ACTIVITY CYCLES AND BODY TEMPERATURES OF *ACANTHODACTYLUS ERYTHRURUS*.—Convergent ecology of lizards in similar, geographically isolated, desert biotopes is well known (Pianka, 1973) but Mediterranean forms have not been studied in detail. Valverde (1967) commented on the seasonal abundance of *Acanthodactylus erythrurus*, but there has been no detailed study of activity. *Acanthodactylus* occupies a niche similar to *Callisaurus* or *Uma* in the deserts of the southwestern United States and this study examined the daily and seasonal activity of fringe-toed lizards in southern Spain.

The study area was at La Algaida, on the

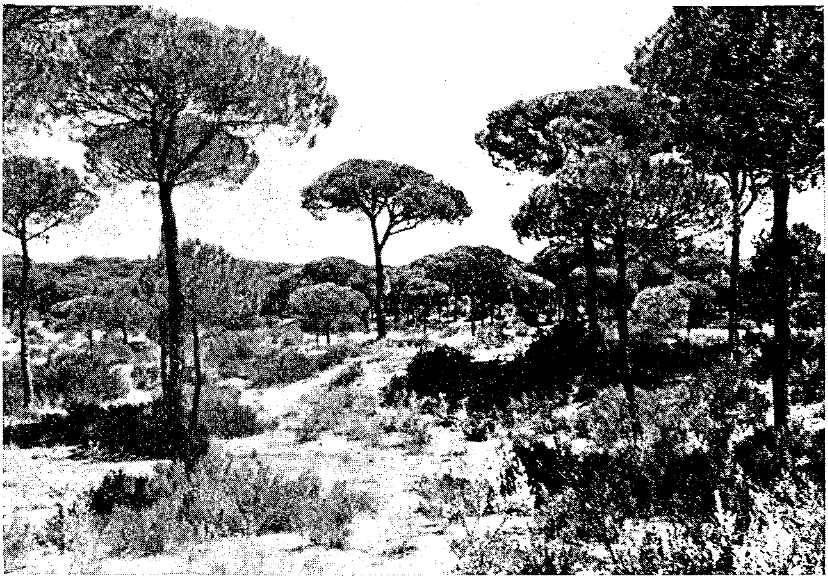

Fig. 1. Habitat of *Acanthodactylus erythrurus* at La Algaida (June). *Pinus pinea* L. (Pinaceae) stands surrounded by *Juniperus phoenicea* L. (Cubresaceae) provide shade. *Halimium halimiifolium* (L.) Willk (Cistaceae) and *Corema album* (L.) D. Don (Empetraceae) are used for foraging and escape from predators.

east bank of the Guadalquivir River 25.5 km (air) NW of Jerez de la Frontera, Cádiz Province, Spain, at an elevation of less than 100 m. Aridity and agriculture typify this region; present vegetation is an open evergreen formation (Fig. 1).

Since La Algaida occupies a similar coastal position and is only 25 km from Rota, the following data from the U. S. Naval Weather Station at Rota reflect the climate at La Algaida. Freezing air temperatures are limited to November through January and maximum temperatures rarely exceed 35 C (June and July). Rainfall occurs primarily during December, January, April and May (Table 1). Comparisons with 10 year weather records show that the study period was during an average year.

Lizards were collected from a one hectare plot on consecutive days once a month between December 1970, and November 1971, during a

TABLE 1. CLIMATIC DATA FROM ROTA AND STUDY SITE.

	Rota				Study site (T_0)			
	Temperature					Max T_0		
Month	Max.	Min.	x̄	Precipitation (mm)	Hr to rise above 13 C	Hr	C	Hr to fall below 13 C
DEC 1970	20.2	−3.8	8.3	92.7	1200	1435	17.2	1830
JAN 1971	18.9	−2.2	11.1	104.9	1400	1505	15.5	1800
FEB 1971	25.0	3.3	12.5	5.1	1200	1532	21.6	1800
MAR 1971	25.0	1.1	12.0	36.6	0800	1240	19.4	1900
APR 1971	24.4	5.0	13.4	104.4	0700	1317	32.5	–
MAY 1971	27.2	7.8	16.4	98.8	0600	1532	32.0	–
JUN 1971	36.7	10.0	19.8	13.2	–	1428	39.5	–
JUL 1971	36.1	13.9	23.6	Trace	–	1428	44.0	–
AUG 1971	34.4	12.2	21.0	25.9	0800	1457	41.0	–
SEP 1971	35.0	12.2	21.8	Trace	0700	1402	36.5	–
OCT 1971	33.3	5.0	20.6	Trace	0730	1329	30.9	–
NOV 1971	23.9	0.0	12.3	37.8	1100	1430	23.0	1900

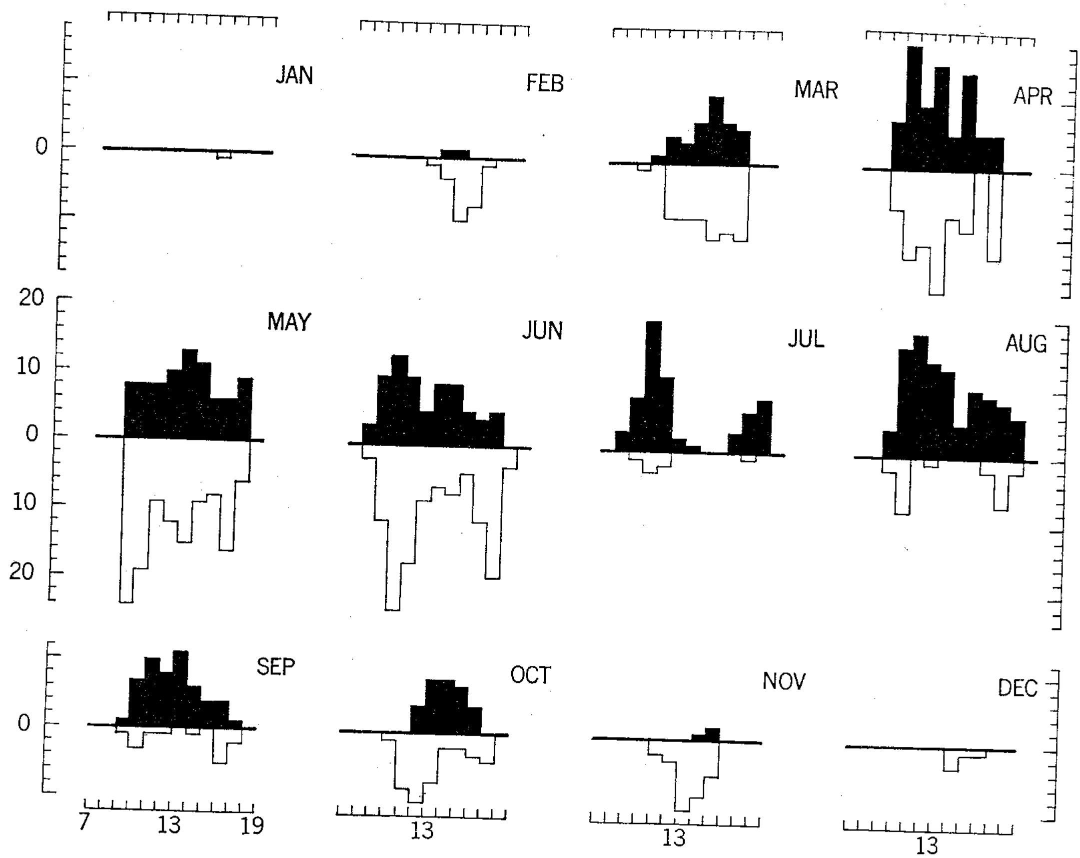

Fig. 2. Seasonal and diel activity of *A. erythrurus.* Vertical axis, observations; horizontal axis, hour of day; solid bars, adults; open bars, subadults.

24 hr period which commenced about 1300 hrs and terminated at that hour on the following day. Daily activity patterns were obtained by collecting during each hour of the day from before sunrise to after sunset (except for December and January when surveys began at 1200 hrs). One hour of seeing no lizards, both in the morning and late afternoon, determined the start and finish of activity. Because specimens were removed, without replacement, from the study area, absolute numbers for morning periods in Fig. 2 are not indicative of the number of specimens usually available for these periods in an undisturbed population and environment. The result of this effect is discussed later. Black body temperatures were used to estimate the body temperature range potentially available to a lizard. Open Shade Black Body (T_0) and Direct Sun Black Body (T_s) temperatures were obtained from a Weksler bi-metal thermometer with a dull black-painted stem placed either in shrubbery providing both shade and a free passage of air or one cm above the sand in direct sun. Body temperatures (T_b) were taken with a Trophy Evermark P7B 4166 fever thermometer graduated from 94° to 108°F. All thermometers were calibrated. Lizards less than 60 mm SVL were considered subadult.

Seasonal activity.—Fig. 2 and Table 1 summarize the monthly activity correlated with T_0. Abundance of active *A. erythrurus* varied seasonally at La Algaida. Adults were not observed between December and January; subadults were active throughout the year. The largest monthly proportion of adults to subadults (1 : 10) occurred during February. Adult/subadult ratios were 0 : 1 and 0 : 5 during December and January; from March through June the ratios varied from 1 : 1 to 2 : 1. From July through September adults outnumber subadults 4–9 : 1 but for October and November the ratios are 1 : 1 and 1 : 9 respectively. Hatchlings enter the population during August, are active

TABLE 2. ACTIVITY PERIODS OF *Acanthodactylus erythrurus* BETWEEN DECEMBER 1970 AND NOVEMBER 1971.

	Adults		Subadults	
Month	Hours of activity	% of maximum activity period (July)	Hours of activity	% of maximum activity period (June)
JAN	–	0	1530–1531	1
FEB	1350–1434	7	1240–1610	36
MAR	1044–1700	62	0948–1705	75
APR	0934–1624	68	0954–1656	73
MAY	0912–1736	84	0906–1750	90
JUN	0847–1724	86	0838–1814	100
JUL	0852–1849	100	0915–1743	88
AUG	0950–1848	90	0930–1845	96
SEP	0956–1721	74	0954–1738	80
OCT	1102–1555	49	0946–1650	73
NOV	1410–1514	10	1147–1621	59
DEC	–	0	1424–1601	16

throughout the fall and winter under suitable conditions, and leave the subadult category, through growth, by late July. Adults had a longer daily activity span in July than any other month, but the highest number of observations (103) was in August. For subadults, the longest activity was in June and the most individuals (118) were seen in May (Table 2 and Fig. 2).

Diel activity.—Activity began at a T_o of 13 C for both adults and subadults (Table 1 and Fig. 2); as a result daily activity of *A. erythrurus* varied seasonally (Table 2). Bimodality in adult activity was apparent during the warmest months but subadults appeared to have a bimodal activity distribution from May through August.

Temperature differentials between T_o and T_s varied with time of day and season; T_s always averaged 6–26 C higher than T_o. Despite intense sunshine and high ambient temperatures some activity occurred at all hours between 0800 hrs and 1900 hrs whenever T_o was at least 13 C. By staying in cool microhabitats, adult *A. erythrurus* remain within thermal regimes that permit aboveground activity all day. Adult activity was interrupted only once (1400–1500 hrs during July) when T_o exceeded 40 C and direct sunlight approached 54 C. Subadult nonactivity was more pronounced (midday during April and from July–September) when T_o varied from 27 to 41 C and T_s from 44 to 57 C. Because of equipment limitations I can only report adult T_b to range from below 33.9 to a maximum voluntary tolerance (Cowles and Bogert, 1944:277) of 41 C. Subadult range was from below 33.9 to 37.4 C.

Discussion.—Seasonal and daily activities resembled the pattern described for other desert lizards (*Callisaurus*, Kay, 1972; *Uta*, Irwin, 1965; and *Uma*, Mayhew, 1964). Adult *Acanthodactylus* were not active in January or December; subadult activity extended throughout the year whenever there was a minimum T_o of 13 C (Fig. 2). The apparent bimodality of lizard activity is probably a real phenomenon rather than an artifact of the field techniques employed. If removal of lizards during the period of observations was reducing the number of individuals active, the maximum number of lizards would be collected in the first few hours of the collecting period. Collecting was begun at 1300 hrs and this time tends to be the dip between the two peaks (Fig. 2). Furthermore, the morning activity peak is higher than the afternoon peak in spite of removal of a portion of the population on the preceding afternoon. In addition, the July sample was obtained solely through observations with no collecting and it demonstrates the same bimodality as adjacent months.

Mayhew (1964) suggested that *Uma* controls effective photoperiod by behavioral means rather than relying on sunrise and sunset. The same appears true of *Acanthodactylus* as activity, even during optimal months, rarely began earlier than 0900 hrs or extended beyond 1845 hrs despite favorable T_o and available sunlight (Table 2). Irwin (1965) reported fluctuations of daily activity in *Uta stansburiana* to be inversely correlated with T_a but suggested that lessened insolation might be a more important regulatory factor. This is probably not an important factor with regard to subadult *Acanthodactylus* which are within the same size range as *Uta*; overcast days are rare from June through September at La Algaida.

Both adult and subadult *A. erythrurus* bury among *Corema album* roots when disturbed; in comparison, *Uma* bury in *Dalea* roots at night but not always when disturbed (Pough, 1970). With regard to winter activity, Cowles (1941) reported that in the Coachella Valley, Riverside Co., California, winter temperatures rise sharply from the surface downward in dry sand; at a two inch depth the soil may sometimes be as much as 27.5 C warmer than the air. From December through February subadult *A. erythrurus* are found buried shallowly in loose sand among *Corema*. Like juvenile *Uma*, they are active on suitable days well into winter (Cowles, 1941). Adults were not found and either dug deeper than subadults or were elsewhere at this time of year. Cowles also suggested that shallow resting places allow the animals to respond to the earliest of activating temperature peaks and this has been demonstrated for subadult *A. erythrurus* (Table 1 and Fig. 2).

Acknowledgments.—I thank Sr. Luis Hidalgo G. of Sanlúcar for permission to use his land and AGCS C. D. Ferguson, U.S.N. for access to the weather data. Plant identifications were made by W. J. Dress of Cornell University, and F. H. Pough of Cornell calibrated the thermometers. W. Robert and Lorraine Maxwell of Waltham, Massachusetts helped with portions of the field work and provided moral support. The staff of the Division of Reptiles and Amphibians, National Museum of Natural History, criticized the manuscript and provided valuable suggestions. My gratitude is extended to all.

Literature Cited

Cowles, R. B. 1941. Observations on the winter activity of desert reptiles. Ecology 22:125–140.

———, and C. M. Bogert. 1944. A preliminary study of the thermal requirements of desert reptiles. Bull. Amer. Mus. Nat. Hist. 83:261–269.

Irwin, L. N. 1965. Diel activity and social interactions of the lizard *Uta stansburiana stejnegeri*. Copeia 1965:99–101.

Kay, F. R. 1972. Activity patterns of *Callisaurus draconoides* at Saratoga Springs, Death Valley, California. Herpetologica 28:65–69.

Mayhew, W. W. 1964. Photoperiodic responses in three species of the lizard genus *Uma*. Herpetologica 20:95–113.

Pianka, E. R. 1973. The structure of lizard communities, p. 53–74. *In*: 4th ann. rev. ecology and systematics. R. F. Johnston, P. W. Frank and C. D. Michener (Eds.).

Pough, F. H. 1970. The burrowing ecology of the sand lizard, *Uma notata*. Copeia 1970:145–157.

Valverde, J. A. 1967. Estructura de una comunidad mediterranea de vertebrados terrestres. Monografías Estación Biol. Doñana, Seville. 1.

Stephen D. Busack, *National Fish and Wildlife Laboratory, U. S. Fish and Wildlife Service, National Museum of Natural History, Washington, D. C. 20560.* Accepted 11 Aug. 1975.