DAILY TIME BUDGET OF THE POSTNESTING VERDIN

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ABSTRACT.—Verdin time budgets in southern Arizona varied depending on temperature. Time spent foraging remained constant until temperatures exceeded 30–35°C. At higher temperatures the majority of time was spent sitting. Diurnal patterns are generally masked by the strong temperature dependency. The suppression of activity when environmental heat gain is greatest has definite energetic implications. *Received 21 October 1975, accepted 10 December 1976.*

THE partitioning of time into various activities by birds has been little studied (but see Verner 1965, Greenlaw 1969, Wiens 1969, Schartz and Zimmerman 1971, Stiles 1971, Utter 1971, Custer and Pitelka 1972, Verbeek 1972, Utter and Lefebvre 1973, Post 1974). The present study deals with the daily time budget of the Verdin (*Auriparus flaviceps*) during the postnesting season on the Santa Rita Experimental Range, Pima County, Arizona. Intensity of foraging and microhabitat use by this species are dependent on ambient temperature (Austin 1976). Accordingly, I designed the study to investigate allocation of time in relation to temperature, on a daily basis.

METHODS

The activities of individual birds were timed with a stopwatch. Subjects included adults that had completed nesting for the year, independent birds of the year, and dependent fledglings. Too few data were gathered for adults with dependent fledglings to be included in this comparison. Observations were concentrated on seven pairs and their young from June to early October 1971. Data for dependent young are analyzed separately from those for other birds. Data for adults without dependent young and independent immatures did not differ and are therefore combined. Ambient air shade temperatures (T_a) and notes on sky condition were taken hourly. Birds were studied only on windless days.

Average daily time budgets were calculated from hourly temperatures obtained from the U.S. Weather Bureau records (Tucson, Arizona) and the time budgets for those T_a's for the appropriate time of day.

All samples were compared using Chi-square on the raw data (in min) with significance at $P < 0.05$.

DESCRIPTIONS OF ACTIVITIES

Foraging.—Verdins forage by nearly constant movement through the vegetation in search of small insects. Foraging is considered all activity involved in searching for, capturing, and ingesting food, including periods of foraging during which adults sang. Occasional incidental capture of an insect from a static perch while sitting or preening was included in the time spent in the respective activity.

Flying.—This includes all time spent flying except for short flights involved in aggression.

Sitting.—This is total time spent on a stationary perch with no movement or other activity except for head movements and shifting of position.

Preening.—Time spent sitting to preen feathers.

Nest building.—Both adults and immatures build roosting nests at all times of the year. This category includes all time spent gathering nesting material and incorporating these materials into the nest. Time spent flying between the site where materials were gathered and the nest site was included in the flying category.

Territorial aggression.—This includes intraspecific aggression either as the aggressor or the intruder.

Feeding behavior.—Time spent by adults actually presenting dependent young with food and time spent by dependent young receiving food from adults. Time spent foraging for food for the young was included in foraging.

Other activities.—This includes interspecific aggression, miscellaneous maintenance (i.e. bill wiping, stretching), and bathing.

TABLE 1. Summary of Verdin time budgets in relation to ambient temperature

Activity	Temperature (°C)					
	15–20	20–25	25–30	30–35	35–40	40–45
Forage	96.9%	84.9%	81.6%	79.2%	37.6%	21.6%
Fly	2.0	3.1	3.8	2.6	1.1	0.3
Sit	0.6	0.4	2.6	9.5	55.8	75.1
Other	0.6	11.6	11.9	8.7	5.4	3.0

RESULTS AND DISCUSSION

Time budget and temperature.—The time budget of the Verdin is highly dependent on temperature (Table 1). The time budget for each temperature range was significantly different from those for all others. The percent of time spent foraging remains relatively constant at temperatures below 32°C but decreases above 32°C. As foraging decreases, the amount of time spent sitting increases. All other activities are largely curtailed at temperatures above 35°C (Table 3). Preening is concentrated mainly at moderate temperatures (25–35°C) while behavior related to territory and nest building occurs mainly at lower temperatures (20–30°C, Tables 3, 4).

Dependent young spend considerably more time sitting and less time foraging than adults and foraging activity was nearly nonexistent at temperatures greater than 35°C (Table 2). No significant differences existed between time budgets at T_a's below 35°C; they all differed from time budgets at T_a's above 35°C.

A relationship between temperature and amount of time spent foraging has also been shown for breeding Mangrove Swallows (*Iridoprocne albilinea*) in Panama (Ricklefs 1971), postbreeding Yellow-billed Magpies (*Pica nuttalli*) in California (Verbeek 1972), and wintering Brewer's Blackbirds (*Euphagus cyanocephalus*) in British Columbia (Verbeek 1964). Amount of time spent resting by breeding male Dickcissels (*Spiza americana*) in Kansas increased as temperatures exceeded 35°C (Schartz and Zimmerman 1971). In contrast to the Verdin, the increase in resting time by the Dickcissel was not at the expense of time spent foraging. The Dickcissel, instead of curtailing foraging at higher temperatures, curtailed behavior associated with reproduction. The Verdin reduces the amount of time spent in both self-maintenance (Table 1) and, apparently, reproductive behaviors as demonstrated by the inverse relation between temperature and number of nest visits to feed nestlings (Austin 1976).

Diurnal activity patterns.—No striking diurnal patterns of behavior were evident for the Verdin except as they related to temperature (Tables 3, 4). Foraging predominated in the cool morning hours and decreased as temperatures increased above

TABLE 2. Time budget of dependent Verdin fledglings in relation to temperature and time of day

Activity	Temperature and time of day			
	20–30 (A.M.)	30–35 (A.M.)	30–35 (P.M.)	35–40 (P.M.)
Forage	76.2%	67.0%	75.0%	9.4%
Fly	1.0	1.6	3.5	0.4
Sit	20.5	24.3	20.3	88.6
Preen	0.0	2.8	0.0	0.7
Territory	1.2	0.3	0.4	0.0
Other	1.0	4.1	0.8	0.8
N (min)	70	46	75	91

TABLE 3. Time budget of the Verdin in relation to temperature and time of day at moderate ambient temperatures

T_a	15–20	20–25		25–30				
Time / Activity	0500–0800	0500–0800	0800–1000	0500–0800	0800–1000	1000–1200	1200–1500	1500–1900
Forage	96.9%	84.4%	83.4%	81.3%	83.7%	75.2%	93.0%	95.4%
Fly	2.0	3.0	3.6	3.8	4.6	3.0	1.8	3.9
Sit	0.6	1.4	0.7	2.2	4.4	1.9	0.7	0.4
Preen	0.4	2.5	7.3	1.7	6.8	13.8	4.4	0.2
Nest	0.0	2.7	0.0	3.6	0.0	4.8	0.0	0.0
Territory	0.0	0.9	1.5	3.1	0.0	0.2	0.0	0.2
Other	0.2	5.1	3.5	4.3	0.5	1.2	0.1	0.0
N (min)	172	753	134	394	229	122	41	23

30°C. On cloudy days when afternoon temperatures remained below 35°C the amount of time spent in foraging and other activities remained relatively constant throughout the day. At temperatures of 25–35°C foraging appears to increase toward the end of the day. Activities concerned with nest building and territory are more important before noon than after.

The only seasonal pattern noted in this study was an increase in the amount of time spent preening in August and September over that in June and July (4–10% to 1–4% at moderate T_a). This increase reflects the period of heaviest molt (Taylor 1970).

Daily time budget.—The time budget of the Verdin is complicated by its dependence on temperature. Activities such as rate of feeding young, foraging intensity, amount of time spent foraging in exposed microhabitats, and others vary inversely with temperature (Table 1 and Austin 1976). Thus average daily time budgets were calculated from the hourly time budget data and hourly temperatures.

Time budgets for average June–September days and for average hot and cool cloudy days in July are presented in Table 5. On average days about 7.5 h are spent foraging compared to less than 6 h on hot days and 10–12 h on cool days. Time budgets for June, July, and August were not significantly different from each other but all differed significantly from September. The time budget for a cool July day differed significantly from that on a hot day.

During average summer days foraging occupies approximately 50–55% of the time and sitting 35–40%. The majority of time in September (80–90%) is spent foraging, as it is during cool cloudy days in mid-summer. The composite time budget for Verdins compares well with data for individuals checked periodically through the

TABLE 4. Time budget of the Verdin in relation to temperature and time of day at high ambient temperatures

T_a	30–35				35–40		40–45
Time / Activity	0800–1000	1000–1200	1200–1500	1500–1900	1200–1500	1500–1900	1200–1500
Forage	74.1%	73.9%	76.8%	88.2%	45.8%	30.3%	21.6%
Fly	2.6	2.5	3.6	2.0	1.1	1.0	0.3
Sit	6.9	15.8	9.1	8.4	49.3	61.7	75.1
Preen	10.3	7.3	7.6	1.0	2.6	4.0	1.8
Nest	4.2	0.0	2.5	0.0	0.2	0.0	0.0
Territory	0.2	0.3	0.0	0.6	0.2	0.0	0.1
Other	1.7	0.2	0.4	0.1	0.8	3.1	1.1
N (min)	193	129	141	230	305	342	368

TABLE 5. Time budgets of the Verdin under different temperature and seasonal regimens

Activity	Average day				July day	
	June	July	Aug	Sept	Cool cloudy	Hot
Forage	54.6%	49.6%	56.3%	89.4%	82.1%	38.5%
Fly	1.6	1.7	2.0	2.9	3.1	1.1
Sit	36.2	41.2	34.3	0.8	6.2	54.1
Preen	3.8	3.4	4.1	4.4	4.5	2.7
Nest	1.2	1.1	0.9	0.7	1.5	0.8
Territory	0.7	0.9	0.5	0.3	1.1	0.7
Other	1.9	2.3	2.2	0.8	1.1	1.6
Photoperiod (h)	14	15	14	13	15	15

course of single days. The proportion of time the Verdin spent foraging during summer was similar to the 40–60% reported for several species occurring in diverse habitats from the arctic to the tropics (Verner 1965, Greenlaw 1969, Wiens 1969, Ricklefs 1971, Utter 1971, Custer and Pitelka 1972, Verbeek 1972, Utter and LeFebvre 1973, Post 1974) but considerably more than the 15–30% reported for many grassland inhabiting species (Wiens 1969, Schartz and Zimmerman 1971) or the approximately 10% for hummingbirds (Pearson 1954, Stiles 1971, Wolf and Hainsworth 1971). During September (and from qualitative observations during winter) the 80–90% of time the Verdin spent foraging is greater than for any species heretofore reported.

Body size (i.e. Gibb 1960, Verner 1965) and temperature (i.e. Verner 1965, Verbeek 1972, this study) do not by themselves govern amount of time spent foraging. Small grassland species spend less than half the time foraging as the larger Eastern Meadowlark (*Sturnella magna*) on the same study plot (Wiens 1969). The Seaside Sparrow (*Ammospiza maritima*) in salt marsh forages 50–80% of the time (Post 1974) compared to 6–33% for four species of grassland sparrows (Wiens 1969). Hummingbirds with a spatially concentrated, high energy food source spend very little time foraging (Pearson 1954, Wolf and Hainsworth 1971, Stiles 1971). Such factors as food habit, size of food, spatial and caloric density of food, community productivity, and vegetation stratification and density may also be involved in the daily allocation of time. The amount of time spent foraging limits the time available for other activities during the course of the day, which may be further influenced by temperature and stage of the annual cycle (Verner 1965, Greenlaw 1969, Schartz and Zimmerman 1971, Utter 1971, Custer and Pitelka 1972, this study).

The reduction of foraging activity and increase in amount of time spent sitting with increasing T_a by the Verdin parallels the shift in microhabitat use from exposed to shaded situations and the reduction in foraging intensity (Austin 1976). Thus, the Verdin reduces both environmental heat gain by retreating to shade and metabolic heat load by suppressing activity at a time when environmental heat gain is greatest. Similar adjustments are apparently made by other desert species although actual time budget data are lacking (Dawson 1954, Smith 1967, Ricklefs and Hainsworth 1968, Ohmart 1969).

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