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The effect of time of day on avian census results.—The ornithological literature often comments on variation in census results during the day (e.g. Berger 1961: 100, Pettingill 1970: 405). Robbins and Van Velzen (1970) found that during the breeding season, the maximum number of avian contacts occurred about 30 minutes after sunrise. Fewer than 80% of this number were recorded in the same area 2 h later. Robbins (1972) also found a variation in winter census results that correlated with time of day. Though my primary interest was to examine the effect of a treatment on population numbers (Shields ms.), I report here the effect of time of day on my census and a technique for counteracting this effect.

I performed field studies in the Watchung Reservation, Union County, New Jersey. Shields and Grubb (1974) describe the study site's vegetation and topography. I performed censuses from the second week of December through the third week of January in 1973 and 1974 and from 28 May through 6 July in 1973. During the winter I used three 1.6 km trails, maintained on the south slope as transects. Each transect was censused once on each of 10 days in 1973 and 11 in 1974. Starting times (0800, 0900, and 1000 E.S.T.)were rotated between transects so that each was begun at every starting time seven times. Local sunrise during the study varied from 0705 to 0717. I measured air temperature at the start and allowed 20–30 min. for the completion of each transect. Using Emlen's (1971) method, I determined coefficients of detectability (CD_{412}). Only the eight most abundant species were included in this analysis. During the breeding season I censused two 0.8 km transects on 24 days. Starting times (0600 and 0730) were rotated daily. Local sunrise varied between 0528 and 0535 E.D.T. during the study. Air temperature was measured at the start and 30–40 min. were allowed for the completion of each transect. Only those species sighted on a total of 3 days on both transects were included in this analysis. The width of the transects was 125 m for both seasons making the areas sampled 10 ha in summer and 20 ha in winter for each transect.

TABLE 1

NUMBER OF CONTACTS PER 1.6 KM OF TRANSECT IN WINTER

Species	0800	0900	1000
Hairy Woodpecker	0.4 (8)[1]	0.6 (12)	0.7 (14)
Downy Woodpecker	0.8 (16)	1.2 (24)	1.3 (25)
Blue Jay	1.8 (36)	1.7 (33)	2.0 (40)
Common Crow	1.0 (20)	1.3 (26)	1.2 (24)
Black-capped Chickadee	2.4 (48)	3.2 (64)	5.5 (110)[2]
Tufted Titmouse	0.6 (12)	1.4 (28)	2.1 (41)[3]
White-breasted Nuthatch	0.9 (19)	1.1 (22)	1.2 (24)
Cardinal	0.7 (14)	0.9 (19)	1.6 (33)[3]

[1] $\bar{x}$ (N)
[2] $P < 0.01$
[3] $P < 0.05$

TABLE 2
COEFFICIENTS OF DETECTABILITY IN WINTER

Species	0800	0900	1000
Hairy Woodpecker	0.312	0.333	0.333
Downy Woodpecker	0.325	0.312	0.475
Blue Jay	0.526	0.483	0.533
Common Crow	0.785	0.900	0.850
Black-capped Chickadee	0.300	0.375	0.433
Tufted Titmouse	0.312	0.333	0.375
White-breasted Nuthatch	0.318	0.350	0.342
Cardinal	0.278	0.324	0.333

I used a partially balanced lattice square analysis of variance (Sokal and Rohlf 1969) and the distribution free Kruskal-Wallis analysis of variance (Edwards 1964) to analyze the winter data. A simple analysis of variance (Sokal and Rohlf 1969) was used on the breeding season data. Scientific names of the bird species mentioned are appended to the text.

The number of winter contacts rose significantly later in the day for three species, while a nonsignificant ($P > 0.05$) rise was noted in the remaining species (Table 1). Coefficients of detectability showed a general correlation with time of day, with higher coefficients later in the day (Table 2). Temperature also rose with the sun, with means of $-2.0°$ C at 0800, $-0.4°$ at 0900, and $+1.5°$ at 1000. This temperature rise was noted on 20 of the 21 census days.

During the breeding season the direction of the trend reversed with fewer contacts at the later starting time. The difference was significant for 14 of 18 species examined (Table 3). The relationship between temperature and time of day remained constant, with a mean of 14.8° C at 0600 and 17.2° at 0730.

During the winter study, I was looking for differences in the number of contacts on each of the three transects. In analysis this factor was called area. Significant differences were found among the three transects for three species when time of day was included as a factor in the analyses of variance. If time of day was ignored, by pooling any variation caused by it and its interactions with error, the significance was lost for one species.

During the breeding season one of the transects was a control, while the other was treated during the second week of the study. To examine the effect of this treatment on bird populations I examined the week by area (W $\times$ A) interaction. This factor was found to be significant in 12 of 18 species examined when

TABLE 3
NUMBER OF CONTACTS PER 0.8 KM OF TRANSECT IN SUMMER

Species	0600	0730
Common Flicker	1.0 (24)[1]	0.7 (18)[2]
Downy Woodpecker	0.7 (17)	0.4 (10)[3]
Great Crested Flycatcher	0.7 (18)	0.3 (7)[2]
Eastern Wood Pewee	1.8 (43)	1.2 (29)[2]
Blue Jay	3.1 (76)	3.0 (72)
Common Crow	3.0 (71)	2.8 (66)
Black-capped Chickadee	0.4 (10)	0.2 (5)
Tufted Titmouse	1.7 (40)	1.5 (36)
House Wren	0.8 (19)	0.6 (14)[3]
Gray Catbird	3.1 (74)	2.6 (64)[3]
Wood Thrush	4.5 (109)	3.8 (92)[2]
Red-eyed Vireo	1.9 (46)	1.2 (30)[2]
Black and White Warbler	0.5 (11)	0.2 (5)[3]
Ovenbird	7.3 (175)	6.5 (156)[3]
American Redstart	0.8 (18)	0.4 (10)[3]
Scarlet Tanager	0.9 (21)	0.3 (8)[3]
Rose-breasted Grosbeak	1.4 (34)	0.8 (19)[3]
Rufous-sided Towhee	3.2 (76)	2.6 (64)[3]

[1] $\bar{x}$ (N)
[2] $P < 0.01$
[3] $P < 0.05$

TABLE 4
ANALYSIS OF VARIANCE TABLE FOR SCARLET TANAGER IN SUMMER

Source of variation	df	Sum of squares	Mean square	*F* statistic
Total	47	17.48	—	—
Week	5	3.85	0.77	5.16[2]
Area	1	0.02	0.02	0.04
Time of day	1	6.02	6.02	40.40[3]
W × A	5	2.35	0.47	3.15[2]
				1.50[1]
W × T	5	0.85	0.17	1.00
A × T	1	0.02	0.02	0.12
W × A × T	5	0.85	0.17	1.16
Error	24	3.50	0.15	
Error pooled with T	36	11.25	0.31	

[1] The W × A interaction *F*-statistic when variation due to time is pooled with error. See text for further details.
[2] $P < 0.05$
[3] $P < 0.01$

time of day was included as a factor in analysis. If time of day was ignored, by pooling its variation with the error, this significance was lost in 7 of the original 12. To conserve space a single example (Table 4) of the effect of confounding time of day with error is presented.

As the coefficients of detectability noted in my study vary sufficiently and agree consistently with the variation in winter contacts, I agree with Robbins and Van Velzen (1970), that the differences are not of number but of detectability. No evidence suggests that this is not true for the breeding season as well. My data are insufficient for anything but speculation about the cause of this phenomenon. The regular variation of various environmental parameters (e.g. temperature, light intensity, wind velocity, and humidity) with time of day does lead me to predict that further study will link one or more of these with changes in detectability.

The economy of the strip census method (Emlen 1971) makes it attractive to those interested in comparing bird populations. Traditionally the bias introduced by diel variations in detectability has been met by limiting censusing to early hours "when birds are most active" (Pettingill 1970). At best the investigator alternates census times between areas in a regular manner. The latter does prevent bias due to regular changes in detectability, yet the variation caused by such changes remains pooled in the overall variance. The former does not hold during winter when the birds are more active in the late morning.

The variation added by not including time of day as a factor inflates the error by which the investigator tests for differences between plots (Table 4). This lessens the sensitivity of such tests to the point where quite large differences may be undetectable by statistical means.

I have shown that removal of this gratuitous variation by including time of day as a fixed factor in sampling procedure increases the sensitivity of analysis. Although this has the greatest import to those conducting strip censuses, the problem cannot be ignored by anyone conducting avian censuses. At the very least care must be taken to eliminate bias by rotating sampling times equitably.

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SCIENTIFIC NAMES OF SPECIES MENTIONED IN TEXT AND TABLES

Common Flicker, *Colaptes auratus*; Hairy Woodpecker, *Dendrocopos villosus*; Downy Woodpecker, *Dendrocopos pubescens*; Great Crested Flycatcher, *Myiarchus crinitus*; Eastern Wood Pewee, *Contopus virens*; Blue Jay, *Cyanocitta cristata*; Common Crow, *Corvus brachyrhynchos*; Black-capped Chickadee, *Parus atricapillus*; Tufted Titmouse, *Parus bicolor*; White-breasted Nuthatch, *Sitta carolinensis*; House Wren, *Troglodytes aedon*; Gray Catbird, *Dumetella carolinensis*; Wood Thrush, *Hylocichla mustelina*; Red-eyed Vireo, *Vireo olivaceus*; Black-and-white Warbler, *Mniotilta varia*; Ovenbird, *Seiurus aurocapillus*; American Redstart, *Setophaga ruticilla*; Scarlet Tanager, *Piranga olivacea*; Cardinal, *Cardinalis cardinalis*; Rose-breasted Grosbeak, *Pheucticus ludovicianus*; Rufous-sided Towhee, *Pipilo erythrophthalmus*.

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Homing of subadult Oldsquaws.—Through a continuing Oldsquaw (*Clangula hyemalis*) banding and marking program that I have conducted near Churchill, Manitoba (Alison 1972, unpublished Ph.D. dissertation, Toronto, Univ. of Toronto) it has been possible to identify in flocks of subadult Oldsquaws on the breeding grounds individuals that were reared in the same vicinity the previous year. Such identification included individuals captured as flightless young and marked with nasal saddles (Alison 1975a, Ornithol. Monogr. No. 18) during July and August of 1974, or unmarked birds banded in previous years and recaptured in 1974 and 1975 within the study ponds.

Male and female subadults are always distinguishable in the field by plumage (Alison 1975b, Bird-banding 46: 248–250). From 1968 through 1975 a few subadult males appeared briefly on the study area in only 2 years; otherwise all subadults present were females. Subadults were present in all years, the maximum number being 29 (all females) in 1975. Although a few arrived each year in late May together with most of the paired adults, the majority typically appeared in mid-June. Some were present as late as 3 September. None was ever observed paired.

The proportion of immature females that returned to the study ponds as subadults is unknown, but of 29 subadult females present in 1975, 4 were reared within 1 km of the recapture sites. The ability to home among subadults of duck species that require 2 or more years to reach sexual maturity has not been published previously. Nonetheless it is well-known that some adult Canada Geese (*Branta canadensis*), Snow Geese (*Chen caerulescens*), (Atlantic) Brant (*Branta bernicla*), and others return to their natal area. Homing by adult anatids has been reported in the Bufflehead (*Bucephala albeola*) (Erskine 1961, Auk 78: 389–396), Oldsquaws (Alison 1975a), Lesser Scaup (*Aythya affinis*), Canvasback (*Aythya valisineria*), and Redhead (*Aythya americana*) (D. Trauger, pers. comm.), and others as well as among the nondiving species.

Perhaps the most remarkable record involved two subadult females, banded as flightless immatures (#s 547–43136 and 547–43145) at the same spot (in the same net) in August 1974 and recaptured together on 25 June 1975 about 4 km from the banding site. These marked birds, which may have been from the same brood and were certainly from the same communal brood, arrived together on the study ponds 23 June 1975 and, when seen later, were always near each other. Another marked subadult female (number 547–43141), captured in 1974 from the same communal brood, was frequently seen in association with these individuals in 1975 and was recaptured 26 June 1975 on the same pond with them. Although we do not know that these individuals migrated and passed the winter of 1974–75 together, it seems doubtful that, had they not done so, they would have reached Churchill together and remained together on the same pond throughout June and July. These observations suggest not only a fidelity to natal territory but also a mutual fidelity among specific individuals in the subadult population. As the pair-bond is especially strong among adult Oldsquaws (Alison 1975a) it is not inconsistent that similar associations occur among subadults, although the purpose of such behavior is unknown.