Cattle use visual cues to track food locations

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Abstract

We tested the hypothesis that cattle aided by visual cues would be more efficient than uncued animals in locating and consuming foods placed in either fixed or variable locations within a 0.64-ha experimental pasture. Eight yearling steers were randomly selected and trained to associate traffic barricades and traffic cones with high- (oat–barley mixture) and low- (straw) quality foods, respectively. Initially steers were randomly assigned to 1 of 4 food location/visual cue treatments: fixed locations/with cues (F/C), variable locations/with cues (V/C), fixed locations/no cues (F/NC), or variable locations/no cues (V/NC). High- and low-quality foods and their respective cue or no cue were placed in the experimental pasture. Individual animals were allowed to explore the pasture for 10 min twice per day every other day for 1 week. Minutes until feeding, first feed type consumed (i.e., high-quality, low-quality, or no food consumed), animal location and activity (i.e., feeding, standing, or moving), and total intake of high- and low-quality feed were recorded during each 10-min trial. At the end of each week, location/visual cue treatments were randomly assigned to another 2 steers, which permitted an independent test of each animal in each treatment over a 4-week period. Animals in the F/C and V/C treatments took about 2 min to initially locate and consume a food, compared to F/NC and V/NC animals who took nearly 4 and 6 min, respectively. The high-quality food was the first food located and consumed by F/C, V/C, F/NC, and V/NC animals during 79, 77, 67, and 54% of sampling occasions, respectively. Cued animals typically spent more time feeding (P < 0.0004) and less time standing (P < 0.005) than uncued animals. Cued animals had a higher mean intake than
uncued animals of high- \( P = 0.001 \) and low- \( P = 0.04 \) quality food. Mean high-quality intake for F/C, V/C, F/NC, and V/NC treatments was 266, 245, 214, and 126 (±22) g, respectively; mean low-quality intake for the same treatments was 36, 32, 12, and 10 (±10) g. Cued animals also consumed more food per distance traveled than uncued animals \( P = 0.005 \). Animals located food quicker \( P = 0.03 \) and consumed more high-quality food \( P = 0.02 \) when food locations were constant than when they were variable. Our data strongly indicate that cattle can learn to associate visual cues with disparate food qualities and use this information to forage more efficiently in both fixed and variable foraging environments. © 2000 Elsevier Science B.V. All rights reserved.

**Keywords:** Animal distribution; Diet selection; Foraging behaviour; Learning; Spatial; Temporal

### 1. Introduction

Livestock producers and land managers need a better understanding of the underlying mechanisms that influence both local and landscape-level foraging patterns observed in cattle and other free-ranging ungulates (Bailey et al., 1996). Increased understanding will allow managers to manipulate animals and forage environments to control animal distribution problems that may cause resource degradation (Bailey and Rittenhouse, 1989; Howery et al., 1996, 1998). Foraging environments are a complex array of habitats and vegetation types, varying temporally and spatially due to a myriad of abiotic and biotic factors (e.g., drought, fire, plant succession, topography and soils). Free-ranging ungulates have evolved sensory mechanisms that allow them to track foraging environments remarkably well as is evidenced by their ability to select diets nutritionally superior to the available standing crop (e.g., Cable and Shumway, 1966).

Ungulates use all of their senses to make foraging decisions (Arnold, 1966a,b; Provenza et al., 1992; Edwards et al., 1996); however, the primary mechanism(s) employed apparently depends upon the scale at which a decision is being made (Senft et al., 1987; Coughenour, 1991; Bailey et al., 1996; Edwards et al., 1997). Fine grain level decisions (e.g., bite, feeding station, patch), may involve livestock associating particular plant characteristics (e.g., odor, structure, hue) with antecedent post-ingestive consequences (Bazely and Ensor, 1989; Laca et al., 1993; Provenza, 1995; Edwards et al., 1997). At larger scales (e.g., camp, home range), herbivores may associate man-made (e.g., windmills) and natural (e.g., trees, mountains, wildlife trails) visual cues with high- or low-quality forage locations across landscapes (e.g., Gillingham and Bunnell, 1989; Bazely, 1990; Ortega and Laca, 1997).

Rangelands and pasture lands comprise a diverse array of landscapes. For instance, irrigated monocultures may be somewhat homogeneous with relatively fixed and predictable forage locations, whereas native rangeland is often spatially more heterogeneous and temporally more variable. Although no landscape is completely devoid of visual cues, homogeneous landscapes may also offer fewer visual cues than heterogeneous landscapes. Thus, domestic ungulates may rely more on visual cues in heterogeneous environments than in homogeneous environments. Because domestic animals forage in both homogeneous and heterogeneous environments that vary temporally
(Bailey, 1995), it is important to understand their ability to associate visual cues with specific forage resources and to use spatial memory. Visual cues may allow animals to predict the location of desirable forage resources from a distance so that they could travel to the forage directly, while spatial memory allows animals to remember the location of desirable forage resources so that they travel directly to the forage (Olton, 1978). For example, willow stringers and other riparian vegetation may provide visual cues to allow cattle to readily find riparian areas and the associated high-quality forage. In other situations, cattle may rely on spatial memory to travel to feeding sites that were not initially visible.

The extent that rangeland herbivores use visual cues has received limited study (Kidunda and Rittenhouse, 1992; Espach et al., 1993; Ortega and Laca, 1997; Edwards et al., 1997; Renken et al., 1998). Our controlled experiment was designed to determine if cattle could learn to use artificial visual cues to track fixed or variable food locations. Artificial cues (traffic barricades and cones) were used because they were easily manipulated and novel. Novel cues were essential to clearly show that cattle had the ability to associate a visual cue with food and use that cue to forage more efficiently. We hypothesized that cued animals would more efficiently locate fixed and variable food locations within an experimental pasture compared to uncued animals.

2. Materials and methods

2.1. Animals

Twenty-four yearling steers with Hereford, Angus, and Brahman breeding (322 ± 6 kg) were randomly-assigned to 4 separate holding pens (6 steers/pen). Two steers from each of the 4 pens were randomly selected as 8 study animals. The additional steers (n = 16) were part of a separate experiment. Routine feeding during a 1-month pen adaptation period was ad libitum high-quality alfalfa hay and a protein supplement in the morning (0630–0700). We also offered small amounts of high-quality (an oat and barley mixture) and low-quality (wheat straw) experimental foods in rubber food bowls (25.4 cm diameter, 10.16 cm depth) during routine feeding to familiarize animals with experimental foods and bowls prior to experimentation. To prevent animal satiety on training and experimental days (i.e., after the 1-month adaptation period), steers were fed 50% of their ad libitum daily alfalfa hay ration in the morning (0630–0700, before training), and 50% in the afternoon (1600–1630, after training). Animals had constant access to fresh water and shade.

2.2. Experimental pasture

All training and experimentation was conducted in a 0.64 ha dry-lot experimental pasture, located at the University of Arizona’s West Campus Agriculture Center in Tucson. The experimental pasture was situated over 200 m from the holding pens. Study animals were unable to see the experimental pasture from their holding pen.
We established an 8 x 8 grid system within the pasture by attaching labeled plywood squares to the pasture fence at 10-m increments. This provided 64, 100 m² grids in which to record animal locations and activities during the experiment. Herbaceous vegetation was manually removed from the experimental pasture.

2.3. Animal training

Two penmates were trained together in the experimental pasture every other day for 6 days, then individually every other day for an additional 6 days, to associate high- and low-quality foods with traffic barricades or traffic cones, respectively. We initially trained animals in pairs to reduce possible trepidation associated with exploring the novel experimental pasture alone. We later trained animals as individuals because that was how they were to be exposed during experimentation.

When penmates were trained together, 2 rubber food bowls were placed in the center of each of the 64 grids to accommodate 2 animals/grid (128 total food bowls); steers were exposed to the experimental pasture during 4, 15-min trials/d (i.e., 2 trials in the morning and 2 in the afternoon). When steers were trained as individuals, there was 1 bowl/grid instead of 2, trials lasted 10 min instead of 15 min, and individuals were exposed to the experimental pasture 2 times/d (i.e., 1 trial in the morning and 1 in the afternoon) rather than 4 times/day. Animals were randomly exposed to the experimental pasture, with the constraint that each individual was exposed the same number of times during morning and afternoon trials. Training lasted 12 days total (6 days for penmates, and 6 days for individuals).

Traffic barricades were 102 x 61 cm; traffic cones were 66 cm high, 16.5 cm diameter at the base, and 5 cm diameter at the top. Traffic barricades and cones and their associated high- and low-quality foods were moved systematically throughout the experimental pasture each trial to ensure that animals (1) explored the entire pasture without biasing any particular area within the pasture, and (2) learned the association between visual cues and food quality.

2.4. Experimental trials

We tested the hypothesis that cued animals would be more efficient than uncued animals in locating and consuming foods placed in either fixed or variable locations within the experimental pasture. Foraging efficiency was measured in several ways including: time until feeding (min), ability of animals to initially locate and consume high-quality foods, animal activity (feed, standing, moving), intake of high- and low-quality foods, and total amount of food consumed per distance traveled (i.e., 100 m² grids).

We randomly assigned two steers in each holding pen to 1 of 4 food location/visual cue treatments: fixed locations/with cues (F/C), variable locations/with cues (V/C), fixed locations/no cues (F/NC), or variable locations/no cues (V/NC). On trial days, 1 food bowl was placed in the center of each of the 64 grids. Four grids were selected in a fixed or variable fashion and 200 g of high- or low-quality foods were placed in the four corresponding food bowls. Food locations were changed before each trial for the
variable treatments, but did not change for the fixed treatments. During cued trials (F/C and V/C), a traffic barricade was placed in the 2 high-quality grids, and a traffic cone was placed in the two low-quality grids. No cues were present during uncued trials (F/NC and V/NC).

An individual animal was herded from its holding pen down an alleyway, and exposed to the experimental pasture for 10 min, once in the morning and once in afternoon. Minutes until feeding (i.e., high- or low-quality food) and the first feed type located and consumed was recorded. Feeding was defined as mouth contact with feed in a bowl. Animals occasionally consumed no food during a 10-min trial in which case "no food" was recorded for those trials. We recorded animal location and activity (i.e., feeding, standing, or moving) by scan sampling every 15 s during each 10-min trial. Uneaten feed was weighed at the end of each trial.

Animals within a pen were exposed to their assigned treatment every other day for about 1 week. At the end of each week, location/visual cue treatments were rotated to the next pen so that a pen previously on a cued treatment was changed to an uncued treatment (and vice versa). This permitted an independent test of each animal to each treatment over a 4-week period. Data from the six observation periods for each animal within a week were averaged for analyses.

Cues (presence or absence), food location (fixed or variable), cue by food location interaction, animals (n = 8), and weeks (n = 4) were included in an analysis of variance model. The primary purpose of this model was to discern differences in animal foraging efficiency due to visual cues or food location. To separate the effects of each of the four treatments (i.e., F/C, V/C, F/NC, and V/NC), a separate analysis of variance of model included animals (n = 8), treatments (n = 4), and weeks (n = 4) as independent variables. Dependent variables for both analyses were minutes until feeding, animal activity (feeding, standing, or moving), intake of high- and low-quality foods, and ratio of intake to the number of grids traversed. When the F-test was significant (P < 0.05), least-significant difference tests were used to differentiate among treatment means.

Table 1

Mean differences between visual cues (presence or absence) and food location (fixed and variable) treatments

<table>
<thead>
<tr>
<th>Dependent variable*</th>
<th>Treatmentb</th>
<th>Visual cues present?</th>
<th>Food location</th>
<th>P value</th>
<th>Fixed</th>
<th>Variable</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minutes elapsed until feeding</td>
<td>2.34</td>
<td>4.75</td>
<td>&lt; 0.0001</td>
<td>3.06</td>
<td>4.03</td>
<td>0.0345</td>
<td></td>
</tr>
<tr>
<td>Feeding</td>
<td>12.18</td>
<td>6.98</td>
<td>0.0004</td>
<td>10.44</td>
<td>8.72</td>
<td>0.1696</td>
<td></td>
</tr>
<tr>
<td>Standing</td>
<td>16.16</td>
<td>20.68</td>
<td>0.0051</td>
<td>17.84</td>
<td>18.99</td>
<td>0.4298</td>
<td></td>
</tr>
<tr>
<td>Moving</td>
<td>9.81</td>
<td>11.41</td>
<td>0.167</td>
<td>10.54</td>
<td>10.68</td>
<td>0.904</td>
<td></td>
</tr>
<tr>
<td>High quality intake</td>
<td>255.52</td>
<td>170.21</td>
<td>0.001</td>
<td>240.10</td>
<td>185.63</td>
<td>0.0225</td>
<td></td>
</tr>
<tr>
<td>Low quality intake</td>
<td>34.01</td>
<td>10.89</td>
<td>0.0375</td>
<td>23.65</td>
<td>21.25</td>
<td>0.8186</td>
<td></td>
</tr>
<tr>
<td>Intake/100 m² grids traversed</td>
<td>34.53</td>
<td>19.12</td>
<td>0.0054</td>
<td>27.74</td>
<td>25.92</td>
<td>0.7127</td>
<td></td>
</tr>
</tbody>
</table>

* Treatment dependent variables correspond to data presented in (Figs. 1, 3–5).

b The cue location interaction was significant only for the ‘Minutes elapsed until feeding’ dependent variable (P = 0.046).
Fig. 1. Mean (+ S.E.) min elapsed before feeding by four treatment groups. Treatments were F/C = fixed locations/visual cues, V/C = variable locations/visual cues, F/NC = fixed locations/no visual cues, V/NC = variable locations/no visual cues. Different letters indicate differences among treatment means (P < 0.05, LSD).

Fig. 2. Percentage of observations (%) within four treatment groups where steers initially located and consumed high-quality (HQ), low-quality (LQ), or no food (N). Treatments were F/C = fixed locations/visual cues, V/C = variable locations/visual cues, F/NC = fixed locations/no visual cues, V/NC = variable locations/no visual cues. High-quality food was consumed before (P = 0.047, chi-square) LQ food.
A chi-square test was used to determine whether cued animals discriminated between high- and low-quality food locations by selecting high-quality food locations first more often than uncued animals.

3. Results

Our results indicate visual cues helped animals to locate and consume foods more efficiently than uncued animals in both fixed and variable environments. Cued animals more quickly located and consumed foods ($P < 0.0001$; Table 1, Fig. 1) and consumed the high-quality food first more often ($P = 0.047$, Fig. 2) compared to uncued animals. Cued animals typically spent more time feeding ($P = 0.0004$) and less time standing ($P = 0.005$) than uncued animals (Table 1, Fig. 3). Accordingly, cued animals consumed more total feed than uncued animals. Mean intake of low- ($P = 0.04$) and high-quality food ($P = 0.001$) was higher for cued than for uncued steers (Table 1). Overall, cued animals consumed more total food per distance traveled ($P = 0.005$) compared to uncued animals (Table 1, Fig. 5).

When the location of food remained constant, steers required less ($P = 0.03$) time to begin feeding than if food locations changed on each trial (Table 1). Uncued steers with food in variable locations (V/NC) required the most time to begin feeding (Fig. 1).

![Graph of Animal activities](image)

Fig. 3. Mean (+ S.E.) number of observations that steers were feeding (F), standing (S), and moving (M) locations by four treatment groups. Treatments were F/C = fixed locations/visual cues, V/C = variable locations/visual cues, F/NC = fixed locations/no visual cues, V/NC = variable locations/no visual cues. Different capital and small letters indicate differences among feeding and standing means, respectively ($P < 0.05$, LSD); means for moving were similar ($P = 0.274$).
Table 2
Mean differences in behavior among individual steers

<table>
<thead>
<tr>
<th>Dependent variable</th>
<th>Steer no.</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minutes elapsed until feeding</td>
<td></td>
<td>2a</td>
<td>3a</td>
<td>2a</td>
<td>10c</td>
<td>2a</td>
<td>3a</td>
<td>2a</td>
<td>5b</td>
</tr>
<tr>
<td>Feeding</td>
<td></td>
<td>8bc</td>
<td>12cd</td>
<td>13d</td>
<td>0a</td>
<td>12cd</td>
<td>14d</td>
<td>11bc</td>
<td>7b</td>
</tr>
<tr>
<td>Standing</td>
<td></td>
<td>15a</td>
<td>17a</td>
<td>14a</td>
<td>32c</td>
<td>13a</td>
<td>16a</td>
<td>15a</td>
<td>25b</td>
</tr>
<tr>
<td>Moving</td>
<td></td>
<td>13b</td>
<td>9ab</td>
<td>13b</td>
<td>8a</td>
<td>13b</td>
<td>10ab</td>
<td>13b</td>
<td>7a</td>
</tr>
<tr>
<td>High quality intake</td>
<td></td>
<td>264cd</td>
<td>207bc</td>
<td>292d</td>
<td>0a</td>
<td>291d</td>
<td>194bc</td>
<td>321d</td>
<td>134b</td>
</tr>
<tr>
<td>Low quality intake</td>
<td></td>
<td>0a</td>
<td>21a</td>
<td>11a</td>
<td>0a</td>
<td>0a</td>
<td>111b</td>
<td>34a</td>
<td>3a</td>
</tr>
<tr>
<td>Intake/100 m² grids traversed</td>
<td></td>
<td>24b</td>
<td>44c</td>
<td>27bc</td>
<td>0a</td>
<td>26bc</td>
<td>36bc</td>
<td>32bc</td>
<td>26bc</td>
</tr>
</tbody>
</table>

*Steer dependent variables correspond to data presented in Figs. 1, 3–5.
Different letters indicated differences among steer means within the same row (P < 0.05, LSD).

Cattle consumed more high-quality food (P = 0.02) when food locations were fixed than when food locations were variable (Table 1). The visual cue by food location interaction was only important (P < 0.046) for minutes elapsed until feeding.

During the first week, steers consumed less (P = 0.04) high-quality food. Animals consumed 163, 227, 204, and 258 g (± 22)/10-min trial during weeks 1 to 4, respectively. Other measures of foraging behavior were similar (P > 0.05) during the 4 weeks of the study.

There was considerable variability in the responses of individual steers for every dependent variable measured (P ≤ 0.04, Table 2). Steers 4 and 8 typically foraged less efficiently than the other six animals. Steer 8 spent the majority of time standing in one place until a 10-min trial was completed and never located or ate any food.

4. Discussion

4.1. Selection of feeding sites (large scale)

Spatial memory likely evolved as a mechanism that allows free-ranging ungulates to revisit nutrient-rich feeding sites while avoiding sites that contain low nutrient levels (Bailey et al., 1996). Cattle used spatial memory to relocate food in mazes and arenas without the benefit of overt visual cues (Bailey et al., 1989a,b; Laca, 1998). In addition, cattle tested in mazes preferentially relocated and consumed foods of high quantity and high quality before visiting locations containing foods of low quantity or low quality (Bailey et al., 1989b; Bailey and Sims, 1998). Animals in our study that used spatial memory (F/NC) generally foraged more efficiently than animals searching randomly (V/NC) (Figs. 1–5). Although cattle apparently have accurate spatial memories, relying on spatial memory alone on extensive pastures would require storing an enormous amount of information. As the number of feeding sites increased, the accuracy of spatial
memory would theoretically decline and adaptation to novel foraging environments would be difficult (Laca, 1998).

Foraging landscapes often contain a variety of natural and man-made cues (trees, rock outcrops, supplement troughs, windmills, mountain ridges, fence boundaries, rivers, trails, etc.). The ability to discriminate among visual cues that are associated with the locations of forage, cover, and water resources, as well as predators and other environmental hazards (Garcia and Koelling, 1966) would be advantageous to free-ranging herbivores. The association of visual cues with various aspects of natural foraging environments likely enhances the spatial abilities of free-ranging ungulates, allowing them to forage more efficiently in nutritionally diverse landscapes (Provenza and Balph, 1990). In this study, the improved performance of the F/C treatment over the F/NC group clearly shows that the presence of overt visual cues enhances memory of a profitable location because cued animals more quickly identified food locations. In maze studies, the importance of visually distinguishing among food sites has been shown by the improved performance of cattle and rats in radial-arm mazes than in parallel-arm mazes where visual cues are less overt (Staddon, 1983; Bailey et al, 1989a). Based on the results of this and other studies, large herbivores should be able to use spatial memory more efficiently in heterogeneous landscapes where visual cues are more distinct.

Fig. 4. Mean (+ S.E.) intake (g) of high-quality (HQ) and low-quality (LQ) foods by four treatment groups. Treatments were F/C = fixed locations/visual cues, V/C = variable locations/visual cues, F/NC = fixed locations/no visual cues, V/NC = variable locations/no visual cues. Different letters indicate differences among high-quality intake treatment means ($P < 0.05$, LSD); intake of low-quality food was similar for all treatments ($P = 0.202$).
4.2. Selections of plants and patches (smaller scale)

At finer scales, large herbivores can associate cues with plants or patches (Bazely and Ensor, 1989; Edwards et al., 1997). This ability would be extremely valuable in extensive, heterogeneous foraging environments where animals would be unable to remember countless locations of plants and patches whose quantity and quality continually change across space and time. The ability to visually discriminate among plants or patches (using visual cues) allows animals to reduce searching and travel distance and improve foraging efficiency (Gross et al., 1995). For example, growing animals that consume more food in relation to the energy they expend traveling typically gain more weight than animals with lower intake levels and higher energy outputs (Osugi, 1974; Sevi et al., 1999). Cued animals in our study took less time before feeding, ate more food, and consumed more food per distance traveled than uncued animals (Table 1, Figs. 1, 4 and 5).

Edwards et al. (1997), in a controlled study, found that sheep selected high-quality foods more efficiently after learning to discriminate between vegetal cues. Cattle in our study were able to learn the relationship between artificial visual cues and food quality and later use this information to forage more efficiently than uncued animals in both fixed and variable environments (Table 1, Figs. 1–5). For example, cued animals took about half the time to initially locate a forage location compared to F/NC animals, and about a third of the time compared to V/NC animals (Fig. 1). Cued animals also clearly discriminated between traffic cones and traffic barricades as reflected in their ability to...
locate and consume high-quality food first nearly 80% of the time compared to uncued animals that located and consumed high-quality food first just 52–68% of the time (Fig. 2). Thus, animals in all 4 treatments clearly preferred the high-quality over the low-quality food (Tables 1 and 2, Figs. 2 and 4), but uncued animals were not as adept at initially locating high-quality foods (Fig. 2).

4.3. Combined impact of visual cues across foraging scales

On extensive rangelands, cattle probably use visual cues to discriminate among plants and patches, and to help locate specific feeding sites. Thus, utilizing visual cues at both fine and coarse scales should improve overall foraging efficiency. Animals in both of the fixed location treatments (F/C and F/NC) returned to locations where they found food during previous trials, however, cued animals (F/C) almost always foraged more efficiently than uncued animals (F/NC) (Figs. 1–5). Cued (F/C) animals evidently used visual cues to more quickly relocate marked food locations and possibly to avoid locations with no food (Fig. 1). Indeed, F/C animals were the most efficient of the four treatment groups because they apparently used previous knowledge of fixed high-quality food locations in combination with the visual cues marking those locations. In addition, V/C animals were generally more efficient foragers than either the F/NC or V/NC animals (Figs. 1–5). Even though food locations were moved each trial (i.e., spatial memory of previous forage locations rendered useless), V/C animals were able to track this movement remarkably well by relying on visual cues. Thus, the association of visual cues to the presence of food conferred an advantage to animals foraging in both fixed and variable environments.

Free-ranging animals foraging in natural, but unfamiliar environments eat less, spend more time walking, and suffer more from malnutrition and predation than those foraging in familiar environments (Provenza and Balph, 1990). The V/NC steers in our study were essentially made to forage in an unfamiliar environment each trial and consequently traversed more of the experimental pasture, found and consumed less food, and spent less time feeding than F/NC, V/C, and F/C animals (Figs. 1–5). Our data supports the study by Laca (1998) who conducted an arena study that exposed cattle to either fixed or variable food locations without visual cues. When food was placed in fixed locations, animals typically took the most direct route to areas where food was found in previous trials (spatial memory). Conversely, when food locations were randomly changed each trial (i.e., spatial memory rendered useless), animals avoided places visited within a trial that contained no food and explored most of the available arena searching for foods. Animals in our F/NC and V/NC treatments performed like Laca’s uncued animals in the fixed and variable treatments.

4.4. Individual variability

Steers 4 and 8 typically foraged less efficiently than the other six animals (Table 2), apparently because they did not learn the relationship between visual cues and forage quality. Throughout the experiment, these two animals appeared more nervous and vigilant than the other animals as they would often stand in one place waiting for a trial
to end. Steer 8’s performance was extremely poor regardless of whether food locations were cued, uncued, fixed, or variable. Vigilance would be adaptive in natural, hazardous environments where predators threaten survival. Conversely, from an experimental and perhaps a management standpoint, vigilance completely hindered steer 8’s ability to learn the relationship between cues and food locations.

5. Conclusions

Our data strongly support the hypothesis that visual cues enhance the ability of cattle to more efficiently locate and consume foods placed in fixed or variable locations within an experimental pasture. Visual cues improved the ability of animals to locate fixed locations, and greatly enhanced the ability of animals to locate variable locations. Cued animals (F/C and V/C treatments) foraged more efficiently than animals relying on spatial memory (F/NC treatment) or random search alone (V/NC treatments). Cued animals took less time to commence feeding, spent more time feeding, ate more high-quality food, and consumed more food per distance traveled than uncued animals. More research is needed to determine whether manipulation of natural and artificial visual cues can be used to address animal distribution problems under field conditions. For example, training animals to recognize specific images and associate them with food may be useful for luring animals to underutilized rangeland with supplement (Bailey and Welling, 1999). Researchers and managers should expect some individual variability in the abilities of animals to learn spatial tasks.

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