Studies in Avian Biology No. 6:287–291, 1981.

DIURNAL ACTIVITY PATTERNS AND POPULATION ESTIMATES OF BREEDING BIRDS WITHIN A DISTURBED AND UNDISTURBED DESERT-SCRUB COMMUNITY

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ABSTRACT.—We censused breeding birds along two 1.6 km transects, one within a transmission-line right-of-way and the other within an adjacent undisturbed desert-scrub community. Our objectives were to compare the diurnal activity patterns of breeding birds along the two transects, and to determine the effects of changes in activity on population estimates. Censuses were conducted between 20 April and 17 May 1974 using a modified strip-transect method. Birds within 63 m of each transect were censused 10 times between 06:00 and 08:00, and 12:00 and 14:00, and 5 times between 17:00 and 19:00. We used the average number of detections (birds/20 ha) as an index to avian activity. Activity patterns and projected densities (birds/40 ha) of permanent and summer residents were compared within and between transects using chi-square or paired t-tests. Similar comparisons were made for projected densities within foraging guilds.

The number of birds detected within the disturbed and undisturbed habitats between 12:00 and 14:00 was 32 to 49% of the number detected in the morning. Activity on the two transects increased in the evening, but with the exception of Mourning Doves, remained lower than that observed between 06:00 and 08:00. Reductions in activity were greatest within the transmission-line right-of-way. Similar differences were observed in projected densities between time intervals on both transects; reductions in population estimates were greatest within the right-of-way. Neither resident status nor foraging guild appeared to alter observed trends. Composition and structure of the two communities varied with time of day. Species richness was greatest on both transects in the morning whereas evenness was greatest between 12:00 and 14:00. Diversity was lowest in the evening. Data indicate census results may be significantly affected by diurnal changes in avian activity. Censuses conducted early in the morning appear to provide the most accurate estimates of habitat utilization by breeding birds within disturbed and undisturbed communities.

Ornithologists have noted changes in avian activity with time of day for decades. However, only recently have effects of diurnal activity patterns on avian census results been quantified (for review, see Shields 1979). During the breeding season, activity and detectability of most bird species are greatest at dawn, decrease to a diurnal minimum at mid-day (Robbins and Van Velzen 1967, 1970; Weber and Theberge 1977; Shields 1977), and increase in the late afternoon (Järvinen et al. 1977b). These changes in avian activity appear to be correlated with weather conditions, particularly air temperature (Shields 1979).

Census techniques are often used to assess the impact of human activities on bird populations (e.g., Grue 1977, Bock and Bock 1978, Cantle 1978, Franzeb and Ohmart 1978). These activities often involve the removal of ground and canopy vegetation. Environmental conditions (e.g., air temperature and solar radiation) may, therefore, be more severe within disturbed habitats. Knowledge of the diurnal activity patterns of birds within disturbed and undisturbed habitats is essential to adequately assess the impact of habitat modification on bird populations using census techniques. However, a comparison of the diurnal activity patterns of breeding birds within disturbed and undisturbed habitats and their effect on population estimates is lacking. We provide here such a comparison for breeding birds within a transmission-line right-of-way and an adjacent undisturbed desert-scrub community in which daytime temperatures normally exceed 38°C.

STUDY AREA

Our study area was located 25.6 km north of Phoenix, Arizona, in Maricopa County (latitude 33°48′N, longitude 112°15′W) at 515 m in elevation. The terrain was flat. Several dry washes traversed the 80 ha study area. The habitat on the study area was relatively open. Ground cover of grasses and forbs was ca. 35%; trees, shrubs, and cacti covered ca. 11% of the study area. Dominant plant species which occurred within the desert-scrub community were saguaro (*Carnegiea gigantea*), cholla and prickly-pear cactus (*Opuntia* spp.), ocotillo (*Fouquiera splendens*), palo verde (*Cercidium microphyllum*), creosote bush (*Larrea tridentata*), burr sage (*Franseria deltoidea*), and catclaw acacia (*Acacia greggii*). Annuals included plantain (*Plantago purshii*), globe mallow (*Sphaeralcea fendleri*), heron bill (*Erodium circutarium*), and milk vetch (*Astragalus* spp.). (Plant names correspond to those given by Kearney and Peebles, 1960.) The study area consisted of two parallel transects, 1.6 km long. One transect was located within the right-of-way of the newly constructed double 500 kV Navajo Project Southern Transmission Line (disturbed transect), the other 250 m to one side of the right-of-way (control).

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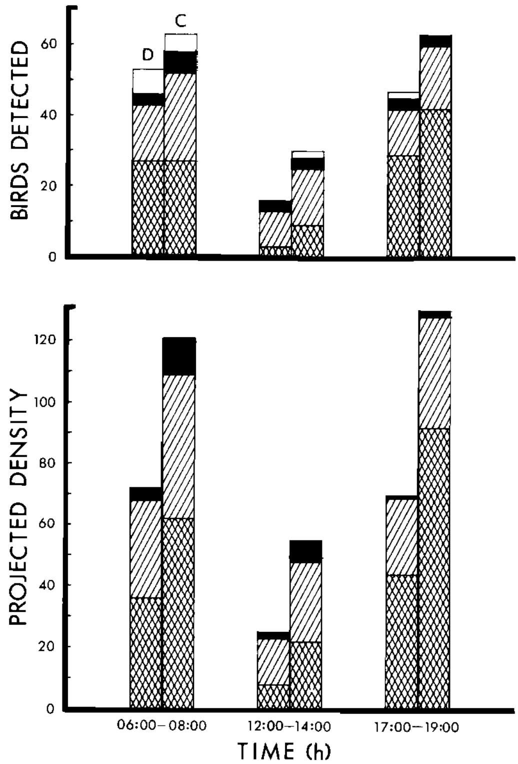

FIGURE 1. Diurnal changes in the average number of detections (birds/20 ha, including birds flying over) and projected densities (birds/40 ha) within a disturbed (D) and undisturbed (C) desert-scrub community during the breeding season. Diagonal lines represent permanent residents (cross-hatching = Mourning Doves), solid bars represent summer residents, and open bars represent transients.

Location of the study area was based on homogeneity of the habitat, accessibility, and lack of disturbances other than those associated with powerline construction. Approximately 5.7 ha of desert-scrub vegetation was removed from the disturbed transect for construction of the transmission line.

METHODS

Censuses of breeding birds were conducted by Grue along both transects between 20 April and 17 May 1974. A modified strip-transect method (J. T. Emlen 1971) was employed. Ten censuses were conducted between 06:00 and 08:00 and 12:00 and 14:00, and five censuses were conducted between 17:00 and 19:00. The two transects were alternated as to which was censused first. Censuses were conducted by slowly walking the transects in succession and recording (with a tape recorder) all birds detected by visual or auditory cues within a lateral distance of 63 m (maximum width of disturbance within the right-of-way). Progression along transects was continuous with stops only to observe and listen. We used the average number of detections (birds/20 ha) on each transect within each time interval as an index to avian activity. The activity index was equal to the total number of birds detected within 63 m divided by the number of censuses conducted; birds flying over were included.

Population estimates (projected densities) were derived using methods described by J. T. Emlen (1971). The mode lateral distance interval was found for each species during each time interval by summing the number of detections within seven lateral distance intervals. The first five intervals were 3.0 m wide, the sixth was 15.2 m wide, and the seventh was 32.6 m wide. Both visual and auditory cues were used to determine the total number of detections per interval; birds flying over were not included except for species which forage from the air. The number of birds detected up to and within the mode lateral distance interval (usually $\geq$15.2 m due to the open habitat and short ground cover) was then extrapolated to a lateral distance of 126 m. This value was then divided by the number of censuses conducted to give the projected number of individuals of a species within either 40 ha of transmission-line right-of-way or undisturbed desert scrub. All densities were rounded up to whole birds.

The activity index and projected densities for each time interval were compared within transects using chi-square tests (Snedecor and Cochran 1967:231) and between transects using paired t-tests (Snedecor and Cochran 1967:91). Similar comparisons were made for the activity and projected densities of permanent and summer residents, and for projected densities within different foraging guilds (ground; picker or gleaner; hawker, hoverer or aerial; and pecker, hammerer, or tearer; after Root 1967). The composition and structure of the disturbed and control avian communities were also compared using the community comparison index (C value, Kulcynski 1937, *in* Oosting 1956) and diversity (Shannon 1948) and evenness (Pielou 1975) indicies.

We placed three constantly recording Honeywell hygrothermographs, each within a standard white weather box, on the study area. One weather box was placed on the access road within the right-of-way. The remaining two weather boxes were placed along the control transect; one in the open on existing ground cover, and the other beneath a palo verde. Operation of the hygrothermographs coincided with morning, noon, and evening bird censuses. Mean temperatures were calculated at 2 h intervals (06:00–18:00) and compared using paired t-tests.

RESULTS

The number of birds detected on the disturbed and control transects between 12:00 and 14:00 was 32 to 49 percent of the number detected in the morning (Fig. 1). Activity on the two transects increased in the evening, but, with the exception of Mourning Doves (*Zenaida macroura*) remained lower than that observed between 06:00 and 08:00. These differences were statistically significant ($P < 0.05$). Differences between time intervals in the number of permanent and summer residents detected were also statistically significant. The majority of transients were also detected between 06:00 and 08:00;

TABLE 1

PROJECTED DENSITIES (RESIDENT BIRDS/40 HA) WITHIN A DISTURBED AND UNDISTURBED DESERT-SCRUB COMMUNITY AT DIFFERENT TIMES OF THE DAY DURING THE BREEDING SEASON

	Disturbed			Undisturbed		
Species	06:00–08:00	12:00–14:00	17:00–19:00	06:00–08:00	12:00–14:00	17:00–19:00
Turkey Vulture (*Cathartes aura*[a]; PR, HHA[b])					1 (1)	
Red-tailed Hawk (*Buteo jamaicensis*; PR, HHA)	1 (2)[c]					
Gambel's Quail (*Lophortyx gambelii*; PR, G)	2 (4)	1 (1)		2 (4)	1 (2)	4 (4)
White-winged Dove (*Zenaida asiatica*; SR, G)	1 (1)			2 (4)		
Mourning Dove (*Zenaida macroura*; PR, G)	36[d] (176)	8 (16)	44 (57)	62[c] (191)	22 (54)	92 (106)
Black-chinned Hummingbird (*Archilochus alexandri*; SR, HHA)			1 (1)	2 (2)	1 (1)	2 (1)
Common Flicker (*Colaptes auratus*; PR, PHT)	1 (4)	2 (6)	2 (3)	3 (6)	1 (1)	1 (1)
Gila Woodpecker (*Centurus uropygialis*; PR, PHT)				2 (6)		1 (2)
Ladder-backed Woodpecker (*Picoides scalaris*; PR, PHT)				1 (1)	1 (1)	
Cassin's Kingbird (*Tyrannus vociferans*; SR, HHA)				1 (1)		
Ash-throated Flycatcher (*Myiarchus cinerascens*; SR, HHA)	2 (5)	2 (3)		6 (16)	3 (9)	
Rough-winged Swallow (*Stelgidopteryx ruficollis*; SR, HHA)	1 (4)				3 (4)	
Verdin (*Auriparus flaviceps*; PR, PG)	5 (16)	3 (9)	2 (1)	3 (14)	2 (5)	7 (5)
Cactus Wren (*Campylorhynchus brunneicapillus*; PR, G)	6 (28)	3 (11)	7 (8)	17 (64)	9 (32)	12 (23)
Curved-billed Thrasher (*Toxostoma curvirostre*; PR, G)	8 (28)	4 (17)	6 (15)	11 (48)	9 (25)	12 (15)
Loggerhead Shrike (*Lanius ludovicianus*; PR, HHA)	4 (15)	2 (5)	4 (8)	1 (2)	1 (1)	1 (1)
Starling (*Sturnus vulgaris*; SR, G)				1 (1)		
House Finch (*Carpodacus mexicanus*; PR, G)	1 (5)		2 (4)	3 (11)	1 (2)	3 (5)
Black-throated Sparrow (*Amphispiza bilineata*; PR, G)	4 (8)		2 (2)	4 (11)	3 (6)	1 (1)
Total Density[e]	36[c]	17	26	59[c]	33	38
Number of Species	13	8	9	16	14	11
Diversity[f]	1.80	1.90	1.36	1.80	2.01	1.17
Evenness[g]	0.70	0.91	0.62	0.65	0.76	0.49

[a] Scientific names, American Ornithologists' Union (1957, 1973, 1976).

[b] Resident status: PR = permanent resident, SR = summer resident, ST = summer transient; after Phillips et al. (1964); and foraging guild: G = ground; HHA = hawker, hoverer, or aerial; PG = picker or gleaner; PHT = pecker, hammerer, or tearer; after Root (1967).

[c] Total number of observations excluding flyovers except for hawkers, hoverers, or aerial feeders.

[d] Differences between times of day significant, chi-square test, ($P < 0.05$).

[e] Excluding Mourning Doves.

[f] Shannon (1948).

[g] Pielou (1975:15).

TABLE 2
PROJECTED DENSITIES (RESIDENT BIRDS/40 HA) WITHIN FORAGING GUILDS AT DIFFERENT TIMES OF DAY WITHIN A DISTURBED AND UNDISTURBED DESERT-SCRUB COMMUNITY DURING THE BREEDING SEASON

Foraging guild	Disturbed			Undisturbed		
	06:00–08:00	12:00–14:00	17:00–19:00	06:00–08:00	12:00–14:00	17:00–19:00
Ground[a]	22[b] (6)[c]	8 (3)	17 (4)	40[b] (7)	20 (5)	26 (5)
Hawker, hoverer, or aerial	8 (4)	4 (2)	5 (2)	11 (4)	8 (5)	2 (2)
Picker or gleaner	5 (1)	3 (1)	2 (1)	3 (1)	2 (1)	7 (1)
Pecker, hammerer, or tearer	1 (1)	2 (1)	2 (1)	6 (3)	2 (2)	2 (2)

[a] Excluding Mourning Dove.
[b] Differences between times of day significant; chi-square test, $P < 0.05$.
[c] Number of species.

very few were detected during noon and evening censuses. Reductions in activity were greatest within the transmission-line right-of-way. The total number of birds detected on the disturbed transect was 16% lower than the number detected on the control between 06:00 and 08:00, 47% lower between 12:00 and 14:00, and 25% lower between 17:00 and 19:00. These differences were statistically significant.

Similar diurnal changes were observed in projected densities (Fig. 1, Table 1). Total projected densities on the disturbed and control transects between 12:00 and 14:00 were 35–46% of densities projected from morning censuses. Projected densities on both transects increased in the evening, but, with the exception of Mourning Doves, remained lower than results of censuses conducted between 06:00 and 08:00. Diurnal changes in projected densities were greatest on the disturbed transect. Total projected densities within the right-of-way were 40% lower than the control in the morning, 54% lower between 12:00 and 14:00, and 46% lower in the evening. All differences were statistically significant. Neither resident status (Fig. 1) nor foraging guild (Table 2) appeared to alter observed trends.

The structure and composition of the avian communities, as indicated by the census results, also changed with time of day. The number of species observed was greatest on both transects between 06:00 and 08:00 (Table 1). Diversity indicies were, however, greatest on both transects between 12:00 and 14:00 due to greater equitability among densities of the species observed. Both species richness and evenness were lowest in the evening on the two transects. Community comparison indices indicate the avian communities observed between 12:00 and 14:00 on the disturbed ($C = 0.28$) and control ($C = 0.33$) transects were the least similar to those depicted by the morning censuses. The disturbed and control communities were also the least similar at this time ($C = 0.40$).

DISCUSSION

Diurnal changes in activity and population estimates similar to those we observed have been reported for breeding birds within cooler and more mesic habitats. With the exception of Järvinen et al. (1977a), these studies have dealt only with changes during the morning. Davis (1965) observed a decrease in singing by male Rufous-sided Towhees (*Pipilo erythrophthalmus*) of 36% within ca. 30 min in the morning. Robbins and Van Velzen (1970) reported reductions in the number of species and individuals detected of ca. 37 and 25%, respectively, within 5 h after sunrise. Shields (1977) observed a 21% decrease in detectability between 06:00 and 07:30. Järvinen et al. (1977a) present data for breeding birds within fields and forests of southern Finland similar to those we collected. These authors reported reductions in density estimates of forest birds of 13% between early and late morning, 49% between early morning and afternoon, and 38% between early morning and evening. The number of species detected decreased from 64 in the early morning to 55 in the afternoon, and increased to 57 by evening. The decrease in population estimates between early and late morning (−38%) was greater for birds within fields. Järvinen et al. (1977a), however, found little difference in diversity indices for forest birds with time of day (diversity = 3.30–3.51, evenness = 0.79–0.83). The changes we observed in the diurnal activity of breeding birds within disturbed and undisturbed desert scrub appear to have been more pronounced than those reported for these cooler and more mesic habitats. Though the decrease in the number of species we observed on both transects between morning and evening censuses may have been due to a reduction in sample size, results are in agreement with those of others (Robbins and Van Velzen 1970, Järvinen et al. 1977a).

The diurnal changes in the activity of breeding birds we observed, as well as those observed by others, are probably due to changes in weather conditions (e.g., air temperature and solar radiation; for review, see Shields 1979). Evidence that activity patterns are in response to changes in air temperature and solar radiation and not some other correlate of time of day is circumstantial. The apparent increase in avian activity in the late afternoon and evening (Järvinen et al. 1977a, and this study) is associated with a decrease in air temperature and solar radiation. In addition, several authors (e.g., Robbins and Van Velzen 1970, Austin 1976) report that declines in activity are more rapid and of greater magnitude on very warm days. That the decreases we observed in the activity of breeding birds within undisturbed desert scrub were greater than those reported for cooler, more mesic habitats supports the hypothesis (Shields 1979) that increasingly stressful weather conditions negatively affect detectability. This hypothesis is further supported by the reported effects of extreme weather conditions on bird song (Welty 1962:199–200, Dorst 1974:162–163) and locomotor behavior (Grubb 1975, 1977, 1978; Austin 1976).

The "stressful weather hypothesis" may also explain the greater decrease in activity of breeding birds within the transmission line right-of-way compared to undisturbed desert scrub. The mean temperature on the access road between 06:00 and 18:00 (24.7 ± 6.4°C) was, however, lower than that recorded on ground cover on the undisturbed transect (25.5 ± 7.1°C). Therefore, increased exposure of birds to solar radiation following removal of 5.7 ha of desert-scrub vegetation for the access road and tower sites appears to have been a major factor in the greater decrease in activity on the disturbed transect compared to the control. Shade appears to be critical to the survival of breeding birds within this habitat, this is true even for permanent residents such as the Verdin (*Auriparus flaviceps*) and Cactus Wren (*Campylorhynchus brunneicapillus*). Foraging activity of Verdins is greatly reduced at temperatures above 35°C and long periods of inactivity are predominant (Austin 1976). The diversity of microhabitats used by Cactus Wrens also decreases as temperature increases (Ricklefs and Hainsworth 1969).

Our data, as well as those of others, indicate results of censuses conducted early in the morning most accurately describe habitat utilization by breeding birds within the habitats studied to date. However, as Shields (1979) notes "it is not enough to haphazardly limit censusing to a random portion of an extended (e.g., 4 h) census period." Guidelines for designing censuses to eliminate biases due to environmental conditions have been presented by Shields (1979) and Conner and Dickson (1980). Replicate or comparative censuses should be conducted at the same time of day. If more than one transect is to be sampled per day, starting times should be alternated, and transects should be started at opposite ends on alternate days. Time of day can also be included as a factor in subsequent statistical analyses removing the variation in densities of breeding birds due to regular changes in census starting times (e.g., Shields 1977).

ACKNOWLEDGMENTS

We gratefully acknowledge the financial support of the Arizona Public Service Company, The Salt River Project, and the Tucson Gas and Electric Company which made this study possible. Thanks are also due C. M. Bunck and G. L. Hensler for help with the statistical analyses, T. A. Grunwald and L. M. Palmer for preparing the illustration, and L. M. Thomas for secretarial assistance. C. J. Ralph and H. F. Recher kindly reviewed the manuscript.