TIME OF DAY AND DESERT BIRD CENSUSES

WESLEY W. WEATHERS, Department of Avian Sciences, University of California, Davis, California 95616

WILBUR W. MAYHEW, Department of Biology, University of California, Riverside, California 92521

Many recent quantitative studies of avian population ecology have used strip transect methods to estimate bird densities (see Emlen 1971, 1977). These methods, and indeed all census methods, suffer from complications and limitations, some of which pertain to the observation conditions (e.g., weather and time of day). Traditionally the bias introduced by diurnal variations in bird detectability has been met by limiting censusing to early morning "when birds are most active" (Pettingill 1970). However, recent findings that detectability may vary inversely with time of day in winter, but directly with time of day in summer (Anderson and Ohmart 1977, Shields 1977), or in some species (Robbins 1981), emphasize the need for further studies.

Since 1978 we have been intensively censusing bird communities along a 2600-m altitudinal gradient in California's Santa Rosa Mountains, using the narrow strip transect method (Merikallio 1946, 1958). In order to sample all of our transects monthly, we have had to census at various times of day. Our early results suggested that, in the open desert habitats of our study region, time of day had little influence on census results, provided air temperature was below about 35 C. Indeed, midday censuses seemed to yield density estimates comparable to those obtained at sunrise. To examine this further, we censused two desert habitats ten times each, twice daily — once around sunrise and once at midday — between 25 March and 9 April 1980.

MATERIALS AND METHODS

The two 50-m wide transects we censused are part of a series of 32 strip transects established at the University of California's Philip L. Boyd Deep Canyon Desert Research Center, located near Palm Desert, California. Both transects lie on an alluvial fan (elevation 250 m) that spreads northward from the base of the Santa Rosa Mountains (Figure 1). One transect (No. 8; desert woodland habitat) is 1.3 km long and follows the sandy bed of a dry desert wash. The dominant plants on this transect are Palo Verde (*Cercidium floridum*), Smoke Tree (*Dalea spinosa*), Desert-willow (*Chilopsis linearis*), Desert-lavender (*Hyptis emoryi*), Chuparosa (*Beloperone californica*) and Cheesebush (*Hymenoclea salsola*). The other transect (No. 1B; scrubland habitat), located to the west of transect 8, follows a paved one-lane road (3-m wide) for 1.5 km across the broad alluvial fan. Dominant plants on this transect include Creosote Bush (*Larrea tridentata*), Burrobush (*Ambrosia dumosa*), Sweet Bush (*Bebbia juncea*), Cheesebush and several species of cacti. A few scattered Palo Verde and Smoke Trees also occur on transect

1B. Plant cover averages approximately 14% on transect 1B and 23% on transect 8 (Zabriskie 1979 and pers. comm.).

Both transects were walked twice daily, once within 2 h of sunrise and again at midday (starting times relative to sunrise are given in Appendices 1 and 2). All transect counts were made by Weathers on calm sunny days. He used all available cues to detect birds and advanced with frequent pauses at speeds averaging 1.7 km/h. Following Emlen (1979), we assumed that in these open habitats few species would show detectability attenuation inside the 25-m boundary. Hence, no density adjustments were made for difficult to detect species.

RESULTS

From the number of birds seen during sunrise and midday censuses (Appendices 1 and 2), we calculated species richness, mean number of species seen, density, and species diversity (Table 1). Significant diurnal differences in these measures of community structure existed only for the desert woodland habitat, in which density was lower and diversity higher at sunrise than at midday. In the more open scrubland habitat, midday and sunrise censuses were comparable. In both habitats a few species exhibited diurnal density changes (Appendices 1 and 2). Although some of these changes were due to variations in detectability, most seemingly resulted from localized

Table 1. Number of species, individuals, and diversity of birds in two desert habitats censused 10 times each at sunrise and midday.

	Desert Woodland Habitat		Scrubland Habitat	
	Sunrise	**Midday**	**Sunrise**	**Midday**
Species richness[a]	25 (11)	25 (11)	18 (10)	20 (10)
Number species/census	11.90 ± 1.66	11.90 ± 1.45	8.20 ± 1.69	9.10 ± 1.60
Density (birds/40 ha)	594 ± 177[b]	719 ± 149	236 ± 111	238 ± 94
Diversity†	0.85 ± 0.03[b]	0.80 ± 0.05	0.72 ± 0.14	0.71 ± 0.09

Values are mean ± standard deviation.

†Simpson's index of diversity: $D = 1 - \sum_{i=1}^{s} (P_i)^2$.

[a]Total species (resident species).

[b]Significantly different from midday value ($p < 0.02$; paired t statistic).

Figure 1. View of Deep Canyon study site, near Palm Desert, California. Location of the desert woodland transect (No. 8) is indicated by the dashed line. The solid line denotes the scrubland transect (No. 1B). Photograph taken from 1100-m elevation looking northeast.

movements by birds. For example, more Gambel's Quail were encountered in the scrubland habitat at sunrise than at midday, whereas the opposite was true for the desert woodland habitat. This circumstance was due to quail leaving their nighttime desert wash roosts at dawn and traveling across the scrubland transect to drink at a nearby stream. After drinking, they returned to the dry desert wash. Similar localized movements may be responsible for higher midday densities of two other desert woodland residents, the Mourning Dove and House Finch. Like the quail, these species require free water and probably left the transect early in the day to drink. Resident birds not dependent upon free water did not show significant diurnal variations in density.

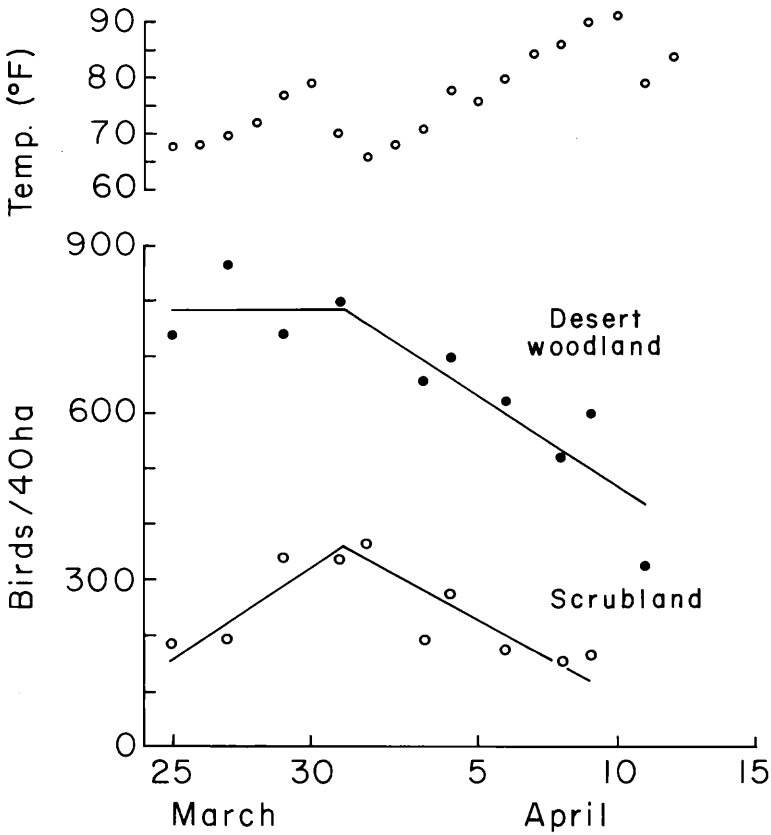

Figure 2. Maximum daily air temperature (above) and mean bird density in two desert habitats (below). Bird density was determined by averaging sunrise and midday transect counts.

In contrast with the pattern seen in resident species, winter visitors were more numerous in the desert woodland at sunrise than at midday. This resulted from greater numbers of sparrows being recorded at sunrise (Appendix 1). In the desert woodland, Brewer's, White-crowned and Golden-crowned sparrows tended to rest in dense bushes at midday and thus were less detectable at that time. Some White-crowned Sparrows probably left the desert wash for the scrubland habitat at midday, however, as their numbers increased there then.

During this study, bird density changed conspicuously with time of year (Fig. 2). In the desert woodland habitat, bird density decreased from around 800 to 330 birds/40 ha within 2 weeks. This decrease, which paralleled an increase in maximum air temperature, was due mainly to the emigration of winter visitors and House Finches. The early April peak in scrubland bird density resulted from beginning those censuses earlier in the day and consequently encountering more Gambel's Quail (Appendix 2). When Gambel's Quail are omitted from the calculations, scrubland bird density follows the desert woodland pattern.

DISCUSSION

The belief that early morning is the best time of day to census birds is widespread. Empirical studies, however, have yielded conflicting results. In some studies (Dawson 1981, Skirven 1981), bird density was independent of time of day, whereas in others (e.g., Robbins and Van Velzen 1967, Järvinen et al. 1977) it decreased with time since sunrise. Although sunrise may be the best time to census densely vegetated habitats (i.e., those in which detecting birds depends heavily on sound cues), in more open habitats other times of day may be equally satisfactory. Indeed, we found that due to local bird movements, the relative density of birds in desert woodland was actually higher at midday than at sunrise (Table 1). If we had limited censuses in this habitat to around sunrise, bird density would have been underestimated by an average of 17%. In three species (Gambel's Quail, Mourning Dove and House Finch), the underestimation would have been closer to 100%. Clearly, one cannot assume *a priori* that sunrise censuses provide the best results in all habitats. Furthermore, in the absence of diurnal effects, limiting censusing to a single time of the day is unnecessary and inefficient.

Number of censuses required

Often, bird community structure is expressed by density, species diversity, and species richness estimates derived from transect data. The number of times that a transect must be censused to obtain reliable estimates of these parameters is thus of crucial importance. Presumably, this will vary with habitat type and season. In mature Honey Mesquite (*Prosopis juliflora*), Anderson and Ohmart (1977) found that a minimum of four censuses of

single transects 0.8 to 1.6 km long was necessary to obtain reliable estimates of bird species diversity and richness, but that a single census was adequate for determining density. In the open desert habitats we studied, single censuses also provided reasonable estimates of density. Indeed, total bird density changed so rapidly throughout our study that calculating a mean density from multiple censuses seems inappropriate.

In Figure 3 we present mean density estimates based on our unpublished censuses of six different desert woodland transects (including data for transect 8). These data confirm the pattern seen in Figure 2, and indicate that during the breeding season density varies markedly. A similar seasonal pattern has been found for birds in a northern hardwood forest by Holmes and Sturges (1975). Likewise, Weber and Theberge (1977) found that bird density in southern Ontario, Canada, changed 53% in 7 weeks. Such rapid changes in bird density suggest that, for a variety of habitats, the precision of density estimates probably improves little after the first census.

Bird species diversity (calculated from the data in Appendices 1 and 2) shows greater variability in the scrubland than in the desert woodland habitat (Table 2). Consequently, whereas only two or three censuses are needed to adequately estimate diversity in the desert woodland, four or five are required in the scrubland.

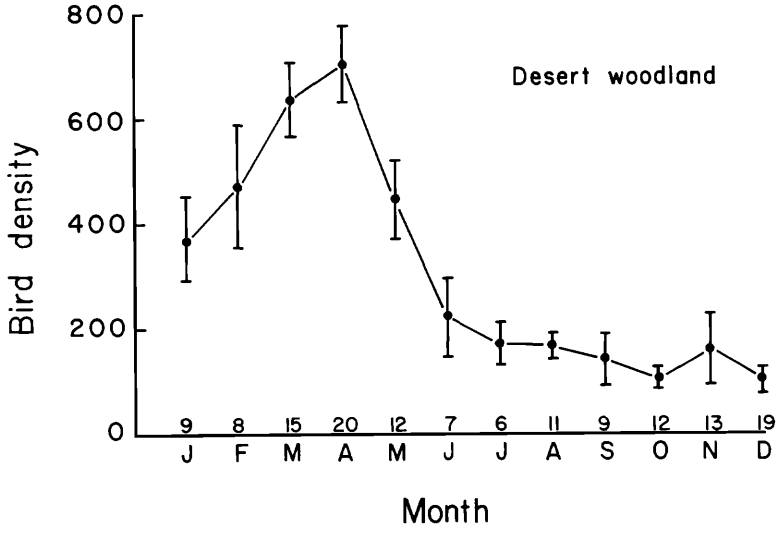

Figure 3. Seasonal change in total bird density (birds/40 ha) in desert woodland habitat at Deep Canyon Desert Research Center, Palm Desert, California. Values are means ± SE for the indicated number of transect counts. Data from six different transects.

Table 2. Bird species diversity (Simpson's Index) calculated from sunrise and midday census data.

	Desert Woodland		Scrubland	
Census Number	**Sunrise**	**Midday**	**Sunrise**	**Midday**
1	0.86	0.72	0.77	0.75
2	0.86	0.81	0.82	0.70
3	0.78	0.78	0.65	0.67
4	0.83	0.70	0.49	0.60
5	0.85	0.80	0.50	0.59
6	0.89	0.80	0.82	0.65
7	0.87	0.82	0.83	0.73
8	0.86	0.87	0.74	0.85
9	0.83	0.83	0.88	0.85
10	0.90	0.83	0.74	0.74
Mean ± SD	0.85 ± 0.03	†0.80 ± 0.05	0.72 ± 0.14	0.71 ± 0.09

†Significantly different from sunrise, $p < 0.01$ paired t statistic.

Species richness, in terms of residents, changed by only one or two species after the fourth census in both habitats (Appendices 1 and 2). Based on more extensive censusing, however, we know that two species not detected during this study are resident in very low numbers in the desert woodland habitat: the Roadrunner, *Geococcyx californianus*, and Abert's Towhee, *Pipilo aberti*. Similarly, the Poor-will (*Phalaenoptilus nuttallii*) is a low density resident in the scrubland. Failure to detect these species during this study reflects their low density and patchy distributions, and, in the case of the Poor-will, nocturnal habits. This finding suggests that in these habitats several transects should be censused to estimate reliably species richness. Based on more extensive data, Anderson and Ohmart (1977) recommended censusing four different transects three times each to obtain adequate estimates of density, species diversity, and species richness in mature Honey Mesquite habitat. This recommendation seems reasonable for our more open habitats as well.

Because a multitude of factors affects bird census results (see Ralph and Scott 1981), our findings do not necessarily apply to other desert habitats. For example, in the Sonoran Desert, Grue et al. (1981) found bird density to be 32-49% lower at midday than at sunrise. Clearly, the prudent course is to assume that each situation is unique, and to determine empirically the best time of day to census birds.

SUMMARY

In desert scrubland, sunrise and midday strip transect censuses produced comparable estimates of species diversity, species richness, and density. In desert woodland, species diversity averaged 6.3% higher and density 17.4% lower at sunrise than midday. Lower sunrise density in the desert woodland resulted from about half the resident Gambel's Quail, Mourning Doves and House Finches leaving this habitat at dawn to drink at nearby water sources. Thus, in our study area, restricting censusing to around sunrise is inappropriate in the desert woodland and unnecessary in the desert scrubland.

In the open desert habitats we studied, density was estimated adequately from a single census, but reliable estimates of species diversity and richness required 4-5 censuses.

ACKNOWLEDGMENTS

We thank J. Michael Scott, Robert D. Ohmart and Charles van Riper III for critically reading the penultimate manuscript, and Debra L. Weathers for providing valuable technical assistance. Our research was supported by funds from the University of California Agricultural Experiment Station. This is contribution No. 2 from the University of California Natural Land and Water Reserve System.

LITERATURE CITED

Anderson, B.W. & R.D. Ohmart. 1977. Climatologial and physical characteristics affecting avian population estimates in southwestern riparian communities using transect counts. U.S. For. Ser. Gen. Tech. Rep. RM-43:193-200.

Dawson, D.G. 1981. Counting birds for a relative measure (index) of diversity. Pp. 13-16 *in* C.J. Ralph & J.M. Scott, eds. Estimating the numbers of terrestrial birds. Studies in Avian Biol. No. 6.

Emlen, J.T. 1971. Population densities of birds derived from transect counts. Auk 88:323-342.

Emlen, J.T. 1977. Estimating breeding season bird densities from transect counts. Auk 94:455-468.

Emlen, J.T. 1979. Land bird densities on Baja California islands. Auk 96:152-167.

Grue, C.E., R.P. Balda & C.D. Johnson. 1981. Diurnal activity patterns and population estimates of breeding birds within a disturbed and undisturbed desert-scrub community. Pp. 287-291 *in* C.J. Ralph & J.M. Scott, eds. Estimating the numbers of terrestrial birds. Studies in Avian Biol. No. 6.

Holmes, R.T. & F.W. Sturges. 1975. Bird community dynamics and energetics in a northern hardwoods ecosystem. J. Anim. Ecol. 44:175-200.

Järvinen, O.R., A. Väisänen & Y. Haila. 1977. Bird census results in different years, stages of the breeding season, and times of the day. Ornis Fenn. 54:108-118.

Merikallio, E. 1946. Über regionale Verbreitung und Anzahl der Landvögel in Sud- und Mittelfinnland, besonders in deren Östlichen Teilen, im Lichte von quantitativen Untersuchungen. I. Allgmeiner Teil. Ann. Zool. Soc. Vanamo. 12:1-140.

Merikallio, E. 1958. Finnish birds. Their distribution and numbers. Fauna Fennica 5:1-181.

Pettingill, O.S., Jr. 1970. Ornithology in laboratory and field. Burgess Publ. Co., Minneapolis.

Ralph, C.J. & J.M. Scott. 1981. Estimating numbers of terrestrial birds. Studies in Avian Biol. No. 6.

Robbins, C.S. 1981. Effect of time of day on bird activity. Pp. 275-286 *in* C. J. Ralph & J.M. Scott, eds. Estimating the numbers of terrestrial birds. Studies in Avian Biol. No. 6.

Robbins, C.S. & W.T. Van Velzen. 1967. The breeding bird survey, 1966. U.S. Bur. Sport Fish. and Wildl., Spec. Sci. Rep. Wildl. 102.

Shields, W.M. 1977. The effect of time of day on avian census results. Auk 94:380-383.

Skirven, A.A. 1981. Effect of time of day and time of season on the number of observations and density estimates of breeding birds. Pp. 271-274 *in* C.J. Ralph & J.M. Scott, eds. Estimating the numbers of terrestrial birds. Studies in Avian Biol. No. 6.

Weber, W.C. & J.B. Theberge. 1977. Breeding bird survey counts as related to habitat and data. Wilson Bull. 89:543-561.

Zabriskie, J.G. 1979. Plants of Deep Canyon and the central Coachella Valley, California. Philip L. Boyd Deep Canyon Desert Res. Cent., Univ. California, Riverside.

APPENDIX 1. Number of birds recorded during sunrise and midday censuses in desert woodland habitat

	Sunrise											Midday										
Census number	1	2	3	4	5	6	7	8	9	10	$\bar{X}$(SD)*	1	2	3	4	5	6	7	8	9	10	$\bar{X}$(SD)*
Start time (hrs. post sunrise)	0.3	1.0	1.3	1.0	0.3	0.0	0.5	0.2	1.3	0.3		6.3	7.0	7.0	7.25	8.0	7.0	7.0	7.0	6.7	6.0	
Residents																						
Cooper's Hawk *Accipiter cooperii*			1								0.1 (0.32)	1										0.1 (0.32)
Gambel's Quail *Lophortyx gambelii*	3	3	1	2	7	10	5	13	4	4	5.2 (3.77)	8	7	11	2	7	21	16	18	22	4	†11.6 (7.17)
Mourning Dove *Zenaida macroura*	6	4	6	10	6	4	9	7	7	2	6.1 (2.38)	4	9	9	12	14	13	14	14	10	19	†11.8 (4.05)
Costa's Hummingbird *Calypte costae*	7	13	4	7	1	1	3	2	2	3	4.3 (3.74)	11	4	5	3	5	5	1	2	1	4	4.1 (2.88)
Verdin *Auriparus flaviceps*	3	3	5	5	3	4	3	4	5	4	3.9 (0.88)	2	1	2	1	3	4	3	5	3	4	2.8 (1.32)
Cactus Wren *Campylorhynchus brunneicapillus*				3		2		2		2	0.9 (1.20)								2		2	0.4 (0.84)
Mockingbird *Mimus polyglottos*	1	5	1	1	1	1	2				1.2 (1.48)	1	11	2	2						1	1.7 (3.37)
Black-tailed Gnatcatcher *Polioptila melanura*	4	3	1	3	2	1			2	1	1.7 (1.34)	2	1	1	2		1	1	1	2	1	1.2 (0.63)
Loggerhead Shrike *Lanius ludovicianus*	1	2			1			1			0.5 (0.71)		1			1	1	2	2	1		0.8 (0.79)
House Finch *Carpodacus mexicanus*	30	32	40	40	18	13	16	7	27	5	22.8 (12.81)	61	52	47	66	40	53	29	16	29	16	†40.9 (17.84)
Black-throated Sparrow *Amphispiza bilineata*										1	0.1 (0.32)	1										0.1 (0.32)
Total	55	65	59	71	39	36	38	36	47	22	46.8 (15.35)	91	86	77	88	70	98	66	60	68	51	†75.5 (15.03)

Appendix 1. (continued)

	Desert woodland habitat																					
	Sunrise											Midday										
Census number	1	2	3	4	5	6	7	8	9	10	$\bar{X}$(SD)*	1	2	3	4	5	6	7	8	9	10	$\bar{X}$(SD)*
Start time (hrs. post sunrise)	0.3	1.0	1.3	1.0	0.3	0.0	0.5	0.2	1.3	0.3		6.3	7.0	7.0	7.25	8.0	7.0	7.0	7.0	6.7	6.0	
Winter Visitors																						
House Wren *Troglodytes aedon*							1				0.1 (0.32)											0.0 (0.00)
Bewick's Wren *Thryomanes bewickii*		1		2		1			1		0.5 (0.71)		2		1		1			2		0.6 (0.84)
Ruby-crowned Kinglet *Regulus calendula*							1				0.1 (0.32)		1									0.1 (0.32)
Phainopepla *Phainopepla nitens*	19	29	32	24	21	20	21	14	14	4	19.8 (7.97)	15	28	23	18	19	23	25	14	16	2	18.3 (7.33)
Lesser Goldfinch *Carduelis psaltria*				1							0.1 (0.32)	4			10						1	1.5 (3.24)
Brewer's Sparrow *Spizella breweri*				2			2				0.4 (0.84)											0.0 (0.00)
White-crowned Sparrow *Zonotrichia leucophrys*	12	12	18	7	23	9	13	13	14	3	12.4 (5.54)		6	1	3	8	7	3	7	6		†4.1 (3.07)
Golden-crowned Sparrow *Zonotrichia atricapilla*	3		1								0.4 (0.97)		1									0.1 (0.32)
Total	34	42	51	36	44	30	38	27	29	7	33.8 (11.98)	19	38	24	32	27	31	28	21	24	3	†24.7 (9.45)
Migrants																						
Western Flycatcher *Empidonax difficilis*											0.0 (0.00)						1					0.1 (0.32)
Orange-crowned Warbler *Vermivora celata*		1	2		2		4				0.9 (1.37)						1	1				0.2 (0.42)
Black-headed Grosbeak *Pheucticus melanocephalus*									1		0.1 (0.32)									1		0.1 (0.32)
Total		1	2		2		4		1		1.0 (1.33)						2	1		1		0.4 (0.70)

Appendix 1. (continued)

	Desert woodland habitat																				
	Sunrise											Midday									
Census number	1	2	3	4	5	6	7	8	9	10	$\bar{X}$(SD)*	1	2	3	4	5	6	7	8	9	10	$\bar{X}$(SD)*
Start time (hrs. post sunrise)	0.3	1.0	1.3	1.0	0.3	0.0	0.5	0.2	1.3	0.3		6.3	7.0	7.0	7.25	8.0	7.0	7.0	7.0	6.7	6.0	
Summer Visitors																						
Ash-throated Flycatcher *Myiarchus cinerascens*										1	0.1 (0.32)										2	0.2 (0.63)
Violet-green Swallow *Tachycinetta thalassina*		1									0.1 (0.32)					1						0.1 (0.32)
Hooded Oriole *Icterus cucullatus*				1					1		0.2 (0.42)			1	1				1			0.3 (0.48)
Scott's Oriole *Icterus parisorum*	2	3		1					1		0.7 (1.06)	5	3	2	3	1	3	1				†1.8 (1.69)
Northern Oriole *Icterus galbula*											0.0 (0.00)		1							1		0.2 (0.42)
Total	2	4		2					2	1	1.1 (1.37)	5	4	3	4	2	3	1	1	1	2	†2.6 (1.43)
Unidentified birds																						
Hummingbirds	11	12	2	3	8	7	6	3	5	6	6.3 (3.33)	9	6	7	4	4	1	4	10	4	7	5.6 (2.72)
Others (mainly sparrow size)	7	7	3	12	6	8	4	2	3	2	5.4 (3.20)		11	6	2	7	8	7	5	6	2	5.4 (3.27)
Total	18	19	5	15	14	15	10	5	8	8	11.7 (5.17)	9	17	13	6	11	9	11	15	10	9	11.0 (3.23)
Total of all individuals	109	131	117	124	99	81	90	68	87	38	94.4 (28.87)	124	145	117	130	110	143	107	97	104	65	†114.2 (23.62)
Total of all species	12	14	12	15	11	11	12	9	12	11	11.9 (1.66)	12	15	11	13	10	13	11	11	12	11	11.9 (1.45)

*Values are mean (standard deviation). To convert to birds/40 ha multiply by 6.3.
†Significantly different from sunrise value $p<0.05$; paired t statistic

APPENDIX 2. Number of birds recorded during sunrise and midday censuses in desert scrubland habitat

Census number / Start time (hrs. post sunrise)	Sunrise											Midday										
	1 1.5	2 2.0	3 0.6	4 0.0	5 0.0	6 1.25	7 1.0	8 1.5	9 1.5	10 0.3	$\bar{X}$(SD)*	1 5.0	2 6.0	3 6.0	4 6.0	5 6.0	6 7.0	7 8.3	8 6.5	9 6.5	10 7.5	$\bar{X}$(SD)*
Residents																						
Gambel's Quail *Lophortyx gambelii*	1		12	50	60	12	11	3	4	18	17.1 (20.91)	1		4	1	1	5	7	7			†2.6 (2.88)
Mourning Dove *Zenaida macroura*		1				2					0.3 (0.67)	3							1			0.4 (0.97)
Costa's Hummingbird *Calypte costae*	2	1		1	1			1	2	2	1.0 (0.82)	1	3	2	2	2	1	2	2	2	1	1.8 (0.63)
Say's Phoebe *Sayornis saya*											0.0 (0.00)			1								0.1 (0.32)
Verdin *Auriparus flaviceps*	1	2	2	2	1	2	2	1	2	2	1.7 (0.48)		3	2	2	3	2	3	1	1	2	1.9 (0.99)
Cactus Wren *Campylorhynchus brunneicapillus*	2				2	1	6	2	2	2	1.7 (1.77)	2			1	1	1	3	4	2		2.0 (1.15)
Mockingbird *Mimus polyglottos*	1						1				0.2 (0.42)											0.0 (0.00)
Black-tailed Gnatcatcher *Polioptila melanura*								1		1	0.2 (0.42)				1						1	0.2 (0.42)
Loggerhead Shrike *Lanius ludovicianus*						2	1	1	2		0.6 (0.84)				1			1		1		0.3 (0.48)
House Finch *Carpodacus mexicanus*	13	8	23	17	9	6	8	11	4	5	10.4 (5.89)	17	23	41	30	31	19	29	8	7	9	†21.4 (11.43)
Black-throated Sparrow *Amphispiza bilineata*	1	1			3		1		3		0.9 (1.20)	2		2	1			2	1	3		1.1 (1.10)
Total	21	13	37	70	76	25	30	20	19	30	34.1 (21.64)	26	29	52	39	38	28	47	24	16	13	31.2 (12.67)

Appendix 2. (continued)

	Scrubland habitat																				
	Sunrise											Midday									
Census number	1	2	3	4	5	6	7	8	9	10	$\bar{X}$(SD)*	1	2	3	4	5	6	7	8	9	10	$\bar{X}$(SD)*
Start time (hrs. post sunrise)	1.5	2.0	0.6	0.0	0.0	1.25	1.0	1.5	1.5	0.3		5.0	6.0	6.0	6.0	6.0	7.0	8.3	6.5	6.5	7.5	
Winter Visitors																						
Ruby-crowned Kinglet *Regulus calendula*					3						0.3 (0.95)											0.0 (0.00)
Phainopepla *Phainopepla nitens*	4	3	3	3	2	3	3	3	2	5	3.1 (0.88)	4	5	4	2	3	2	2	3	3	6	3.4 (1.35)
Lesser Goldfinch *Carduelis psaltria*							1				0.1 (0.32)	1				1	1	2		1		0.6 (0.70)
Savannah Sparrow *Passerculus sandwichensis*											0.0 (0.00)					1						0.1 (0.32)
Brewer's Sparrow *Spizella breweri*						1					0.1 (0.32)		1						3			0.4 (0.97)
White-crowned Sparrow *Zonotrichia leucophrys*		6	5		3	5	8	1	8	1	3.7 (3.13)	3	6	21	7	1	2	3	9	1	1	5.4 (6.15)
Total	4	9	8	3	8	9	12	4	10	6	7.3 (2.95)	8	12	25	9	6	5	7	15	5	7	9.9 (6.17)
Migrants																						
Orange-crowned Warbler *Vermivora celata*											0.0 (0.00)					1						0.1 (0.32)
Chipping Sparrow *Spizella passerina*						1					0.1 (0.32)			3		1						0.4 (0.97)
Total						1					0.1 (0.32)			3		2						0.5 (1.08)

Appendix 2. (continued)

	Scrubland habitat																					
	Sunrise											Midday										
Census number	1	2	3	4	5	6	7	8	9	10	$\bar{X}$(SD)*	1	2	3	4	5	6	7	8	9	10	$\bar{X}$(SD)*
Start time (hrs. post sunrise)	1.5	2.0	0.6	0.0	0.0	1.25	1.0	1.5	1.5	0.3		5.0	6.0	6.0	6.0	6.0	7.0	8.3	6.5	6.5	7.5	
Summer Visitors																						
Violet-green Swallow *Tachycinetta thalassina*	3										0.3 (0.95)					2						0.2 (0.63)
Hooded Oriole *Icterus cucullatus*											0.0 (0.00)		1									0.1 (0.32)
Scott's Oriole *Icterus parisorum*											0.0 (0.00)		1									0.1 (0.32)
Northern Oriole *Icterus galbula*				1							0.1 (0.32)											0.0 (0.00)
Total	3			1							0.4 (0.97)		2			2						0.4 (0.84)
Unidentified birds																						
Hummingbirds	1	1							1		0.3 (0.48)		1	1	1	1		2				0.6 (0.70)
Others (mainly sparrow sized)	1	4		1	2	1			3	3	1.4 (1.51)	3	1				1	3	1	3	2	1.4 (1.26)
Total	2	5			2	1			4	3	1.7 (1.83)	3	2	1	1	1	1	5	1	3	2	2.0 (1.33)
Total of all individuals	30	27	45	74	86	36	42	24	33	39	43.6 (20.45)	37	45	81	49	49	34	59	40	24	22	44.0 (17.30)
Total of all species	9	7	5	6	9	10	10	9	9	8	8.2 (1.69)	9	8	9	10	12	8	10	10	9	6	9.1 (1.60)

*Values are mean (standard deviation). To convert to birds/40 ha multiply by 6.3.
†Significantly different from sunrise value $p<0.05$; paired t statistic.

Accepted 5 February 1982

Gambel's Quail

Sketch by Narca Moore