

# Socially-related and Spontaneous Circadian Thermo-acrophase Shifts in *Rhabdomys Pumilio* — Complications for Chronopharmacologists

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## ABSTRACT

The reportedly diurnally-active African four-striped field mouse, *Rhabdomys pumilio* (Sparrmann, 1784; Rodentia: Muridae), studied with food freely available singly-caged at  $24 \pm 1^\circ\text{C}$  by the use of an intraperitoneal transensor for telemetry, exhibits a prominent circadian rhythm in core temperature. A reliably diurnally-active rodent is a potential tool for pharmacologists interested in the possibility of extrapolating data from their experimental animals to diurnally active human beings. Spontaneous and socially-induced shifts in timing of temperature pattern along the 24-h scale, gauged by the fit of a 24-h cosine for acrophase computation, occur and lead to drastic inter-individual differences in timing of core temperature rhythm for singly-housed *Rhabdomys* kept in different cages, yet in the same experimental environment (same isolation chamber). The importance of individualized monitoring of a marker rhythm such as core temperature before drawing conclusions as to the diurnality or nocturnality of metabolism emerges from these findings. Drug responses related to any marker rhythm are best individualized while the monitoring of a few individuals from a larger socially synchronized group is a second, yet practicable and cost-effective choice, as also documented herein for *Rhabdomys*.

## KEYWORDS

Synchronizer, synchronizor, synchronizee, circadian, circannual, chronopharmacology, acrophase, amplitude, nocturnality, diurnality, four-striped mouse, *Rhabdomys*, *Mus*, *Rattus*, temperature

## INTRODUCTION

Wild rodents from South Africa have been suggested as laboratory models for research, notably but not exclusively on infectious diseases, and have been successfully bred by Keogh and Isaacson (1978a and b). In view of its reported diurnal activity pattern, we here consider (and find serious limitations to) the use of one of these animals for purposes of chronobiologic research. For chronopharmacologic and other studies, it seems plausible that data on the time-dependence of a



drug effect may be more readily extrapolated to human beings, if they describe a diurnally active rodent (rather than the widely used nocturnally active mouse or rat), yet only if these rodents meet the many other requirements of amenability to ready standardization, ease of breeding, ready maintenance, etc. (Halberg, 1959; Halberg, E. and Halberg, F., 1980).

*Rhabdomys pumilio* is a common and widely distributed mouse in eastern, central, and southern Africa. Murid rodents typically are thought of as having nocturnal activity patterns. *Rhabdomys* and perhaps *Lemniscomys griselda*, the one-striped mouse (Keogh, personal communication), appear to be rare exceptions in that they are noted to be primarily diurnal--Shortridge (1934), Smithers (1971) and Walker and others (1975). This diurnal motor activity of *Rhabdomys* has been studied in the laboratory by Choate (1972). Under field conditions that included a mark-recapture study, Christian (1977) observed what he described as "no tendency toward nocturnality or crepuscularity, but a display of continuous activity throughout the day". Christian's observations (1977) did include a few mice (5%) that were captured at night.

The literature on *Rhabdomys* (cf. also Brooks, 1974, and Marais, 1974) includes further mention of crepuscular and nocturnal activity: Smithers (1971) noted some tendency toward crepuscularity and Shortridge (1934) mentions finding *Rhabdomys* moving about on warm moonlit nights. Furthermore, Choate (1972) observed some activity extending into the night, yet describes *Rhabdomys* as largely diurnal, *Lemniscomys griselda* as diurnal/crepuscular and *Otomys angoriensis* as nocturnal/crepuscular.

In a thesis, Peter Martin Brooks (1974) included temperature measurements on *Rhabdomys pumilio* under field conditions simulated on a university campus in open air. Since his data, to our knowledge, may be the first systematic temperature measurements on this species, they are presented as Table 1, combining Tables 19 and 20 of Brooks' thesis. By sampling at only two convenient timepoints, Brooks found a statistically significant within-day difference for each sex in only one of two test-seasons. Within-year differences in some aspects of a rhythm, gauged by only 2 sampling times along the 24-h scale, need not indicate the disappearance of the rhythm in a given season. For each sex, the data suffice to establish, at least in one season, a statistically significant rise in core temperature from morning to afternoon, a finding highly suggestive of the diurnality of the temperature peak since such rises during the illuminated portion of the day are not usually seen in nocturnally-active rats and mice (Halberg and others, 1954a, 1954b, 1971).

TABLE 1 Core Temperature of Adult *Rhabdomys pumilio*\*

Month of study	Clock time	Mean ambient temperature (°C)	# of mice	Rectal temperature Mean (°C)	Range	P (Student's t-test)
<u>Males</u>						
August	0820-1100	17.5	9	35.6	33.5-36.8	
	1400-1630	24.0	14	35.7	34.7-37.2	< .05
November	0800-0915	17.0	9	35.9	34.8-37.0	
	1430-1530	28.5	10	37.3	36.5-38.3	< .001
<u>Females</u>						
August	0820-1100	17.5	11	35.6	34.0-36.3	
	1400-1630	24.0	12	36.2	34.8-37.8	< .05
November	0800-0915	17.0	10	36.0	34.5-36.6	
	1430-1530	28.5	10	37.0	37.0-38.7	< .001



\*Data from Pretoria (25°45'S 28°12'E), South Africa, in Tables 19 and 20 from Brooks (1974).

In results of dense and long intraperitoneal core temperature monitoring at 10-minute intervals for several months, to be here reported, within-day differences are consistently found in the laboratory, and these same measurement series reveal changes within the year, some of them likely induced socially and one occurring apparently in a spontaneous fashion, Fig. 1.

We document such findings in the absence of handling for measurement by objective inferential statistical analyses. We show that the acrophase, a so-called microscopic measure of timing, usually occurs in midlight, under conditions involving the alternation of light (L) and darkness (D) at 12-h intervals (LD12:12), the habitual environmental physico-chemical synchronizer (Halberg et al., 1959). The acrophase can also occur near mid-dark in the laboratory, as also noted occasionally in the field, but is found more often near mid-light. The thermal acrophase apparently undergoes spontaneous changes as well as socially-induced ones; other animals introduced into the isolation chamber housing Rhabdomys, in separate cages, can (but must not) become synchronizers or synchronizees. These points are critical for a chronopharmacologist in search of a diurnally active, relatively small laboratory animal (who may consider work on Rhabdomys pumilio).

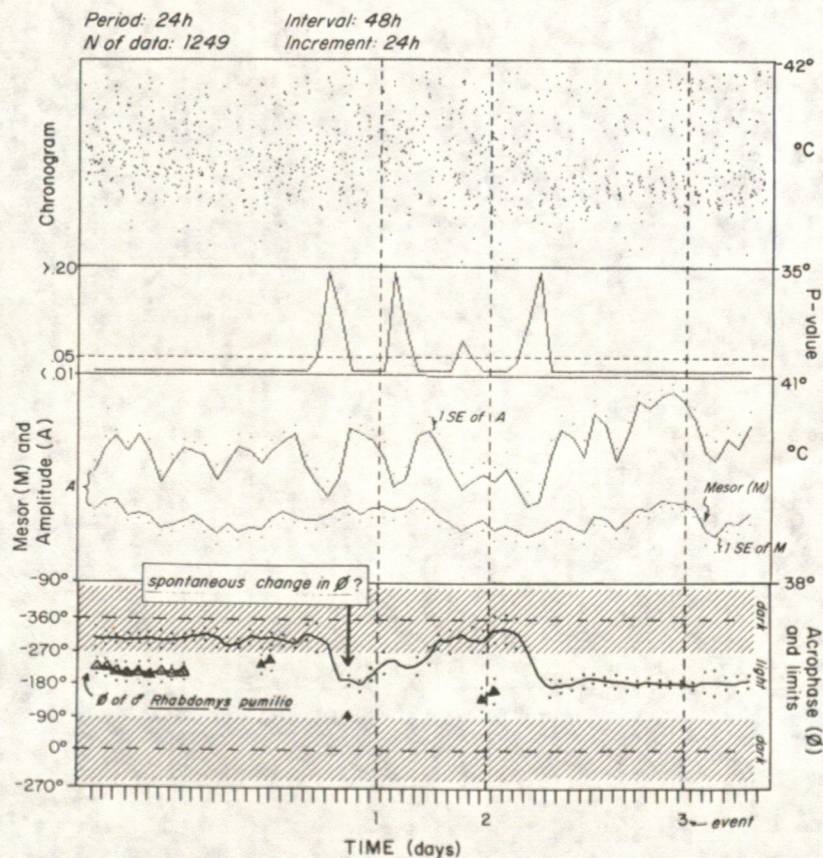
#### METHODS

In the course of a series of rectal temperature studies on hypothalamically lesioned and intact rats, Rattus norvegicus (Rodentia: Muridae), measurements were made concomitantly at 4-hour intervals for several 24-hour spans on 3 Rhabdomys pumilio, individually caged in the same experimental room, maintained at about 24°C and 50% relative humidity and with lights-on from 06<sup>00</sup>-18<sup>00</sup> daily. In one of these studies involving Rhabdomys, the highest rectal temperature occurred in these animals in the light span (with an acrophase, defined below, at 16<sup>40</sup>, i.e., at 10 hours and 40 minutes from light-on at 06<sup>00</sup>). Following this impression, apparently corroborating that this species may be diurnally-active, transensors were implanted intraperitoneally in one male and one female Rhabdomys and core temperatures were monitored automatically every 10 minutes around the clock for several months before, during and after the introduction of female CD<sub>2</sub>F<sub>1</sub> mice (Mus musculus) and later of ♂ Sprague-Dawleys (Rattus norvegicus) into adjacent cages in the same chamber. Some of the ♀ Mus and ♂ Rattus with intraperitoneally-implanted transensors were also monitored. Antennae for the individual cages monitored the radio frequency signal from the transensor for readout at the predetermined intervals. Data were stored on magnetic tape, edited and analyzed with separate computers serving for data collection and analysis.

The systems for data collection and analysis have been described earlier by Halberg and others (1971) and Runge and others (1974), respectively. The calibrated transensors were not surgically removed and recalibrated during the life of the batteries. Nonetheless, temperature values are probably fair approximations of original temperature (in the absence of any signs of transensor failure, such as drifts). Moreover, even in the presence of a drift or a trend (Greek: cline), rhythmic changes in values are amenable to assessment by clinorhythmometry (the study of a spectrum of rhythms and trends). Throughout the recording span, the animals were kept singly-caged in LD12:12 at 24 ± 1°C and a relative humidity of approximately 50%. Purina Laboratory Chow and deionized water were freely available. Data automatically transmitted to magnetic tape were analyzed by the single cosinor method and chronobiologic serial sections (Halberg and others, 1972, 1977). In both of these procedures, a 24-hour cosine function is fitted to a given data section in order to: 1) test the assumption of "no rhythm" (i.e., the null hypo-



## Chronobiologic Serial Section of Telemetered Core Temperature of Female Rhabdomys pumilio\*



\*

## Event lines:

- 1) 10 female Mus introduced into isolation chamber in different cages;
- 2) saline or antimalarials given to Mus;
- 3) Mus removed from isolation chamber.

Data span 1980-09-18(00<sup>00</sup>) to 1980-11-18(13<sup>30</sup>) begins just before autumnal equinox; amplitude and mesor of circadian temperature rhythm suggest infradian (estral ?) modulation. Note apparently spontaneous acrophase change from nocturnality to diurnality and return to nocturnality after introduction of nocturnal female mice into chamber. Triangles represent thermal acrophases of male Rhabdomys (kept in different cage in same isolation chamber) bearing an intermittently and finally failing transensor.

Fig. 1. Spontaneous and "socially-induced" changes in thermal acrophase of Rhabdomys pumilio revealed by chronobiologic serial section. Rhabdomys ~14 weeks of age at start of record.



thesis of a zero amplitude) and (if the null hypothesis is rejected) 2) obtain point and interval estimates of rhythm parameters. The period ( $\tau$ ) used for analysis was a priori equated to 24 hours ( $\sim 360^\circ$ ), on the basis of prior evidence of synchronization of the motor activity rhythms of many other rodents by schedules of LD12:12. Data averages for consecutive 1-h spans were preferred to relative changes, i.e., to data expressed as percent of mean, since in the case of temperature, such values differ as a function of the original scale used for measurement.)

The numerical methods here used provide concomitantly: 1) a rhythm-adjusted mean, i.e., a midline-estimating statistic of rhythm (briefly mesor, M), 2) a measure of the extent of rhythmic change determined from the fitted cosine curve (the double amplitude, 2A), and 3) a measure of timing (the lag of the peak in the fitted cosine curve from the phase reference), the acrophase,  $\phi$ . The single cosinor method summarizes these characteristics as an overall result on an entire data series, or on sections of this series exhibiting consistent characteristics--a so-called biostationarity (Halberg and others, 1977). The chronobiologic serial section serves to scrutinize for such consistency; it is carried out by fitting (in the case of the data here analyzed) a 24-hour cosine curve to intervals, chosen by the analyst, displaced with increments, also chosen by the analyst, along the length of the total series, so as to examine any changes with time in the aforementioned rhythm characteristics.

The pair of Rhabdomys utilized in these experiments were laboratory-reared offspring of a small colony (five pair) brought to this country in 1973 from Gorab, Maltahöhe District, Namibia (South West Africa) ( $25^\circ 09'S$ ,  $16^\circ 31'E$ ). Reference specimens from this locality were deposited by one of us (R.T.) in the Field Museum of Natural History in Chicago, Illinois, USA.

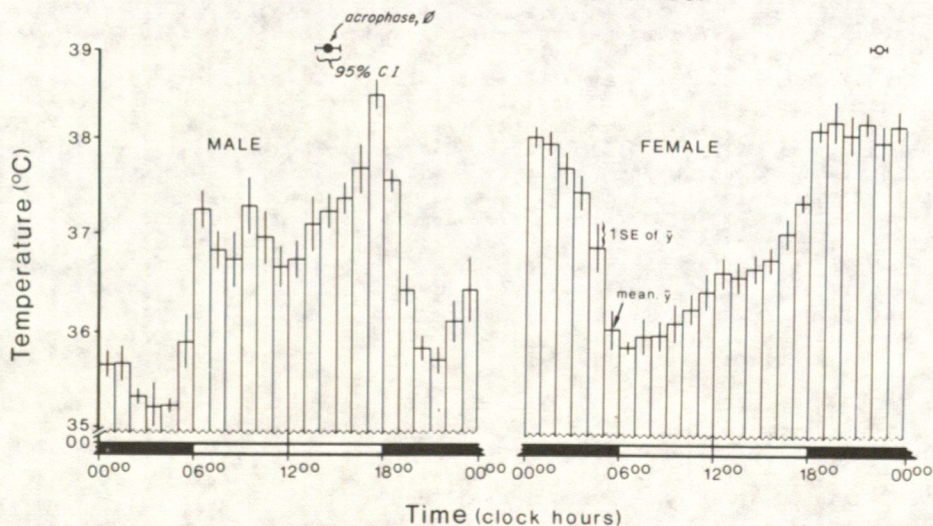
## RESULTS

Some regularity in the changes in temperature, like circadian variation, is apparent to the eye in Fig. 2, which shows that two concomitantly monitored Rhabdomys, singly caged in the same isolation chamber, can exhibit drastic differences in timing of their circadian rhythm of intraperitoneal temperature.

Chronobiologic serial sections for the 2 mice (see Fig. 1) reveal a range of variation of about  $5^\circ C$ . P-values are mostly at or below the 1% level, for results from fitting a cosine with a 24-hour period to 24-hour data intervals displaced in increments of 12 hours. The amplitude is large and exhibits considerable variability in itself. Even in the laboratory, under conditions of controlled environmental temperature (here  $24 \pm 1^\circ C$ ), the total thermal range (and also the circadian thermal amplitude) are considerable in Rhabdomys as compared to other murids such as Mus or Rattus. These results on range are in keeping with those from spot-checks at 2 time points in open air at an ambient temperature varying from  $17.0$  to  $28.5^\circ C$ ; under such conditions, Brooks found a rectal temperature range from  $33.5$  to  $38.3^\circ C$ . These ranges in themselves are of interest, and indeed Rhabdomys constitutes a rodent with a large circadian thermal amplitude (Table 2). The macroscopic extent of change or the microscopic amplitude is not so large in Rhabdomys as has been reported for temperature and other variables in some species such as the heteromyid pocket mouse, Perognathus parvus, which undergoes a daily torpor (Lindberg and others, 1973; additional references in Hart, 1971). Moreover, in the longitudinal study limited to 2 animals, an inter-individual difference stands out clearly and consistently. The particular female Rhabdomys' mesor is consistently higher than that of the male studied (by  $4-6^\circ C$ ); the circadian amplitude of variation is also consistently greater in the female (see also references in Hart, 1971). For Rhabdomys in open air, a sex difference in rectal temperature was not found by Brooks (1974); the present difference can only serve as an indication of



Nocturnality and Diurnality of High Temperatures  
in Two *Rhabdomys pumilio* Kept (in different cages)  
in the same Isolation Chamber\*



\* Aug 25 - Sept 2, 1980; telemetered temperature data recorded every 10 minutes and averaged hourly  
Note high values during the light span for the male and the dark span for the female.

Fig. 2.

inter-individual variability in dense data obtained under controlled conditions. The acrophase, as a function of time (in days), shows little change, in the case of the record for the male *Rhabdomys* studied; it is consistently near midlight. The acrophase for the female, however, undergoes a surprising jump in the absence of any known stimulus (see Fig. 1). Spontaneously, as far as core temperature behavior is concerned, a previously nocturnal animal becomes a diurnal one.

When cages containing  $CD_2F_1$  (nocturnal) female mice (*Mus musculus*) are added to the chamber housing the *Rhabdomys*, some degree of nocturnality in the striped mouse gradually results from the presence of the  $CD_2F_1$ s (see Fig. 1). Although the  $CD_2F_1$  mice were actually in different cages (in the same chamber) and because of partitions could not see each other or the *Rhabdomys*, there is an adjustment of the thermal acrophase of the *Rhabdomys*, despite an unchanged lighting cycle. This adjustment may be mediated, perhaps, by sound and/or smell. We may be dealing with a possible social or socioecologic synchronization which is gradual rather than abrupt (Halberg and others, 1954, 1959; further references in Regal and Conolly, 1980). When the *Mus* were removed from the chamber, the core temperature acrophase of the female *Rhabdomys* returned to midlight over a number of days, gradually rather than abruptly (see Fig. 1). Table 2 shows data after these adjustments: there is a rather steady location in the light span for the thermal acrophase of both animals investigated.



TABLE 2 Thermal Acrophase of 2 Singly-Housed African Striped Mice (*Rhabdomys pumilio*) Prior to and After Addition of Sprague-Dawley Rats (in Separate Cages) to Chambers\*

Animal #	Date in 1980/81	# of hourly means	Range (°C)	Mesort±SE	Amplitude±SE	Acrophase (95% CL*) (degrees)
Rhabdomys (#1 male; #2 female) No other species present in chamber						
1	12/09-23	288	37.59-41.93	40.08±.041	1.299±0.058	-184° (-179, -189)
2	"	136	33.05-38.88	36.07±.081	0.936±0.113	-224° (-210, -237)
1	12/29-	191	37.07-41.91	39.64±.048	1.896±0.068	-183° (-179, -187)
2	01/06	187	33.21-37.37	34.73±.061	0.832±0.087	-220° (-209, -232)
1	01/13-20	167	37.38-41.87	39.50±.051	1.875±0.072	-186° (-182, -191)
2	"	167	32.81-36.30	34.09±.058	0.785±0.082	-217° (-205, -228)
1	01/27-	332	36.87-41.99	39.73±.048	1.334±0.055	-198° (-193, -202)
2	02/10	334	32.59-36.41	33.97±.041	0.827±0.058	-220° (-212, -227)
1	02/10-17	167	37.42-41.97	39.60±.048	1.606±0.069	-191° (-187, -196)
2	"	167	32.41-36.13	33.74±.060	0.842±0.086	-227° (-216, -238)
Other species present in chamber						
1	02/27-	12	37.33-40.38	38.76±.149	1.234±0.191	-179° (-161, -197)
2	03/09	220	32.28-36.34	33.85±.063	0.719±0.089	-221° (-207, -235)
Rattus (all males)						
	02/27-	240	34.19-38.64	37.34±.037	0.546±0.052	-359° (-348, -10)
		239	34.32-39.27	37.59±.044	0.573±0.062	-5° (-353, -18)
	03/09	75	36.88-40.86	38.45±.069	0.612±0.091	-339° (-320, -358)

\*Note consistent diurnality of *Rhabdomys* thermal acrophases, even after introduction of Sprague-Dawley rats to chambers. Same *Rhabdomys* had earlier been exposed to 11 separately caged female CD<sub>2</sub>F<sub>1</sub> mice ~10 weeks of age (see symposium summary). \*360° ≡ 24 hours; 15° = 1 hour; acrophase reference = 00° in LD12:12 (L06<sup>00</sup>-18<sup>00</sup>). CL = confidence limit. (Cf. Fig. 1.)

This diurnal timing of both striped mice persisted when nocturnal male rats (*Rattus*) were introduced into the same chamber. On the other hand, it appeared that the circadian temperature rhythms of one of the introduced rats was slightly shifted by the presence of *Rhabdomys* to the extent that these rats tended to become diurnal insofar as the core temperature rhythm is an indication (Table 2). Follow-up studies of the same 2 *Rhabdomys* from July 20 to August 12, 1981, again singly caged, yet with 7 other singly-housed *Rhabdomys* in the same isolation chamber, revealed a consistent acrophase during L rather than D, with the acrophase range of the 9 *Rhabdomys* extending from -194° (from mid-dark) over -197°, -197°, -206°, -221°, -230°, -233°, -235° to -251°.

#### DISCUSSION

We have been unable thus far to induce a few pairs of breeding *Rhabdomys* to raise their litters, despite opportunities for exercise and dietary additions. Keogh (personal communication) has been able to raise them, but anecdotally remarked that this is possible with lots of grass in their cages and in about 1 out of 10 breeding pairs. Our difficulties in breeding restrict the number of animals used by us and might perhaps restrict the broader use of *Rhabdomys* in chronopharmacology, in view of cannibalism. *Lemniscomys griselda*, found to be diurnal in activity pattern by Choate (1972), may be a better diurnal experimental animal and awaits tests in this context.

Herein, we record the relatively large extent of variations in core temperature and shifts in the timing of the circadian rhythm in core temperature primarily of only two African four-striped mice, *Rhabdomys pumilio*, studied for several months--



both in the presence and absence of CD<sub>2</sub>F<sub>1</sub> mice and Sprague-Dawley rats. Much of this paper is restricted to a consideration of data from a single animal which shows, in the time course of its circadian temperature rhythm, a dramatic acrophase jump on a fixed regimen of light (L) and darkness (D) alternating at 12-hour intervals (LD12:12). This change in the timing of a core temperature peak from nocturnality to diurnality occurred suddenly, presumably as an endogenous phenomenon, and should be viewed in the light of earlier observations on diurnal activity for this species (Choate, 1972; Brooks, 1974; Christian, 1977; Walker and others, 1975).

Much more information than that obtained here will be needed longitudinally, on more than a few animals, with monitoring preferably for a lifetime, to check on the several possibilities found in the available data:

1) First, that some animals show a consistent diurnality of thermal acrophase, whereas others will abruptly and spontaneously change the timing of their rhythm in core temperature, from a major temperature peak in the dark span to one in the light span. Whether such a change is perhaps the result of endogenous infradian (e.g., circannual) intermodulation with the circadian rhythm is a possibility deserving scrutiny. Large differences as a function of circannual stage have been recorded recently for the timing of a circadian rhythm in adrenocortical responsiveness *in vitro* and *in vivo* (Halberg, 1969; Halberg and others, in press; Haus and others, 1980; Zbiegieni, 1980), and changes in pattern of motor activity have been noted (Pittendrigh and Daan, 1974, 1976). One cannot decide with data from only a few four-striped mice whether the apparently consistent diurnality of the male is sex-related. The role of potential (smell- or sound-related) external synchronizers must be considered and further experimentation, according to Keogh (personal communication), may well utilize the more readily handled one-striped African mouse, Lemniscomys griselda.

2) Social synchronization of Rhabdomys core temperature rhythmicity by factors related to the presence of CD<sub>2</sub>F<sub>1</sub> mice, and the possible influence on the circadian temperature rhythm in one rat by the presence of four-striped mice--the reversed if partial synchronization of Rattus by the Rhabdomys--is demonstrated as an interesting feature of a budding experimental social chronobiology.

3) Social synchronization, as noted earlier for synchronization more generally (Halberg and others, 1954, 1959; Halberg, 1969) is often a gradual rather than an abrupt process, in contrast to the spontaneous phase jump in relation to external schedules (resulting perhaps from the operation of internal mechanisms) here noted in a female Rhabdomys. Regal and Connolly (1980) reported both gradual and abrupt socially-induced shifts in activity rhythms of lizards kept under LD conditions.

The circumstance that social synchronization will occur in some animals but not in others, and that the "synchronizer" can become the "synchronizee", raises interesting questions as to the importance of relative kinds and levels of activity in two or more interacting individuals or species. The consequences of such interaction for biological rhythms, notably when different individuals or groups of different size and sex as well as strain or species interact at different ages, all await more extensive study. While acrophase differences among certain species, such as predators and their prey, have attracted considerable attention, the relations within a given species and their changes deserve scrutiny for the underlying physiologic mechanisms and with a view to the optimization of social relations (discussion in Regal and Connolly, 1980).

Attention to studies on human beings may be useful, with proper concern for the danger of anthropomorphism. Hoskins *et al.* (1979) have reviewed (and added to) the literature on circadian aspects of psychometrically assessed activation in human beings. Tools are indeed available for the assessment of personality con-



flict among human beings in conjunction with the monitoring of physiologic functions such as core temperature, here documented for the African four-striped mouse, the hybrid laboratory mouse and the inbred rat.

One may speculate that the female *Rhabdomys* could shift activity to correspond to the timing of a group of females, though of another species, and add, again speculatively, that one of a group of male rats tends toward the timing of the only female in the chamber. The interpretations placed on the data are only interesting inferences and in any event questions of mechanisms remain, as in other such reports (Regal and Connolly, 1980); cyclic adrenal cortical function was indirectly assessed in the original experiments on social synchronization (Halberg and others, 1959) and the adrenal cortical cycle (not some imaginary adrenocortical "homeostasis"), which can now be directly assessed, awaits scrutiny in the context of the broader webs of neuroendocrine rhythms (Halberg, F. and others, 1979).

The data reported here suggest, in any event, interesting studies for the future. The "goals" sought by the prey in relation to a predator and vice versa are out-of-phase-ness and in-phase-ness, respectively, and their realization may in itself be an interspecies bioperiodicity superimposed upon underlying within-species rhythms (Nel, 1978).

Nel remarks that foraging and feeding activity of bat-eared foxes (*Otocyon megalotis*) observed by him in the Kalahari-Gemsbok National Park, South Africa, changes with the seasons: diurnality in winter alternates with nocturnality in summer, a phenomenon interpreted as the result of the availability of invertebrates selected as food items, with termites predominating among them.

Can such relations be carried to still broader chronoecologic perspectives for the optimization of a given niche? It is here that work both in the experimental laboratory and in the field on interacting life forms, including human beings, is still in its infancy, yet constitutes a very promising approach to the spatio-temporal structure of a given area (cf. also Christian, 1950).

4) *Rhabdomys* may provide a study species with which spontaneous, perhaps circannual changes from diurnality to nocturnality of the thermal acrophase can be studied in the laboratory, as here documented by core temperature telemetry. Such work could complement studies by Andreasson (1969, 1973), Andreasson and Müller (1969), Erkinaro (1961, 1969), Müller (1969, 1970a, 1970b, 1973) and Westin (1971), who have reported for the activity rhythm a timing change similar to that here documented for the temperature rhythm. These authors reported a seasonal shift between nocturnal and diurnal activity patterns (of about 180° in relation to the natural synchronizer) in both fishes and small rodents. This change into a near antiphase of a physiologic rhythm's timing in relation to a presumably fixed environmental schedule may lead us to discuss a critical stage in some infradian, perhaps circannual rhythm. Circannual changes from diurnality to nocturnality of the bat-eared fox, *Otocyon megalotis*, has been described by Nel (1978) as being opportunistically dependent upon changes in food supply. Internal adrenal-gonadal intermodulations are of interest in the same context, in view of the results reported by Haus and others (1980) and Zbiegieni (1980) as a potential equivalent of the mechanisms leading to ovulation in a sex-related cycle. For other aspects of circannual as well as circadian changes in temperature regulation of rats, the reader is referred to the work of Heroux (1979).

5) The temperature data here presented can be complemented in the future by longitudinal urinary monitoring, perhaps of corticoids, in view of possible adrenal cyclic mechanisms (Halberg and others, 1954) and of melatonin.

Haim and Fourie (in press) studied the thermogenic response to melatonin in *Rhabdomys* and *Praomys patalensis* with the intent of comparing a "diurnal" with a noc-



turnal murid species. Experimental groups received 10 mg melatonin (Sigma) coated with beeswax capsules (20 mg) implanted subscapularly. Sham-operated groups received 30 mg beeswax capsules. Chronobiologically unspecified melatonin treatment "increased" oxygen consumption at ambient temperatures of 6, 25, 32 and 34°C, as compared to that of sham-operated mice not given melatonin. Enzymatic activity (malate dehydrogenase, a putative representative of the Krebs cycle, and lactate dehydrogenase as an index of the glycolytic pathway) "increased" in both species as compared to controls. Haim and Fourie (1980) suggest that melatonin can mediate a thermal response in both a diurnal (*R. pumilio*) and in a nocturnal (*P. natalensis*) species. "An increase in endogenous melatonin secretion due to extension of scotophase is likely to result partly in winter acclimatization of heat production mechanisms", write Haim and Fourie (in press). Some endogenous change did occur spontaneously in at least one *R. pumilio* without a change in scotofraction, and it seems worthwhile to check whether this phenomenon is reproducible and possibly involves melatonin (cf. also Ralph, 1979).

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