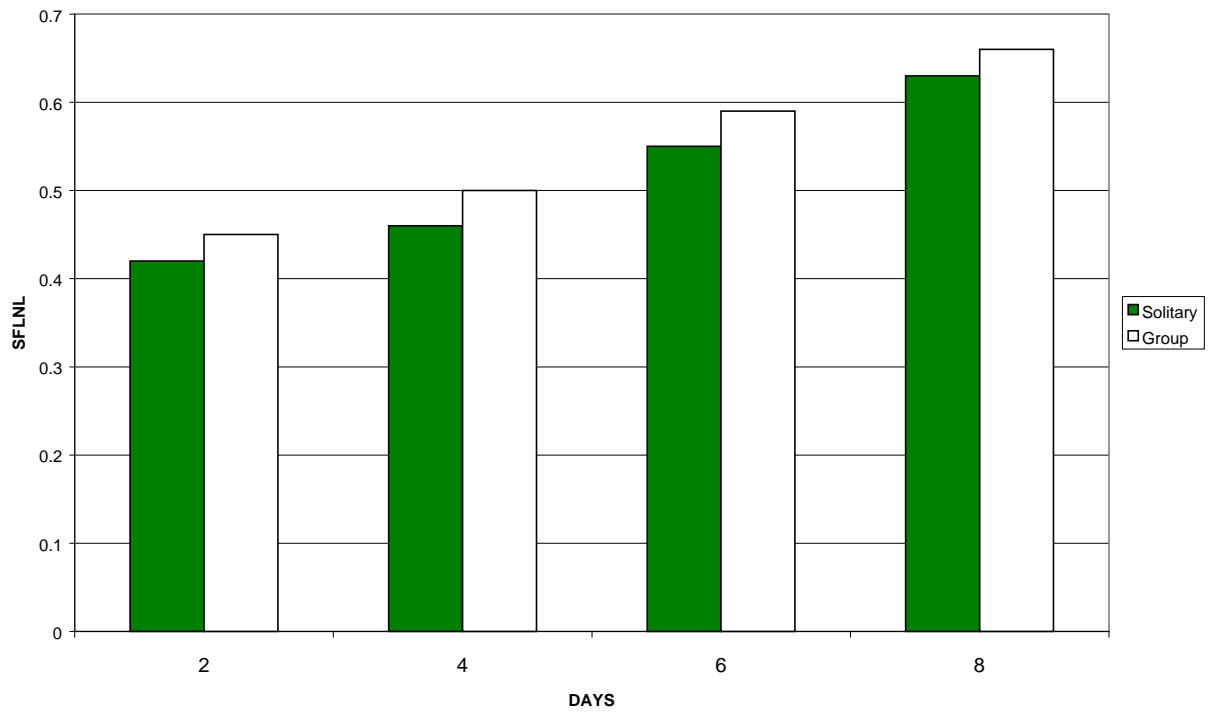
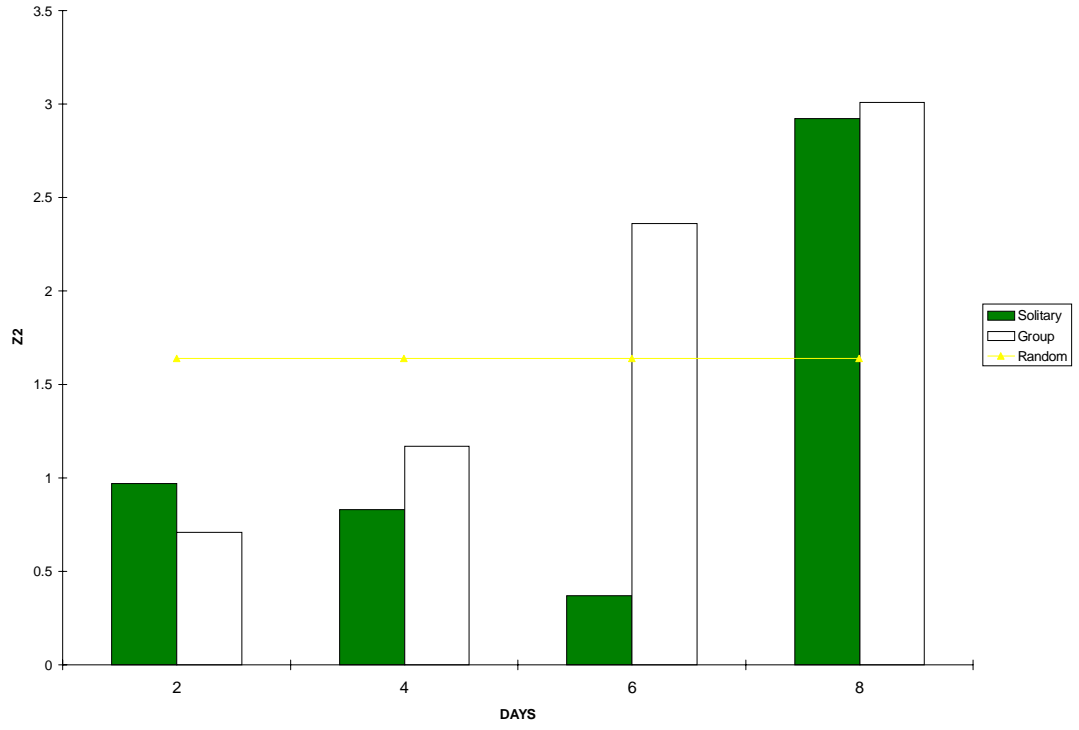


Fig
T1



Steers
arch

5. Literature Cited

- Alpern, H.P. and T.D. McIntyre. 1985. Individual versus group learning: developmental and social differences in two selected mouse lines. *Psychol. Rec.*, 35:203-211.
- Bailey, D.W., J.E. Gross, E.A. Laca, L.R. Rittenhouse, M.B. Coughenour, and D.M. Swift. 1996. Mechanisms that result in large herbivore grazing distribution patterns. *J. Range Manage.*, 49:386-400.
- Galef, B.G. 1980. Diving for food: Analysis of a possible case in social learning in wild rats. *J. Comp. Physiol. Psychol.*, 95:416-425.
- Galef, B.G., D.J. Kennett, and M. Stein. 1984. Transfer of information concerning distant foods in rats: a robust phenomenon. *Anim. Learn. Behav.*, 12:292-296.
- Green, G.C., R.L. Elwin, B.E. Mottershead, and J.J. Lynch. 1984. Longterm effects of early experience to supplementary feeding in sheep. *Proc. Aust. Soc. Anim. Sci.*, 15:373-375.
- Howery, L.D., F.D. Provenza, R.E. Banner, and C.B. Scott. 1996. Differences in home range and habitat use among individuals in a cattle herd. *Appl. Anim. Behav. Sci.*, 49:305-320.
- Provenza, F.D. and D.F. Balph. 1987. Diet learning by domestic ruminants: theory, evidence and practical implications. *Appl. Anim. Behav. Sci.*, 18:211-232.
- SAS Institute Inc. 1985. *SAS user's guide: Statistics*. Cary, NC 27511-8000. 956 p.

- Scott, C.B., F.D. Provenza, and R.E. Banner. 1995. Dietary habits and social interactions affect choice of feeding location by sheep. *Appl. Anim. Behav. Sci.*, 45:225-237.
- Thorhallsdottir, A.G., F.D. Provenza, and D.F. Balph. 1990. Ability of lambs to learn about novel foods while observing or participating with social models. *Appl. Anim. Behav. Sci.*, 25:25-33.
- Tillié, Y., J.A. Newman., and S.D. Healy. 1996. New tests for departures from random behavior in spatial memory experiments. *Anim. Learn. Behav.*, 24:327-340.
- Warren, J.T. and I. Mysterud. 1993. Extensive ranging by sheep released onto an unfamiliar range. *Appl. Anim. Behav. Sci.*, 38:67-73.
- Wcislo, W.T. 1992. Attraction and learning in mate-finding by solitary bees. *Behav. Ecol. Sociobiol.*, 31:139-148.