Survival and Recovery Rates of Mottled Ducks in Georgia 2006–2013

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Abstract: The mottled duck (*Anas fulvigula*) naturally occurs in two populations: one in the coastal marsh of the western Gulf of Mexico and another in peninsular Florida. A third, introduced, population occurs on the southern Atlantic coast in South Carolina and Georgia. Most mottled ducks in Georgia occur on Altamaha Wildlife Management Area, McIntosh County. In 2006, we began banding mottled ducks in Georgia using airboats at night and collected banding and recovery data from 2006 through spring 2014. We used Program MARK to estimate survival rates, Seber recovery rates, and Brownie recovery rates. We captured and banded 232 mottled ducks and received 47 band recoveries. Our model weights suggested that survival and recovery rates were mostly constant across time and age and sex class. Averaged model results indicated that adult survival was 0.351 for males and 0.347 for females, juvenile survival was 0.348 for males and 0.352 for females, adult Brownie recovery rate was 0.141 for males and 0.162 for females, and juvenile Brownie recovery rate was 0.153 for males and 0.140 for females. Survival rates were lower and recovery rates were higher than those reported from Texas-Louisiana and Florida. We hypothesize that this pattern occurred because we banded in areas with both the greatest hunting pressure and alligator densities, and we observed rapid deterioration of bands which may have caused under-reporting.

Key words: Anas fulvigula, band recovery, Georgia, mark-recapture, mottled duck, Program MARK, recovery, survival

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The mottled duck (*Anas fulvigula*) is a non-migratory duck endemic to coastal marshes of the western Gulf of Mexico from Alabama through Texas with a separate population in peninsular Florida (Moorman and Gray 1994). Between 1976 and 1981, approximately 1,200 mottled ducks were relocated from Texas, Louisiana, and Florida to four sites in South Carolina (Weng 2006). Since 1981, this introduced population has apparently become well-established in South Carolina and expanded southward to the mouth of the Savannah River and Altamaha delta. Mottled ducks are commonly found in protected marshes or managed impoundments such as the Savannah National Wildlife Refuge, the Savannah Confined Disposal Facility of the Savannah Harbor, and the Altamaha Waterfowl Management Area (WMA). Since the late 1990s, mottled ducks have become more commonly harvested on Altamaha WMA and have become a "trophy" duck for many hunters. In response to the newly established mottled duck population and the hunter interest, Georgia Wildlife Resources Division staff began banding mottled ducks in 2006 to gather information on movement and population parameters such as survival and recovery rates.

Methods

The Altamaha WMA is 4614 ha located at the mouth of the Altamaha River in McIntosh County, Georgia, and contains several waterfowl impoundments amid three independent management units: Butler Island, Champney Island, and Rhetts Island. Butler and Champney Island impoundments are tidal, freshwater areas managed for moist soil plants such as fall panic grass (*Panicum dichotomoflorum*), wild millets (*Echinocloa* spp.), and smartweeds (*Polygonum* spp.) Rhetts Island impoundments are tidal, brackish systems managed to produce saltmarsh bulrush (*Scirpus robustus*) and wigeon grass (*Ruppia maritima*). Mottled ducks are most frequently encountered at Rhetts Island and occasionally on Butler or Champney Islands.

We captured mottled ducks using two airboats for two nights during the established 1 July to 20 September pre-season mottled duck banding period (Merendino and Lobpries 1998) each year from 2006 to 2013 in managed waterfowl impoundments of Altamaha WMA. Two Georgia Wildlife Resources Division staff members per boat used spotlights to search for ducks as airboats maneuvered through emergent marsh in impoundments, typically beginning at 2130 hours until 0200 hours. We captured by hand any ducks that we spotted. We recorded age and sex of birds following Stutzenbaker (1988) and Carney (1992) and also recorded date, location, and band number for each duck captured. We used band recovery data from the USGS Bird Banding Laboratory's periodic "Reports to Bander" and one additional banding reported directly to our agency staff by a local hunter.

We created capture histories in the live-dead format using new bandings and dead recoveries from mottled ducks that were shot during the hunting season from 2006–2013. We used Program MARK to estimate survival rate (S) and recovery probability (r)

by age and sex (White and Burnham 1999). Because there were no live recaptures, we could not estimate recapture probability or fidelity. We allowed both parameters to vary by group (g), time (t), group and time (g*t), or to be constant (.). This created $4^2 = 16$ potential models to explain variation in the estimates. We ranked models using quasi-Akaike's Information Criterion ($\Delta QAIC_c$) scores adjusted for sample size and a calculated variance inflation factor ($\hat{c} = 2.1919$) generated from 1000 bootstrap simulations of the global model (S(g*t) r(g*t); Burnham and Anderson 2002, Cooch and White 2007). We calculated averages for parameter estimates from all models with weights (w) > 0.0 and calculated unconditional standard errors using the delta method (Powell 2007). We summed model weights over all top-supported models to assess the relative importance of group and time in each parameter estimate.

Using the dead recovery model as implemented in Program MARK, we calculated the recovery probability (r) according to the Seber model rather than the typical Brownie recovery rate $f = K(c)\lambda$, where K = kill rate, c = probability of being retrieved, and λ = reporting rate (Seber 1970, Brownie et al. 1985, Burnham 1993). Given that the relationship between the Brownie recovery rate and the Seber recovery probability was $f = r(1\text{-}S)$, and harvest rate $= f/\lambda = K(c)$ (Williams et al. 2002), we calculated harvest rates using survival rates, Seber recovery probabilities, the standard crippling loss estimate of 0.2 (Anderson and Burnham 1976, Martin and Carney 1977), and the current waterfowl band reporting rate of 0.73 (Garrettson et al. 2014). Using the Seber dead recovery model in Program MARK also allows Bootstrap Goodness of Fit simulations for c-hat adjustment. We assumed no band loss during the study period, nor did we include any estimates of band loss into our calculations.

Results

Between 2006 and 2013 we captured 232 mottled ducks and received 47 total band recoveries, of which 36 were direct recoveries (Table 1). A direct recovery is defined as a recovery occurring in the hunting season immediately following the banding period; indirect recoveries occur in future hunting seasons. Of the 16 models tested in Program MARK, there was some model-selection uncertainty with the top two models having $\Delta QAIC_c < 4$ (Table 2). These two models comprised 92.4% of the total model weight from the 16 *a priori* models (Table 2). These models suggested that survival rates were constant across time and by age and sex class, and that recovery rates were either constant across time or varied by age and sex class (Table 2). Most of the model weight suggested that survival was constant ($w = 0.958$) and recovery rate was constant ($w = 0.836$) across time and by age and sex class.

Table 1. Number of bandings and recoveries by year and age class of mottled ducks banded at Altamaha Wildlife Management Area, Georgia, 2006–2013.

	Adult		*Juvenile*	
Year	Bandings	Recoveries	Bandings	Recoveries
2006	5	3	27	4
2007	0	0	14	4
2008	6	2	23	10
2009	1	1	9	2
2010	9	2	33	6
2011	4	0	35	5
2012	2	0	11	1
2013	3	0	50	7
Total	30	8	202	39

Table 2. Models with best $QAIC_c$ (Akaike's Information Criterion adjusted for sample size and lack of fit) values and model weights (w_i) > 0.00 that explain variation in survival and recovery probabilities of mottled ducks banded at Altamaha Wildlife Management Area, Georgia, 2006–2013, with number of parameters (K), model weight (w_i), and deviance (Qdev).

Model[a]	K	ΔQAICc	w_i	Qdev.
S (.) r (.)	2	0.00	0.799	46.249
S(.) r(g)	6	3.71	0.125	41.635
S(.) r(t)	9	6.31	0.034	37.801
S(t) r(.)	9	7.42	0.019	38.914
S(g) r(.)	6	7.65	0.017	45.573
S(t) r(g)	13	11.97	0.002	34.604
S(g) r(g)	10	12.06	0.002	41.364
S(g) r(t)	13	13.49	0.001	36.121
S(t) r(t)	15	16.94	<0.001	35.022

a. Model notation follows Program MARK (White and Burnham 1999) where *S* indicates survival, *r* indicates recovery probability, g indicates group (adult or juvenile), and (.) indicates constant. The best approximating model had QAICc = 141.779.

Model averaged results from all models with $w > 0.0$ indicated that annual adult male survival rates varied from 0.341 to 0.363 with an average of 0.351 (SE = 0.052). Annual adult female survival rates varied from 0.338 to 0.359 with an average of 0.347 (SE = 0.043). Annual juvenile male survival rates varied from 0.339 to 0.360 with an average of 0.348 (SE = 0.041). Annual juvenile female survival rates varied from 0.343 to 0.364 with an average of 0.352 (SE = 0.046).

Annual adult male Seber recovery probabilities varied from 0.208 to 0.225 with an average of 0.216 (SE = 0.028). Annual adult female Seber recovery probabilities varied from 0.240 to 0.257 with an average of 0.248 (SE = 0.037). Annual juvenile male Seber recovery probabilities varied from 0.227 to 0.244 with an average of 0.234 (SE = 0.022). Annual juvenile female Seber recovery probabilities varied from 0.206 to 0.223 with an average of 0.214 (SE = 0.023).

Table 3. Survival and Brownie recovery rate estimates (and standard errors) for mottled ducks in Georgia, Texas-Louisiana, and Florida.

Parameter	Georgia	Texas-Louisiana[a]	Florida[b]
Adult Male Survival	0.351 (0.052)	0.578	0.548
Adult Female Survival	0.347 (0.043)	0.469	0.503
Juvenile Male Survival	0.348 (0.041)	0.477	0.909
Juvenile Female Survival	0.352 (0.046)	0.373	0.474
Adult Male Recovery	0.141 (0.019)	0.056	0.046
Adult Female Recovery	0.162 (0.025)	0.042	0.030
Juvenile Male Recovery	0.153 (0.016)	0.095	0.086
Juvenile Female Recovery	0.140 (0.016)	0.075	0.057

a. Source: Johnson 2009
b. Source: Johnson et al. 1995

We then converted Seber recovery probabilities to Brownie recovery rates within Program MARK by changing the data input type to "Dead Recoveries" (Brownie et al. 1985) and let MARK calculate the Brownie recovery rates. The annual adult male Brownie recovery rates varied from 0.136 to 0.146 with an average of 0.141 (SE = 0.019). Annual adult female Brownie recovery rates varied from 0.158 to 0.168 with an average of 0.162 (SE = 0.025). Annual juvenile male Brownie recovery rates varied from 0.149 to 0.159 with an average of 0.153 (SE = 0.016). Annual juvenile female Brownie recovery rates varied from 0.135 to 0.145 with an average of 0.140 (SE = 0.016). Using a reporting rate of 0.73, Brownie recovery rates convert to estimated harvest rates of 0.193 and 0.222 for adult males and females, respectively, and 0.210 and 0.192 for juvenile males and females, respectively. For ease of comparison to past studies, we reported overall average survival and recovery rates by sex and age class (Table 3).

Discussion

Estimated survival rates for Georgia mottled ducks were similar to, but slightly lower than, survival rates for a declining population of mottled ducks in Texas and Louisiana (TX-LA) as reported by Johnson (2009) and lower than survival rates for mottled ducks in Florida as reported by Moorman and Gray (1994) and Johnson et al. (1995) (Table 3). These relatively low survival rates may be reflective of high harvest levels or potentially high predation, possibly from alligators. Elsey et al. (2004) found that 1 in 5 alligator stomachs in LA contained mottled duck remains during the summer. The Rhetts Island unit has one of the highest documented alligator densities in Georgia (Georgia WRD, unpublished data).

Harvest levels also can have an effect on long-term survival rates, and estimated Brownie recovery rates for Georgia mottled ducks were noticeably higher than recovery rates for mottled ducks in TX-LA and in Florida as reported by Johnson (2009) and Johnson et al. (1995) (Table 3). One of the factors affecting recovery rates is hunting season length, and hunting regulations were stable throughout the study period with a 60-day season length and a bag limit of one black (*Anas rubripes*) or one mottled duck. Converting the Brownie recovery rates to harvest rates indicated that mottled ducks in Georgia were harvested at a higher rate than eastern mallards (*Anas platyrhynchos*) (0.141), mid-continent mallards (0.116), western mallards (0.124), and northern pintails (*Anas acuta*) (0.126) as modeled by the U.S. Fish and Wildlife Service under a 60-day hunting season (USFWS 2013).

Low survival rates and high harvest rates would normally be indicative of a declining population, such as the TX-LA population (Johnson 2009); however, mottled duck population indices (aerial surveys) have remained relatively stable on the Altamaha WMA (Georgia WRD, unpublished data); therefore, we are somewhat skeptical of these survival and harvest rate estimates. Our survival and recovery rates may not be truly reflective of the at-large population of mottled duck in Georgia because we conducted banding on Altamaha WMA, where both the mottled duck population and hunter density are greatest in the state. We acknowledge that these factors could have biased our survival rates low and our recovery rates high. We advocate the importance of strategically adding capture locations in the future in Georgia to attain a more representative distribution of banding and recovery data to more precisely estimate survival and recovery. However, if the current estimates of survival and recovery rates are accurate, the Georgia Wildlife Resources Division may have to consider other actions (e.g., increased habitat management, more conservative regulations, etc.) to assist in the long-term conservation of this population.

In addition to having a small banded sample, our dataset was limited by not having live recaptures during the study period and fewer than expected indirect recoveries. It could be that the standard aluminum bands used could not tolerate the brackish water in marshes frequented by mottled ducks. Though we did not have any live recaptures in future banding periods, we did have some live recaptures within banding periods (e.g., caught in July, then re-caught in August of same banding period). We were surprised at the amount of discoloration and tarnishing that occurred within the few weeks between captures. Our field staff had to use small brushes to clean the bands in order to record the band numbers. We have seen this on both mottled ducks and black-bellied whistling ducks (*Dendrocygna autumnalis*) using similar coastal habitats. We are unsure if the tarnishing and discoloration of the bands may have affected the hunter's ability to read the numbers and thus impacted reporting rates. Hard metal bands provide a potential alternative for mottled ducks but evidence is equivocal. Kadlec (1975) could not differentiate recovery rates for herring gulls

(*Larus argentatus*) banded with aluminum, incoloy, or stainless steel bands. Alternatively, Gaston et al. (2013) found that survival rates were less for three species of gulls wearing aluminum versus hard metal bands, and hence suggested that hard metal bands should be used on long-lived species, including some waterfowl. Gaston et al. (2013) also stated that there was no evidence that soft bands lasted longer in freshwater compared to saltwater.

We advocate that an important direction for studies of mottled ducks in Georgia include more geographic representation in banding sites, and more comprehensive studies of habitat use and life history dynamics of mottled ducks. Additionally, the use of hard metal bands on ducks using coastal marsh in the southeastern United States should be explored.

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