Waterfowl and American Coot Habitat Associations with Mississippi Catfish Ponds

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Abstract: Approximately 41,375 ha of catfish ponds in Mississippi attracted as many as 150,000 waterfowl and American coots (*Fulica americana*) during winters in the mid-1980s. We evaluated relationships between numbers of northern shoveler (*Anas clypeata*), ruddy duck (*Oxyura jamaicensis*), scaup (*Aythya affinis, A. marila*), and American coot and habitat features of catfish farms in west-central Mississippi during winters 1983–1986. All species tended to use large clusters of ponds with other ponds nearby. High waterfowl use also occurred on pond clusters near the Mississippi River. Although catfish ponds do not require special management to attract the above species, our results suggested that pond-complex size and relative location within the study area were primary proximate factors influencing waterfowl and coot use. Present strategies to deter piscivorous birds from exploiting catfish may disperse wintering waterfowl and American coots from catfish farms.

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The Mississippi Alluvial Valley (MAV) is an historically important wintering area for diverse communities of waterfowl and other wetland avifauna (Reinecke et al. 1989). Loss and modification of natural wetlands in the MAV, especially hardwood bottomlands, have been extensive. Over 80% of the original 10 million ha of hardwood bottomlands in the MAV has been deforested primarily for agriculture (Forsythe 1985). Moreover, vast acreages of artificial ponds have been constructed recently in southeastern United States largely for production of channel catfish (*Ictalurus punctatus*) and crayfish (*Procambarus* spp.) (Wellborn 1983).

Catfish farming became an industry in Mississippi in the mid-1970s (Wellborn

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1983). Mississippi currently ranks first in the United States in commercial catfish production and area (41,375 ha) of catfish ponds (Brunson and Brown 1991). As many as 150,000 waterfowl and American coots have used Mississippi catfish ponds in winter during the mid-1980s, indicating the importance of these artificial wetlands for these birds (Dubovsky and Kaminski 1987).

In an earlier study, Christopher (1985) used simple correlation analysis to detect a positive relationship between total waterfowl abundance and surface area of catfish-pond complexes in western Mississippi. Additionally, Christopher and Hill (1989) and Dubovsky (1987) tested for associations between waterfowl use of individual catfish ponds and pond characteristics. However, the sampled catfish farms were not randomly selected in these 2 studies. Results and inferences may apply only to the selected farms and ponds and not to the entire region of intensive catfish aquaculture in western Mississippi. Our objective was to test hypotheses about relationships between abundances of wintering waterfowl and coot and habitat characteristics of a random sample of catfish farms distributed throughout a large portion of Mississippi's alluvial valley. Results could provide information of potential value to individuals who, in addition to producing catfish, want to provide habitat for wintering waterfowl.

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Methods

Study Area

The MAV in Mississippi is a relatively flat region bounded on the west by the Mississippi River and on the east by silty loess hills (Pettry and Koos 1980). The study area included parts of Bolivar, Holmes, Humphreys, Leflore, Sharkey, Sunflower, and Washington counties in west-central Mississippi. This area contained >95% of the catfish-pond acreage in Mississippi (Wellborn et al. 1986). Catfish farms ranged in size from 20–850 ha ($\bar{x}$ = 114 ha), and typically consisted of clusters of contiguous rectangular 8-ha ponds (Christopher 1985, Brunson and Brown 1991). Ponds were 1–2 m deep, formed by levees with an approximate slope of 2.5:1 (Christopher 1985).

Aerial Surveys

Christopher (1985) conducted aerial surveys of waterfowl and American coots on catfish ponds during winters 1983–1985. Dubovsky (1987) conducted surveys during winter 1985–1986. Catfish-pond clusters were groups of contiguous ponds separated from other groups by a distance equal to or greater than the width of a 2-lane road (Christopher 1985). Ninety-two, 115, and 99 randomly selected clusters were aerially surveyed during autumn and winter 1983–1984 (N = 19 weekly surveys), 1984–1985 (N = 11 biweekly surveys), and 1985–1986 (N = 12 biweekly surveys), respectively. Aerial surveys were conducted from a Cessna 172 fixed-wing aircraft flown at 100 km/hour and 65 m above ground level using previously described techniques (Dubovsky and Kaminski 1987, Christopher et al. 1988). The survey period extended from October or November through February or March of each winter. In 1984 M. W. Christopher and J. A. Dubovsky independently identified and counted the same waterfowl and American coots simultaneously from an aircraft. Except for American coot ($\bar{x}$ difference = 3.6 coots/cluster), no other differences ($P > 0.05$, paired t-test) in species abundances and total birds were detected between observers (Dubovsky and Kaminski 1987). Because of the similarity in estimates, we used data collected by both observers in our analyses.

Explanatory Variables

We formulated hypotheses for potential relationships between species abundances and catfish-farm habitat features (Table 1). Characteristics of clusters and

Table 1. Acronyms, definitions, and hypothesized relationships between waterfowl abundance and habitat variables of catfish-pond clusters in Mississippi during winters 1983–84 to 1985–86.

Acronym	Definition	Hypothesized relationship
DISTCLUS	Distance (km) from cluster to the nearest pond cluster	−
DISTMR	Distance (km) from cluster to the Mississippi River	−
DISTOWN	Distance (km) from cluster to nearest town with a population >1,000 people	+
DISTRD	Distance (km) from cluster to nearest road	+
INTERSP	Index of pond interspersion = number of ponds in cluster/WATAREA	+
JUXTA	Index of juxtaposition = WATAREA/contiguous shoreline length (km)[a]	+
LAT	Latitude of cluster (to nearest minute)	−
PCTCAT	% of total area within a 1.6-km band around each cluster that was catfish ponds	+
SDI	Shoreline development index = PERIM[b]/$(2\sqrt{3.14*\text{WATAREA}})$[c]	+
SDINDEX	Spatial diversity index = INTERSP*JUXTA	+
SHRLINE	Shoreline length (km)/cluster	+
WATAREA	Surface water area (ha)/cluster	+

[a]Contiguous shoreline was the length (km) of levees in a cluster that contained ponds on both sides.
[b]PERIM = cluster perimeter (km).
[c]Adapted from Wetzel (1975).

surrounding habitats were quantified from county maps and aerial infrared slides provided by the ASCS of landscapes photographed during the summer or fall prior to annual aerial surveys. Slides were available for 82, 107, and 93 clusters for winters 1983–1984, 1984–1985, and 1985–1986, respectively.

Dependent Variable and Statistical Analyses

Northern shoveler, ruddy duck, scaup, and American coot comprised 79%–93% of all birds annually observed on catfish ponds (Dubovsky and Kaminski 1987). Thus, analyses were restricted to these species, using their yearly mean number on sampled clusters as a dependent variable of species relative abundance. Additionally, seasonal averages were used to avoid correlation among successive counts of birds on the same clusters during winter.

We tested hypotheses invoking a correlational approach because catfish farms and ponds could not be experimentally manipulated. Stepwise multiple regression (SAS Inst., Inc. 1982) was used to test for associations between species abundances and independent habitat variables. Separate regression analyses were conducted for each species within each winter. Collinearity among habitat variables was assessed using simple correlation analysis (Zar 1974) and by examining variance inflation factors (VIF) of the regression models (Kleinbaum et al. 1988). To calculate VIF, the squared multiple correlation (R_j^2) is found by regressing the j^{th} independent variable on the remaining independent variables. Then, the VIF for each independent variable is calculated by $VIF_j = 1/(1-R_j^2)$. One variable of any correlated ($r \geq 0.70$) pair of variables was omitted from regression analyses (Kim and Kohout 1975, Kaminski and Prince 1984). A VIF $\geq$10 suggested collinearity (Kleinbaum et al. 1988). Significance was set at $P < 0.10$.

Results

VIF's of the regression models ranged from 1.00–1.57, indicating sufficient independence among habitat variables. All multiple regression models were significant ($0.0001 \leq P \leq 0.0002$) and retained 1–4 independent variables (Table 2). Models explained 15%–76% of the yearly variation in species abundance.

Abundances of northern shoveler, ruddy duck, scaup, and American coot were associated positively with surface water area (WATAREA) of clusters in 1984–1985 and 1985–1986. This variable also generally had the highest standardized partial regression coefficients (SPRC) and the highest partial r^2 values. Percent of surrounding habitat in catfish ponds (PCTCAT) also positively correlated with cluster use by all species in ≥1 winter. In 1983–1984, shoreline length (SHRLINE) had the highest positive SPRC and partial r^2 values for all species.

Except for northern shoveler, abundances of other species were negatively associated with distance to the Mississippi River (DISTMR) in ≥1 winter. Abundances of all duck species were inversely associated with cluster latitude (LAT) in 1985–1986 and with indices of catfish-pond structural diversity (SDI, SDINDEX) in 1983–1984 and/or 1984–1985.

Table 2. Standardized partial regression coefficients (β), partial correlation coefficients (r^2), and multiple correlation coefficients (R) for habitat variables related to abundances of 3 duck species and American coots observed on Mississippi catfish ponds during winters 1983–84 to 1985–86.

Species	Independent variables[a]	1983–84 (N = 82)[b]		1984–85 (N = 107)		1985–86 (N = 93)	
		β	r^2	β	r^2	β	r^2
Northern shoveler	WATAREA	[c]		0.65	0.41	0.43	0.41
	SHRLINE	0.84	0.48				
	SDINDEX	−0.26	0.05				
	SDI			−0.12	0.02		
	LAT					−0.31	0.06
	PCTCAT					0.18	0.03
		R^d = 0.73		0.65		0.71	
Ruddy duck	WATAREA			0.59	0.41	0.50	0.59
	PCTCAT	0.15	0.02	0.13	0.02	0.14	0.02
	SDI	−0.14	0.02	−0.13	0.02		
	DISTMR			−0.20	0.04	−0.14	0.02
	SHRLINE	0.81	0.41				
	SDINDEX	−0.32	0.08				
	LAT					−0.40	0.09
		R = 0.73		0.69		0.85	
Scaup	WATAREA			0.61	0.38	0.46	0.38
	PCTCAT	0.14	0.02			0.15	0.02
	SHRLINE	0.78	0.43				
	DISTMR	−0.17	0.03				
	SDINDEX	−0.28	0.06				
	LAT					−0.22	0.03
		R = 0.74		0.62		0.66	
American coot	WATAREA			0.32	0.12	0.33	0.13
	SHRLINE	0.63	0.39				
	DISTMR			−0.18	0.03		
	DISTRD					0.72	0.61
	PCTCAT					0.15	0.02
		R = 0.63		0.39		0.87	

[a] Defined in Table 1.
[b] N = *Number of clusters*
[c] Blanks denote nonsignificant ($P > 0.10$) variables.
[d] Multiple correlation between waterfowl abundance and variables retained by stepwise regression.

Discussion

Significant correlates of waterfowl and American coot abundance on Mississippi catfish ponds could be generalized into the following 3 categories: (1) cluster area (WATAREA, PCTCAT, SHRLINE), (2) cluster location (DISTRD, DISTMR, LAT), and (3) habitat structural diversity (SDI, SDINDEX). Except for structural diversity, associations of waterfowl and American coots with other variables generally were consistent with our hypotheses, but relationships were not significant in all years. We realize that correlations may not indicate causal relationships (Romesburg 1981; Wiens and Rotenberry 1981; Rexstad et al. 1988, 1990; but see Taylor 1990). Moreover, data on animal abundance without demographic data may not reflect habitat quality (Van Horne 1983). Therefore, we suggest the following preliminary interpretations for observed bird-habitat associations.

Abundances of the 4 species were positively correlated with WATAREA and PCTCAT. WATAREA often had the highest SPRC and partial r^2 values, indicating that it had the greatest influence on explaining variation in species' abundances. Catfish ponds in close proximity to surveyed clusters may appear to waterfowl and American coots as contiguous habitats. Wetland area has been correlated with habitat use by breeding (Kaminski and Weller 1992), migrating (LaGrange and Dinsmore 1989), and wintering waterfowl (Hobaugh and Teer 1981, Guthery et al. 1984, Christopher 1985). These results suggest a cross-seasonal pattern of increasing duck and coot use with increasing wetland area.

SHRLINE had the highest SPRC and partial r^2 values in winter 1983–1984. Precipitation was greater in winter 1983–1984 than in 1984–1986 (Dubovsky and Kaminski 1987). Increased precipitation and pond water levels during winter 1983–1984 increased inundation of shallow shoreline zones and vegetation, which may have enhanced availability of aquatic invertebrates for foraging ducks and coots. Dubovsky (1987) found that invertebrate densities were generally greater along catfish-pond shorelines than centrally within ponds.

LAT was negatively associated with abundance of all waterfowl in 1985–1986. Humphreys County, located in the southern portion of the study area, had the highest acreage of ponds (Christopher et al. 1986). Further, many clusters were situated close to each other. Therefore, waterfowl use may not be related to catfish-pond latitude *per se*. Instead the relationship may have been an artifact of high densities of pond clusters in Humphreys County.

DISTMR was inversely related to abundance of all species except northern shoveler. The Mississippi River is an important avian migration corridor. Clusters near the Mississippi River may be more easily found by water birds than clusters more distant. This inverse relationship seemed consistent with a prediction of island-biogeography theory (MacArthur and Wilson 1967). Perhaps large clusters near the river functioned like large islands near mainlands, which tend to have more abundant and diverse avifauna than small distant islands. Insular waterfowl species also exhibit distribution patterns consistent with biogeography theory (Weller 1980:44–48).

Contrary to our predictions, SDINDEX and SDI were negatively associated with waterfowl use. We are unable to explain these results.

Management and Research Implications

Mississippi catfish ponds are providing increasing acreage of permanent wetlands for migrating and wintering waterfowl, especially diving ducks, northern shovelers, and American coots (Dubovsky and Kaminski 1987, Christopher et al. 1988, Reinecke et al. 1989). Manipulation of habitat variables measured in this study (e.g., amount of levees, placement of roads) may not be required to attract these species because farm size, amount of surrounding catfish pond acreage, and relative locations of farms within the study area were primary correlates of bird use. However, dabbling ducks (Anatini), wood ducks (*Aix sponsa*), and geese (Anserini) were rarely observed on catfish ponds (Dubovsky 1987, Christopher et al. 1988), suggesting that catfish ponds may not supply habitat needs of these species. Therefore, complexes of natural wetlands, flooded cropland, and cool-season grasslands should be conserved to provide habitat for these waterfowl in the MAV (Reinecke et al. 1989).

Recently, wintering populations of piscivorous, double-crested cormorants (*Phalacrocorax auritus*) have increased dramatically on Mississippi catfish ponds and in the MAV (Hodges 1989, Dolbeer 1991). Farmers and federal animal-control personnel use various methods to disperse cormorants and wading birds from ponds (Stickley and Andrews 1989). Although catfish ponds seemed to provide undisturbed wintering habitat for waterfowl (Christopher and Hill 1989) during the 1970s and mid-1980s, that may no longer be the case. Future associations between habitat features of catfish ponds and abundances and distributions of waterfowl and American coot may be affected by this harassment.

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