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EFFECT OF CLUSTERING BEHAVIOR ON BODY TEMPERATURE REGULATION IN *Carollia perspicillata* (CHIROPTERA: PHYLLOSTOMIDAE)

EFECTOS DEL COMPORTAMIENTO DE AGRUPAMIENTO SOBRE LA REGULACIÓN DE LA TEMPERATURA CORPORAL EN *Carollia perspicillata* (CHIROPTERA: PHYLLOSTOMIDAE)

HUGO MANTILLA-MELUK[1], ALEX MAURICIO JIMENEZ-ORTEGA[2]

ABSTRACT

The roosting behavior of a colony of the frugivore bat *Carollia perspicillata* was observed for three days inside a cavity of the hollow tree of *Dipteryx panamensis* in a secondary forest located at La Selva Field Station in Costa Rica. Individuals in the colony were classified by sex and age and their clustering pattern was documented through the sampling period. Temperature and humidity were recorded inside the cavity and temperature variation of the roosting site was contrasted against body temperature of individuals in the bat colony. Clustering individuals of *C. perspicillata* maintained their body temperature above the environmental temperature; in the same manner the average temperature of individuals in the cluster was higher than the corporal temperature of peripheral individuals. A tradeoff between physiological and social determinants is suggested as an explanation of the observed pattern.

Keywords: Bats; *Carollia perspicillata*; Clustering; Roosting behavior; Temperature regulation.

RESUMEN

El comportamiento de descanso de una colonia del murciélago frugívoro *Carollia perspicillata* fue observado por tres días al interior de una cavidad de un árbol hueco de *Dipteryx panamensis* en un bosque secundario localizado en la Estación Biológica La Selva en Costa Rica. Los individuos en la colonia fueron clasificados de acuerdo a edad y sexo y su comportamiento de agrupamiento fue documentado a lo largo del período de observación. Al mismo tiempo, la temperatura y humedad relativa fueron registradas en el interior del sitio de descanso. La temperatura dentro del sitio de descanso fue contrastada con la temperatura corporal de los individuos en la colonia de murciélagos. Individuos agrupados mantuvieron su temperatura corporal por encima de la temperatura ambiental y en promedio su temperatura corporal fue superior a la de individuos periféricos al agrupamiento. Una negociación entre determinantes fisiológicos y sociales es sugerida como explicación al comportamiento observado.

Palabras clave: Murciélagos; *Carollia perspicillata*; Agrupamiento; Comportamiento de descanso; Regulación de temperatura.

INTRODUCTION

Due to their activity mainly nocturnal and their high metabolic rate, bats spend most of their time saving energy while they are resting in their roosts (Kunz 1980). Although the role of roosting may not be directly related to energy conservation, maintaining a normothermic body temperature can be costly for bats because they have a large surface-to-mass ratio that results in high mass-specific thermal conductance and the potential for rapid heat loss (McNab 1982). Consequently, if bats spend prolonged periods roosting at night it is reasonable to assume that they select a roost site or roosting strategies that minimize energetic expenditures while in the night roost. On the other hand, bats are perhaps among the most gregarious of mammals (Stak 1988), and in some species resting activity includes the conformation of groups or clusters (Kunz and Lumsden 2003). The function and potential advantages of the clustering

1. Texas Tech University Lubbcok, TX 79409-1313. e-mail: hugo.mantilla@ttu.edu
2. Grupo de Investigación en Manejo de la Fauna Silvestre Chocoana; Universidad Tecnológica del Chocó, Quibdó, Colombia. e-mail: almajior@hotmail.com
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Table 1
Environmental variables inside the roost and average body temperature of *C. perscipillata*

	Humidity	Environmental temp.	Soil temp.	Average number of bats clustering	Cluster temp.	Solitary bats temp.
Average	97.31	23.82	25.44	9.39	27.87	24.3
Standard deviation	2.64	0.35	1.02	1.95	0.67	1.63

behavior is still a source of debate in the literature. The frugivore bat *Carollia perspicillata* is commonly found in the Neotropics, and its roosting behavior include a wide variety of structures from hollow trees and caves to human constructions such as tunnels and houses. Clustering behavior has been reported in *C. perspicillata* (Fleming 1988). In order to study the role of clustering on colony thermal regulation in the frugivore bat *C. perspicillata*, we studied the roosting behavior of a *C. perspicillata* colony found inside the cavity of a hollow tree of *Dipteryx panamensis* in a secondary forest located at La Selva Field Station in Costa Rica.

MATERIALS AND METHODS

During three days, 9th, 10th, and 11th of July 2001, the clustering behavior of a colony of 23 individuals of *C. perspicillata* resting in a hollow tree of *Dipteryx panamensis* was observed. The relative location, height, and number of individuals in the colony were recorded every 10 minutes from 2:00 pm to 7:30 pm before the bats starting their foraging. The corporal temperature of every individual in the colony was measured with a non contact thermometer (Raynger Resolution $\pm$0.82ºC/100 m). At the same time, data on environmental temperature, soil temperature and humidity inside the cavity of the tree was recorded for every time set of 10 minutes.

RESULTS

Characterization of the roosting site. The roosting site corresponded to a13 m tall *D. panamensis* dead hollow tree. The diameter of the tree at its base was variable due to the presence of tabloid roots which cover a circular area of approximately 9.62 m^2. The cavity was two thirds of the total height of the tree and corresponded to a cylinder of 1.5 m of diameter on average. The appearance of the walls inside the cavity was smooth with many folds created by the natural destruction of the xylem in the lower part of the trunk below four meters. The internal chamber has three entrances located at the base of the trunk and separated by tabloid roots.

Bat colonies. Three species of chiropterans were found roosting inside the *D. panamensis* tree: *Saccopteryx bilineata*, *Desmodus rotundus*, and *C. perspicillata.* A vertical partitioning was observed among the three bat species inside the chamber. *Carollia perspicillata* was located in a lower height range between 2.75 and 3.15 m; *S. bilineata* was located between 4.15 and 6 m; and *D. rotundus* preferred the upper part of the chamber at more than 7 m.

Clustering. The observed group of *C. perspicillata* consisted of 23 individuals. Clusters of *C. perspicillata* varied in size from 4-14 individuals with approximately 9 individuals on average (Table 1). Average body temperature of individuals in the cluster was higher, in comparison with average body temperature of solitary animals (Table 1). Clusters were formed mostly by females and juveniles including lactating individuals. Large size individuals of *C. perspicillata* tended to rest separately from the group. Eight individuals observed resting away from the group were identified as males. Peripheral individuals were also the first in leaving the roost followed by the most external individuals of the cluster.

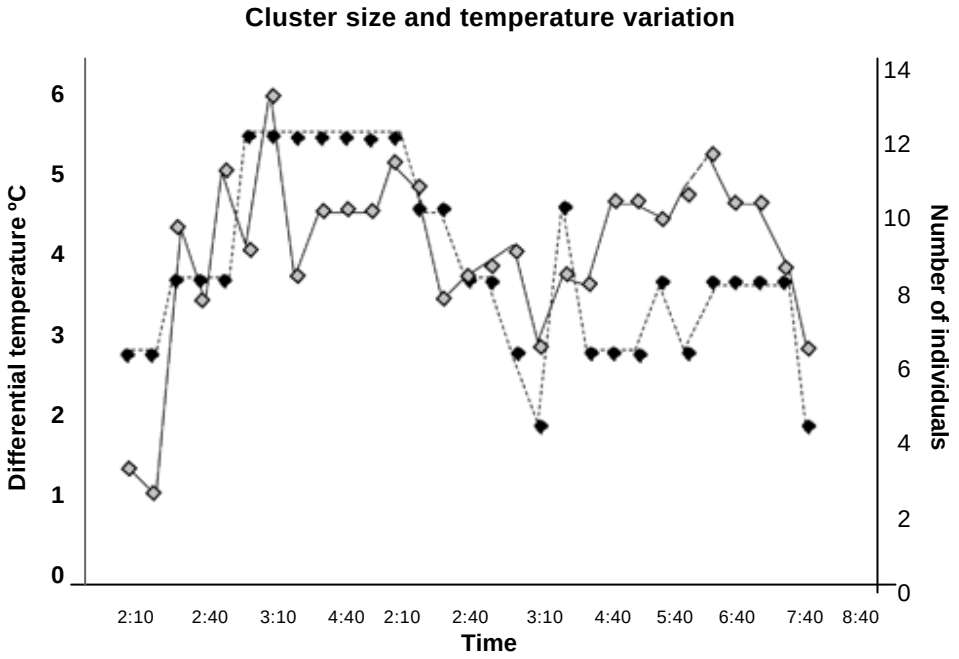

Figure 1. Differential temperature between clustering individuals of *C. perscipillata* and the interior of the roosting site (gray), and number of individuals clustering (black).

Environmental variables. Temperature dropped throughout the night inside the cavity. However, the average temperature of the colony of *C. perspicillata* (27.87ºC) remained above the average temperature of the chamber (23.82ºC). A significant correlation between number of individuals in the cluster and temperature was found by a linear regression analysis ($r^2 = 0.554$) (Figures 1, 2).

DISCUSSION

Energy is the currency of living organisms and an important question in behavioral studies refers to the way free ranging animals find their energetic resources and how the obtained energy is allocated during their resting periods. Among bats, roost selection include aspects such as reduction of predation risk and reduction of commuting costs, but the evidence in the literature suggests that roosts microclimate and its impact on thermoregulation are the primary factors involved in roosts selection by bats (Barclay and Kurta 2007). Although many authors have invoked thermoregulation and its costs as reason for selection of particular roost traits, few provide any data supporting the suggestion and no study in Canada or the Unite States has experimentally tested the hypothesis (Barclay and Kurta 2007). Bats are perhaps one of the most gregarious mammals and clustering during resting has been documented for several species (Kunz and Lumsden 2003). The strong tendency to cluster by many species has often been claimed to have thermoregulatory and/or energetic significance (Davis 1970). However, the effect of roosting in energy allocation among chiropterans is still poorly investigated (Kunz 1980).

Howell (1976) compared the Basal Temperature (Tb) of clustering individuals of the nectarivorous bat *Glossophaga soricina* during their resting time in captivity; groups of *G. soricina* varied in sizes from 1 to 8 individuals. In spite of the small size of the groups, Howell (1976) demonstrated that clustering behavior resulted in higher Tb's for individuals in the cluster. Same results were obtained for other bat species such as *Tadarida brasiliensis*, clustering in groups of various sizes (1 to dozens) (Herreid 1967), and *Phyllostomus discolor*, clustering in groups of 1 to 4 (Mc Nab 1969). Our results are congruent

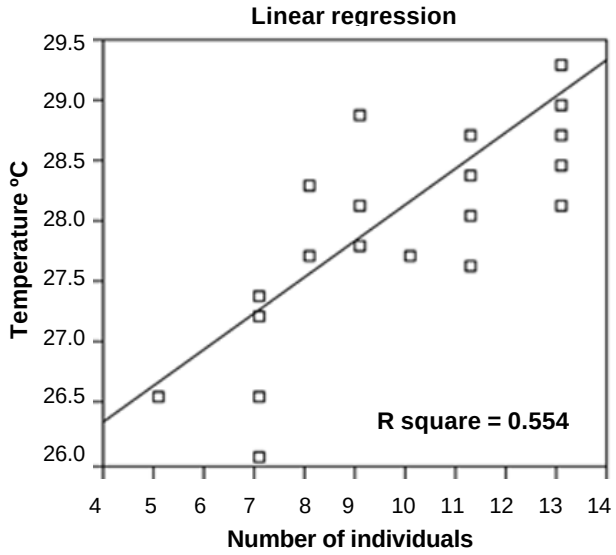

Figure 2. Linear regression between number of *C. perspicillata* in the cluster and temperature of the cluster.

with the above mentioned observations. Body temperature of individuals in the cluster was higher than peripheral individuals.

If cluster explanation relies on benefits in individual thermoregulation is something that is not completely known (Lyman 1970), but the evidence point on the clear social benefit for plausible option. The commonness of clustering in gregarious animals like bats raises the possibility of social facilitation probably based on Kin selection (inclusive fitness). Inclusive fitness in *C. perspicillata* was supported in the present study by the presence of lactating individuals and juveniles always clustering beside adult females. In addition, it has been observed that many bats, especially reproductive females and young, favor minimizing the energetic expense of the thermoregulation by behavioral rather than physiological means (Herreid 1967).

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