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ECOLOGICAL FACTORS DETERMINING NESTING HABITAT FOR AMERICAN AVOCETS ON THE INLAND SEA SHOREBIRD RESERVE

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Introduction

The American Avocet (Recurvirostra americana), is a large shorebird that breeds and congregates in open, shallow, saline wetlands (Robinson et al. 1997). Its long, recurved bill is well adapted for stirring up and feeding on invertebrates from the benthos. Because they fill such a narrow habitat niche, the majority of avocets concentrate in the thousands to breed in a few hot spots such as Mono Lake in California, and the Great Salt Lake in Utah (Robinson et al. 1997). Avocets arrive at the Great Salt Lake in late March and nest from mid-April to mid-July (Sordahl 1981). They require 15-20 cm (5.9 to 7.9 inches) of water for foraging (Robinson et al. 1997). Avocets lay 3-4 cryptic, pyriform eggs in a soft, alkali ground scrape lined with vegetation (Robinson et al 1997) or built up on small patches of vegetation over water (Paton et al. 1992). They nest near the water's edge (Robinson et al. 1997) and on islands whenever possible (Sidle and Arnold 1982). Pairs may re-nest if the first site is heavily disturbed or depredated (Robinson et al. 1997).

American Avocets were extirpated from the east coast of the U.S. in the early 1900s (Robinson et al. 1997). Human civilization's continual encroachment upon wetlands through agricultural conversion or urban sprawl (Dahl 1990) has already led to significant avocet population declines (Bent 1927, Page et al. 1994). This study aims to determine which ecological variables affect nesting habitat for American Avocets on the Inland Sea Shorebird Reserve (ISSR). Saline wetlands and restoration efforts such as this will become crucial for the conservation of the American Avocet in North America (Robinson et al. 1997). The resulting data will serve as a baseline for further studies, assesses current avocet management practices, may shape future improvements, and may serve as a model for other mitigation wetland sites.

Study Site

The Inland Sea Shorebird Reserve (ISSR, Fig. 1), a Kennecott Utah Copper wetlands mitigation site, is a 3,670-acre reserve on the south end of the Great Salt Lake ecosystem established in 1997. The ISSR is part of the Gilbert Bay complex on the south end of the Great Salt Lake, which has been identified as a Birdlife International Very Important Bird Area for many avian species, including American Avocets (National Audubon Society 2004. Important Bird Area Program, Utah (http://www.audubon.org/bird/iba/utah/sites.html#Gilbert>). The reserve contains several natural shallow depressions of varying sizes with high clay soils, called playas, which hold water well after rainfall. Kennecott land managers engineered the reserve to allow these depressions to maintain water year-round, due to a series of canals and artificial structures that control water flow into the ponds. The resulting ponds provide ample feeding and roosting habitat for shorebirds, waterfowl, passerines, and raptors attracted to various prey items on the reserve (SWCA 2003). Six of its nine ponds are shallow and adequately saline to provide suitable feeding and nesting habitat for hundreds of American Avocets, the most numerous avian species on the reserve. The following ponds were surveyed: South A, Southwest, West A, Northwest, North, and Goggin.

Methods and Materials

I recorded all American Avocets and nests on six of the nine ponds on the ISSR (Fig. 1). Survey points were placed at eight ponds, according to areas of avocet nesting activity and feeding concentration. At each point, I counted avocets and nests with binoculars or a spotting scope. Surveys were repeated twice a week, from May 24, 2005 to August 12, 2005. I also recorded the pond depth at each gauge on each day observed. The number of avocets and nests were compared with
American Avocets at ISSR

Figure 1. Map of the Inland Sea Shorebird Reserve (ISSR) study site on the south shore of the Great Salt Lake with ponds indicated. The top of the map is north, with the Great Salt Lake to the west and north of the study site.

pond depth in cm in a linear regression analysis with the statistical program Systat 11. Pond size, pond edge, and island presence were analyzed using a repeated-measures ANOVA test. Because I counted many of the same nests and avocets every day surveyed, a repeated-measures ANOVA was used. Pond size was divided into three categories: large, medium, and small. Pond edge was divided into three categories as well: high, medium, and low. Islands were either present or absent in the middle of each pond. I also constructed a cluster diagram based on Euclidian distance, which gives a linear measure of how similar the ponds are to each other, based on size, edge and presence of islands.

Results and Discussion

Table 1 shows the results of avocet and nest count observations throughout the study period. Southwest Pond contained the highest number of total avocet (1882) and total nest observations (459) throughout the study period. North Pond had the next highest avocet numbers (1771) and nests (238). Northwest Pond had the least number of avocets (138) and nests (2). South A Pond had 1572 avocet observations and 106 nest observations. West A Pond recorded 1171 avocet observations, but only 34 nests. Goggin Pond had few avocets (642) compared to the other ponds, but recorded a high number of nests (113).

In the repeated-measures ANOVA for total avocets (Table 2), the categorical variable Islands was significant (p=0.004). Pond size and pond edge were not significant (p=0.990 and p=0.177). For total nests (Table 2), none of the three variables were statistically significant. For pond size, the p-value was 0.635, the p-value for pond edge was 0.089, and the p-value for Islands was 0.352 (Fig. 2). Figure 2 shows the Euclidian distance between sites as a measure of Index Similarity.

The linear regression analysis showed that pond depth was highly correlated with avocet nests (p= 0.000, R²= 0.270), which validated our observations. During the course of the study, it became immediately obvious that water management on the reserve affected the behavior of nesting avocets, perhaps more so than any other ecological factor. As long as a pond maintained a threshold value of 17.8 cm (7 in) of water, avocets continued nesting in the vicinity. If water levels dropped below this threshold, avocets abandoned their nests. This corresponds with the 15-20 cm reported in the literature (Robinson et al. 1997).
American Avocets at ISSR

Table 1. Total avocet and total nest observations at each pond throughout the study period (May-Aug, 2005).

<table>
<thead>
<tr>
<th>Pond</th>
<th>South A</th>
<th>Southwest</th>
<th>West A</th>
<th>Northwest</th>
<th>North</th>
<th>Goggin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Avocets</td>
<td>1572</td>
<td>1882</td>
<td>1171</td>
<td>138</td>
<td>1771</td>
<td>642</td>
</tr>
<tr>
<td>Total Nests</td>
<td>106</td>
<td>459</td>
<td>34</td>
<td>2</td>
<td>238</td>
<td>113</td>
</tr>
</tbody>
</table>

Table 2. Results of the repeated-measures ANOVA analysis of three categorical variables on total avocet and nest numbers across all six ponds throughout the study period. An * indicates possible significance biologically, but not statistically.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Levels</th>
<th>Category</th>
<th>Total Birds</th>
<th>Total Nests</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pond Size</td>
<td>3</td>
<td>Small, Medium, Large</td>
<td>0.99</td>
<td>0.635</td>
</tr>
<tr>
<td>Pond Edge</td>
<td>3</td>
<td>Low, Medium, High</td>
<td>0.177</td>
<td>0.089*</td>
</tr>
<tr>
<td>Islands</td>
<td>2</td>
<td>Present, Absent</td>
<td>0.004</td>
<td>0.352*</td>
</tr>
</tbody>
</table>

As the summer progressed, it soon became increasingly difficult to maintain ideal water levels in all of the ponds simultaneously. Priority was given to Southwest and North ponds, known to harbor the majority of avocet nests on the reserve. Southwest Pond, due to restrictions imposed by its large size, could not be maintained at the southern end, resulting in decreasing observations of avocets until this end dried up completely. It was also determined for management reasons that Goggin Pond would be allowed to dry during the hot summer season, and avocet nesting was abandoned. Avocet numbers dropped as well throughout this period, as food sources diminished on this pond. Absence of a close water source or feeding habitat may play into negative feedback that would cause an avocet to abandon its nest. Flying to another pond may be too costly in time away from the nest or in energy. Since avocets have developed complicated anti-predator countermeasures (Hamilton 1975, Sordahl 1986), a ground-based nest with a parent sitting on it is most likely safer than a nest alone, despite its cryptic coloration. These observations and statistical analyses all indicate that water management plays a vital role in maximizing avocet nesting habitat and lays the groundwork for future studies to determine exact level requirements for each pond.

Pond size (Table 2) was not statistically significant for total avocets or total nests (p= 0.990 and 0.635), which supports our observations. Southwest and North ponds both carried hundreds of avocets and nests, but the other large pond, Northwest, only had 138 avocets and 2 nests throughout the season (Table 1). Likewise, small ponds could support many avocets and nests, as with South A (1572 and 106), or fewer, as with West A, which sustained a fair amount of avocets (1171), but few nests (34, Table 1). Goggin, a medium-sized pond, maintained a good amount of nests (113), but not as many avocets (642) compared to the other ponds of different sizes (Table 1). These data show no clear pattern in relation to pond size.

Pond edge was not statistically significant (Table 2) for total avocets (p= 0.177), but probably biologically significant for total nests (p= 0.089, Table 2). Ponds with a varied shoreline and high edge, such
as Southwest and North, seemed to attract high avocet nest numbers (459 and 238, Table 1). Low edge ponds such as South A and West A had fewer nests (106 and 34), while Goggin, a pond with medium edge, sustained a middle value of 113 nests (Table 1). Observations seemed to indicate that avocets nested closer to the shoreline, which matches the literature (Robinson et al. 1997), probably for easy access to feeding resources and perhaps for predator avoidance and escape as well. A pond with more edge had much more shoreline than one with little edge.

The presence of islands in the ponds (Table 2) was statistically significant for total avocets (p= 0.004), but not for total nests (p= 0.352). However, based on observations throughout the study period and the literature (Sidle and Arnold 1982), islands seemed to be a very important ecological factor in avocet nesting. As previously stated, avocets on islands nested in extremely close proximity to each other compared to nests on the shoreline. This spatial tolerance on islands seems logical, since terrestrial predators could not reach this isolated ground to depredate avocet nests, as indicated by Sidle and Arnold (1982). However, closer nesting proximity would be a disadvantage on the shoreline because such a predator, upon finding one avocet nest, could easily locate others.

Statistically, islands have been shown as important for total avocet observations on the ponds in the ISSR, but how can they not prove significant for nests as well? Based on our observations, generally avocets seemed more prevalent at islands when they were nesting. Of the 6 ponds surveyed, four contain islands: Southwest (459 nests), North (228 nests), South A (106 nests), and West A (34 nests, Table 1). Northwest Pond had no islands and only 2 nests, but Goggin, also containing no islands, had 113 nests (Table 1), more than South A and West A ponds which rendered islands statistically insignificant. However, water management may have played an important role in minimizing islands as a factor determining avocet nesting. The southern end of Southwest Pond had at least 19 nests flooded out on a larger island early in the study period. After the flooding, avocets may have re-nested on the island again, but shortly thereafter, water could not be maintained, that portion of the pond dried up and the island became accessible by land and terrestrial predators. This scenario may have occurred on islands in the other three ponds, enough to invalidate the significance of the role of islands in avocet nesting.

The cluster analysis of Euclidian distances assigns values to dissimilarity between pond sites and draws a cluster diagram based on these values, according to the habitat variables, pond size, edge and island presence. Our cluster diagram (Fig. 2), shows that Southwest and North ponds are the most alike and stand apart from the other ponds. Both ponds are large, have medium or high edge and contain islands. These two ponds also sustained both the highest total avocets and total nests throughout the season and should be the highest management priority for avocet nesting and water manipulation. Figure 2 shows South A Pond as also very different than the remaining four ponds. This pond is small with small edge, but contains islands. Larger, quality islands at this pond may make up for low pond edge, surmised to be biologically significant. Further quantifiable studies on island habitat and quality may illuminate why this pond supported such high avocet and nest numbers. South A maintained the third highest avocet numbers and was only slightly behind Goggin, the third highest in nest numbers, with 106 nests versus 113 nests (Table 1). However, South A attracted approximately twice and a half times more avocets than Goggin, and should be the next highest management priority for avocet nesting and water manipulation on the ISSR. West A Pond should occupy a low priority, based on few avocets and nests numbers, small size, low edge and small islands. Northwest Pond should be the lowest priority for management and avocet conservation purposes. Even though it is large, it has little varied shoreline and no islands.

Conservation of the American Avocet will depend on preserving wetlands and the few saline hot spots where these shorebirds breed in large colonies. Reserves like the ISSR are crucial in this effort and determining nesting dynamics on similar reserves individually will allow managers to maximize avocet nesting by maintaining water levels
above nesting thresholds. Future wetland mitigation site designs managing for American Avocets should include ponds with high edge and islands.

**Figure 2.** Cluster diagram indicating similarity between pond sites based on the Euclidean distance scale at the bottom. The diagram shows how similar the sites are to each other based on size, edge, and islands. More similar sites cluster next to each other and have the same or close Euclidian distances than sites that are dissimilar.

**Acknowledgments**

I would like to thank Kennecott Utah Copper for funding this study. I would also like to thank Dr. Loreen Allphin Woolstenhulme at the Plant and Wildlife Sciences Department at Brigham Young University for statistically analyzing our data set.
HINDLIMB FLIGHT POSTURE OF UTAH SHOREBIRDS

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Birds use one of two hindlimb postures during flight. The legs are either held under the body with the hip, knee and ankle joints flexed, or are trailed behind the body, a posture in which the hip and knee are flexed, but the ankle is extended (Fig. 1). Shorebirds, raptors, ducks, geese and parrots fly using the extended posture, whereas perching birds and woodpeckers use the flexed position (Barrett-Hamilton 1903, Townsend 1909, Shepard and Meyers 2006). There has been surprisingly little research investigating the reason a bird uses one or the other posture, but we are in the process of evaluating several hypotheses (Shepard and Meyers 2006, McFarland and Meyers, 2008).

The maintenance of the hindlimbs in either of these positions represents a postural activity. Posture is associated with isometric muscle contractions, which occur when a muscle contracts with no change in length (Goldspink 1980). Slow contracting muscle fibers are considered best suited for isometric contractions, as they are more efficient at long-term contractions (Goldspink 1980, 1981). Previous research has demonstrated a relationship between a muscle’s slow fiber distribution and its function in posture for a number of avian behaviors including folded wing posture (Meyers 1992), wing-drying posture in cormorants (Meyers and Mathias 1997), and soaring flight posture in Turkey Vultures (Rosser and George 1986), pelicans (Rosser et al. 1994) and albatrosses (Meyers and Stakebake 2005).

We began our larger study of the structure and function of avian flight posture by examining the hindlimb of two species that use the extended hindlimb posture, American Avocets (Recurvirostra americana) and Black-necked Stilts (Himantopus mexicanus). These species were chosen due to a paucity of existing data, their extremely long legs, and local abundance. Our goals in this study were to (1)