Proceedings of the Indiana Academy of Science
(1994) Volume 103 (1-2) p. 93-98

EFFECTS OF RAINFALL AND TEMPERATURE ON WEIGHT GAIN IN THE BIG BROWN BAT, *EPTESICUS FUSCUS*

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ABSTRACT: Nineteen maternal colonies of the big brown bat, *Eptesicus fuscus,* were located and revisited several times in Delaware and Grant Counties from 21 May to 22 September 1992. Bats were captured, sexed, aged, weighed, and banded at each site. Rainfall in the summer of 1992 was below normal in May and above normal in June and July. Temperatures were below normal throughout the study period. The weights of the bats captured in 1992 were compared to the weights of the bats captured in the same area during the same time period in 1988 (a dry, warm year) and 1989 (a medium, wet year). Both 1988 and 1989 had near normal temperatures. Weights of juvenile bats trapped in the summer of 1988 were lower and showed a wider range in variation than those caught in 1989 and 1992. Lower weight gain for juveniles and adult females in the late spring and early summer of 1988 was associated with lower than average rainfall and higher than average temperatures during that period.

KEYWORDS: Big brown bat, *Eptesicus fuscus,* effect of rainfall on weight gain in bats, effect of temperature on weight gain in bats, weight gain in bats.

INTRODUCTION

This study is a continuation of one begun in 1988 by Howell (1990) on the effects of rainfall on weight gain in the big brown bat *(Eptesicus fuscus).* Howell's study included bats from Delaware, Grant, Blackford, Henry, Jay, Madison, and Randolph Counties in east-central Indiana and indicated a correlation between the amount of rainfall and the weight gain pattern of the bats. Weight gain in the dry year (1988) was lower than in the wet year (1989).

In 1992, only bats from Delaware and Grant Counties were studied. Most of Howell's data were from Delaware and Grant Counties, and these colonies could be relocated. The current study tested the hypothesis that a change in the temperature/rainfall pattern during the spring and summer would influence the weight gain pattern of the big brown bat.

MATERIALS AND METHODS

Nineteen maternal colonies in Delaware and Grant Counties, Indiana, were studied. Not all colonies were visited in each of the three years. Maternal colonies of the big brown bat are normally found in buildings. In some cases, the structure in which the bats were roosting was no longer present, or when visited in 1992, the bats were absent. Colonies that were located by Howell (1990) were revisited on or as close to the original date as possible. The authors assumed that bats

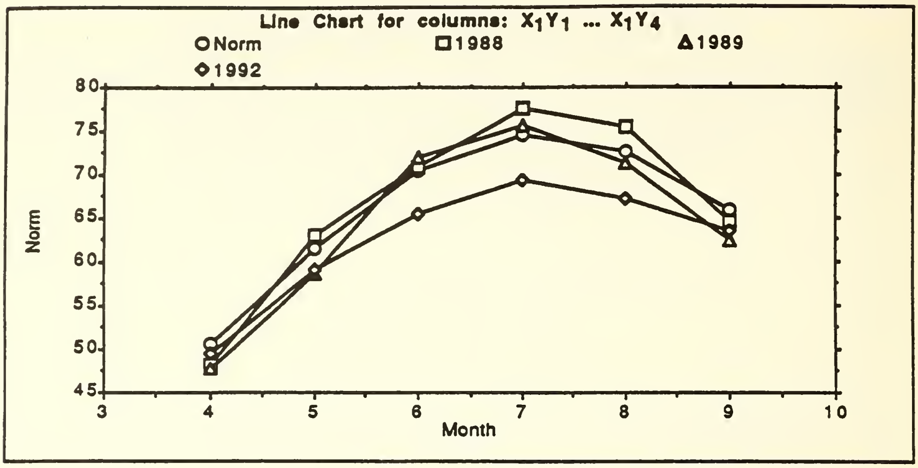

Figure 1. Mean monthly temperatures during the study period (May to September) during 1988, 1989, and 1992.

located in a similar geographic location would show the same pattern of weight gain.

To locate bat colonies, fliers that read "Bats Wanted" were posted in areas frequented by large numbers of people. In addition, public service radio interviews and announcements were used to let the public know bat colonies were being sought.

Suspected colonies were visited to verify identification. Bats were then captured with mist nets, butterfly nets, mechanic's bolt grabbers, or by hand. Observations began on 21 May 1992 and lasted until 22 September 1992. Captured bats were placed in a holding cage until release. Bats were weighed to the nearest 0.1 gram using an American Scientific Products digital scale and banded with a #2 flanged, individually numbered band (Gey Band and Tag Company).

All captured bats were examined for sex, reproductive condition (nursing or post lactating), tooth wear, and age. Tooth wear was recorded as sharp, slightly worn, worn, and very worn. While tooth wear is not useful for indicating the specific age of individual bats due to wide individual variation (Mills, *et al.*, 1975), tooth wear was used to assign each bat to a broad age category. Age was recorded as either juvenile or adult. Bats were identified as juveniles (born that summer), if the epiphyseal cartilage had not been replaced by bone (Kunz and Anthony, 1982).

Table 1. Number and average weight of bats caught by year.

Year	Number Caught	Average Weight (g)	Standard Deviation
Juvenile (total = 1069)			
1988	209	12.50	2.08
1989	219	13.68	2.55
1992	641	13.24	2.99
Adult Female (total = 1147)			
1988	311	18.21	2.20
1989	160	19.64	1.99
1992	676	19.07	1.86

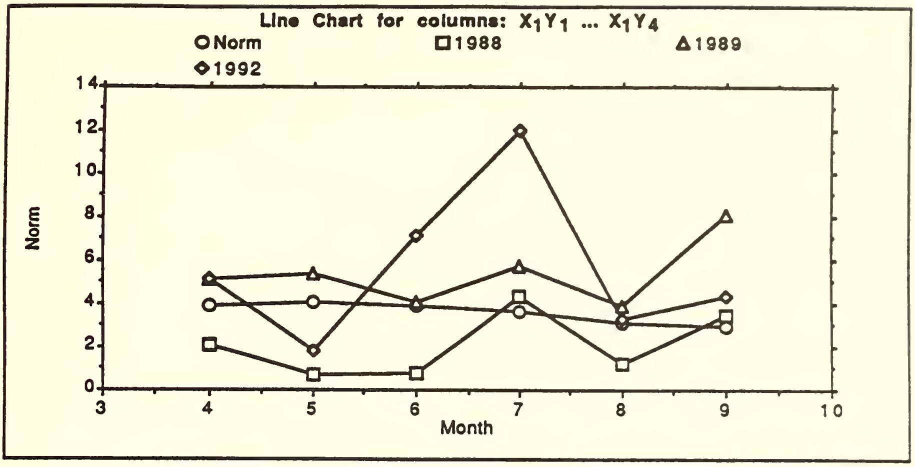

Figure 2. Monthly rainfall during the study period (May to September) during 1988, 1989, and 1992.

Weather information was obtained from the Ball State University Weather Station, Muncie, Indiana. The data were analyzed by multiple linear regression analysis using SPSS with the following variables: the dependent variable was weight on the day of capture; the independent variables were year (temperature/ rainfall pattern), age, and day. Year and age were dummy coded. Day one was equal to 21 May.

RESULTS AND DISCUSSION

Mean monthly temperatures during the study period are shown in Figure 1. The mean monthly temperature is the sum of the daily average temperatures divided by the number of days in the month. The "Norm" is the average mean monthly temperature recorded over the 59 years for which records are available. In 1988, the warmest year during the study, temperatures averaged 1.8° F above normal. In 1989, the temperatures averaged 1.2° F below normal. In 1992, much of the summer had below normal temperatures. The average temperature for the season was 3.6° F below normal.

Figure 2 shows the total monthly rainfall for the same time period as temperature (Figure 1). The "Norm" is the average total monthly rainfall for the 59 years for which records are available. As indicated, 1988 received

Table 2. Weather conditions and weight gain during each year of the study.

Year	Temperature	Rainfall	Juvenile Weight Gain	Adult Weight Gain
1988	Warm	Dry	Lowest	Lowest
1989	Middle	Wet	Highest	Highest
1992	Low	Very Wet	Middle	Middle

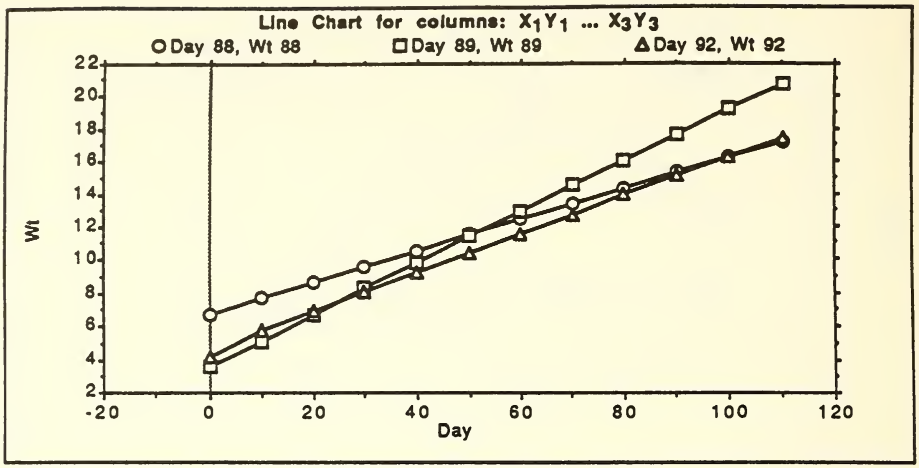

Figure 3. Weight gain pattern in juvenile males and females during 1988, 1989, and 1992.

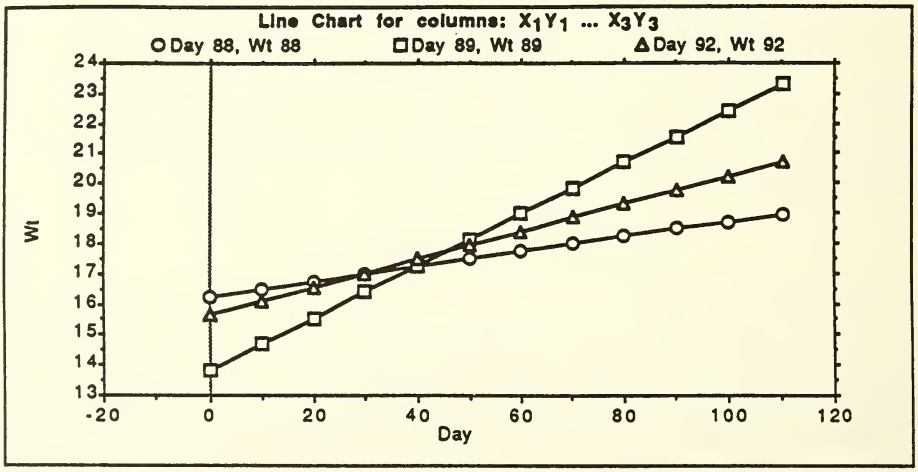

Figure 4. Weight gain pattern in adult females during 1988, 1989, and 1992.

below normal rainfall (8.9 inches below normal). Rainfall in 1989 was 10.6 inches above normal for the season and was evenly distributed throughout the summer. The summer of 1992 was the wettest of the three years, receiving 12.1 inches of rainfall more than normal. June and July had excessively heavy rains. June had 3.14 and July 8.32 inches of rain above normal.

Over the three years of study, a total of 2216 bats was captured (Table 1). Juveniles made up 48% of the total; 209 were caught in 1988, 219 in 1989, and 641 in 1992. The number of adult females captured was 311 in 1988, 160 in 1989, and 676 in 1992. Only adult females were recorded in this study due to the low number of adult males captured in maternal colonies (299 in three years). A small percentage of the bats (16%) were recaptured during the study. These bats were included in the regression analysis after tests for normality found their effect to be insignificant.

To analyze the difference in the weight gain pattern between seasons, multiple linear regression analysis was used. Only data collected after day 40 (29 June) were used to compensate for the weight gain experienced by adult females prior to giving birth. The overall regression was significant ($F = 25.2$, $P < 0.00005$) and had an R^2 of 0.75. The R^2s increase for year ($F = 64.6$, $P < 0.00005$), age ($F = 3582.3$, $P < 0.0005$), and their interactions with day (year, $F = 36.9$, $P < 0.00005$; age, $F = 25.2$, $P < 0.00005$) were significant. Therefore, individual equations for each age class by year were developed. Then, these six equations were used to calculate the difference in the weight gain pattern over time for juveniles and adult females in all three years (Figures 3 and 4).

In 1988, the year with dry weather and the warmest temperatures, juvenile bats had the slowest weight gain over time (Figure 3). During 1989, with wet conditions but normal temperature, juvenile bats had the fastest weight gain. In 1992, weight gain was slightly greater than in 1988. Rainfall was above normal in 1992, but temperatures were lower than normal (Figures 1 and 2).

Adult females had the slowest weight gain in 1988 (Figure 4). In 1989, the adult female bats started with the lowest weights but showed the fastest weight gain over the season. Their low starting weight was probably due to the low weight of the bats entering hibernation in 1988. In 1992, weight gain was just slightly faster than in 1988.

CONCLUSIONS

Rainfall and temperature both appear to be important factors affecting weight gain in the big brown bat (Table 2). The lowest rate of weight gain in both adult females and juveniles was associated with a year (1988) of very low rainfall and near normal temperatures. Above normal rainfall coupled with temperatures slightly below normal seemed to have a positive effect on weight gain in 1989 (Howell, 1990). The climate may have favored larger insect populations (Lack and Lack, 1951). However, rainfall that is far above normal, or excessively heavy at night (the time when foraging occurs), appears to have a slight negative effect, as seen in 1992. If a slower weight gain is related to excessive rainfall at night, the slowdown in weight gain could result from decreased insect activity, decreased foraging proficiency, or both (Church, 1957; Stebbings, 1968).

Below normal temperature, as seen in 1992, also seems to have a negative effect on weight gain. Perhaps bats are inefficient thermoregulators, and if energy is expended to warm themselves in the daytime roosts, growth is slowed. Colder nighttime temperatures during foraging could have a similar effect (Kunz, 1973; Racey, 1969). While weight gain appears to be associated with temperature and rainfall, these factors may not be the direct cause. More research on how weather conditions affect insect populations and bat thermoregulation is needed.

ACKNOWLEDGMENTS

The authors would like to thank the following people for their contributions: Ralph Kirkpatrick, William Rogers, Christi Alexander, Tom Gordy, Darrin

Hoggett, Jeff Laborda, and the Department of Biology, Ball State University. A special thanks to all of the people who allowed us to come into their homes and catch bats.

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