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Natural Activity Patterns and Thermal Experience in Dipodomys merriani

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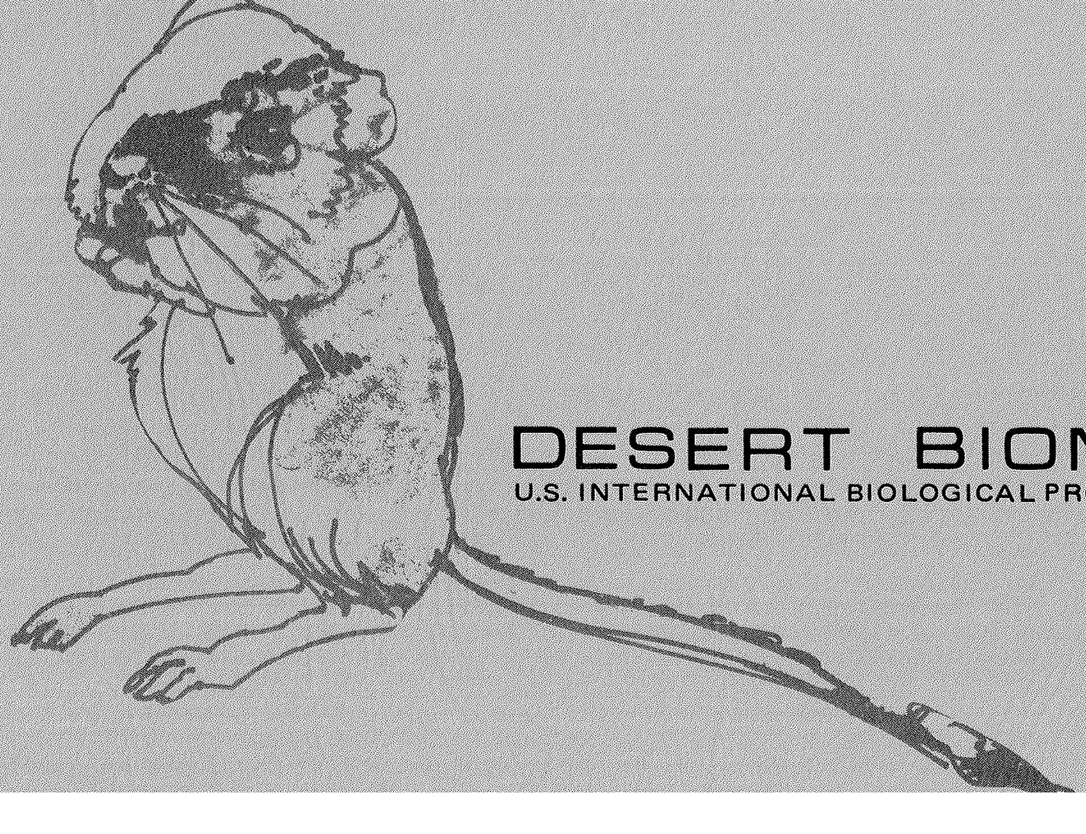

DESERT BIOME

U.S. INTERNATIONAL BIOLOGICAL PROGRAM

1972 PROGRESS REPORT

NATURAL ACTIVITY PATTERNS AND THERMAL EXPERIENCE IN *Dipodomys merriami*

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ABSTRACT

Objectives of this study were to document by biotelemetric techniques the natural activity patterns and thermal experience of *Dipodomys merriami* on the western Sonoran desert. Tecnhical difficulties prevented us from obtaining functional telemetric equipment. One year's demographic data on *D. merriami* and associated nocturnal rodents were obtained, along with temperature measurements of burrow, surface, and air. Activity patterns of *D. merriami* under simulated desert summer and winter conditions were examined in the laboratory.

Perognathus formosus was the most abundant nocturnal rodent in every month except December. Highest densities of *Dipodomys merriami* occurred from April through June. *Perognathus spinatus, P. fallax,* and *Peromyscus eremicus* were found in low numbers throughout the year. Biomass of *D. merriami* varied from 151 g/ha in April to 29.1 g/ha in January, while that for *P. formosus* varied from 196 g/ha in July to 21 g/ha in December. *D. merriami* was reproductively active from late February through September, and *P. formosus* and *P. spinatus* from late April through August. The study area was coldest, both above and below ground, from November through February. Burrow temperatures of 34-39.5 C were recorded from June through September, but we suspect *D. merriami* move to burrows deeper than 30 cm in these months. Captive *D. merriami* were active an average of 5.02 (± 0.38) hours during cooler months and 5.89 (± 0.51) hours during summer months. 68% of all activity was before midnight during winter while only 57% of summer activity was before this time. Captives thus seem to avoid the coldest part of winter nights, but space activity evenly over summer nights.

INTRODUCTION

The purpose of this study was to define the natural activity patterns of *Dipodomys merriami* on the western Sonoran desert, and to document the thermal experiance of this species as a result of activity patterns. Knowledge of activity patterns is of prime importance in estimating energy flow as these patterns determine the regimes of temperature that the individual encounters. Thermal experience largely determines rate of energy flow, since most energy flow of endotherms is a function of temperature regulation and food gathering to satisfy the energy requirement for this regulation. No estimate of energy flow can be made until demographic and reproductive parameters are known for the species. These values, coupled with estimates of metabolic rates at different ambient temperatures, permit calculation of energy flow through the species by the equations proposed by Chew and Chew (1970).

The study of natural activity patterns in the past has been complicated by the techniques, such as repeated trapping, used to determine these patterns. Important to this study was the development of biotelemetric techniques for monitoring activity patterns and thermal experience. Early in 1970 the project leader began working with General Dynamics, Pomona, on the design of biotelemetric equipment for the project. and by late 1971 functional models were breadboarded. In spite of this progress we have experienced an inordinate delay in receipt of the finished system, and no transmitters were made available to the project in 1972. Our work this year was therefore devoted to obtaining necessary demographic and micro-temperature data. A laboratory environmental chamber has been used to collect data on activity patterns of *D. merriami* exposed to simulated desert temperature regimes.

In December 1972 we began work on an alternate telemetry system recently described in the literature (Osgood and Weigl, 1972) which shows promise for this type of study. Efforts in early 1973 will be directed toward use of this system to obtain the needed information on natural acitvity patterns and thermal experience.

OBJECTIVES

1. To determine the species of nocturnal rodents utilizing the study area in addition to *D. merriami*, and to determine the population dynamics and reproductive phenology of all species.
2. To determine the pattern of microtemperatures to which *D. merriami* is exposed, both in its burrow system and above ground, in the course of one calendar year.
3. To estimate the amount of time spent outside the burrow each night in the field, determine the times of activity in both warm and cold months, under simulated natural conditions in the laboratory.

METHODS

Study area

All studies were conducted at the Philip L. Boyd Deep Canyon Desert Research Center in Riverside County, California, operated by the University of California at Riverside. Deep Conyon extends in a north-south axis approximately 13 km from the northern face of Santa Rosa Mountain in the Santa Rosa range to its mouth on the desert slopes below to the north. The study area was located on an alluvial fan in Sheep Canyon at 275 m elevation, just south of where this smaller canyon drains into Deep Canyon.

The climate of this region is characterized by scant, erratic rainfall, high summer temperature, and cold winter nights. Based on ten-year averages, rainfall is heaviest in March and November-December, while April through June are the driest months. In the larger canyons sufficient ground water seeps along the drainage to support those desert plants requiring greater soil moisture, such as palo verde and smoke tree. High winds, often exceeding 48 km/hr are most prevalent during the spring months.

The study area lies entirely within the lower Sonoran life zone, and can be characterized as creosote-palo verde habitat. Creosote bush, *Larrea tridentata*, and palo verde, *Cerdidium floridum*, are scattered throughout the wash in which the area is located. Other perennial shrubs, such as burro bush, *Franseria dumosa*, indigo bush, *Dalea schottii*, smoke tree, *Dalea spinosa*, desert lavender, *Hyptis emoryi*, and cheesebush, *Hymenoclea salsola*, are also present. Frequency of occurrence and percentage cover for common shrub and tree species, as well as dominant soil types, are presented in Table 1. The only herbaceous plant found in the open sandy areas is a spurge, *Euphorbia* sp.

Population dynamics/reproductive phenology

In January 1972 we began mark and release studies (DSCODE A3UWW01) on an 8.9 ha study area in Deep Canyon previously utilized by the project leader for other studies. In April 1972 studies were shifted to a new 3.9 ha grid 0.5 km to the east in Sheep Wash in an area with a higher density of *D. merriami*. Stations in both of these areas were on a 15 m grid, with one trap per station. At initial capture each animal was marked by toe-clipping. For each capture we recorded sex, weight to the nearest 0.1 gm, and station of capture. The cheek pouches of heteromyid rodents were emptied prior to weighing. Reproductive condition was noted as follows: for males -- testes undeveloped or developed (with tubules of cauda epididimides distended by mature sperm); for females -- teats undeveloped or developed, parous (teats showing evidence of previous lactation) or nulliparous, vulva perforate or imperforate, lactating, pregnant, number of embryos as determined by palpation.

Table 1. Frequency of occurrence and percentage cover for common shrub and tree species, and dominant soil types, on Sheep Wash study area

Species	% Frequency	% Cover
Larrea divaricata	6.94	1.98
Cercidium floridum	6.54	3.68
Hymenoclea salsola	11.80	2.27
Hyptis emoryi	4.16	1.57
Beloperone californica	6.94	2.19
Krameria grayi	1.73	0.21
Dalea schottii	2.77	1.03
Dalea spinosa	0.69	0.23
Bebbia juncea	2.43	0.27
Encelia farinosa	0.69	0.08
Franseria dumosa	3.47	0.41
Acacia greggii	1.38	0.47
Opuntia bigelovii	7.29	0.43
Opuntia ramosissima	6.59	0.78
Opuntia acanthocarpa	1.38	0.12
Opuntia basilaris	2.08	0.19
Mammillaria microcarpa	0.69	0.02
Echinocactus acanthodes	0.69	0.04
Echinocereus englemannii	0.34	0.01
Total Plant Material		15.98
Dead Material	31.25	6.51
Sandy Soil	64.45	57.27
Medium Rocky Soil	35.55	20.24
		100.00

Densities were estimated by use of the Hayne (1949) equation. The area sampled for each species was estimated by adding the mean distance traveled between captures for each species as a zone around the boundary of the study grid.

Microtemperature

For this aspect of the study temperatures were monitored at the following locations: 10 cm above ground in an instrument shelter, thermal element lying on the surface, thus measuring absorbed and radiated heat, and in two *D. merriami* burrows at approximately 30 cm depth (DSCODE A3UWW02). Recording instruments for burrow and surface were not available until May 1972, and readings earlier in the year were taken manually with a Yellow Springs telethermometer, which failed at the end of February and was not repaired until April. The surface recording instrument was destroyed by a flash flood in the middle of September.

Activity patterns under simulated desert conditions

A 14.15 m^3 chamber equipped with temperature and light control was used to study activity patterns under simulated conditions (DSCODE A3UWW03). Temperature controls permitted replicable diel fluctuation of ambient temperature within the range of an early afternoon high and a night low set by the experimenter to conform with the desert conditions desired. Activity was indicated by movement through the burrow entrance or to food and water sources as recorded by mercury microswitches and a Rustrak 8-channel event recorder. Each animal was tested for one to two weeks at each set of environmental conditions, after first allowing the animal to become acclimated to the experimental setup. Warm season (afternoon high 40 C, night low 24 C) and cold season (afternoon high 24 C, night low 7 C) temperature regimes were utilized. Light cycles were held at 12L-12D throughout the entire experiment to standardize this variable. For six months animals that were kept in a constant temperature room (24 C) at 12L-12D were arrhythmic, suggesting that diel temperature fluctuation as experienced in the wild is of more importance than alternation of light and dark in influencing activity patterns in this species.

RESULTS

Population dynamics/reproductive phenology

Five species of nocturnal rodents occurred on the two study areas in Deep Canyon, DSCODE A3UWW01, (Table 2); but only *D. merriami* and *P. formosus* were trapped in significant numbers. Trap success for *D. merriami* varied from 1.60 to 8.47 individuals per 100 trap-nights, while success for *P. formosus* varied from 1.00 to 16.00 (Table 2). Densities of *D. merriami* varied from a high of 3.98 individuals per ha in April to a low of 0.81 per ha in January, while those of *P. formosus* varied from a high of 13.02 per ha in July to a low of 1.32 per ha in December (Table 2, Figure 1b). Mean weights of adults for each species per month are presented in Table 3. Biomass of *D. merriami* varied from 151 g/ha in April to 29 g/ha in January, while that of *P. formosus* varied from 196 g/ha in July to 21 g/ha in December (Table 2, Figure 1a).

Reproductive phenology, as determined by the presence of fertile males, pregnant or lactating females, and immatures in the trapped population, is indicated in Figure 2. No reproductively active female *P. spinatus* were taken, reproductively active female *P. formosus* were taken in only two months, and those of *D. merriami* in only one month. Using the growth data of Chew and Butterworth (1959), approximate ages were obtained for the immature *D. merriami*. These ages are added along the curve for this group in Figure 2.

Table 2. Index of density and biomass of nocturnal rodents (A3UWW01)

Density (individuals per ha)	JAN	FEB	MAR	APR	MAY
Dipodomys merriami	0.81	1.11	1.72	3.98	2.77
Perognathus formosus	3.63	10.62	3.09	4.45	7.09
Perognathus fallax	0	0	0	0.33	0.33
Perognathus spinatus	0.81	0.67	1.34	2.80	0.49
Peromyscus eremicus	0	0.81	0.94	0.82	0

Biomass (gm per ha)	JAN	FEB	MAR	APR	MAY
Dipodomys merriami	29.06	40.92	62.44	150.56	106.84
Perognathus formosus	53.87	157.81	45.89	65.77	109.26
Perognathus fallax	0	0	0	5.00	5.00
Perognathus spinatus	10.81	8.93	18.50	41.75	6.57
Peromyscus eremicus	0	12.64	14.78	12.96	0

JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
3.49	2.29	0.84	0.96	1.81	1.93	1.32
10.05	13.02	3.30	5.93	3.62	2.64	1.32
0.49	0.49	0.16	0	0.16	0.49	0.33
1.15	1.15	0.99	2.64	2.14	1.15	0.16
0.16	0.16	0.16	0	0.33	0.33	0.33
131.96	80.10	31.92	26.07	62.77	67.07	45.42
157.78	195.95	51.98	88.18	52.24	40.15	21.00
6.66	6.12	2.24	0	1.68	5.44	4.46
17.71	15.26	12.18	32.50	27.71	14.66	1.96
2.80	2.08	3.20	0	4.54	4.50	5.44

Microtemperature

Three separate sets of data are available from this portion of the study (DSCODE A3UWW02); ambient temperature taken 10 cm above the ground in a weather station (Figure 3), surface temperature (Figure 4b), and temperature within *D. merriami* burrows at 30 cm depth (Figure 4a). Two such burrows were monitored, but the data gathered did not differ significantly so only one is presented graphically. Surface temperatures for May through September go off the scale during much of the day as the instrument does not read over 50 C, and thus the values in Figure 4b stop and start according to the range of the instrument.

Activity patterns under simulated desert conditions

Sixteen individuals were run for two weeks each under summer conditions during the spring and summer of 1972 and sixteen were similarly run for one week each under winter conditions during the fall and winter of this year (DSCODE A3UWW03). Mean minutes of activity per quarter hour and mean duration of activity per night in hours is presented in Figure 5 for summer conditions and Figure 6 for winter conditions. Each figure also shows at its head mean minutes of activity per hour for all individuals under that temperature regime. Mean activity per night for winter conditions is 5 ± 0.38 hr at the 95% confidence level, and 5.9 ± 0.51 hr for summer conditions. The means are different at the 0.10 level, but not at the 0.05 level.

Table 3. Mean weight of adults and 95% confidence interval (A3UWW01)

	D. merriami	*P. formosus*	*P. fallax*	*P. spinatus*	*P. eremicus*
JAN	35.87±1.61	14.84±0.64		13.35±1.67	
N	10	33		7	
FEB	36.86±1.08	14.86±0.57		13.33±2.61	15.61±3.56
N	50	47		6	8
MAR	36.30±1.90	14.85±0.73		13.81±1.19	15.72±2.72
N	20	29		9	9
APR	37.83±0.92	14.78±0.75	15.16±1.16	14.91±0.87	15.80±2.00
N	57	29	3	13	5
MAY	38.57±0.96	15.41±0.47	15.16±1.16	13.40±1.56	
N	56	42	3	5	
JUNE	37.81±0.96	15.70±0.37	13.60±0.52	15.40±1.38	17.50
N	64	86	3	10	1
JULY	34.98±2.46	15.05±0.48	12.50±1.49	13.27±1.21	13.00
N	31	66	3	11	1
AUG	38.00±1.55	15.75±0.52	14.00	12.30±0.67	20.00
N	18	28	1	10	1
SEPT	37.57±1.15	14.87±0.44		12.31±0.57	
N	32	50		22	
OCT	34.68±0.68	14.43±0.43	10.50	12.95±0.51	13.75±1.45
N	57	46	1	35	2
NOV	34.75±0.52	15.21±0.54	11.10±0.95	12.75±1.22	13.62±1.08
N	65	26	5	10	4
DEC	34.41±1.20	15.91±1.77	13.50±4.89	12.00	16.50±0.97
N	30	6	2	1	2

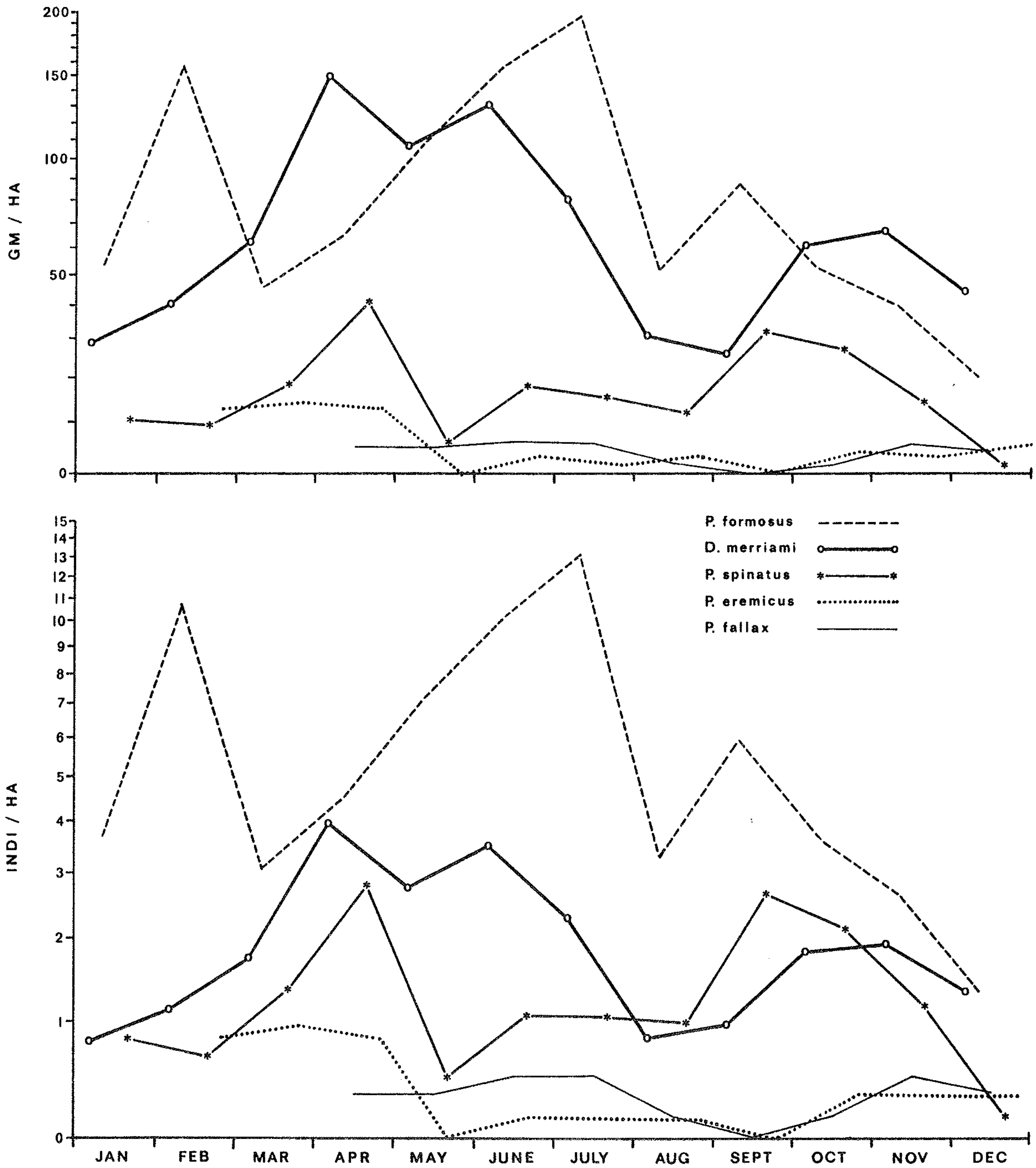

Figure 1. A.(top) semi-log plot of biomass of nocturnal rodents each month (g/ha) A3UWW01.

B.(bottom) semi-log plot of density of nocturnal rodents each month, individuals per ha (A3UWW01).

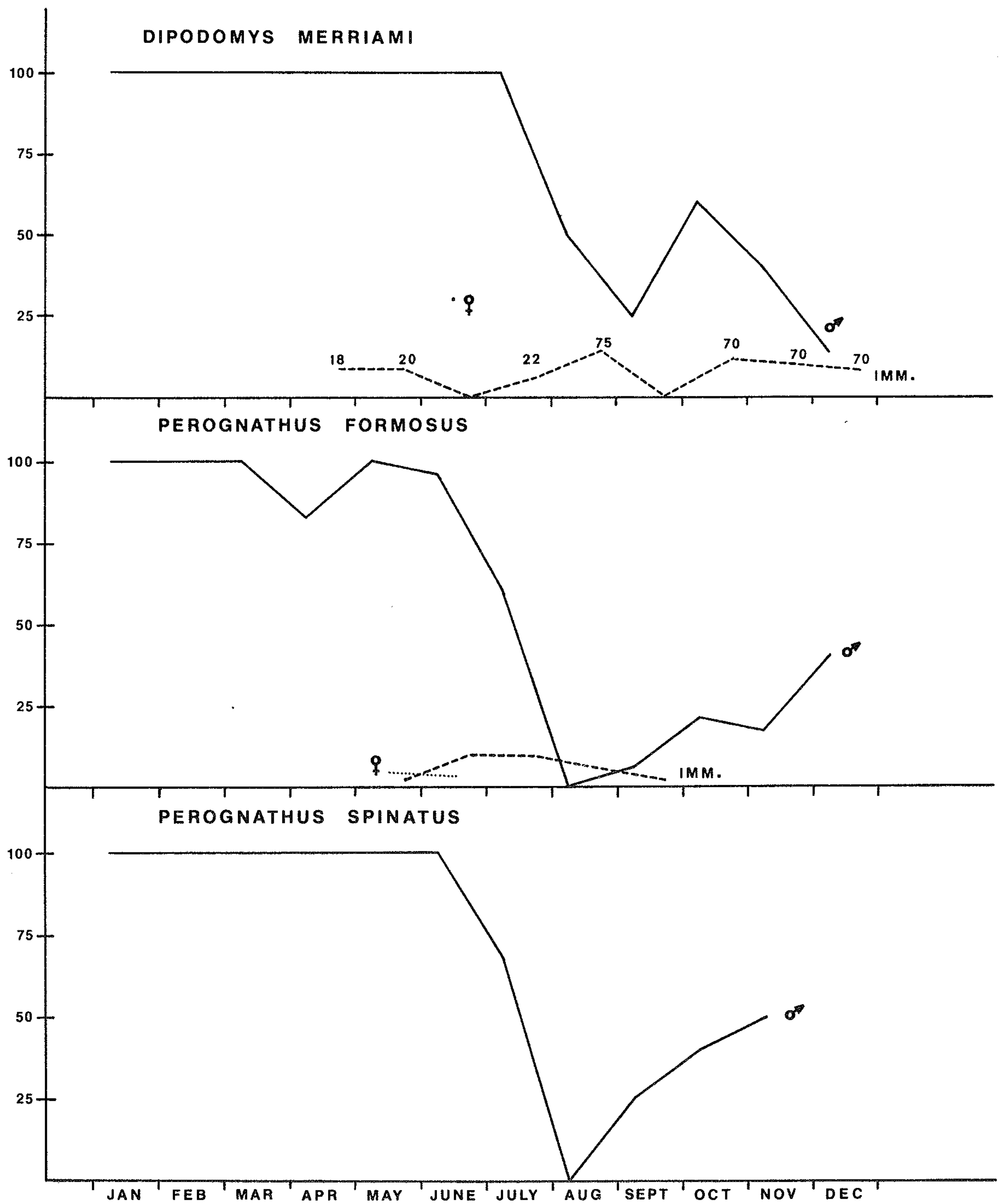

Figure 2. Reproductive phenology. Percent adult males fertile, percent adult females pregnant or lactating, percent of total catch immature, for each month. Numbers on immature line for *D. merriami* are approximate ages of immatures trapped for that month as determined from data of Chew and Butterworth (1959). A3UWW01.

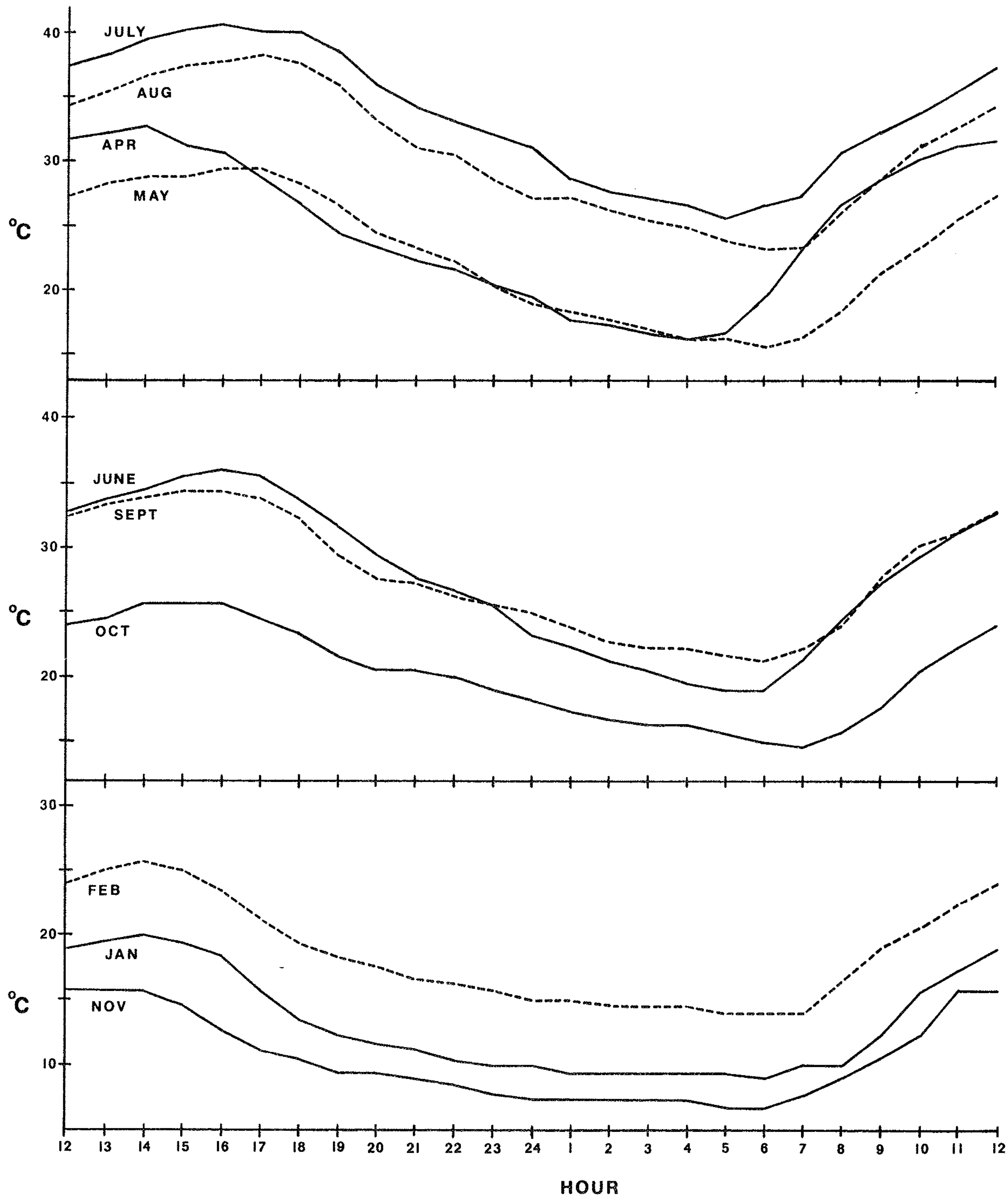

Figure 3. Ambient temperature (C) taken 10 cm above ground in weather station, mean values per hour plotted by month (A3UWW02). See text for explanation of missing data.

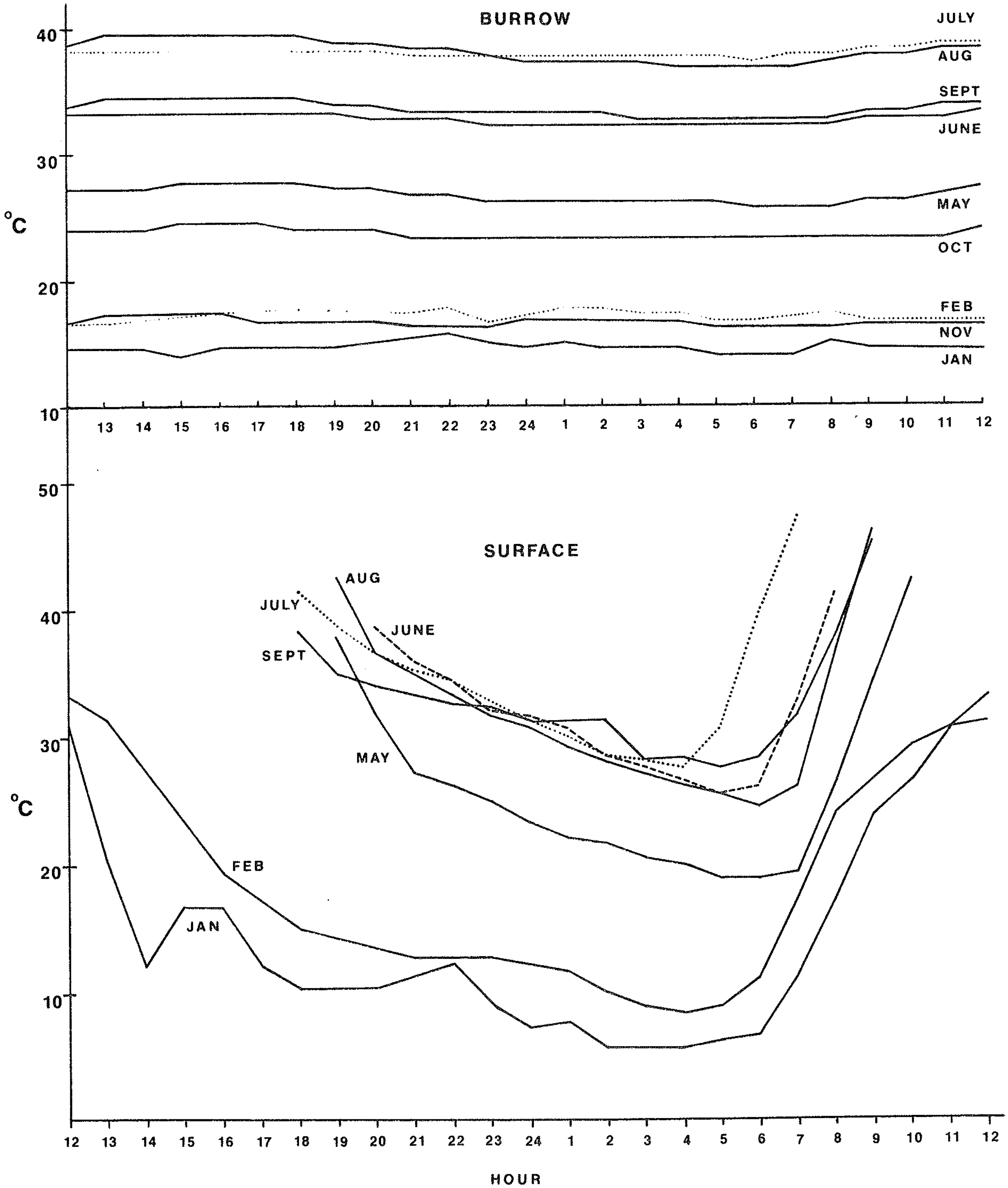

Figure 4. A. (top) Temperature (C) in *D. merriami* burrow at 30 cm depth, mean values per hour plotted by month (A3UWW02). See text for explanation of missing data.

B. (bottom) Surface temperature (C), mean values per hour plotted by month (A3UWW02). See text for explanation of missing data. Surface temperatures from May through September go off instrument scale (>50 C) during day.

DISCUSSION

Previous data on rodent demography in the creosote-palo verde of Deep Canyon are available only from three trapping periods (29 April-2 May, 1964, 15-18 October 1964, and 12-15 January, 1965) reported by Ryan (1968). Our demographic data on *D. merriami* (Figure 1) show that this species was most abundant in the creosote-palo verde habitat from April through June, though Ryan (1968) found greatest densities in October and January. *Perognathus formosus* was the most abundant nocturnal rodent in every month of the year except December, whereas Ryan (1968) found it only in his October trapping period. *Perognathus spinatus* and *P. fallax* were not recorded in the creosote-palo verde habitat by Ryan (1968). We found small numbers of the latter from April through December; *P. spinatus* numbers were greatest in April and September, and were second only to *P. formosus* from August through October. *Peromyscus eremicus* was not recorded from the creosote-palo verde habitat by Ryan (1968), and was found sporadically by us in low numbers, being most common from February through April. An explanation of the differences in demographic data between this study and that of Ryan (1968) is not immediately forthcoming, but several factors may be significant; seven years separated the collection of the two sets of data. The period preceding and during which Ryan conducted his study were wet (total rainfall for 1963 151.4 mm, for 1964 73.3, for 1965 204.5 mm), while 1971 (35.1 mm) and 1972 (60.5 mm) were considerably drier. Ryan's study area (1.77 ha) was less than half the size of that (3.9 ha) used in the present study. Ryan trapped nine nights in a year; the data of this study are based on six nights of trapping per month. And although the exact location of Ryan's study area is not known to the authors, it is believed to have been further up Deep Canyon in more rocky terrain whereas our study area was in sandy terrain.

Reproductive phenology for *D. merriami*, *P. formosus* and *P. spinatus* may be ascertained by examination of Figure 2. Reproductively active *D. merriami* females were taken only in June, and *P. formosus* females in May and June. Immature weight *D. merriami* were taken from April through December, and immature *P. formosus* from May through September. A decline in percent fertile adult males for all three species in the latter half of the year is interpreted to be due to an increase in the proportion of sexually immature males of adult weight in the catch, rather than a loss of fertility in older males. Our data suggest that the reproductive period for *D. merriami* starts as early as late February and extends into September, and a peak in pregnancies in May and June. Ryan (1968) found reproductively active male *D. merriami* in Deep Canyon from January through April, and lactating females from mid-April to late June, with immatures first appearing in mid-April. We found reproductively active female *P. formosus* only in May and June, but the presence of immature *Perognathus* in the population suggests that births occurred from late April or early May to August or September. The curve for male *P. spinatus* is similar to that for *P. formosus*.

Temperature data from the study area (Figures 3 and 4) show that the months of November through February are coldest, both above and below ground. Temperature 10 cm above ground in these months (Figure 3) decreases sharply from a high about 1400 hr until 2400 hr, then decreases slowly until a minimum is reached at 0500 or 0600 hr. After dawn temperature again rises sharply toward the 1400 hr peak. The time of daily high changes with season, no doubt influenced considerably by day length. The April and October highs occur at 1400, as in the cooler months, but those from May through September occur from 1500 to 1700 hr. There is no corresponding shift in the time of daily low with season, lowest temperatures occurring between 0400 and 0700. Lowest ambient temperatures in warm months are usually shortly after dawn, but before the sun has reached the bottom of Deep Canyon, whereas in winter months coolest temperatures occur before dawn.

Surface temperatures follow a pattern generally similar to ambient (Figure 4b) with absolute lows occurring from 0200 to 0400 hr in the cooler months and from 0400 to 0600 hr in the warmer months. Surface peaks near 35 C about 1200 in the cooler months, and regularly exceeds 48 C between 0600 and 2000 hr in the warmest months of summer.

In any given month there was little diel variation in burrow temperature (Figure 4a), the greatest being 2.1 C in May and 2.3 C in July. We are suspicious of the burrow temperature data for June through September, as we doubt that any endothermic mammal would select burrow temperatures so high. Yet all temperatures from May through November were recorded from a single probe placed at 30 cm in a burrow which was in use in May when the probe was placed, and there was no significant difference between the two burrows measured. Chew and Chew (1970), measuring burrow temperature at 15 cm in the Chihuahuan desert, recorded means of 28.3 C and 26.8 C for July and August, respectively, while the range noted for those two months during our study was 36.8 C to 39.5 C. It is not known whether *D. merriami* move to deeper burrows during the summer months at Deep Canyon.

As might be expected, great individual variability was observed in mean minutes of activity for *D. merriami* exposed to both winter and summer temperature conditions in the laboratory (Figures 5 and 6), as well as in total time out per night, which varied from 3.20 to 6.51 hours for the winter temperature regime and from 4.36 to 8.30 hr for the summer. Some individuals were active at dusk and just before dawn both summer and winter. However, a significant ($P<0.05$) difference is seen in the total time active between winter and summer regimes and the spacing of this activity.

Mean total activity for winter animals is very close to five hours (5.02 ± 0.38), and 68% of this activity is between dusk and midnight. The tendency then of confined animals is to reduce total activity on simulated winter nights and to concentrate more activity before midnight, thus avoiding the colder hours of early morning. Captives exposed to a simulated summer cycle had nearly one hour more total activity, and showed little tendency to concentrate activity to the hours before midnight.

EXPECTATIONS

Though this project was not funded for 1973, an extension of permanent equipment funds is permitting us to build and test the telemetric system described by Osgood and Weigl (1972). This system will be used to collect activity pattern and thermal experience data throughout 1973. At the same time an increased number of temperature recording instruments made available by Pomona College will permit us to simultaneously monitor several active burrow systems at different depths to check data obtained on two systems in 1972. This information will be added to Biome data banks as it becomes available, along with demographic data collected in the live-trapping phase of this project.

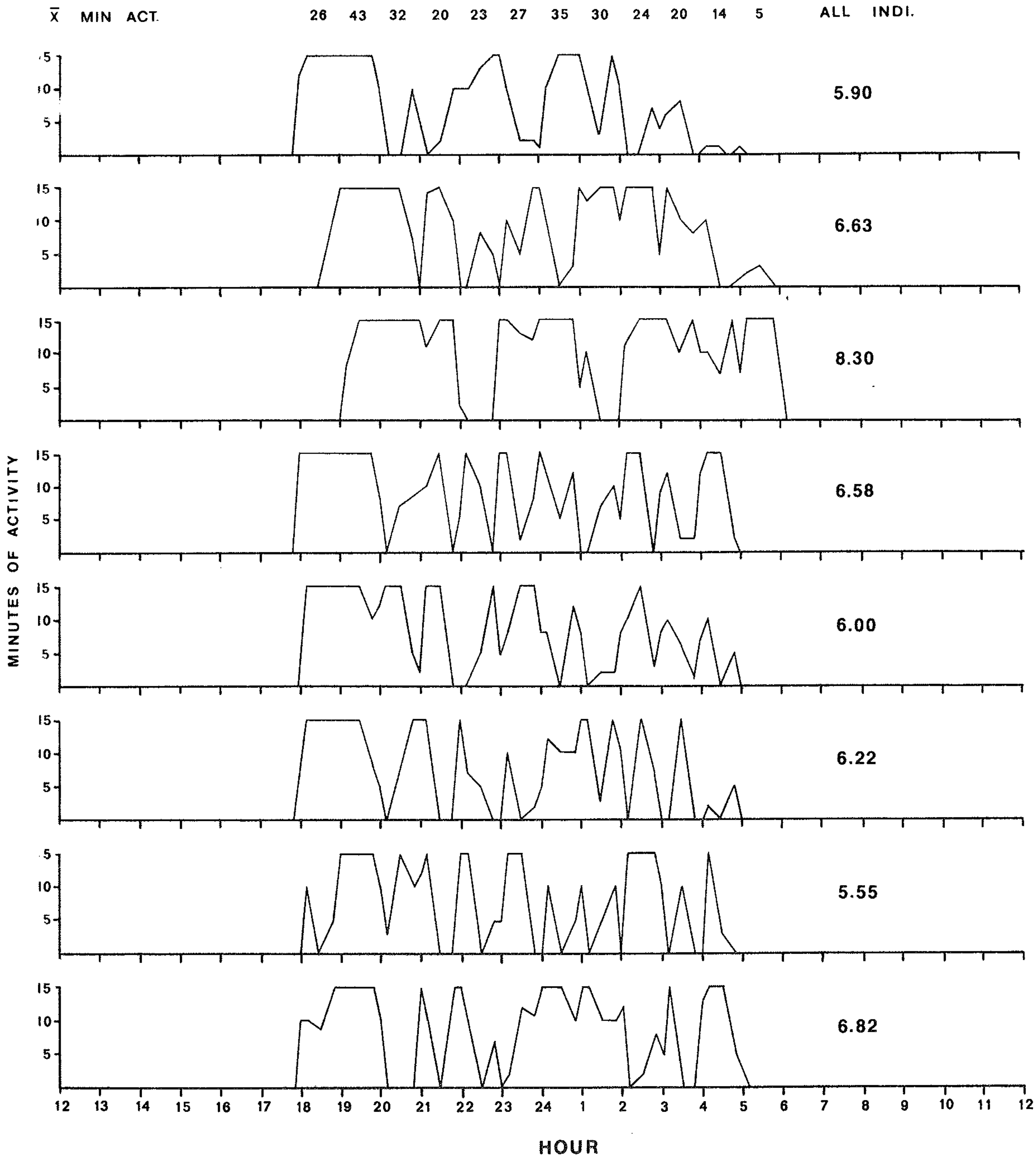

Figure 5. Activity patterns of *D. merriami* exposed to summer temperature conditions in environmental chamber (A3UWW03). Mean total hours of activity per night in bold face to right for each individual. Mean minutes of activity per hour for all individuals at top. (Continued on next page).

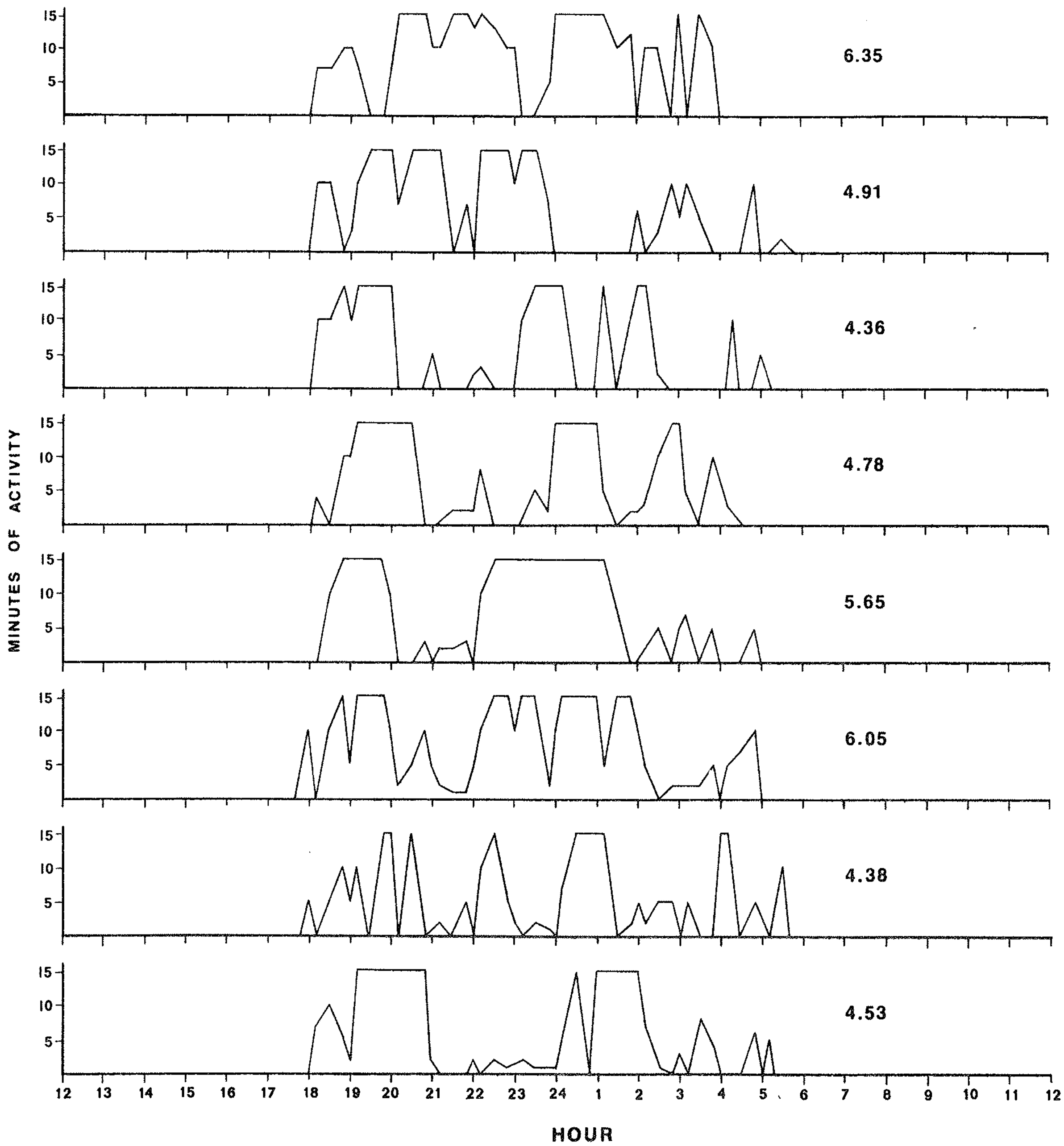

Figure 5. Continued.

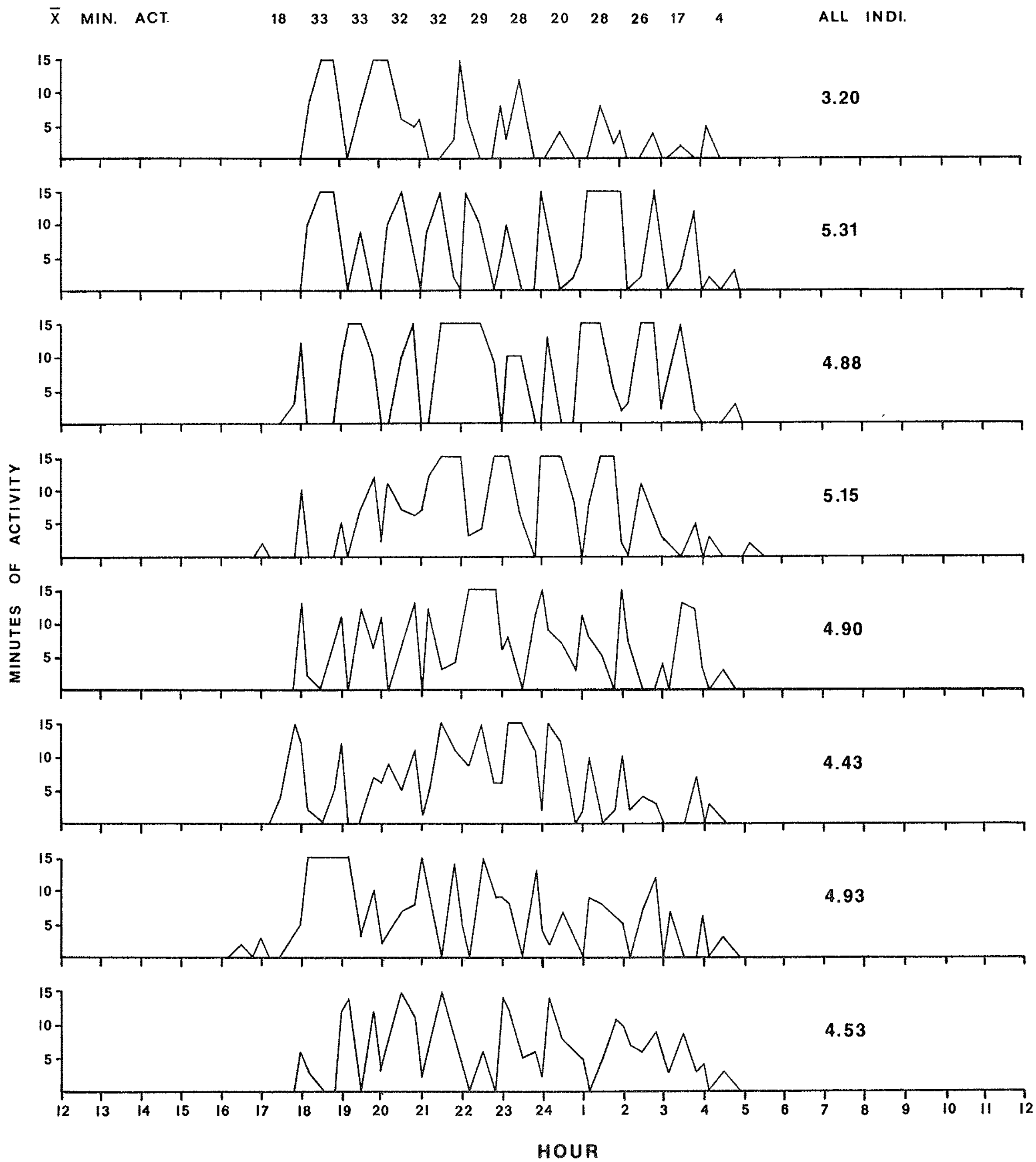

Figure 6. Activity patterns of *D. merriami* exposed to winter temperature conditions in environmental chamber (A3UWW03). Mean total hours of activity per night in bold face to right for each individual. Mean minutes of activity per hour for all individuals at top. Continued on next page.

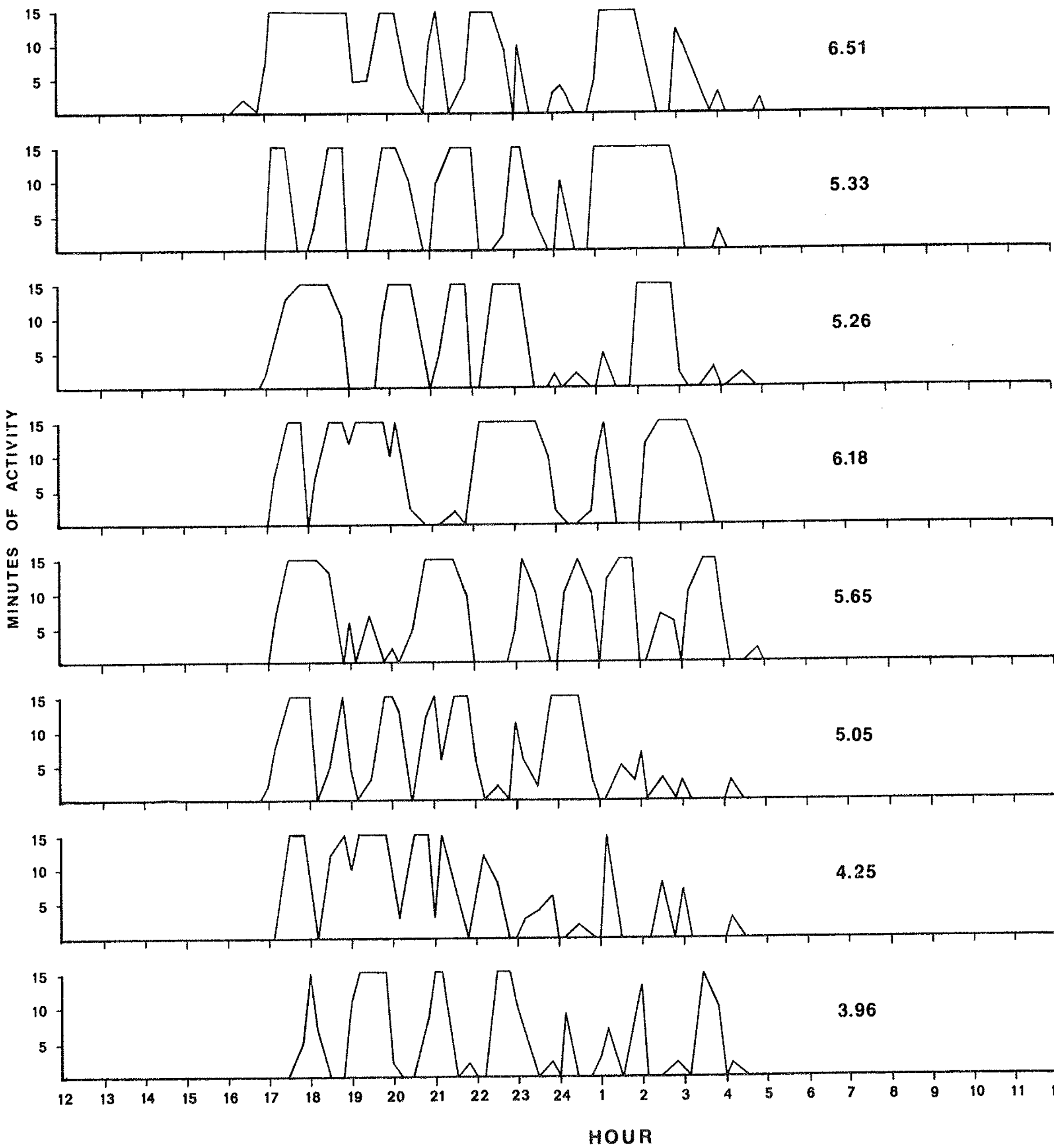

Figure 6. Continued.

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