J. Field Ornithol., 56(3):258–264

A COMPARISON OF INTERVAL AND CONTINUOUS SAMPLING METHODS FOR BEHAVIORAL OBSERVATIONS

By Thomas C. Tacha, Paul A. Vohs, and George C. Iverson

Behavioral analysis is an important component of modern field ornithology. Frequency of occurrence, duration, and percent of time spent exhibiting behavior have specific values in ethological studies (Altmann 1974). The type of behavioral analysis depends on the study objectives. Avian behavioral studies often relate percent allocations of time exhibiting specific behavioral patterns to habitats (e.g., Weins 1969, Seigfried 1974); time of day or year (e.g., Verner 1965, Schartz and Zimmerman 1971); age, sex, and social or reproductive status (e.g., Dwyer 1975, Tacha 1981a); or energy expenditures (e.g., King 1974, Kendeigh et al. 1977, Fredrick and Klaas 1982). Most avian behavioral studies use some form of interval or continuous sampling method. Our purpose is to quantitatively demonstrate important differences among these more commonly used behavioral sampling methods, and to provide some basic guidelines to consider when selecting methods.

Many different methods are available to record, describe, quantify, and analyze animal behavior (see Hutt and Hutt 1970, Weins et al. 1970, Altmann 1974, Hazlett 1977, Lehner 1979). For example, a study may sample all occurrences of specific action patterns, or sample all or selected behavior of individuals or groups. Sampling may begin and end with a specific behavior, a specific time of day, or at random. Duration of observations may be defined by length of a specific behavior of interest, the time a focal individual or group is available, or by predetermining length of observations. Within an observation period, behavior may be recorded continuously, or at specified intervals. Our study compares continuous and interval sampling methods, using fixed-length behavioral observations of individual Sandhill Cranes (*Grus canadensis*). Specifically, we document the effects of interval length and sample size (number of observation periods) on bias and precision of estimates of the percentage of time spent exhibiting behavioral patterns of varying frequency of occurrence and average duration.

METHODS

A repertoire of 34 mutually exclusive behavioral patterns provided a basis for time budgets of Sandhill Cranes (Tacha 1981a). These included 4 forms of agonism, 8 of courtship, 1 alert, 2 preflight, 5 preening, 3 stretching, 2 sleeping, 2 loafing, 3 locomotion, and 4 foraging. The percentage of time devoted to each pattern was calculated for each observation period. Behavior was recorded continuously from individual Sandhill Cranes during 327 20-min observation periods in March and early April 1980 in the Platte River Valley near Hershey, Nebraska (see

Tacha 1981a). Distribution of observation periods included all major habitat types used by cranes during all daylight hours; stratification by age groups ensured adequate sampling of young-of-the-year. A subsample of 97 observation periods was later selected at random to evaluate the effect of sample size. Behavioral patterns were recorded to the nearest full second when continuous observations were transcribed from tapes to coding sheets for subsequent computer analyses.

The 34 behavioral patterns were categorized by frequency and average duration. Patterns observed in less than 10% of observation periods were considered rare, 11–50% were considered moderately frequent, and >50% were considered common. Patterns with an average duration of less than 10 s were considered short, 11–60 s were moderate duration, and >60 s were considered long.

Interval observations were obtained from each of the 327 observation periods by using a computer program to tabulate behavior occurring at specified intervals (e.g., 10 s) within each 20-min observation period. Use of 10-s intervals resulted in 120 observations from each 20-min (1200-s) period. The percentage occurrence of each behavior within a period was then calculated and used as an estimate of the percentage of time spent exhibiting each behavior (after Altmann 1974). Completed compilations for each observation period provided 7 estimates of the percent of time spent exhibiting each of 34 behavioral patterns; one estimate from the original continuous observations, and one for each of 6 different interval lengths (i.e., 10-, 12-, 15-, 20-, 30-, and 60-s intervals).

Intervals of 10, 12, 15, 20, 30, and 60 s were the most common found in avian behavioral literature. For example, Weins et al. (1970) sampled bird behavior at 10-s intervals, but intervals of up to 60-s have been used (e.g., Verner 1965, Tacha 1981b).

The Statistical Analysis System (Helwig and Council 1979) was used for data analyses. Frequency distributions allowed detection of behavior recorded by continuous observations but not recorded by intervals. Paired *t*-tests were used to test for differences between interval and continuous observations in the mean percentage of time calculated for each behavior. Standard *F*-tests compared variance estimates from interval and continuous observations.

RESULTS AND DISCUSSION

Unrecorded behavior.—Between 1 and 9 of the 34 behavioral patterns observed in continuous observations were not detected in interval observations (Table 1). Patterns not detected in interval observations were generally rare and of short duration. Longer intervals increased the number of behavioral patterns missed.

Reducing the number of observation periods from 327 to 97 doubled the number of patterns missed by interval observations (despite their presence in the 97 continuous observation periods), and patterns of moderate frequency and duration were missed when 30- and 60-s in-

TABLE 1. Number of categories of behavior present using continuous observations of Sandhill Cranes that were not recorded by interval observations.

No. of observation periods	Frequency and duration of behavior[a]	No. of categories available using continuous observations	Interval length (s)					
			10	12	15	20	30	60
327	Frequency							
	Rare	21	1	2	2	0	3	4
	Moderate	9	0	0	0	0	0	0
	Common	4	0	0	0	0	0	0
	Duration							
	Short	18	1	2	2	1	3	4
	Moderate	9	0	0	0	0	0	0
	Long	7	0	0	0	0	0	0
97	Frequency							
	Rare	21	2	2	4	4	7	8
	Moderate	9	0	0	0	0	0	1
	Common	4	0	0	0	0	0	0
	Duration							
	Short	18	2	2	4	4	6	8
	Moderate	9	0	0	0	0	1	1
	Long	7	0	0	0	0	0	0

[a] Frequency of occurrence of behavior using continuous observations where rare ≤ 10%, moderate = 11–50%, and common > 50%. Mean duration of behavior using continuous observations was classified as short ≤ 10 s, moderate = 11–60 s, and long > 60 s.

tervals were used (Table 1). Nine behavioral patterns were missed when n = 97 and 60-s intervals were used. Although the 9 patterns represented 26% of the behavioral repertoire and 44% of the rare and short duration patterns, they accounted for only 0.1% of the total time.

If the purpose of behavioral observations was (for example) to calculate energy expenditures, the 9 missing patterns would make little difference because they cumulatively accounted for so little time. However, if the purpose was to trace social relationships then 60-s intervals and 97 observation periods were inadequate because important social behavior was missed. The 4 agonistic patterns and 8 courtship patterns of Sandhill Cranes were recorded using continuous observations with n = 327, but all 4 agonistic and 7 of 8 courtship patterns were missed with n = 97 and 15-, 30-, or 60-s intervals (9 of the 11 were missed with 60-s intervals). The 7 courtship patterns undetected with small sample sizes and interval observations were rare and of short to moderate duration, but were essential to pair formation.

Bias of interval observations.—Interval observations both overestimated

TABLE 2. Bias associated with interval observations when compared with continuous observations of Sandhill Cranes. Table entries are the number of behavioral categories where interval observations significantly (paired t-tests, $P < .05$) overestimated (+) or underestimated (−) the mean percentage of time obtained from continuous observations.

No. of observation periods	Frequency and duration of behavior[a]	Interval length (s)					
		10	12	15	20	30	60
	Frequency						
	Rare	1−	1−	0	1−	1−	1−
	Moderate	0	0	0	0	1−	2+
	Common	0	0	0	0	0	0
327							
	Duration						
	Short	1−	1−	0	1−	1−	1−
	Moderate	0	0	1−	0	1−	0
	Long	0	0	0	0	0	2+
	Frequency						
	Rare	1 + 1−	1+	1−	2−	0	1−
	Moderate	0	0	2 + 1−	1+	1+	1 + 1−
	Common	0	0	1−	0	0	0
97							
	Duration						
	Short	1+	1+	1 + 2−	1−	0	2−
	Moderate	1−	0	1−	1−	0	0
	Long	0	0	1+	1+	1+	1+

[a] See footnote to Table 1.

and underestimated ($P < .05$) the percentage of time spent in exhibition of various behavioral patterns (Table 2). Significant ($P = .05$) differences can be expected for 1 of every 20 patterns due to random chance. The frequency of significant differences ($P < .05$) in Table 2 approximates random chance. However, the direction of bias was associated with the frequency and duration of behavior, and twice the number of biased estimates accrued when n was reduced from 327 to 97. Interval observations tended to underestimate the percentage of time for rare and short and moderate duration behavior, and overestimate behavior of moderate frequency and long duration. For example, preening the wings was a rare behavior of moderate duration that interval observations underestimated by half. Sleeping while standing was a moderately frequent behavior of long duration that interval observations (n = 327, 60-s interval) overestimated by about 5%. Frequency of occurrence and duration of behavior should be considered when combining categories for use with interval observations. Use of behavioral categories that contain only rare and short duration behavior could bias results.

Precision of interval observations.—Estimates from interval observations of the percent time spent exhibiting different behavioral patterns were consistently less precise than estimates from continuous observations

TABLE 3. Fraction[a] of behavioral categories where variance estimates from interval observations were significantly (F-tests, $P < .05$) higher than variance estimates from continuous observations of Sandhill Cranes.

No. of observation periods	Frequency and duration of behavior[b]	Interval lengths (s)					
		10	12	15	20	30	60
327	Frequency						
	Rare	12/20	13/19	14/19	15/20	12/18	13/17
	Moderate	2/9	1/9	2/9	2/9	2/9	2/9
	Common	0/4	0/4	0/4	0/4	0/4	0/4
	Duration						
	Short	13/17	13/16	14/16	16/17	12/15	12/14
	Moderate	1/9	1/9	2/9	1/9	2/9	3/9
	Long	0/7	0/7	0/7	0/7	0/7	0/7
97	Frequency						
	Rare	8/19	11/19	8/17	8/17	9/14	9/13
	Moderate	2/9	2/9	2/9	2/9	2/9	1/8
	Common	0/4	0/4	0/4	0/4	0/4	0/4
	Duration						
	Short	10/16	12/16	8/14	10/14	10/12	8/10
	Moderate	0/9	1/9	2/9	0/9	1/8	2/8
	Long	0/7	0/7	0/7	0/7	0/7	0/7

[a] Number of categories/number available.
[b] See footnote for Table 1.

(Table 3). Variance estimates from interval observations were significantly ($P < .05$) higher for 60–75% of rare and 11–33% of moderately frequent behavioral patterns, and for 62–82% of short and 0–33% of moderate duration patterns. Variance estimates from interval and continuous observations were similar ($P > .60$) for common and long duration patterns. Generally, as interval length increased, the percent of patterns with inflated variance estimates increased. The reduction from n = 327 to 97 had little effect on precision of estimates from interval observations.

The high variance estimates of interval observations reduced our ability to detect differences in mean percent of time spent exhibiting a behavior between ages, sexes, habitats, or other variables of interest. For example, the percent of time spent exhibiting each of the 7 courtship patterns was significantly different ($P < .05$) between adult and juvenile Sandhill Cranes using continuous observations, but no difference ($P > .15$) between adults and juveniles was found for any of the courtship patterns when even 10-s intervals (n = 327) were used. Inability to detect differences in time allocations could severely restrict interpretation of time budget data.

SUMMARY AND CONCLUSIONS

Continuous and interval sampling methods were compared using 327 and a subsample of 97 twenty min observation periods of Sandhill Cranes. Interval observations did not record up to 26% of rare and brief behavioral patterns, and tended to underestimate the percent of time spent exhibiting the remaining rare and brief patterns and to overestimate patterns of moderate frequency and long duration. Interval observations also provided estimates of percentage of time that were consistently less precise than continuous observations. As interval length increased, more rare and short duration behavior was missed, and the proportion of patterns with inflated variance estimates increased. Reduction in sample size from 327 to 97 interval observation periods resulted in doubling the number of rare and brief behavioral patterns missed.

Biologists should select between continuous or interval observations based on study objectives. Continuous observations are required for studies where comparisons of absolute frequency occurrence or duration of behavior are important. Continuous observations are more valuable than interval observations for studies that involve behavioral categories that are of an average duration less than twice the interval length used or are rare in frequency of occurrence. Continuous observations are also more valuable for studies where any comparison among variables of the percentage of time spent exhibiting specific behavioral patterns is made. However, our experience suggests that continuous observations require more complicated decoding and analysis than interval observations.

ACKNOWLEDGMENTS

We thank M. E. Heitmeyer for reviewing this manuscript and W. D. Warde for assistance with statistical analyses. This study was funded by Contract 14-16-0008-2133, Accelerated Research Program for Migratory Shore and Upland Game Birds, administered by the Central Management Unit Technical Committee and the Migratory Bird and Habitat Research Laboratory, U.S. Fish and Wildlife Service. Additional funding was acquired from the Migratory Bird Habitat Research Laboratory (USFWS), the Oklahoma Cooperative Wildlife Research Unit, Oklahoma State University, and the National Wildlife Federation. The Oklahoma Cooperative Wildlife Research Unit has Oklahoma State University, Oklahoma Department of Wildlife Conservation, U.S. Fish and Wildlife Service, and Wildlife Management Institute cooperating.

LITERATURE CITED

ALTMANN, J. 1974. Observational study of behavior: sampling methods. Behavior 49: 227–265.

DWYER, T. J. 1975. Time budget of breeding Gadwalls. Wilson Bull. 87:335–343.

FREDRICK, R. B., AND E. E. KLAAS. 1982. Resource use and behavior of migrating Snow Geese. J. Wildl. Manage. 46:601–614.

HAZLETT, B. A. (ED.). 1977. Quantitative methods in the study of animal behavior. Academic Press, New York.

HELWIG, J. T., AND K. A. COUNCIL (EDS.). 1979. SAS User's Guide, SAS Inst., Raleigh, NC.

HUTT, S. J., AND C. HUTT. 1970. Direct observation and measurement of behavior. Charles C Thomas Co., Springfield. 224 pp.

KENDEIGH, S. C., V. R. DOL'NIK, AND V. M. GAVRILOV. 1977. Avian energetics. Pp. 127–204, *in* J. Pinowski and S. C. Kendeigh, eds. Granivorous Birds in Ecosystems. Cambridge Univ. Press, New York.

KING, J. R. 1974. Seasonal allocations of time and energy resources in birds. Pp. 4–70, *in* R. A. Paynter, Jr., ed. Avian Energetics. Nuttall Ornithol. Club, Cambridge, Mass.

LEHNER, P. N. 1979. Handbook of ethological methods. Garland STPM Press, New York.

SCHARTZ, R. L., AND J. L. ZIMMERMAN. 1971. The time and energy budget of the male Dickcissel (*Spiza americana*). Condor 73:65–76.

SEIGFRIED, W. R. 1974. Time budget of behavior among Lesser Scaups on Delta Marsh. J. Wildl. Manage. 38:708–713.

TACHA, T. C. 1981a. Behavior and taxonomy of Sandhill Cranes from mid-continental North America. Ph.D. thesis, Oklahoma State Univ., Stillwater.

———. 1981b. Autumn activities of Blue Jays in an urban environment. Southwestern Nat. 26:90–91.

VERNER, J. 1965. Time budget of the male Long-Billed Marsh Wren during the breeding season. Condor 67:125–139.

WEINS, J. A. 1969. An approach to the study of ecological relationships among grassland birds. Ornithol. Monogr. No. 8.

———, S. G. MARTIN, W. R. HOLTHAUS, AND F. A. IWEN. 1970. Metronome timing in behavioral ecology studies. Ecology 51:350–352.

Cooperative Wildlife Research Unit, 404 Life Sciences West, Oklahoma State University, Stillwater, Oklahoma 74078. (Present address: (TCT) *Cooperative Wildlife Research Laboratory, Southern Illinois University, Carbondale, Illinois 62901;* (PAV) *Denver Wildlife Research Center, USDI-Fish and Wildlife Service, Building 16, Federal Center, Denver, Colorado 80225;* (GCI) *Forest Wildlife Headquarters, R.R. 2, Box 477, Mitchell, Indiana 47446.*) Received 6 June 1984; accepted 17 July 1985.