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NEW TECHNIQUES FOR TIME-ACTIVITY STUDIES OF AVIAN FLOCKS IN VIEW-RESTRICTED HABITATS

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Abstract.—Focal-animal sampling was compared to a newly developed technique, focal-switch sampling, to evaluate time budgets of Mourning Doves (*Zenaida macroura*) in habitats where the field of view was restricted. Focal-switch sampling included a formula employed to weight habitat use and test for restrictions of habitat structure on behavior, and a standard waiting period to decide when to end sampling or continue pursuit of lost flocks. Focal-animal sampling biased estimates of active behavior downward, whereas estimates of inactive behavior were similar for both methods. Focal-switch sampling increased research efficiency by 12%. The standard waiting period saved 24% of samples from premature termination and reduced observer bias by maintaining equal sampling effort per flock. Weighting of habitat use also reduced sampling bias. Focal-switch sampling is recommended for use in conjunction with focal-animal sampling when sampling in view-restricted habitats.

NUEVAS TÉCNICAS PARA EL ESTUDIO DE ACTIVIDADES DE CONGREGACIONES DE AVES EN HABITATS CON VISIBILIDAD RESTRINGIDA

Resumen.—La técnica de observación directa de animales (focal-animal) es comparada con un nuevo método en donde se evaluan los presupuestos de actividades en *Zenaida macroura* en habitats en donde el campo de visión estaba restringido. La nueva técnica (cambio-focal) incluye una fórmula para "pesar" la utilización de habitat y medir las restricciones que imponen la estructura del habitat en la conducta. Incluye además, un período de espera estandarizado que permite al observador decidir cuando terminar sus observaciones o continuar las mismas. El muestreo de un solo animal (focal-animal) tiene un sesgo para estimar la conducta activa, mientras que los estimados para conducta inactiva fueron similares para ambos métodos. El nuevo método incrementó la eficiencia del estudio en un 12%. El período de espera estandarizado evitó que se terminara prematuramente con el 24% de las muestras observadas y redujo el sesgo al mantener el mismo esfuerzo de muestreo por agregación de aves. Se recomienda la utilización del nuevo método en conjunción con el previamente descrito cuando se muestree en habitat donde la visibilidad pueda ser obstruida.

There are many effective and widely used methods to study activity budgets of avian flocks (e.g., Altmann 1974, Baldassarre et al. 1987). Most studies have focused on species that congregate in open habitats (e.g., shoreline and open water) where large numbers of individuals can be sampled readily (Maxson and Bernstein 1984, Paulus 1984a, Quinlan and Baldassarre 1984, Tamisier 1976). However, problems of visibility bias arise in studies of species in dense habitats (Bradley 1985), because the investigator is confronted with sampling constraints that often cause data variability and biases (Kessel 1976, Verner 1965).

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Focal-animal sampling is the observation of an individual for a predetermined period of time (Altmann 1974). It may be the best method for detailed analysis of behavior and the only method available to sample small numbers of individuals. Focal-animal sampling is therefore appropriate for studies of species in dense vegetation where the number of potential sample individuals is frequently reduced by vegetation.

A major, unresolved problem with focal-animal sampling occurs when focal individuals disappear from view (hereafter referred to as "out-of-view"; see Lehner 1979). For example, Verner (1965) arbitrarily recorded Marsh Wren (*Cistothorus palustris*) out-of-view data as feeding, whereas Maxson (1977) broadly measured Ruffed Grouse (*Bonasa umbellus*) activity by radiotelemetry. Other observers (e.g., Paulus 1984b, Rave 1987) had biased results because they were unable to focal-sample flying birds. Such limitations may discourage time-activity studies of flocking upland species. Accordingly, techniques must be developed to address problems associated with: (1) focal individuals disappearing from view; (2) the amount of time a focal individual should be observed; (3) the spatial distribution of flock individuals among heterogeneous habitats; and (4) the elimination of observer-expectancy bias when a sample flock departs before the termination of the sample period.

We report a new technique, focal-switch sampling, developed to address these sampling problems during an activity-budget study of Mourning Dove (*Zenaida macroura*) flocks in northern Alabama. We also report some results of the activity study by relating behavioral frequencies to broad habitat categories while employing both focal-animal and focal-switch sampling.

METHODS

Focal-switch sampling was tested against focal-animal sampling using radio-fitted hatching-year (HY) Mourning Doves to lead observers to dove flocks on the Swan Creek Wildlife Management Area, Wheeler National Wildlife Refuge, and surrounding areas in northern Alabama. Dove flocks were located from July to September 1987. Radio-marked individuals were not observed for behavioral data to eliminate potential bias induced by the radio transmitter. Flocks were sampled during three observation periods (OP1 = sunrise to 3.5 h after sunrise, OP2 = 3.5 h after sunrise to 3.5 h before sunset, OP3 = 3.5 h before sunset to sunset) to block-out variation caused by differing periods of Mourning Dove activity (Deuver and Fatora 1968).

The closest readily visible individual in the flock was selected as the first bird to be sampled (Altmann 1974). Two observers (one per method) collected data on each sample flock. Each method was used by all four observers during the study. The total data include 30.5 h (OP1 = 10 h, 10 min; OP2 = 10 h; OP3 = 10 h, 20 min). Behavioral categories were: feeding, locomotion, comfort, resting, alert, and out-of-view.

Focal-switch sampling, unlike focal-animal sampling, allowed switching to a new focal individual (nearest neighbor) if the original focal

TABLE 1. Demonstration of weighting focal samples according to habitat use (Y_i) where $n_A = 50$, $n_B = 25$, $n_C = 25$, $N = 100$, $T = 60$ min, and $f = 5$ min.[a]

	Focal-unit (sample {s}; no sample {—})											
Habitat	1	2	3	4	5	6	7	8	9	10	11	12
A	s	—	—	s	—	—	s	—	—	s	s	s
B	—	s	—	—	s	—	—	s	—	—	—	—
C	—	—	s	—	—	s	—	—	s	—	—	—

[a] $Y_i = (n_i/N) \times (T/f)$ where: Y_i = number of focal-units (f) sampled in habitat i; n_i = number of individuals in habitat i; N = total number of individuals in flock; T = duration of sample period; f = duration focal-unit. Then $Y_A = n_A/N \times T/f = 50/100 \times 60/5 = 6$, $Y_B = 3$, and $Y_C = 3$.

individual went out-of-view. To avoid observer-expectancy bias (Balph and Romesburg 1986), two consecutive out-of-view recordings were allowed before focal-switching. Focal-switching also was restricted to individuals in the same habitat as the out-of-view individual. This controlled the effects of habitat structure on behavior. For example, if a focal individual in habitat A moved to habitat B and was lost from view, focal-switching was allowed only on individuals in habitat B.

The null hypothesis tested was that the two methods resulted in the collection of the same amount of data per behavioral category during a given unit time. We used Hotelling's multivariate t-tests (SAS Institute, Inc. 1985) to determine the overall difference in results obtained by use of the two methods. Because the data were normally distributed, we used paired t-tests (SAS Institute, Inc. 1985) to compare behavioral frequencies between methods for each observation period. A probability level of 0.05 was used for all statistical tests.

The sample period (T), the maximum time limit for sampling a flock, was divided into focal-units (f) where: $T = 60$ min, and $f = 5$ min. The focal-unit was the predetermined time within which behavior of the focal individual(s) was sampled instantaneously every 20 s (Altmann 1974) as dictated by a tape recorder used as a metronome (Paulus 1984a, 1984b). The number of complete focal-units (focal-switching not needed) versus the number of incomplete focal-units (focal-switching necessary) was tested for equality using paired t-tests (SAS Institute, Inc. 1985).

To begin sampling a flock, the observers estimated visually the number of individuals using major habitat types (e.g., upland field, forest canopy, willow thicket) and focal-units were distributed proportionately (Table 1). Habitat weighting was tested by comparing activities sampled in perch (e.g., forest canopy + willow thicket canopy) versus non-perch habitats (e.g., upland field + mudflat). Unpaired t-tests (SAS Institute, Inc. 1985) were used to test the null hypothesis that the two habitat structures affected behavior equally.

When a sample flock departed before termination of the sample period, we allowed a standard period of 10 min for a new sampling situation to

TABLE 2. Number of instantaneous recordings (mean ± SE) of each Mourning Dove behavior collected using focal-animal and focal-switch methods simultaneously during each observation period, northern Alabama, 1987.

Behavioral category	Observation period[a]	Method[b]	
		Focal-animal	Focal-switch
Locomotion	1	4.5 ± 1.1*	9.5 ± 2.3*
	2	2.6 ± 1.3*	5.2 ± 1.9*
	3	6.9 ± 1.4*	11.9 ± 2.4*
Feeding	1	21.0 ± 5.0*	32.3 ± 8.5*
	2	1.4 ± 0.5	4.5 ± 2.3
	3	38.6 ± 8.0	49.0 ± 11.0
Resting	1	13.8 ± 3.1	12.3 ± 2.2
	2	30.1 ± 6.4	30.3 ± 6.4
	3	18.8 ± 2.4	21.4 ± 6.7
Comfort	1	21.8 ± 6.7	28.7 ± 7.6
	2	39.2 ± 7.2	47.5 ± 7.5
	3	27.6 ± 4.2	27.5 ± 6.3
Alert	1	35.8 ± 6.4	40.4 ± 6.0
	2	26.0 ± 5.2	31.3 ± 5.4
	3	31.2 ± 3.3	36.6 ± 2.5
Out-of-view	1	55.0 ± 8.4*	26.8 ± 5.0*
	2	49.7 ± 9.4*	30.1 ± 6.4*
	3	45.9 ± 4.6*	22.3 ± 2.7*

[a] Sample size (no. of flocks) for OP1 = 12, OP2 = 14, and OP3 = 11.
[b] Asterisks indicate differences ($P < 0.05$) between methods.

arise once all individuals in the sample flock had left the area, had been sampled, or were out-of-view. Once the standard waiting period expired, a new flock was selected for sampling.

The standard waiting period was used to avoid observer-expectancy bias (Balph and Romesburg 1986). For example, if a flock departs before the end of the sample period, the investigator, upon deciding whether to end sampling or to continue pursuing the flock, could induce bias by chasing flocks he knows are easy to locate and ignoring those difficult to locate (observer-expectancy bias). The standard waiting period provided a constant for these decisions. We recorded the number of times the standard waiting period was needed.

RESULTS

The amount of behavioral data collected by the two methods was significantly different. Focal-switch sampling resulted in an average of 11.7% more data per sample period than focal-animal sampling. More ($P < 0.05$) locomotion data were collected with focal-switch sampling than focal-animal sampling during all observation periods (Table 2). Feeding time was greater ($P < 0.05$) with focal-switch sampling than focal-animal sampling during OP1, but not during OPs 2 and 3 ($P > 0.05$; Table 2). There were no differences ($P > 0.05$) between methods during any

TABLE 3. Comparison of the number of complete vs. incomplete focal-units (mean ± SE) collected on Mourning Doves (methods pooled) during each observation period, northern Alabama, 1987.

	Focal-unit (type)[b]	
Observation period[a]	Complete	Incomplete
1	4.1 ± 0.5*	6.1 ± 0.6*
2	4.7 ± 0.6*	5.2 ± 0.5*
3	4.2 ± 0.4*	7.1 ± 0.6*

[a] Sample size (no. of flocks) for OP1 = 24, OP2 = 28, and OP3 = 22.
[b] Asterisks indicate differences ($P < 0.05$) between focal units.

observation period for resting, comfort, or alert behavior (Table 2). Frequencies of out-of-view data were greater ($P < 0.05$) with focal-animal sampling than with focal-switch sampling during all observation periods (Table 2).

The number of incomplete and complete focal-units collected per sample period did not differ ($P > 0.05$) between methods. Overall, sample periods contained more ($P < 0.05$) incomplete focal-units than complete focal-units (methods pooled) for all observation periods (Table 3). We maintained observations on individual Mourning Doves for complete focal-units during 48% of the sample periods, so focal-switching was needed more often than not.

Regardless of method employed, feeding time was greater ($P < 0.05$) in non-perch habitats than perch habitats (Table 4). Locomotion was greater ($P < 0.05$) in non-perch habitats than perch habitats for focal-switch sampling, but was similar ($P > 0.05$) between habitats using focal-animal sampling (Table 4). Resting and comfort behavior were greater ($P < 0.05$) in perch than non-perch habitats for both methods (Table 4). Alert behavior was similar ($P > 0.05$) between habitat structures for both methods (Table 4).

The standard waiting period was used in 21% of the samples ($n = 37$) and saved sample periods from premature termination 24% ($n = 9$) of the time by allowing sampling to continue on flocks that occasionally had all individuals out-of-view.

DISCUSSION

The major problem we encountered with focal-animal sampling was losing visual contact with the focal individual before the focal-unit ended (as per Lehner 1979). Thus, focal-animal sampling was inefficient because no data were collected from active birds in dense habitats. This problem was alleviated by focal-switching to visible birds when the focal individual was lost from view.

Both methods were equally effective in collecting data on comfort, resting, and alert behavior because these were generally stationary states. Individuals engaged in such behavior were less likely to disappear from

TABLE 4. Number of instantaneous recordings (mean ± SE) of each Mourning Dove behavior collected using focal-animal (FA) and focal-switch (FS) methods simultaneously in perch and non-perch habitats, northern Alabama, 1987.

		Habitat[a,b]	
Behavioral category	Method	Perch	Non-perch
Feeding	FA	1.9 ± 1.3*	33.0 ± 21.0*
	FS	1.6 ± 0.8*	55.0 ± 26.0*
Locomotion	FA	1.7 ± 0.6	7.5 ± 6.5
	FS	2.4 ± 0.7*	12.5 ± 5.5*
Resting	FA	25.4 ± 7.1*	0.5 ± 0.5*
	FS	23.2 ± 6.8*	5.5 ± 0.5*
Comfort	FA	41.7 ± 9.3*	3.5 ± 3.5*
	FS	50.6 ± 9.9*	3.0 ± 2.0*
Alert	FA	33.1 ± 6.1	39.0 ± 37.0
	FS	36.1 ± 7.1	33.5 ± 25.5

[a] Sample size (no. of flocks) for perch habitat = 10, non-perch = 2.
[b] Asterisks indicate differences ($P < 0.05$) between habitats.

view into vegetation compared to active individuals so focal-switching often was not needed.

The most common causes of out-of-view data at feeding times were visual obstructions caused by ground vegetation (visibility bias), and the focal bird becoming "lost" in the group by intermixing with flock members. While recording out-of-view data on an individual the investigator can lose feeding data because of the increasing likelihood that the flock will terminate its feeding bout. For example, by the time the observer finishes a focal-unit on an out-of-view individual, the entire flock may be engaged in a different activity (e.g., resting), and thus overall feeding time is underestimated.

Feeding data also may be under-represented with focal-animal sampling through sampling bias, even though the majority of the flock may have been foraging. For example, using focal-animal sampling, if two flock individuals perched in a tree were sampled, and each received 15 records "resting" and 0 records "out-of-view" their sum "resting" would equal 30 (15 resting × 2 birds = 30). During the same sample, if 10 other birds in the same flock were sampled from a field and each received 1 record "feeding" and 14 records "out-of-view," their sum "feeding" would equal 10 (1 feeding × 10 birds = 10). Therefore the flock's feeding percentage would equal 25% (10 feeding/40 total = 10 feeding/30 resting + 10 feeding) and resting would equal 75% (30/40); the overall estimation of feeding would be too low. Focal-switch sampling eliminates this problem because it permits switching to in-view feeding birds.

Like feeding, locomotion probably was underestimated with focal-animal sampling because flying individuals were lost almost instantaneously. Focal-switch sampling permitted continuous sampling of flying individuals because it allowed use of the sky as a habitat. For example, if 50 birds on the ground including the focal bird took flight and the focal bird was lost, other flying individuals in the flock were sampled by focal-switching until the last one went out-of-view. Radio-marked HY Mourning Doves usually departed areas in small groups and often made sustained flights (>2 km) to their next area; hence, by the time the last focal-switch was made on a group leaving an area, the original focal bird probably was still in flight.

Although it is apparent from the out-of-view data that focal-switch sampling can be an efficient means of studying highly active species in dense vegetation, it should only be used if the physical obstruction between the observer and focal animal has no influence on the focal animal's immediate behavior. For instance, focal-switch sampling could not be used effectively with bay ducks (Anatinae) because individuals cannot be followed underwater; hence, feeding probably would be underestimated in this situation (Baldassarre et al. 1987). Also, being above and below the water surface may be considered use of two different habitats.

Incomplete focal-units (*f*) were more common than complete *f*'s in this study. Had our *f* duration of 5 min been lower, more complete *f*'s would have been collected. If the objectives of a study warrant comparisons among individuals in a flock, the investigator should strive to collect as many complete *f*'s as possible, because each represents an individual bird (i.e., the sampling unit). Comparisons between flocks can be made by pooling complete and incomplete *f*'s because the sampling unit would be the flock.

The duration of the focal-unit (*f*) should be correlated inversely with relative flock size to sample more birds when flock size is large, and to account for behavioral variation among flock members. Theoretically, the ultimate duration of the *f* would allow for sampling the entire flock in order to remove assumptions about variability within, and among individuals. For example, in a 60 min sample period, a flock of 12 individuals would require $f = 5$ min whereas a flock of 60 would require $f = 1$ min. However, since flock size inevitably will vary, the investigator should establish an *f* that will account for an average size flock for the species and study objectives. Using marked (e.g., wing-tagged) individuals, when feasible, could reduce potential bias of sampling the same individual more than once per sample period.

It is apparent that habitat structure affects avian behavior in different ways. In Mourning Doves, active behavior (e.g., feeding, locomotion) generally was highest in non-perch habitats, stationary behavior (e.g., comfort, resting) was highest in perch habitats, and alert behavior was independent of habitat structure. Use of the equation in Table 1 assures that samples will reflect the flocks' overall behavioral state. The investigator should be cautious when using this equation and not assume that a group of birds constitute a flock unless there is evidence of flock unity. For example, birds using three habitats can be considered a flock only if there is a reciprocal movement of individuals among the three habitats. The investigator may find it useful to divide major habitat types (e.g., forest) into subtypes (e.g., perch with canopy vs. perch without canopy).

Observer-expectancy bias can be avoided by incorporating a standard waiting period. This would maintain an equal sampling effort for each flock and eliminate bias from expected predictions by the investigator (Balph and Romesburg 1986). Also, our data suggest potential for increased research efficiency using a standard waiting period to control premature sample termination caused by observer bias. Duration of the standard waiting period should reflect the behavior of the species under study. Those capable of large daily movements and having a low probability of returning to view, should have a shorter standard waiting period than species with small daily movements and a high probability of returning to view. Also, view-restricted areas should have a long standard waiting period to allow time for individuals to return to view. These factors should be evaluated prior to data collection, and the techniques practiced on the species before selecting a duration for the standard waiting period.

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