Habitat Use and Productivity of Mottled Ducks on the Atchafalaya River Delta, Louisiana

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Abstract: We studied nesting habitat selection, nest density, and nest success of mottled ducks *(Anas fulvigula)* on islands in the Atchafalaya River Delta, Louisiana, 1995–1996. Nesting mottled ducks preferred shrub-moderate habitats and avoided shrub-sparse and marsh habitats. Other habitats were neither preferred nor avoided. Nest densities using non-random plot sampling in 1995 and line-transect sampling in 1996 averaged 3.9 nests/ha and 1.3 nest/ha, respectively. Mayfield nest success estimates on individual islands ranged from 6.0% to 67.1%. The Atchafalaya River Delta is potentially one of the most important areas for mottled ducks nesting along the Gulf Coast. In order to sustain high mottled duck use of islands, managers should consider implementing vegetation management practices that are aimed at maintaining shrub-moderate habitats.

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Mottled ducks *(Anas fulvigula)* are one of the few non-migratory dabbling ducks in North America (Bellrose 1980). There are 2 populations of mottled ducks; one along peninsular Florida and the other along the northwestern coast of the Gulf of Mexico, extending from Veracruz, Mexico, eastward to the coastal marshes of Alabama (Moorman and Gray 1994). Herein, we focus on mottled ducks inhabiting the northwestern coast of the Gulf of Mexico, unless otherwise specified.

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Stutzenbaker (1988) divided the range of the mottled duck into 3 broad regions: the coastal marsh region; the rice production and cattle pasture region; and the cattle pasture, shallow bay, and citrus-truck farm region. Previous investigations in these regions suggest mottled ducks primarily nest in cordgrass (*Spartina* spp.) meadows and near rice fields (Engeling 1950, Singleton 1953, Baker 1983, Stutzenbaker 1988). However, vegetation types and habitats available to nesting mottled ducks in the Atachfalaya River Delta (ARD) differ greatly from areas where previous research has been performed. The ARD is a complex of islands and shallow, freshwater wetlands (Johnson et al. 1985). Islands potentially offer the most productive and attractive nesting habitats for dabbling ducks (Duebbert et al. 1983, Clark and Shutler 1999). Indeed, densities of mottled ducks nesting on islands in the ARD (3.7 nests/ha) may be greater than elsewhere along the Gulf Coast (Johnson et al. 1996). However, no data exists on nest success or on habitats used by nesting females in the ARD.

Our objective was to identify factors affecting the ecology of nesting mottled ducks in the ARD. Specifically, we examined habitat selection by nesting females, nest success with respect to island, and nest density using 2 different methods. We also provided suggestions for management of islands in the ARD.

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Methods

Study Area

Our study was conducted on islands in the ARD, Louisiana. The ARD is located in St. Mary Parish approximately 25 km south of Morgan City, Louisiana. Islands in the ARD are located in the northern, freshwater portion of Atchafalaya Bay. These islands were formed by natural sediment accretion and by placement of dredge-spoil material (Roberts and van Heerden 1982). Vegetation associations on islands are dependent on island age and seral stage and have been described by Johnson et al. (1985) and Penland et al. (1995).

Nesting Habitat Selection

In 1996, vegetation characteristics were measured in circular plots (10 m^2) systematically located on 11 islands (Bonham 1989). Circular plots were located at 100-m intervals along randomly placed transects. Each transect had a random starting point and direction. At each circular plot we visually estimated percentage horizontal

Table 1. Criteria[a] used in classifying habitats on the Atchafalaya River Delta, Louisiana.

Habitat	Dominant species	% Ground cover	% Cover at 1.5 m
Bareland		<10	
Grassland	>50% grasses[b]	≥10	
Marsh	>50% marsh[c] and marsh-margin[c]	≥10	
Shrub-sparse	Herbaceous[d] and woody[e] <6 m	≥10–≤30	<10
Shrub-moderate	Herbaceous and woody <6 m	>30	≥10–<50
Shrub-dense	Herbaceous and woody <6 m	>30	≥50
Forested	Woody ≥6 m	≥10	

a After Penland et al. (1995).

b. *Andropogon virginicus* and *Panicum repens*.

c. *Eleocharis* spp., *Hydrocotyle* spp., *Scirpus amaricanus* and *Senecio glabellus*.

d. *Solidago sempervirens*.

e. *Baccharis halimifolia, Salix nigra* and *Sesbania drummondii*.

cover of vegetation at ground level and at 1.5 m above ground, and noted the 5 dominant plant species. Habitat classifications are described in Table 1.

We located nests by walking straight-line transects. Transects were randomly located as per methodology outlined above. While walking, we switched the cover with laths in order to flush females from their nests (Higgins et al. 1969). Following a flush, vegetation was measured in a 10-m^2 circular plot centered at the nest and habitats were classified using the methodology previously described. Islands were searched twice during the nesting season, and were randomly selected for order of searching. Searches were conducted between 0800 and 1500 to increase the likelihood of finding females on the nest (Gloutney et al. 1993). Islands searched early in the day during the first search were searched late in the day during the second search to reduce probability of biases associated with diurnal nest use and detection.

We used the Neu et al. (1974) method as described by Byers et al. (1984) for analysis of habitat use versus availability for nesting mottled ducks. We used chi-square tests (Freund and Wilson 1993) to evaluate the null hypothesis that habitats were used in proportion to their availability. We excluded bare-land from the analysis because it was used infrequently by nesting mottled ducks. Similarly, we pooled forested and shrub-dense habitats because of low expected values for each habitat type, and because their vegetation structure appeared similar. Finally, we calculated Bonferonni simultaneous confidence intervals for each habitat (Byers et al. 1984). We concluded that a habitat was used disproportional to its availability if the chi-square was significant and the expected probability of usage was not within the estimated Bonferonni interval.

Nest Density

We searched 21 plots of perceived suitable nesting habitat on 13 islands in 1995. Plots were not uniform in size (size range 0.49–2.69 ha) and were non-randomly placed in areas thought to provide suitable nesting cover. We did this to increase likelihood of finding nests and because we suspected certain habitat types (e.g., dense, wooded areas; see Stutzenbaker 1988) to have low value for nesting females. Plots were placed in march, grassland, shrub-sparse, shrub-moderate, and shrub-dense areas. If >1 plot (regardless of habitat) occurred on an island, plot areas were summed to obtain a total plot size/island. Plots were searched twice during the nesting season and in a random order as described in the previous section. Plots were searched in a systematic manner to insure that all area within the plot was covered during the search. In estimates of nest density we used only nests found within plot boundaries and during plot searches; we excluded nests found incidentally during follow up nest checks.

In 1996, we used line-transect sampling to estimate mottled duck nesting density. We switched to line-transect sampling because we felt this method would provide a better overall estimate of nest density than our plot searches did the previous year. Transects were randomly located as described in the section on nesting habitat selection. Transects were searched at least twice during the nesting season, and in a random order, as described previously. When a mottled duck flushed, the perpendicular distance from the transect to the nest was measured. We excluded nests >10 m perpendicular distance from a transect; at distances beyond this, flushes were likely an anomaly (Burnham et al. 1980). Transect searches falling outside of the 20 March–29 May peak nesting period (Holbrook 1997) also were excluded from analysis. Total transect length was the product of transect length and number of searches. We used the Fourier series estimator in program TRANSECT to estimate nest density (Laake et al. 1979, Burnham et al. 1980).

Nest Success

Nest success was estimated by monitoring nests detected during plot and transect sampling, nests found incidentally during subsequent nest visits, and nests found during searches of portions of islands not covered during plot and transect sampling. At each nest we recorded number of eggs and incubation stage. Incubation stage was determined by candling (Weller 1956); nest initiation date was determined by backdating (incubation stage when found—clutch size; Westerskov 1950). We covered eggs with nest material before leaving (as female ducks do) and laid 2 small twigs across the covered nest in a manner that would allow us to determine if the female returned. We attempted to monitor nests on a 7- to 10-day schedule until they were terminated. Nests from which at least 1 egg hatched, as evidenced by presence of young or detached egg shell membranes in or around the nest, were considered successful. Unsuccessful nests were classified as flooded, depredated, non-viable, or abandoned. Nests that females abandoned because of researcher activity were excluded from analyses.

Apparent nest success is frequently used in studies involving islands if investigators have a high probability of detecting all nests (Johnson and Shaffer 1990). We chose not to use this approach because the large size of many islands prevented complete coverage during searches; instead, we used the Mayfield method as modified by Johnson (1979) to estimate nest success. Exposure days for each nest equaled the period the nest was monitored: that is, number of days from date the nest was found until date the nest was terminated (hatched, depredated, flooded,

Table 2. Observed and expected frequencies of available and used habitats by mottled ducks nesting in the Atchafalaya River Delta, Louisiana, during 1996.

	Available		Used	
Habitat	Observed[a]	Expected	Observed	Expected
Grassland	23	27.9	8	3.1
Marsh	67	62.1	2	6.9
Shrub moderate	93	99.8	18	11.2
Shrub sparse	61	55.8	1	6.2
Shrub-dense/forested	51	49.5	4	5.5

a. Observed frequencies differ from expected frequencies (χ^2_4=22.4, P=0.001).

etc). When the termination date was unknown, we considered it to be midway between nest visits if the interval was ≤14 days, and 40% if the interval was >14 days (Johnson 1979).

We used an Analysis of Variance (PROC GLM, SAS Inst. 1990) to determine if Daily Survival Rates (DSRs) differed among islands and years. Because the variance of an estimated DSR is inversely proportional to the square-root of total number of exposure days, the model was weighted by the square-rot of the sum of exposure days for each island (Johnson 1979, as modified by Garrettson 1999). If needed, we used contrast statements (PROC GLM) to compare group means of main effects (Freund and Wilson 1993). Only islands where >5 nests were found in each year were included in this analysis. Although we discuss both Mayfield estimates and DSRs, all statistical comparisons (P-values, F-tests, etc.) are based on DSRs.

Results

Nesting Habitat Selection

In 1996, we collected 317 habitat samples along our straight-line transects and 33 habitat samples at nests. We excluded 22 habitat samples from our analysis because they occurred on bare land. Nesting mottled ducks did not use habitat types in

Table 3. Simultaneous confidence intervals using the Bonferonni approach to compare habitats available and used by nesting mottled ducks in the Atchafalaya River Delta, Louisiana, during 1996.

Habitat type	Expected proportion of usage P_{io}	Actual proportion of usage P_i	Bonferonni intervals for P_i
Grassland	0.071	0.242	0.050 $\leq P_i \leq$ 0.435
Marsh	0.227	0.060	−0.046 $\leq P_i \leq$ 0.168[a]
Shrub-dense/forested	0.173	0.121	−0.025 $\leq P_i \leq$ 0.268
Shrub-moderate	0.315	0.545	0.0322 $\leq P_i \leq$ 0.769[a]
Shrub-sparse	0.207	0.030	−0.047 $\leq P_i \leq$ 0.107[a]

a. Indicates a difference at α = 0.05.

Table 4. Mottled duck nest densities estimated from plot searches during 1995 in the Atchafalaya River Delta, Louisiana.

Island	Plot area (ha)	*N*	Nests / ha
Andrew	3.26	15	4.6
Big	0.57	0	0.0
Community	2.53	3	1.2
Donna	0.84	0	0.0
Gods	1.21	15	12.4
Horseshoe	1.73	1	0.6
Long	3.04	33	10.6
Mile	1.46	16	11.0
Poule d'eau	0.49	1	2.0
Roger Brown	3.19	0	0.0
Skimmer	1.38	1	0.7
T-Pat	2.39	1	0.4
Total	22.22	87	3.9

proportion to their availability (χ^2_4=22.4, P=0.001; Table 2). Bonferonni confidence intervals indicated that shrub-moderate habitats were used more than expected, whereas shrub-sparse and marsh habitats were used less than expected (Table 3). Other habitats were not used more or less than expected.

Nest Density

In 1995 we found 87 nests within 19 plots (22.22 total ha) located on 12 islands. Nest density across all plots and islands was 3.9 nests/ha. Nest density on each island ranged from 0.0 nests/ha to 12.4 nests/ha (Table 4). Most (91%) nests were on 4 of 12 islands. Average density on these islands was 8.1 nests/ha.

In 1996 we searched 55,300 m of transects and found 38 nests on 11 islands. However, 3 nests were >10 m from transect lines and were deleted from analyses. A nest density estimate of 1.3 nests/ha (95% CI=0.3–2.2) over the entire ARD was calculated. Small sample sizes made comparisons of nest densities among individual islands inappropriate.

Nest Success

We found 140 nests on 9 islands during 1995 and 171 nests on 11 islands during 1996. We excluded 52 nests from analyses because their fates were not determined or because they were abandoned due to investigator activity. We also excluded all data from islands where we did not find at least 5 nests during each year of the study (islands=5, nests=31).

Mayfield nest estimates on islands ranged from 6.0% to 67.1% (Table 5). DSRs differed among islands ($F_{5,11}$)=7.97, P=0.01), but there was no effect of year ($F_{1,11}$=0.21, P=0.66). Contrast statements indicated that Long Island had the lowest DSR (Table 6).

Table 5. Daily Survival Rates and Mayfield nest success estimates of mottled duck nests on islands in the Atchafalaya River Delta, Louisiana, 1995–1996.

Island	Daily survival rate	Mayfield success[a]	*N*
Andrew	0.983	54.4%	52
Community	0.965	29.0%	15
Gods	0.984	56.3%	28
Long	0.923	6.0%	66
Mile	0.966	29.8%	43
T-Pat	0.989	67.1%	24

a. Daily Survival Rates (s) were converted to Mayfield nest success estimates (P) using the equation from Klett et al. (1986): $P = s^h$, where h is equal to incubation period + mean laying period. The incubation period for mottled ducks is 26 days (Afton and Paulus 1992), and the average laying period during this study was 9.2 days (R. S. Holbrook, unpubl. data).

Discussion

Nesting Habitat Selection

Just over half (55%) of our nests were found in the shrub-moderate habitat type, and this was the only habitat type used more than expected by mottled ducks. This habitat was characterized by herbaceous vegetation, typically goldenrod *(Solidago sempervirens),* and scattered baccharis *(Baccharis halimifolia)* shrubs. Elsewhere along the Gulf Coast, mottled ducks appear to nest in herbaceous vegetation only occasionally (Engeling 1950), and they tend to avoid areas that have been invaded by baccharis (Baker 1983). The most common areas used by nesting mottled ducks in

Table 6. Contrast statements comparing Daily Survival Rates[a] of mottled duck nests between islands in the Atchafalaya Delta, Louisiana.

Contrast	df	*F* value	*P* >*F*
Long vs. Andrew	1	27.40	0.003[b]
Long vs. Community	1	9.30	0.028[b]
Long vs. Gods	1	22.86	0.005[b]
Long vs. Mile	1	12.74	0.016[b]
Long vs. T-Pat	1	26.43	0.004[b]
Andrew vs. Community	1	1.70	0.249
Andrew vs. Gods	1	0.00	0.977
Andrew vs. Mile	1	2.31	0.189
Andrew vs. T-Pat	1	0.23	0.653
Community vs. Gods	1	1.54	0.270
Community vs Mile	1	0.00	0.994
Community vs. T-Pat	1	2.59	0.169
Gods vs. Mile	1	1.99	0.217
Gods vs. T-Pat	1	0.17	0.698
Mile vs. T-Pat	1	3.31	0.128

a. Daily Survival Rates are weighted by the square-root of total exposure days for each island.
b. Indicates a difference at $\alpha = 0.05$.

southwestern Louisiana and in Texas are cordgrass meadows (Baker 1983, Stutzenbaker 1988). Cordgrass, however, was not a common species in our study area.

Grasslands were the second most used habitat type in our study, although they were not preferred or avoided. Grasslands in our study were dominated by broomsedge *(Andropogon virginicus)* and torpedo grass *(Panicum repens)* and were qualitatively similar to areas where both Engeling (1950) and Singleton (1953) found nests in Texas. Like grasslands, shrub-dense/forested habitats were neither preferred nor avoided. Interestingly, Stutzenbaker (1988) did not find any mottled duck nests in areas dominated by dense, woody cover.

Mottled ducks avoided nesting in shrub-sparse and marsh habitats. Shrub-sparse habitats were characterized by bare ground, scattered goldenrod, and occasional baccharis shrubs, and perhaps did not offer suitable cover to nesting females. Marsh habitats were indicative of lower elevations, which were typically found on island fringes (Penland et al. 1995). Although mottled duck nests are often found in high areas (ridges) of marshes, females typically avoid nesting in areas that are regularly subject to flooding (Baker 1983, Stutzenbaker 1988). Our marsh habitats were periodically inundated by high tides, which likely contributed to their low use.

Nest Density

Our plot searches, which were based on a non-random sampling scheme, yielded extremely variable nest densities across islands. Although we searched 12 islands, 91% of nests were found on 4 islands. This average on these 4 islands (8.1 nests/ha) is comparable to densities (9.6 nests/ha) reported from a single island at Merritt Island National Wildlife Refuge, Florida (Stieglitz and Wilson 1968). Although results from our plot searches are likely biased high, the estimate of 1.3 nests/ha that was derived from transect methodology is greater than peak densities reported for Texas and southwestern Louisiana, which were 1 nest/1.4 ha and 1 nest/1.5 ha, respectively (Baker 1983, Stutzenbaker 1988).

Our results suggest mottled ducks are not unlike prairie nesting dabbling ducks, particularly mallards *(Anas platyrhynchos)* and gadwall *(A. strepera),* with regards to their propensity to nest at high densities on islands. Lokemoen and Woodward (1982) found an average density of 6.6 nests/ha on 209 islands in North Dakota, South Dakota, and Montana. Similarly, Duebbert (1982) found densities of 10.9 nests/ha and 13.2 nests/ha on islands in North Dakota.

Nest Success

Nest success estimates on most (5 of 6) of our islands were greater than previous estimates reported for mottled ducks. In order to compare our estimates to those from previous studies, which all reported apparent nest success, we had to convert previous estimates to Mayfield equivalents using Green's (1989) method. Mayfield equivalents from previous studies were 11% (Texas, Engeling 1950), 5% (Louisiana, Baker 1983) and 9% (Texas, Stutzenbaker 1988). Only Stutzenbaker's (1988) estimate was based on more than 100 nests, but it is unclear how many seasons and study sites his data covered. Nest success in the only other study of island nesting mottled ducks, which occurred in Florida, was also high; the Mayfield estimate in that study was 57% (Stieglitz and Wilson 1968).

Long Island had the largest sample of nests and the lowest DSR (Mayfield estimate 6.0%). Interestingly, during preliminary searches of islands in ARD in 1994, 82 nests were found on Long Island and the Mayfield estimate was 48% (W. P. Johnson, unpubl. data). Long Island had the largest sample of nests and the lowest DSR (Mayfield estimate 6.0%) Interestingly, during preliminary searches of islands in 1994, 82 nests were found on Long Island and the Mayfield estimate was 48% (W. P. Johnson, unpubl. data). Although we lack information on predator abundance, most nest losses during this study were the result of depredation. Therefore, it appears that predator numbers on Long Island increased after preliminary investigations in 1994. Additionally, we suspect that differences in nest success among islands were due to differences in relative predator abundance.

Management and Research Implications

Nest density is an important component of productivity. In fact, waterfowl managers in prairie states use density estimates to direct their efforts toward areas where the highest numbers of breeding ducks are likely to be affected (Reynolds et al. 1996). The high nest densities that we found suggest the ARD merits special consideration from managers, as it is potentially the most important locality for breeding mottled ducks along the Gulf Coast. This is true even if our lower density estimate is used.

Nesting mottled ducks used the shrub-moderate habitat type most frequently. Therefore, management efforts at the ARD should focus on maintaining and creating shrub-moderate areas. Without management, these areas will likely become more dense, and subsequently less attractive to nesting females. Potential options for reverting succession are mechanical disturbance, herbicides, and fire. Nesting mottled ducks used the shrub-moderate habitat type most frequently. Therefore management efforts at the ARD should focus on maintaining and creating shrub-moderate areas. Without management, these areas will likely become more dense, and subsequently less attractive to nesting females. Potential options for reverting succession are mechanical disturbance, herbicides, and fire. Because of the remote location of the ARD, burning will perhaps prove to be most practical and cost effective.

For prairie nesting dabbling ducks, nest success needs to be maintained at or above 15% to 20%, depending on species, to sustain stable breeding populations (Cowardin et al. 1985, Klett et al. 1988). Nest success on most islands we examined was well above this. Although avoidance of predators is considered a primary benefit to ducks nesting on islands (Clark and Shutler 1999), nest loss on islands is frequently catastrophic once predator populations are established (Johnson and Shaffer 1990). To insure continued importance to mottled ducks, nest success at the ARD should be monitored on a regular basis, and if nest loss due to predators becomes a serious problem, predator management should be considered.

Stronger conclusions could be made about the overall importance of the ARD to mottled ducks if information were available concerning other factors that play a role in productivity. Foremost among these needs is knowledge of female and brood survival. Because of recent advances in radio-telemetry technology, it should be possible to obtain this information without negatively impacting the behavior or survival of radio-marked individuals (e.g., Rotella et al. 1993, Davis et al. 1999, Garrettson et al. 2000).

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