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Relationships of environmental factors to onset of autumn morning vocalizations in an Ozark community.—Birds frequently vocalize near daybreak but little quantitative work exists concerning environmental factors which may affect the precise onset of vocalizations (Armstrong, A Study of Bird Song, Oxford Univ. Press, London, England, 1963). However, a few detailed studies deal with the relationship of song activity to time of day and light (e.g., Wright, Auk 29:307–327, 1912; Wright, Auk 30:512–537, 1913; Allard, Am. Nat. 64:436–469, 1930; Emlen, Bird-Banding 8:81, 1937; Groebbels, Ornithologische Mitteilungen 8:61–66, 1956; Leopold and Eynon, Condor 63:269–293, 1961). Our objective was to quantitatively assess the relationships of several environmental factors to time of first vocalization in bird communities in the forested Ozarks during autumn. If the microclimate is physically ideal for sound transmission at dawn (Henwood and Fabrick, Am. Nat. 114:260–274, 1979), it may be reasonable to associate many communicative auroral bird sounds with climatic factors. Therefore, we include all bird vocalizations (song, call, chip, scold, etc.) in our analysis.

Study region.—The study was conducted in the White Rock Wildlife Management Area/Ozark National Forest, in northwestern Arkansas. This region includes several hundred square km of unbroken upland oak-hickory forest in the 25–50 year class with occasional farm clearings and abandoned fields containing grasses and shrubs. The topography is hilly with 150 m local relief rising to 670 m above mean sea level.

Methods.—Five secluded areas were visited in random order from 30 min before dawn until 30 min after sunrise, between late August and December 1978, until each area was studied an average of five mornings. Relative humidity (percent, using a sling psychrometer), wind speed (km/h, using a Dwyer wind meter, held 1.5 m above ground) and barometric pressure (inches of mercury, barometer) were measured at the start and conclusion of each visit. Ambient air temperature (°C), light intensity (foot-candles, photometer facing open sky in clearings), percent cloud cover (visual estimate) and local time (CST) were recorded as each bird species was first heard vocalizing.

Multiple linear and stepwise correlation and regression (step-up model) analyses were performed between the time of first vocalization (Y) per morning per species and eight independent variables—time of sunrise (Sun), elevation (Elev), relative humidity (Hum) (arcsine-transformed), ambient temperature (Temp), light intensity (Lite), wind speed (Wind), percent cloud cover (ClCov) (arcsine-transformed) and barometric pressure (BaroP). This was done for each of 11 species with 10 or more morning records (N = 178 bird-mornings). Data on six species with more than four but fewer than 10 morning records were analyzed by univariate analyses only (totalling 35 bird-mornings).

Results.—Time of first vocalization, recorded 232 times for 28 species, was positively correlated with time of sunrise, wind speed, cloud cover and barometric pressure most often (Table 1). However, time of sunrise and light intensity together accounted for over 92% of the variance in vocalization time in stepwise correlation and regression (77 and 15%, respectively; $P < 0.001$; other independent variables seldom explained a statistically significant fraction of variance; Table 2). The large component of the variance accounted for by time of sunrise alone means that it can serve as a useful predictor of time of first vocalization (Table 3).

For birds with 10 or more records, we performed partial correlation analysis with the effects of time of sunrise held constant to better understand the association of other variables to time of first vocalization (Kerlinger and Pedhazur 1973; Table 1). This analysis shows that light intensity and percent cloud cover were associated with time of first vocalization for many species. Too few data were obtained for 11 species to warrant analysis.

TABLE 1

SIMPLE (AND PARTIAL)[a] CORRELATIONS BETWEEN ENVIRONMENTAL VARIABLES AND TIME OF FIRST VOCALIZTION FOR BIRDS WITH FIVE OR MORE MORNING RECORDS

Species	Number of mornings	Environmental variables[b]							
		Sun	Elev	Hum	Temp	Lite	Wind	ClCov	BaroP
Cardinalis cardinalis	19	0.96***[c]					0.79***		0.76***
(Cardinal)						(0.94)***		(0.66)**	
Carduelis tristis	13	0.96***					0.75**	0.61*	0.84***
(American Goldfinch)						(0.86)***		(0.88)***	
Melanerpes carolinus	14	0.93***					0.65*	0.60*	
(Red-bellied Wood-pecker)						(0.86)***			
Colaptes auratus	18	0.93***					0.71***	0.66**	0.62**
(Common Flicker)						(0.73)**		(0.66)**	
Corvus brachyrhynchos	23	0.95***				0.62**	0.71***		0.60**
(Common Crow)				(0.68)**		(0.89)***		(0.57)*	
Cyanocitta cristata	15	0.65**					0.51*		
(Blue Jay)					(0.61)*	(0.80)**			
Dryocopus pileatus	16	0.90***					0.73***		0.65*
(Pileated Woodpecker)									
Dumetella carolinensis	10	0.94***			−0.77**				
(Catbird)									
Parus carolinensis	5	0.88*		0.95*					
(Carolina Chickadee)									

TABLE 1
CONTINUED

Species	Number of mornings	Environmental variables[b]							
		Sun	Elev	Hum	Temp	Lite	Wind	ClCov	Baro P
Picoides pubescens	11	0.92***						0.63*	0.67*
(Downy Woodpecker)						(0.91)***			
Pipilo erythrophthalmus	18	0.97***			−0.48*	0.66**	0.76***		0.73***
(Rufous-sided Towhee)						(0.76)**			
Sitta carolinensis	21	0.93***					0.75***		0.49*
(White-breasted Nuthatch)				(0.66)**		(0.99)***			
Thryothorus ludovicianus (Carolina Wren)	6	0.91*		0.94**					
Turdus migratorius (American Robin)	5	0.98**							
Vireo griseus (White-eyed Vireo)	6								−0.97*
Wilsonia citrina (Hooded Warbler)	6	0.95**					0.91*		
Zonotrichia albicollis (White-throated Sparrow)	7	0.78*							

[a] Partial correlation with variable time of sunrise held constant for birds with 10 or more records is in parentheses.
[b] Sun = time of sunrise (CST); Elev = elevation (m); Hum = relative humidity (%); Temp = ambient temperature (°C); Lite = light intensity (foot-candles); Wind = wind speed km/h); ClCov = % cloud cover; BaroP = barometric pressure (inches of mercury). Hum and ClCov values were arcsine-transformed.
[c] Significance levels: * $P < 0.05$; ** $P < 0.01$; *** $P < 0.001$; blank space $P > 0.05$.

TABLE 2

PERCENTAGE VARIANCE (R^2) ACCOUNTED FOR BY SIGNIFICANT ($P < 0.05$, F-STATISTICS) ENVIRONMENTAL VARIABLES AND MULTIPLE STEPWISE REGRESSION EQUATIONS FOR TIME OF FIRST VOCALIZATION FOR BIRDS WITH 10 OR MORE MORNING RECORDS

Species	Minimum no. of records	Significant environmental variables (% variance)[a]	Stepwise regression equation
C. cardinalis	16	$X_1(92)$, X_2 = Lite(7)	$Y = -0.46 + 1.012X_1 + 0.161X_2$
C. tristis	12	$X_1(92)$, X_2 = ClCov(6)	$Y = -0.13 + 0.983X_1 + 0.004X_2$
M. carolinus	14	$X_1(87)$, X_2 = Lite(10)	$Y = -1.76 + 1.243X_1 + 0.022X_2$
C. auratus	17	$X_1(87)$, X_2 = Lite(7), X_3 = ClCov(3)	$Y = -0.23 + 1.002X_1 + 0.015X_2 + 0.003X_3$
C. brachyrhynchos	19	$X_1(90)$, X_2 = Lite(8), X_3 = ClCov(1)	$Y = -0.20 + 0.971X_1 + 0.054X_2 + 0.001X_3$
C. cristata	13	$X_1(42)$, X_2 = Lite(37), X_3 = ClCov(15)	$Y = -0.43 + 1.004X_1 + 0.013X_2 + 0.004X_3$
D. pileatus	16	$X_1(82)$	Same as Table 3
D. carolinensis	10	$X_1(89)$	Same as Table 3
P. pubescens	11	$X_1(85)$, X_2 = Lite(13)	$Y = -1.36 + 1.173X_1 + 0.031X_2$
P. erythrophthalmus	14	$X_1(95)$, X_2 = Lite(3), X_3 = Hum(1)	$Y = -2.31 + 1.205X_1 + 0.210X_2 + 0.008X_3$
S. carolinensis	17	$X_1(86)$, X_2 = Lite(14)	$Y = -1.63 + 1.224X_1 + 0.018X_2$

[a] X_1 = time of sunrise (CST) = Sun; Lite = light intensity (foot-candles); ClCov = % cloud cover (arcsine-transformed); Hum = relative humidity (arcsine-transformed); Y = time of first vocalization (CST).

TABLE 3
MEAN DEVIATIONS AND REGRESSION EQUATIONS BETWEEN TIME OF SUNRISE AND TIME OF FIRST VOCALIZATION FOR BIRDS WITH FIVE OR MORE MORNING RECORDS

Species	Equation[a]	Mean deviation[b]
C. cardinalis	$Y = -0.30 + 1.00X$	−19.4
C. tristis	$Y = -0.71 + 1.11X$	−1.7
M. carolinus	$Y = -2.14 + 1.33X$	+0.3
C. auratus	$Y = -1.15 + 1.18X$	+2.0
C. brachyrhynchos	$Y = -1.07 + 1.13X$	−16.0
C. cristata	$Y = 1.27 + 0.79X$	−2.0
D. pileatus	$Y = -0.44 + 1.08X$	+5.1
D. carolinensis	$Y = -0.01 + 0.94X$	−23.0
P. carolinensis	$Y = -1.92 + 1.29X$	+3.5
P. pubescens	$Y = -0.88 + 1.14X$	+1.5
P. erythrophthalmus	$Y = -2.37 + 1.31X$	−25.8
S. carolinensis	$Y = -1.56 + 1.24X$	−3.6
T. migratorius	$Y = -1.70 + 1.24X$	−5.2
T. ludovicianus	$Y = -0.22 + 1.07X$	−15.0
V. griseus	$Y = 4.24 + 0.29X$	+4.1
W. citrina	$Y = -2.09 + 1.36X$	+5.2
Z. albicollis	$Y = 1.05 + 0.81X$	−17.5

[a] Y = time of first vocalization (CST), X = time of sunrise.
[b] Mean min before (−) or after (+) time of sunrise (CST) for first vocalization.

Discussion.—Closely related species usually respond similarly to similar environmental factors. In this study, birds in the same family (Picidae) usually first vocalized within 5 min of each other (Table 3, unpubl.).

We have studied several ecological factors common to all avian species of a given community. We might expect all avian species of a community to display temporal cohesiveness in behavior towards these factors since factors which affect one species in the community could have similar effects on other avian species of the same community. That is, many of the same environmental obstacles to genic survival are confronted by all avian species of a given community. Thus we might expect optimal adaptations for a particular set of ecological conditions regardless of the degree of genetic relatedness. For example, in our study all but one cavity nester (3 tits, 5 woodpeckers) first vocalized on average ±5 min within time of sunrise (N = 87 bird-mornings) (Table 3, unpubl.). Birds that lived in the earlier stages of succession (*C. cardinalis, D. carolinensis, P. erythrophthalmus* and Brown Thrasher [*Toxostoma rufum*]) all vocalized about 20 min before sunrise (N = 49 bird-mornings), earlier than all studied species (Table 3, unpubl.). Furthermore, nearly all the environmental factors we studied were similarly associated to time of first vocalization in each species (Tables 1, 2 and 3).

We have established correlations between several environmental factors and the timing of a behavioral trait. Since different species confronted with similar environmental factors have independently evolved similar timing of this trait, in effect we have found supportive evidence for the hypothesis that these environmental factors are responsible for the course of evolution that time of first vocalization has taken (*sensu* Alcock, Animal Behavior: an Evolutionary Approach, Sinauer, Sunderland, Massachusetts, 1979:204).

Alternatively, the correlations may be a result of one species vocalizing as soon as it hears another species vocalizing. In our study, vocalizations were not arranged in any specific order with respect to species but this hypothesis needs further study.

At any rate, our data support the possibility that similar proximal factors mold the epigenetic systems of birds of a given community causing congruence and convergence in many behaviors. This could form a coevolved complex of behaviors, behaviors which were associated with each other and with the environment.

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Possible courtship behavior by Snowy Owls in winter.—Sutton (Mem. Carnegie Mus. 12:3–267, 1932), Watson (Ibis 99:419–462, 1957), Taylor (Living Bird 12:137–154, 1973) and others have described the breeding behavior of Snowy Owls (*Nyctea scandiaca*). Courtship consists of vocalizations, and ground and aerial displays used principally by males. Behavior resembling some elements of these displays has been reported on the wintering grounds. Mitchell (Can. Field-Nat. 61:68–69, 1947) described an owl with white plumage (male?) and another with very heavy markings (female?), that were seen perched together in a field in mid-March. The birds took flight at dusk, rose to a considerable height, and flew northwards side by side. Weir (Ont. Field Biol. 27:3–17, 1973) observed a small white owl (male) and a larger, darkly-barred owl (female) standing on the ground 1 m apart, swaying and bobbing their heads at each other, on 5 March. These actions were occasionally interrupted by short, joint flights, and the birds remained together for at least 5 h. Such reports may have led to the claim that Snowy Owls may arrive on the breeding grounds already mated (e.g., Karalus and Eckert, The Owls of North America, Doubleday, New York, New York, 1973). Except for these two brief observations, the nature and frequency of courtship outside the breeding season is unknown. This note describes several cases of possible courtship observed during a study of this species near Calgary, Alberta, and suggests the significance of such behavior.

Observations were made with 20–40× telescopes and recorded on a cassette recorder. The owls were observed at a distance of 50–200 m from a parked automobile. Sexes were identified by plumage characteristics and size (Witherby et al., The Handbook of British Birds, Vol. 2, H. F. and G. Witherby, London, England, 1938; Portenko, Die Schnee-Eule, Neue Brehm-Bucherei, No. 454, A. Ziemsen Verlag, Wittenberg, 1972; Josephson, J. Field Ornith. 51:149–160, 1980). Adult males are almost immaculately white. Adult females were distinguished from immature males by their larger size and by the absence of the mottled coverts characteristic of immature birds. The heavy barring and conspicuously mottled coverts of immature females permit their recognition. We have verified the validity of these plumage characters on over 50 specimens whose sex and age were confirmed by internal dissection and molt pattern (Lein, unpubl.).

Observations.—On 9 February 1978, an adult male was perched on an 8 m high utility pole, hooting at a female on a similar perch 400 m away. The male had been observed in the area for 2 days, and the female had been resident since mid-January. From 16:26–16:30, the