short distances and at low altitudes. Females, on the other hand, were usually in the upper extremities of the trees and made longer flights.

Males and females appeared to forage in the same way, and uncommonly did feed close together. Probing and peering were the primary means of food searching, although the birds tapped the trunk and larger limbs as they moved along them. Birds of both sexes scratched bark from the trunk with the feet, using both feet simultaneously. I also saw a male scratch bark loose with one foot while retaining his grasp to the tree with the other. On one occasion a male flew vertically up from branch to branch, several feet away from the trunk. Both sexes often foraged upside down on small limbs. These observations, like those of Davis (Auk 82:548, 1965), indicate that searching for food is primarily by means other than vigorous hammering or drilling.

The birds foraged primarily on pines, but also visited oaks. Of 25 consecutive trees in which a foraging male was observed, three were small or medium-sized oaks and the rest were pines.

Hairy Woodpeckers (*D. villosus*) were common in this area, but the two species appeared to take no notice of each other. On several occasions individuals of both species were seen in the same tree.

COMPARISONS WITH OTHER SPECIES OF *DENDROCOPOS*

The fight between the two male *stricklandi* differed from conflicts of *villosus, pubescens* (Kilham, Auk 77:259–270, 1960; Condor 64:126–139, 1962; Wilson Bull. 78:251–265, 1966), and *arizonae* (personal observation), in that in these species there is much bill-waving as the heads are swayed back and forth, and the tail of the aggressive bird is spread. In all four species each sex is aggressive only toward intruders of the same sex. Contrastingly, in *borealis* both members of a pair actively attack a single intruder (personal observation). This also appears to be true for *scalaris*.

Both *stricklandi* and *borealis* feed predominantly on pines and demonstrate a similar kind of sexual dimorphism in foraging. Males and females of each species forage in different portions of the trees, and beak-length dimorphism is not pronounced. This method of differential foraging is unlike that found in *arizonae* in southern Arizona, where the sexes differ in beak size and utilize the same foraging sites in different ways (personal observation). Davis (Auk 82:566–567, 1965, figs. 6 and 7) presents measurements demonstrating that Arizona populations of *arizonae* are much more dimorphic in beak length than either *stricklandi* or *borealis*.

The single nest site of *stricklandi*, in a dead limb of a living pine, seemed to me to be most like that of *pubescens*. Both *arizonae* (personal observation) and *villosus* (Bent, U.S. Natl. Mus. Bull. 174:14, 1939) often excavate nest cavities in living trees, although the site of excavation may be weak internally. *Borealis* excavates its cavities in living pines (Bent, U.S. Natl. Mus. 174:74, 1939).

Of these comparisons, only the means of territorial fighting may be useful in determining relationships within the genus. This suggests that the affinities of *stricklandi* are indeed with the *arizonae-villosus* group than with the ladder-backed group of North American *Dendrocopos*, as indicated by other lines of evidence. Differences between *stricklandi* and *arizonae* are greater than those between *arizonae* and *villosus*, and suggest that *stricklandi* probably is not conspecific with *arizonae*, as most recently suggested by Davis (Auk 82:537–590, 1965).

This study was supported by the National Science Foundation Training Program in Systematic and Evolutionary Biology (GB-3366), through the University of Michigan Museum of Zoology. I wish to thank B. G. Murray, Jr., R. W. Storer, and H. B. Tordoff for reading and offering constructive criticism of the manuscript. (Present address: Department of Biology, Idaho State University, Pocatello, Idaho 83201.)

Accepted for publication 23 January 1967.

THE DIURNAL ACTIVITY OF THE ROADRUNNER, *GEOCOCCYX CALIFORNIANUS*

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The Roadrunner is a well-known ground cuckoo of the deserts, chaparral edges, and arid grasslands in the southwestern United States and northern México (Dobie 1956; Sutton 1940). Information on the activity of the Roadrunner in relation to the time of day or environmental temperatures is virtually nonexistent. Cursorial habits in hot and open locations would seem to place a large burden on the temperature-regulation abilities of this bird. The following observations were made as an adjunct to laboratory studies of the roadrunner (Calder 1966).

The study was made at the Santa Rita Experimental Range, located in desert and desert-grassland vegetation at the eastern edge of the Sonoran Desert, south of Tucson, Arizona. (For a discussion of the vegetation, see Lowe 1964.)

Because of the furtive habits of the species and its large home range, it was usually difficult to keep track of a Roadrunner for extended periods. Limited observations of nest-spacing, a boundary dispute, and hunting sorties suggested that the territory of an adult pair in this habitat might be about one-half mile in diameter. Thus continuous day-long surveillance was not feasible, and data from shorter observations were pooled to obtain an index of activity (observations per hour afield). In all, 87 observations were made during 164 hours in the field. These ranged from brief roadside sightings to long periods of hunting observed from a hillside vantage point. Observations of Roadrunners that were flushed from the shade or vegetation thickets were excluded from the index because it was not possible to ascertain whether they had been resting or active.

The official maximum air temperature recorded at the range headquarters (elevation 1310 m) during the study period (10 June–5 July 1965) was 38.8° C. This was similar to the average high temperature for this period (Smith 1956). The Roadrunners were observed at elevations of ca. 950–1280 m where air temperatures were slightly higher. The maximum air temperature in the shade recorded in the field was 40.7° C.

The Roadrunners reduced their activity by slightly less than one-half during the hottest hours. The data from hourly intervals (and longer intervals before

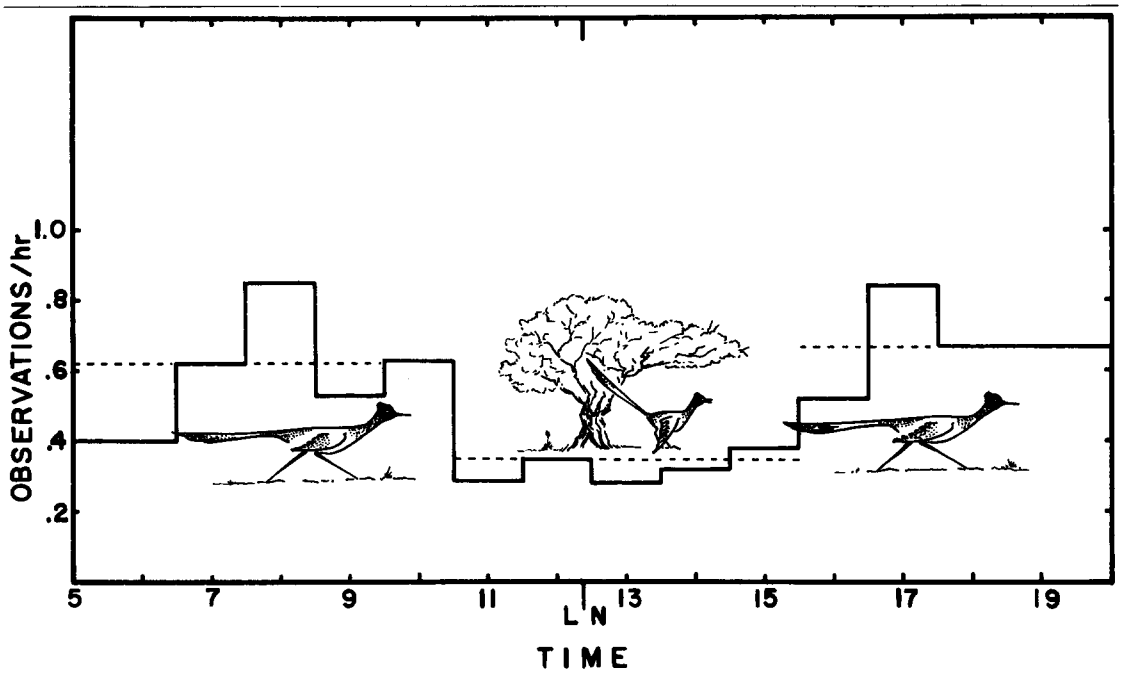

FIGURE 1. Frequency of observation of wild active Roadrunners, an index of activity, as a function of standard zone time. The histogram shows the mean frequency of observation for the time periods indicated. The broken lines depict the mean values for morning (05:00–10:30), midday (10:30–15:30), and afternoon (15:30–20:00) periods. LN = local noon.

06:30 and after 17:30) seem to fit into three groups (fig. 1). Mean activity indexes for morning and afternoon periods did not differ significantly ($0.6 < P < 0.7$), while a t-test of morning and afternoon, on the one hand, compared with midday, on the other, shows a highly significant difference ($0.001 < P < 0.005$).

Individuals observed for longer periods in midday seemed to divide their time between hunting activity and cooling in the shade. Under mesquite trees, the Roadrunners would gape, flutter the gular region, and hold the wings out from the body, presumably to expose the lightly feathered axillary regions. One bird in obvious heat stress did not flutter the gular region, but did gape, as if utilizing a strong wind blowing at the time to move the air for evaporative cooling.

Miller and Stebbins (1964) observed a reduction in the activity of Roadrunners in the Mojave Desert at midday. Mojave and Sonoran patterns also seem to be similar in midmorning activity peaks: "Food consists largely of lizards and small snakes, and the former, especially, need to be hunted in mid-morning at the peak of their activity."

This reduction in activity at midday would reduce the demands for heat dissipation and the consequent expenditure of water for evaporative heat loss during the hottest part of the day. When studied in the laboratory, the Roadrunner was very similar to the Domestic Pigeon in its abilities to tolerate high air temperatures and to dissipate heat by evaporation (Calder 1966). This finding suggests that the Roadrunner relies upon behavioral and ecological means rather than special physiological capacities for surviving desert conditions. More extensive ecological studies of the Roadrunner might show that the proportion of the time spent resting and cooling at midday is directly related to ambient temperatures.

I am grateful to S. Clark Martin and the U.S. Forest Service for use of facilities at the Santa Rita Experimental Range, and to Charles H. Lowe, University of Arizona, for making arrangements for this study. Financial support was provided by a National Science Foundation graduate fellowship. (Present address: Department of Biology, Virginia Polytechnic Institute, Blacksburg, Virginia 24061.)

LITERATURE CITED

CALDER, W. A. 1966. Temperature regulation and respiration in the Roadrunner and the pigeon. Doctoral dissertation, Duke University.

DOBIE, J. F. 1956. The roadrunner in fact and folklore. Newsletter Tex. Ornithol. Soc. 4:1–14.

LOWE, C. H. 1964. The vertebrates of Arizona. Univ. Arizona Press, Tucson.

MILLER, A. H., and R. H. STEBBINS. 1964. The lives of desert animals in Joshua Tree National Monument. Univ. Calif. Press, Berkeley and Los Angeles, Calif.

SMITH, H. V. 1956. The climate of Arizona. Arizona Expt. Sta. Bull. 279.

SUTTON, G. M. 1940. *Geococcyx californianus* (Lesson): Roadrunner. Pp. 36–51, *in* Bent, A. C., Life histories of North American cuckoos, goatsuckers, hummingbirds, and their allies. U.S. Natl. Mus. Bull. 176.

Accepted for publication 23 January 1967.