

TEMPERATURE AND HUMIDITY-INDUCED SHIFTS IN THE FLIGHT ACTIVITY OF LITTLE BROWN BATS¹

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ABSTRACT. The importance of ambient environmental conditions to flight activity in little brown bats, *Myotis lucifugus*, has received attention, but the influence of relative humidity has been largely ignored. Through the use of mist net captures, activity of male and female *M. lucifugus* were examined in relation to temperature and relative humidity. Activity of males was significantly greater under conditions of both higher temperature and relative humidity, suggesting that these bats alter their flight activity in response to changes in air saturation.

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INTRODUCTION

The importance of ambient environmental conditions to flight activity in little brown bats, *Myotis lucifugus*, has been a topic of recent attention (Anthony and Kunz 1977, Anthony et al. 1981). Relationships of temperature to insect availability and subsequent foraging success and the costs of thermoregulation in flight have been proposed. However, the influence of relative humidity has been largely ignored.

Studies in controlled environments have shown evaporative water loss to increase with higher levels of activity among flying bats (Studier 1970), and from trials on pregnant female *M. lucifugus*, Proctor and Studier (1970) demonstrated an inverse relationship between ambient water vapor pressure and evaporative water loss at a temperature below the thermal neutral zone. These investigators suggested that higher ambient water vapor pressures produced lower vapor pressure deficits between the respiratory tracts of bats and the ambient environment, resulting in decreased evaporative water loss. If this relationship holds for *M. lucifugus* in flight,

it is hypothesized that flight activity in this species should be affected by ambient water vapor pressure, with greater activity expected on more humid nights.

METHODS AND MATERIALS

To test this hypothesis I used the mist net captures obtained during a survey of the distribution and abundance of bats in southeast Ohio (Lacki and Bookhout 1983). *Myotis lucifugus* was the most common bat in this region and consequently was captured in sufficient numbers for analysis. Mist nets of 3.2-cm nylon mesh, 2-ply denier, 2.1 m in height, and either 5.4 or 12 m in width were set over streams and monitored from 2100 h until 0030 h. Nets remained up and were examined again at dawn. Duration of the study was from 19 June to 7 September 1979 and from 28 April to 25 August 1980. For additional details consult Lacki and Bookhout (1983).

Humidity was measured with a Model SAC wet bulb-dry bulb sling psychrometer and temperature with a pocket thermometer once each night between 2100 h and 2130 h at net sites. Only locations at which these data were collected are included in the analysis ($n = 112$).

Activity, measured in number of captures, of males ($n = 56$) and females ($n = 22$) was examined separately. Data were arbitrarily grouped into categories of high (>90%) or low (<89%) percent relative humidity and high (>20°C) or low (<19°C) temperature. Contingency tables (2×2) were developed to compare activity over relative humidity and temperature with a Chi-square test of independence. Because of the differential distribution of total netting effort over the 4 test cells, expected capture frequencies for a given cell were calculated by multiplying the percentage of total netting effort, in cross-sectional area, associated with a given cell by the total number of captures (table 1).

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TABLE 1
Distribution of mist netting effort and observed capture frequency among cells of contingency tables.

Cell*	Mist netting effort (%)	Observed frequency (%)	
		Male	Female
LH × LT	33.8	30.4	45.5
LH × HT	17.2	7.1	22.7
HH × LT	13.1	10.7	9.1
HH × HT	35.9	51.8	22.7

*Contingency table groupings: low humidity (LH); high humidity (HH); low temperature (LT); and high temperature (HT)

RESULTS AND DISCUSSION

Activity of male *M. lucifugus* was significantly greater under conditions of both higher temperature and relative humidity, suggesting an interaction effect ($\chi^2 = 7.63$, 1 df, $P < 0.01$). The percentage of male captures present in this cell was much greater than expected based on relative netting effort (table 1). Activity of females showed no significant statistical relationship ($\chi^2 = 2.63$, 1 df, $P > 0.10$). Females were captured less often in the study, probably due to a patchy distribution of maternity colonies along the watersheds. Consequently, the lower number of captures for females resulted in expected frequencies for two cells below five, making interpretations speculative (Cochran 1954).

Anthony and Kunz (1977) have documented associations between changes in insect abundance and variability in foraging success among pregnant *M. lucifugus*. Because fluctuations in ambient temperature were also correlated with insect availability, especially in spring and early summer, they concluded that temperature was an important factor controlling resource availability for *M. lucifugus*. Subsequent analyses revealed strong correlations of long night roosting periods, and thus lowered flight activity, with cool nights and low prey density (Anthony et al. 1981). Energetic advantages of reduced

activity during periods of lowered foraging success and higher thermoregulation costs were postulated. The relationship of ambient temperature to flight activity of male *M. lucifugus* captured in the present study supports these earlier findings.

Higher activity of male *M. lucifugus* was simultaneously associated with increased relative humidity, thus supporting my earlier hypothesis. O'Farrell and Bradley (1970) recorded activity of bats in southern Nevada through the use of mist nets and found that the activity of *Pipistrellus hesperus* and *M. californicus* was associated with higher temperatures but lower relative humidities. Implications for evaporative water loss in these species were not discussed, however. Comparisons of *M. l. lucifugus* with a western subspecies *M. l. occultus* demonstrated the eastern form to be far less efficient at concentrating urine (Bassett and Wiebers 1979). The investigators concluded that *M. l. lucifugus* would not substantially benefit from an ability to concentrate urine for enhanced water conservation because it forages primarily over water and occupies geographic regions with more saturated ambient environments than *M. l. occultus*. The possibility of highly specialized physiological mechanisms for water conservation in *P. hesperus* and *M. californicus* would explain the abilities of these western species to exploit arid environments.

Proctor and Studier (1970) have shown an inverse relationship between ambient water vapor pressure and evaporative water loss in *M. lucifugus* at a temperature below the thermal neutral zone (28°C); thus I believe that the observed association of activity with relative humidity in male *M. lucifugus* indicates that these bats may modify their activity in response to changes in air saturation. With the exception of one night (29°C), air temperatures during this study were consistently below the temperature that Proctor and Studier used in their trials. Thus, although environmental conditions may not have selected for renal adaptations to summer water stress in *M. l. lucifugus*, more subtle

behavioral modifications, such as shifts in the amount of flight activity, may be used by this subspecies to compensate for large vapor pressure deficits encountered during flight.

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