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THE EFFECTS OF WEATHER, SEX AND SEASON ON THE NOCTURNAL ACTIVITY OF *PEROMYSCUS TRUEI* (RODENTIA)

JOHN S. SCHEIBE

ABSTRACT.—The nocturnal activity of *Peromyscus truei* was investigated on a seasonal basis for one year. Females showed bimodal activity patterns during all seasons. Males were unimodal in the winter and differed significantly from the females during the spring. Activity was positively related to ambient temperature and negatively related to moonlight during the fall and winter months. Summer activity was positively related to cloud cover. Weather variables were good predictors of *P. truei* activity during the fall but less so during other seasons.

The purpose of this paper is to elucidate some of the abiotic factors which are related to the nocturnal activity of *Peromyscus truei*, and to explore the effects of sex and season on the activity patterns of this species. Numerous studies have been concerned with the effects of weather on rodent activity (Gentry and Odum, 1957; Orr, 1959; Marten, 1973; O'Farrell, 1974; Blaustein and Fugle, 1981; Vickery and Bider, 1981) although few have investigated the role of sex or season. Most studies pool the data for both sexes and different seasons to achieve overall activity relationships. This paper reports on some of the environmental variables related to the nocturnal activity of *P. truei* and shows that the relationship between weather and activity is dependent on the season. Also, it will be shown that during some seasons male and female activity patterns differ considerably.

METHODS.—The study was situated in a Pinyon Woodland habitat in the Tehachapi Mountains, Kern County, California and was monitored on a monthly basis for one year, from August 1975 to August 1976. This site was located on the west-facing slope of Walker Pass, 8.9 km east of Highway 14 (on Highway 178) and 3.5 km south of Highway 178 at an elevation of 1800 m. The dominant vegetation of the area consisted of the one-leaved Pinyon (*Pinus monophyla*), Basin Sagebrush (*Artemisia tridentata*), Cooper goldenbrush (*Haplopapus cooperi*), Mormon Tea (*Ephedra viridis*), Curl-leaf Mountain Mahogony (*Cercocarpus ledifolius*), and Joshua Tree (*Yucca brevifolia*). The nocturnal rodent community was composed of the Pinyon mouse (*Peromyscus truei*), the deer mouse (*Peromyscus maniculatus*), the desert woodrat (*Neotoma lepida*), the Panamint kangaroo rat (*Dipodomys panamintinus*) and the Great Basin pocket mouse (*Perognathus parvus*).

The rodent community was sampled using a 12 by 12 station grid with 15 m trap spacing. Live trapping was conducted between the last and first lunar quarter for a period of three nights each month. Traps were checked at 2-hour intervals throughout the night. In general, 30 minutes were required to complete each trap run. The rodents were released at the point of capture. The relative humidity, wind velocity, and air temperature were recorded prior to each 2-hour trap interval. Relative humidity was measured with a Bacharach model sling psychrometer. Wind velocity was determined with a Dwyer model hand held anemometer and temperature was measured with a mercury thermometer placed 20 cm above the soil surface. In addition, cloud cover (percentage) and condition of the moon (phase and obscuration) were estimated by visual inspection.

The data were analyzed using the SAS computer package (Barr et al., 1976). Stepwise multiple regression was used to investigate seasonal relationships between the level of *P. truei* activity and the weather variables. The analysis of variance routine of the general linear models procedure was

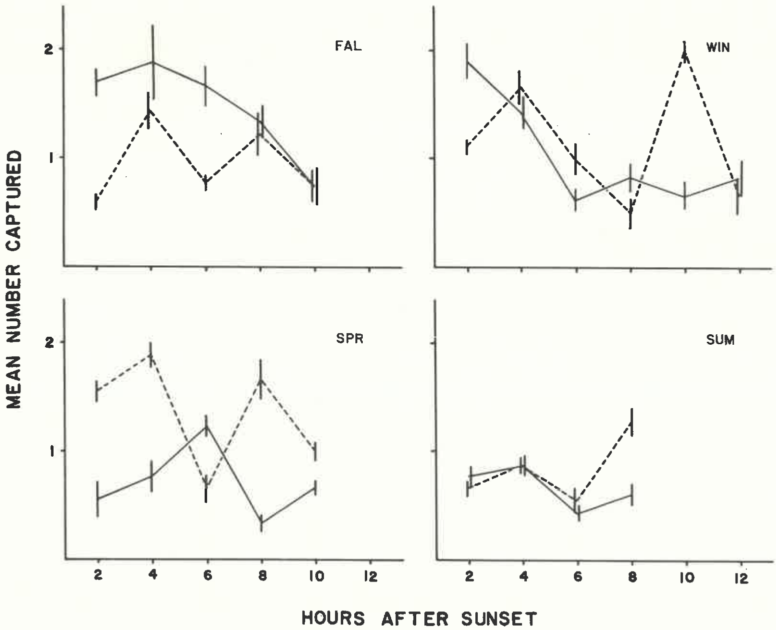

FIG. 1.—Seasonal activity patterns for male (solid lines) and female (broken lines) *P. truei. The vertical lines represent one standard error of the mean. Fall* (late August through October) = FAL, winter (November through January) = WIN, spring (February through April) = SPR and summer (May through early August) = SUM.

used to test for differences in nocturnal activity patterns with respect to time, sex and the time by sex interaction. Data for this portion of the analysis were normalized using the log transformation. Normality was checked with nonparametric schematic plots of residuals (Tukey, 1977).

RESULTS AND DISCUSSION.—The mean number of male and female *P. truei* captured during each time period is shown on a seasonal basis in Fig. 1. These activity patterns represent the chance of capturing a male or female *P. truei* at a particular time during a given season and reflect the number of animals captured during that season (Table 1).

Female activity tended to be bimodal whereas the male patterns were variable. Results of the analysis of variance revealed no significant differences between male and female activity in the fall. However, a significant time effect (df = 5,48; F = 3.04; $p < .05$) and a time by sex interaction effect (df = 5,48; F = 2.97; $p < .05$) were present in the winter. Although the male and female patterns were not significantly different across all winter time periods, a linear contrast showed the levels of activity to differ significantly ($p < .05$) ten hours after sunset. This suggests that the females were bimodal while the males were not (Fig. 1, WIN). The significant time effect indicates that the mice were not active at equal levels throughout the night. The greatest activity occurred at two, four and ten hours after sunset.

During the spring, overall female activity was significantly greater than that of the males (df = 1,50; F = 8.45; $p < .01$). To some extent this reflects

TABLE 1.—*The number of mice captured (CAPT) and the mean ($\bar{X}$ RECAPT) and standard deviation (sd) of the number of recaptures for individual mice by sex and season.*

	CAPT	$\bar{X}$RECAPT	sd
Fall Males	80	1.667	0.975
Fall Females	56	1.600	0.976
Winter Males	60	1.429	0.770
Winter Females	61	1.649	0.887
Spring Males	33	1.500	0.964
Spring Females	61	1.849	1.439
Summer Males	24	1.714	0.825
Summer Females	29	1.933	1.223

the greater number of females captured during this season (Table 1). However, the greater activity of females is also indicated by their annual recaptures, which averaged 1.85 times within a spring trapping session, while males were recaptured 1.5 times. The summer activity of males and females did not differ with respect to time or sex.

The capture of a juvenile mouse in January (Scheibe, 1977) may indicate that reproduction can occur during all seasons. Thus, the generally higher recapture rates for females and the tendency for bimodality may reflect the high energetic cost of female reproduction (Millar, 1978).

The multiple regression models estimated for each season are presented in Table 2. Since the analysis of variance procedure revealed male and female activity to be significantly different during the spring, sex was included in this model as an indicator random variable (Neter and Wasserman, 1974). This component of the model was found to be significant ($p < .05$) and thus two separate models are presented for this season.

Both fall and winter activity levels were positively related to ambient temperature, fall activity was negatively related to moonlight. Males and females were positively related to cloud cover during the summer. The fall regression model accounted for 33.0 percent of the variation in activity level while the winter, spring and summer models accounted for only 17.3, 13.0 and 14.1 percent respectively.

The fact that activity is positively related to ambient temperature during the fall and winter is reasonable and is corroborated by the work of Gentry and Odum (1957), Orr (1959), Kenagy (1973) and Marten (1973). As ambient temperatures drop below the thermal neutral zone the metabolic cost of activity is necessarily greater. Thus, the mice can increase net energy intake by foraging during warm time periods.

The moderate intensities of moonlight (last or first lunar quarter) corresponded to depressed *P. truei* activity during the fall, and somewhat during the winter. This result differs from the observations of Marten (1973) who found no strong effect of moonlight on *P. truei* activity. However, Owings and Lockard (1971) found *Peromyscus californicus* to respond negatively to artificial moonlight while *Peromyscus eremicus* responded positively.

Rodent activity showed some relationship with cloud cover and wind speed during the spring and summer. Numerous studies have reported a

TABLE 2.—*Multiple regression models for the seasonal levels of* P. truei *activity (fall = FAL, winter = WIN, spring males = M SPR, spring females = F SPR, summer = SUM) versus ambient temperature (TA), relative humidity (RH), moonlight (Moon), cloud cover (Cloud) and wind speed (Wind). The intercept (Int) and* R^2 *are also given. Statistical significance is denoted by* ** = .01 *level,* * = .05 *level and* + = .10 *level.*

PARAMETER	FAL	WIN	M SPR	F SPR	SUM
Int	−0.844	2.494	−0.036	0.765	1.272
TA	0.227**	0.140*			
RH					
Moon	−0.979*	−1.473+			
Cloud			0.221+		0.437*
Wind			0.202+	0.202+	
R^2	0.330	0.173	0.130		0.141

positive association between rodent activity and cloud cover (Gentry and Odum, 1975; Marten, 1973; Vickery and Bider, 1981) but the causal relationship is not clear. Perhaps as noted by Falls (1968), this is actually a relationship with temperature or rainfall. The fact that males showed some association with cloudy time periods during the spring while females did not may be a result of the lower reproductive energy requirements of males and consequently, the ability to select more favorable time intervals.

The precision with which these models describe *P. truei* activity is dependent on season. The best fit of 33.0 percent achieved during the fall corresponds with mild weather, abundant food resources in the form of annuals and insects, and consequently the ability to optimize with respect to weather.

The data presented in this paper suggest that *P. truei* activity is composed of at least two components. One of these components is the statistically significant bimodality of females during the winter, while the males were variable. The second component of *P. truei* activity concerns the various weather variables. The relationship between activity and weather is dependent on season. This seasonal dependence may result from the energetic requirements of the mice, the experienced ranges of the variables and consequently the ability of the mice to optimize with respect to weather.

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Address of author: *Dept. of Biology, Univ. of New Mexico, Albuquerque, NM 87131.* Present address: *Dept. of Biology, Southeast Missouri State Univ., Cape Girardeau, MO 63701.*