Inter-observer Variability in Wading Bird Survey Data

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Abstract: Evaluating the contribution of wading bird populations to avian biodiversity and wildlife managers' ability to maintain viable wading bird populations requires accurate information on population levels and trends. Wading bird population surveys often use multiple observers in single or over multiple years, but inter-observer variability is seldom evaluated. We conducted a study to test for significant inter-observer variability among experienced biologists and to determine the impact of variability on biologists' ability to accurately survey colonies and to monitor statewide trends in colonial wading bird populations. Inter-observer variability was not significantly different, but statistical power was low. Based on the results of this study, we believe that an analysis of inter-observer variability should be a component of any wading bird survey that includes multiple observers in single or over multiple years.

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Colonially-nesting wading birds (i.e., herons, storks, ibises, and spoonbills; Order: Ciconiiformes) are conspicuous components of wetland ecosystems. As such, they have attracted the attention of wildlife conservationists since descriptions by early naturalists of their 19th century population levels (e.g., see review by Frohring et al. 1988). Wading birds have been proposed as biological indicators of the health of aquatic systems (Custer and Osborn 1977) and are important components of local, regional, and national avifaunas. Maintaining viable wading bird populations is important to maintaining aquatic avian biodiversity. However, evaluating the contribution of wading bird populations to avian biodiversity and wildlife conservationists' ability to maintain viable wading bird populations requires accurate information on population levels and trends.

Many wading bird species in Florida have exhibited regional or statewide declines in nesting populations, shifted to more northern nesting locations, or shown a reduction in the size of their breeding colonies (Robertson and Kushlan 1974; Kushlan and White 1977; Ogden 1978, 1991; Nesbitt et al. 1982; Frederick and Collopy 1988; Frohring et al. 1988; Powell et al. 1989; Runde 1991; Runde et al. 1991; David 1994*a,b*). For example, south Florida nesting populations have decreased by perhaps as much as 95% since the 1800s (Kushlan and White 1977). Because of their importance in maintaining Florida's overall avian diversity, apparent population declines, and the need for additional and more reliable population data, Millsap et al. (1990) and Gore et al. (1991) identified wading birds as a priority group of species for conservation action, including continued population monitoring.

Numerous wading bird population surveys have been conducted in Florida and elsewhere. Techniques have included ground and aerial approaches (King 1978) utilizing single counts at individual sites with different observers among sites in single or over multiple years. Monitoring the population levels of up to as many as 15 species in mixed-species colonies over vast wetland habitats is a difficult undertaking because of the time and resources required (Kushlan and White 1977). Consequently, annual surveys with a single observer or surveys across years with the same observer(s) are usually impossible. Inter-observer biases in these surveys can result from differences in visual acuity, alertness, experience, and knowledge (Verner 1985). Analyses of population trend data should, therefore, include an evaluation of inter-observer variability. However, although wading bird population surveys using multiple observers in single or over multiple years are common, inter-observer variability is seldom evaluated (Custer and Osborn 1977; Kushlan and White 1977; Blacklock et al. 1978; Ogden 1978; Portnoy 1978; McCrimmon 1981; Nesbitt et al. 1982; Paul and Woolfenden 1982; Dallinga and Schoenmakers 1987; Dusi and Dusi 1987; Powell 1987; Powell et al. 1989; Hoffman et al. 1990; Runde 1991; Brooker 1993; David 1994*a,b;* Waters and Cayford 1994). Typically, inter-observer variability has simply been assumed to be negligible (e.g., Rodgers et al. 1995).

To determine the implications of inter-observer variability on past (Nesbitt et al. 1982, Runde 1991) and future statewide wading bird surveys, we conducted a study to evaluate the variability in counts of nests, chicks, and adults in a wading bird colony in Leon County, Florida. Our objectives were to test for inter-observer variability among experienced biologists and to determine the effect of variability on their ability to accurately survey colonies and monitor statewide trends in colonial wading bird populations.

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Methods

During the 1994 and 1995 breeding seasons, we surveyed nesting wood storks (*Mycteria americana*) and great egrets (*Casmerodius albus*) in wading bird colony #592003 (Nesbitt et al. 1982, Runde et al. 1991) located in Leon County, Florida (30° 32.0′ latitude 84° 22.9′ longitude). Nesting in this 1-ha colony was in black gum (*Nyssa sylvatica*). The forested wetland used as nesting substrate formed a peninsula extending into a small lake. The colony was visible from a CSX railroad right-of-way surrounding >50% of the wetland.

From 19 April–29 June 1994, the total number of nests, adults, and hatchlings of each species was counted weekly by 1–3 observers. The total number of nests, adults, and hatchlings of each species was counted on 3 May, 19 May, and 8 June 1995 (see Tables 1 and 2 for sample sizes). Counts were simultaneously recorded by observers from the railroad right-of-way with no interaction among observers until each survey was completed. Access via the railroad right-of-way allowed for collection of survey data without disturbing nesting birds. All surveys were conducted between 0900 and 1200 hours EST using binoculars and spotting scopes. To minimize observer expectancy bias, data were not compiled until all weekly surveys were completed in 1994 and until all surveys were completed in 1995. Compared to sampling conditions at wading bird colonies previously sampled in Florida, we considered this to be an "easy" colony from which to collect ground survey data. Therefore, we assumed that the implications of inter-observer variability to evaluation of ground survey data from this colony would represent a theoretical minimum for colonies to be sampled in future statewide wading bird surveys.

Our analyses included an ANOVA (SAS Inst. 1990) of nest, adult, and nestling counts among observers by species within years. Analyses of nest

Table 1. The mean number of nests, hatchlings, and adult wood storks and great egrets counted by 3 observers at a wading bird rookery (#592003), Leon County, Florida, 1994.

Species	Variable	Observer	Mean	N^a	cv[b]	f^c	$1 - \beta^d$
Wood stork	nests	A	91	5	11.2		
		B	90	6	9.1		
		C	79	4	19.5	0.46	46%
	hatchlings	A	85	6	72.4		
		B	75	7	63.2		
		C	129	4	20.2	0.42	40%
	adults	A	94	4	3.7		
		B	96	4	13.5	0.08	11%
Great egret	nests	A	7	4	20.7		
		B	9	6	15.8		
		C	8	3	25.0	0.39	28%
	hatchlings	A	5	6	51.9		
		B	5	7	58.1		
		C	4	4	35.4	0.22	18%
	adults	A	9	6	22.1		
		B	10	7	30.9		
		C	12	4	27.0	0.29	27%

[a]N = number of replicate counts.
[b]cv = coefficient of variation.
[c]f = effect size index (Cohen 1988) used in calculations of statistical power.
[d]$1 - \beta$ = statistical power at $\alpha = 0.10$.

Table 2. The mean number of nests, hatchlings, and adult wood storks and great egrets counted by 3 observers at a wading bird rookery (#592003), Leon County, Florida, 1995.

Species	Variable	Observer	Mean	N[a]	cv[b]	f[c]	$1 - \beta$[d]
Wood stork	nests	A	120	3	1.3		
		B	128	3	22.0		
		C	119	2	23.1	0.17	14%
	hatchlings	A	167	3	54.7		
		B	144	3	71.9		
		C	129	2	68.1	0.21	15%
	adults	A	113	3	71.6		
		B	93	3	39.6		
		C	66	2	53.5	0.31	21%
Great egret	nests	A	14	3	44.8		
		B	12	3	41.6		
		C	18	2	7.6	0.42	30%
	hatchlings	A	14	3	71.3		
		B	10	3	29.6		
		C	14	2	4.9	0.29	19%
	adults	A	13	3	65.5		
		B	14	3	55.9		
		C	17	2	12.1	0.23	16%

[a] N = number of replicate counts.
[b] cv = coefficient of variation.
[c] f = effect size index (Cohen 1988) used in calculations of statistical power.
[d] $1 - \beta$ = statistical power at $\alpha = 0.10$.

(wood storks: 17 May–16 June 1994; great egret: 9 May–16 June 1994), adult (wood storks: 9 May–31 May 1994; great egret: 9 May–29 June 1994), and nestling (wood storks and great egrets: 9 May–29 June 1994) counts corresponded to the period of stable nest and adult detectability (i.e., nest initiation completed and at least 1 nestling still remaining in nest, and nest initiation completed and at least 1 adult continuously at the nest, respectively). Data were only collected in 1995 during this period of stable detectability. An equality of variance test and a paired t-test on the coefficients of variation were used to test for differences in variance among observers within years and by observer among years. Cumulative means and coefficients of variation of 1994 wood stork nest data were used to evaluate the effect of increasing sample size on precision and accuracy of mean counts. Power analyses for statistical tests were conducted following techniques described by Cohen (1988).

Results and Discussion

Individual and mean counts of wood stork and great egret nests, adults, and hatchlings varied among observers (Tables 1, 2). None of the comparisons between observers in mean variable values, however, were significant in 1994 or 1995 ($P > 0.2$; Tables 1, 2). Generally, variance (expressed as the coefficient of variation) in replicate variable counts by individual observers was high, effect size indices (Cohen 1988) were low, and sample sizes (i.e., the number of replicate surveys by each observer) were low (Tables 1, 2). Consequently, the statistical power of inter-observer mean comparisons in both 1994 and 1995 was low ($\leq$0.46) and our ability to detect significant differences was minimal.

In 1994 and 1995, inter-observer variance in wood stork and great egret nest, adult, and hatchling counts was not significantly different (equality of variance test, $P > 0.12$ and 0.14, respectively). Five of 17 individual comparisons of variance (expressed as coefficients of variance in Tables 1 and 2) in wood stork and great egret nest, adult, and hatchling counts for each observer between 1994 and 1995 were significant (wood stork nests—observer B; wood stork hatchlings—observer C; great egret nests—observers B and C; great egret adults—observer A; equality of variance test, $P < 0.01$). Except for the difference in variance in great egret nest counts by observer C between 1994 and 1995, all significantly different variances were higher in 1995. Overall, coefficients of variation were not significantly different between 1994 and 1995 (paired *t*-test, $P = 0.12$), but the power of this test was low (i.e., 0.24). Cumulative means and coefficients of variation for individual observers did not change significantly ($P > 0.05$) with > 2 replicates (Fig. 1).

Although differences in mean counts among observers was not significantly different, variation in individual observer counts could have resulted in inaccurate nesting data if replicate surveys had not been conducted. For an endangered species like the wood stork, some individual counts (e.g., 107 versus 66 nests as recorded by observers A and C, respectively, on 31 May 1994) would result in significant differences in estimating the nestling production of individual colonies or the species' population recovery rate for a region. Annual means from multiple counts for each observer in this study were, however, similarly accurate. When absolute numbers are to be estimated (e.g., nests, adults, or hatchlings), a survey must be designed to maximize accuracy even if it is at the expense of precision (Caughley 1974). Our results agree with those of Kushlan and Frohring (1985): single annual counts at wading bird colonies are insufficient to survey populations and do not maximize accuracy.

Our study data also support previous findings that the timing of wading bird colony surveys is critical and that only surveys conducted on the schedule of each individual colony, and species in the colony, will yield sufficiently accurate information (Kushlan and Frohring 1985). In wading bird colonies, there is seasonality in nesting within and between years (Kushlan and White 1977, Dusi and Dusi 1987, David 1994*a*) and variations in yearly nesting populations due to changing habitat conditions (Hoffman et al. 1990). Although we surveyed this colony in 1994 from the onset of nesting well into the fledging period, analyses in both years were conducted only on data temporally meeting the same sampling assumptions (e.g., closed populations and equal detection probabilities). Surveys outside peak breeding violate these assumptions and will underestimate colony size (Blacklock et al. 1978, Milton and Austin-Smith 1983). We believe the implications of inter-observer variability on count data of wading

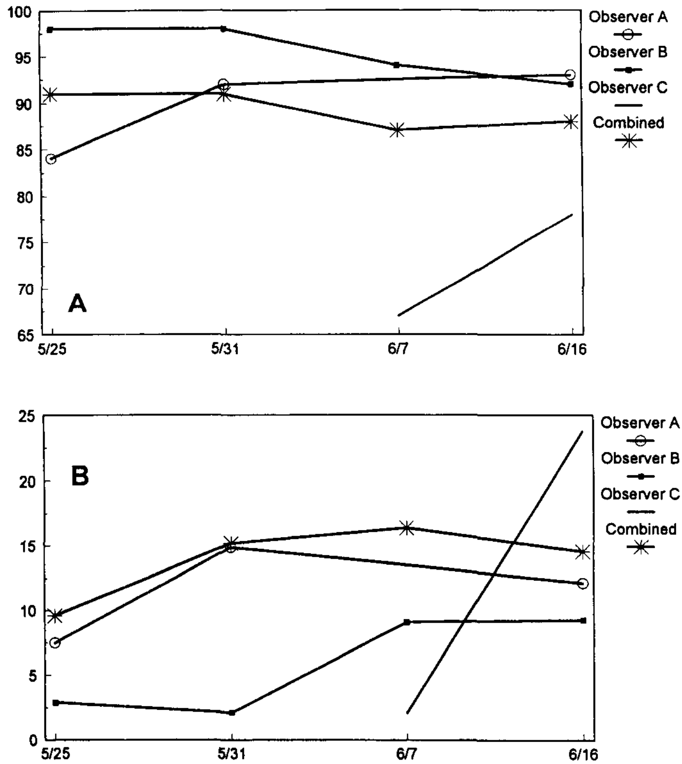

Figure 1. Cumulative mean (A) and coefficient of variation (B) of wood stork nests counts in 1994 at wading bird colony #592003, Leon County, Florida.

birds and nests would be greatest during these off-peak periods because of behavioral differences in adult birds and greater differences among observers in detection probabilities of the nests. For example, during peak nesting, wood stork nests can be clearly identified by either having an adult, nestling, or an adult and nestling on the nest. Outside of the peak nesting period, the stability of these visual cues is uncertain. In addition, surveys outside of the peak nesting period would result in larger coefficients of variation in replicate counts by individual observers.

Wildlife scientists charged with managing wading bird populations and habitats in Florida occasionally repeat regional or statewide wading bird surveys in an attempt to document colony site locations and monitor population trends. There have been 3 attempts to survey statewide wading bird colonies in Florida: 1) between 1957 and 1959 by the Florida Audubon and National Audubon societies, with the cooperation of the FGFWFC and the U.S. Fish and Wildlife Service (USFWS); 2) in 1975 and 1976 by the Florida Audubon and National Audubon societies and the FGFWFC, sponsored by the USFWS; and 3) 1987 through 1989 by the FGFWFC (Ogden 1978, Runde et al. 1991).

Too often, however, surveys are conducted that cannot be statistically compared to previous surveys (David 1994*b*). Examples include comparison of results reported by Milton and Austin-Smith (1983) to those of Lock and Ross (1973) and results reported by Runde (1991) to those of Nesbitt et al. (1982). One of the elements that prevents statistical comparisons of repeated surveys is a lack of inter-observer variability analyses.

Only the most rigorous and comparable surveys should serve as a basis for trend analyses and management of wading bird populations (Frohring et al. 1988). Based on the results of this study, we believe that an analysis of inter-observer variability should be a component of any wading bird survey that includes multiple observers in single or over multiple years. Portnoy (1978) found that aerial estimates of great egrets by 2 experienced observers usually were within 10% of each other. Morton et al. (1993) addressed inter-observer variability by recognizing statistical differences only when results from all observers were significant. We suggest that pilot studies quantifying inter-observer variability be conducted prior to large-scale wading bird surveys and that results for individual observers be used to compensate of observer bias. Pilot studies should also be used to determine the variance in counts at individual colonies and these variance estimates should be used to determine the number of annual replicates needed for addressing specific monitoring objectives. Replicate counts should be used to minimize the effects of inter-observer variability on the accuracy of wading bird surveys.

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