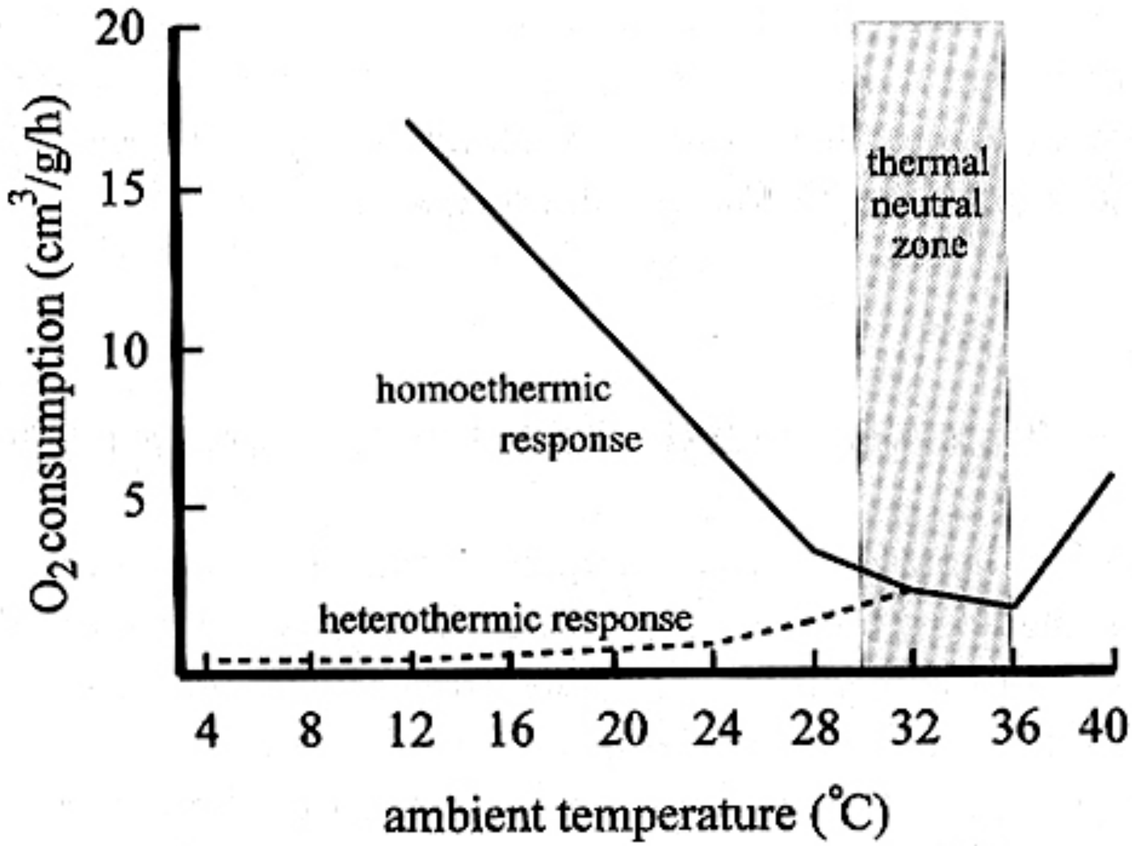
Energetics

- Metabolic scaling relationships
- Behavioral thermoregulation
- Torpor and hibernation
- White-nose syndrome
- Migration
- Bats and wind turbines

Aerobic respiration

- Occurs in mitochondria of all aerobic organisms
- Glucose + oxygen + water =>
  carbon dioxide + water + energy
- $C_6H_{12}O_6 + 6O_2 + 6H_2O \Rightarrow 6CO_2 + 12H_2O$ + energy
- Energy is stored by converting ADP -> ATP
- 1 mole of glucose contains 670 kcal
- Consequently, oxygen consumption can be used to measure energy production

Energetics of homeothermy



Energy expenditure in the western pipistrelle (*Pipistrellus hesperus*)

Homeothermy: maintain constant warm body temperature. Most mammals are at 35-39°C

Heterothermic: allow body temp to fall with ambient temperature

Animals must spend energy to keep warm or cool off when the ambient temperature is out of their thermal neutral zone

Thermal conductance

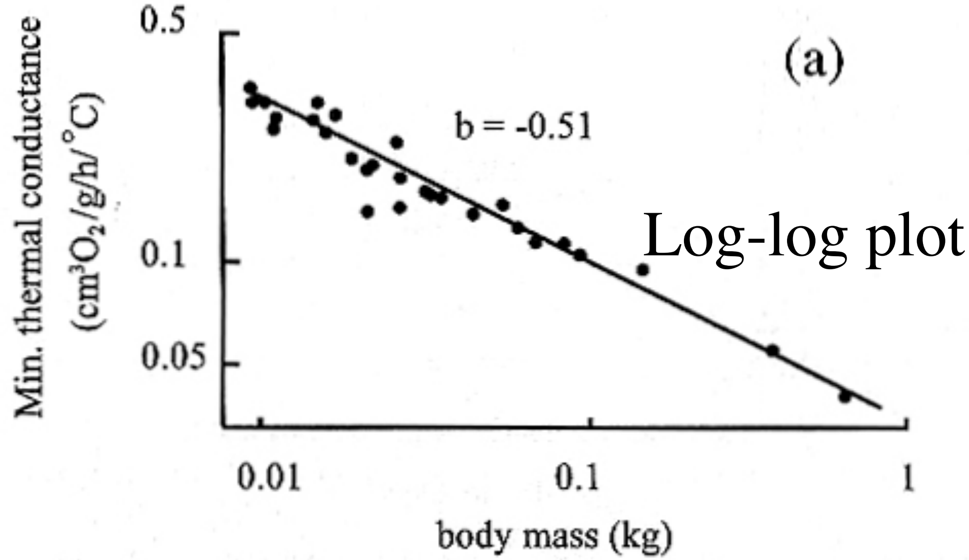
Heat conduction occurs when there is a temperature difference between body and air.

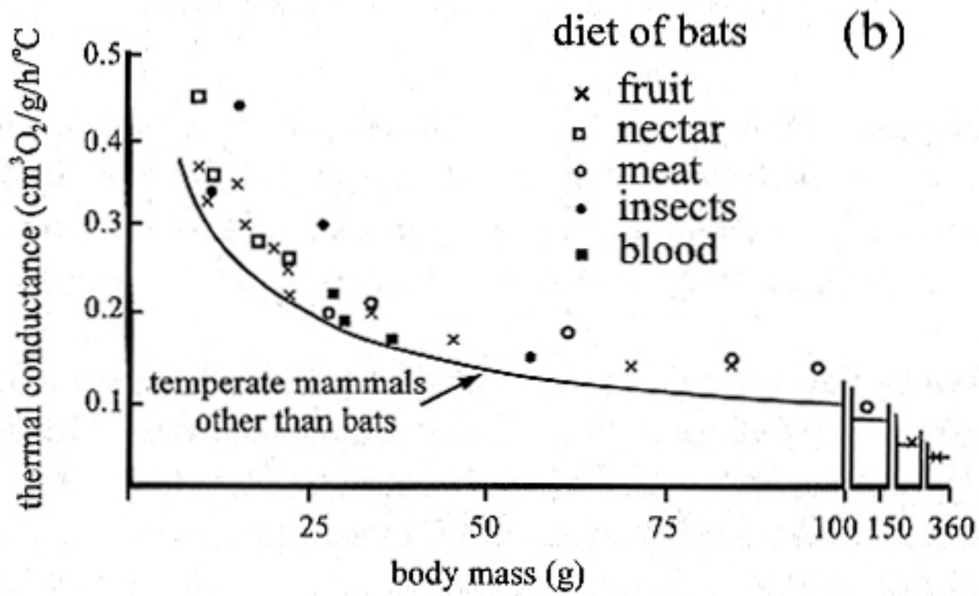
Depends on surface area of animal.

Measured as the amount of energy needed to maintain that difference.

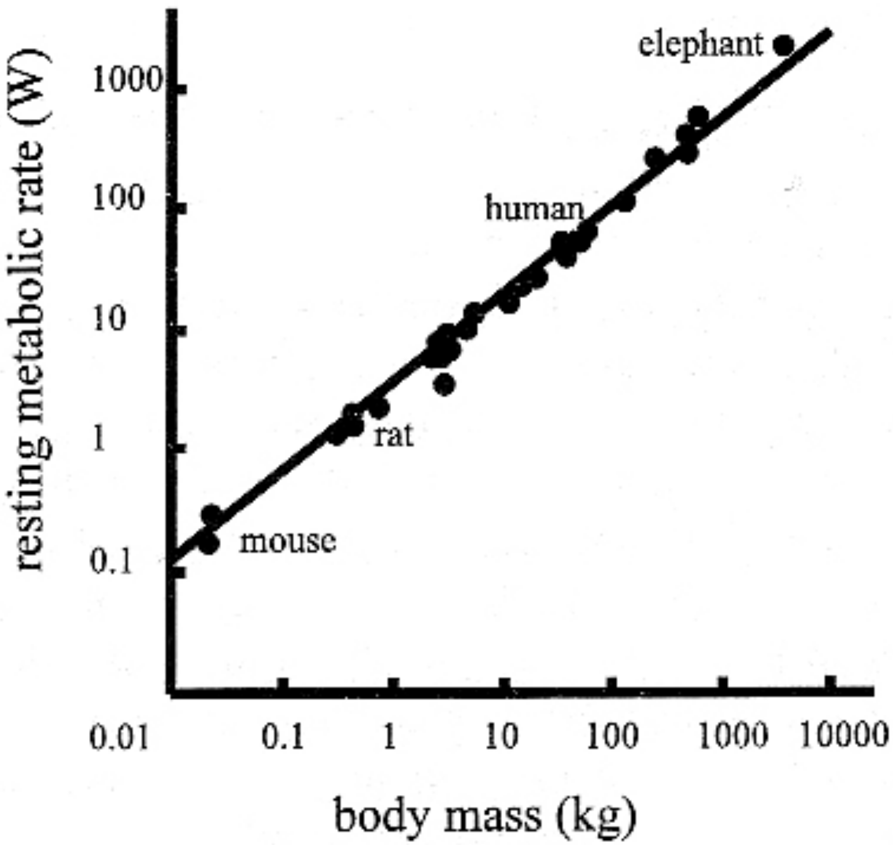
Note that small mammals have high conductance due to high surface area to volume ratios.

Bats have higher conductance than other mammals due to large lungs and large wing membranes





Metabolic rate scales with body mass$^{.75}$

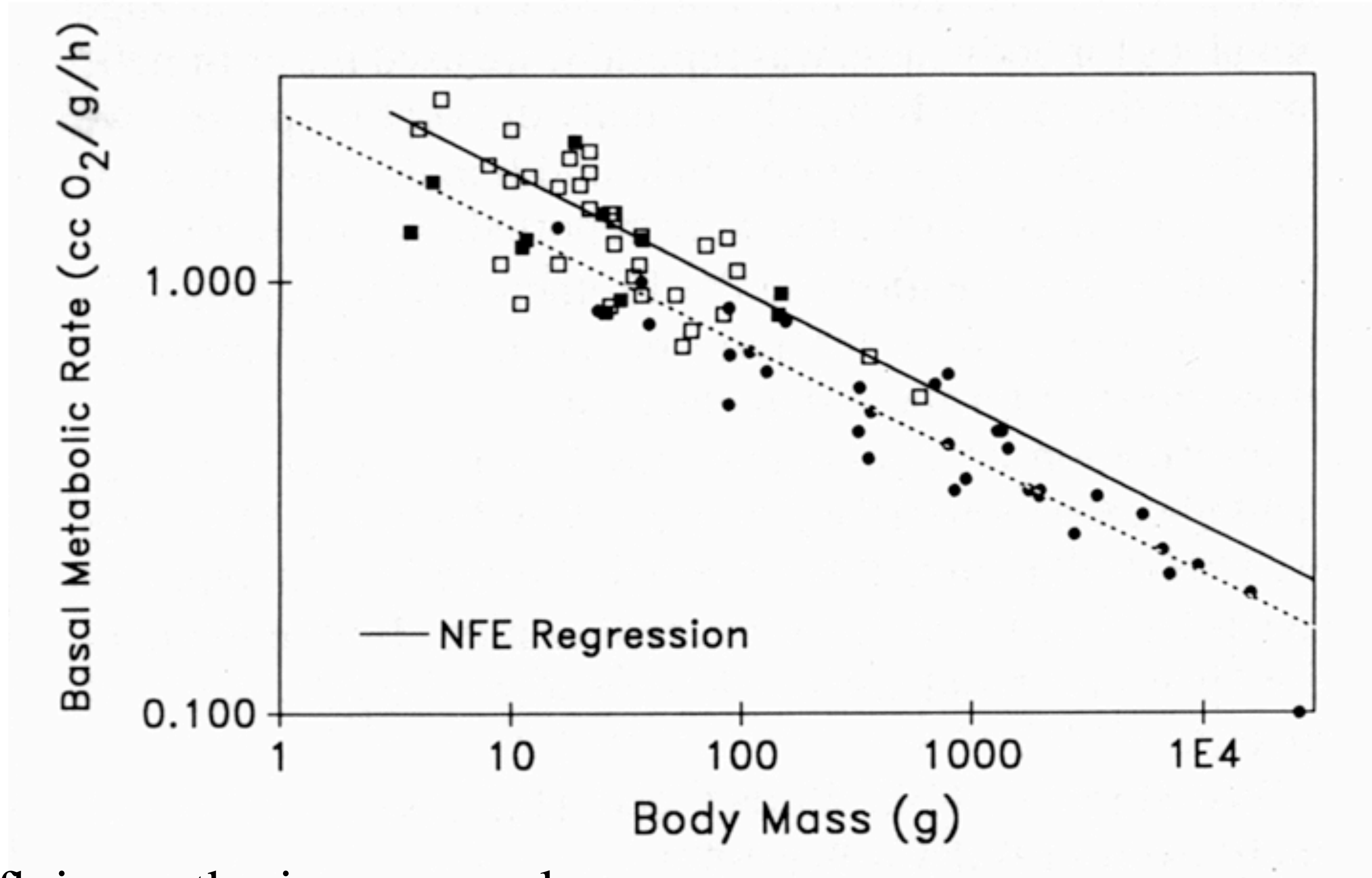


Note: if $y = aM^b$ then
$\log y = \log a + b*\log M$

If $b < 1$, then y increases slower than M

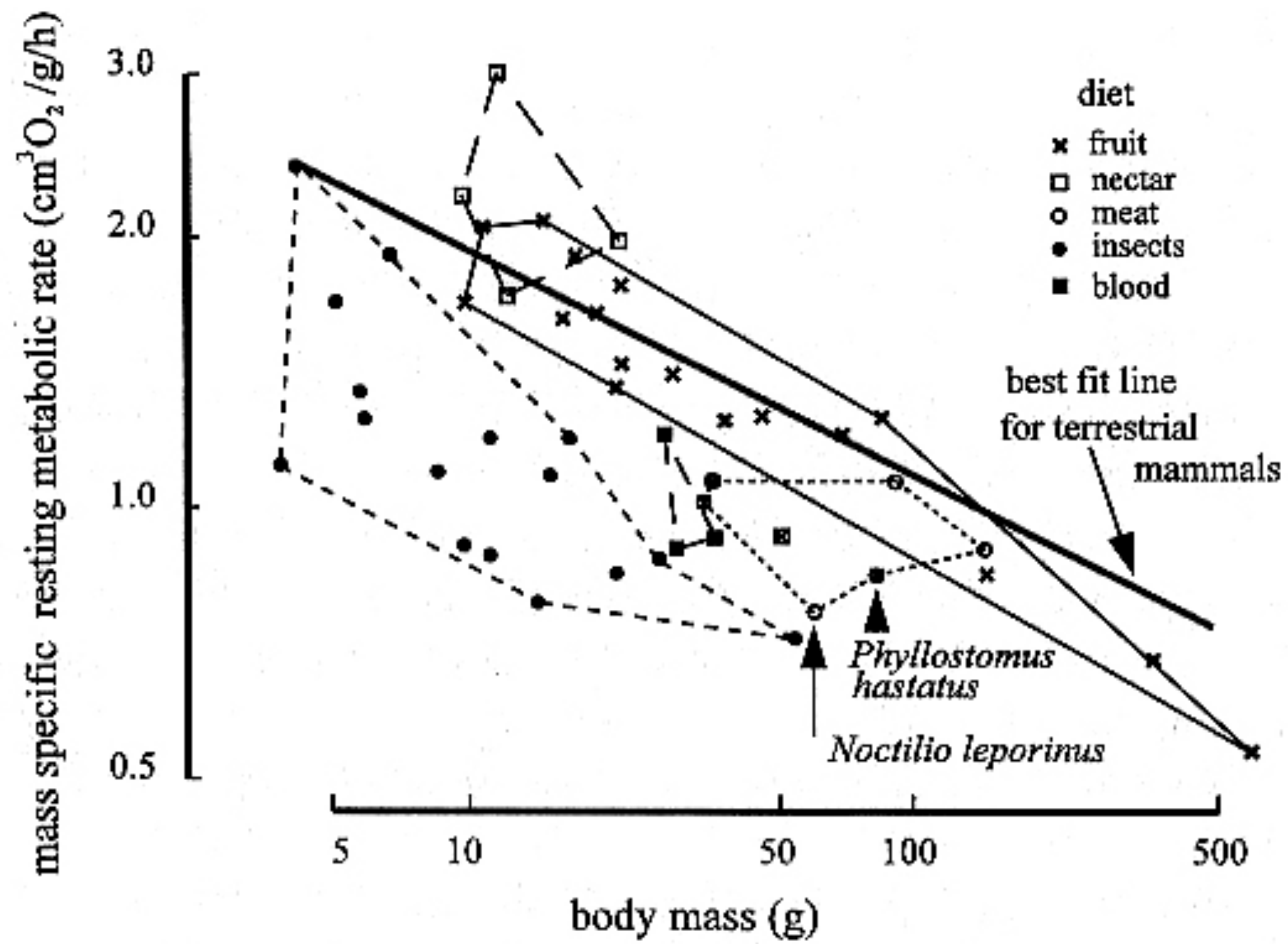
If $b > 1$, then y increases faster than M

Therefore, mass specific metabolic rate declines with body size in birds and mammals

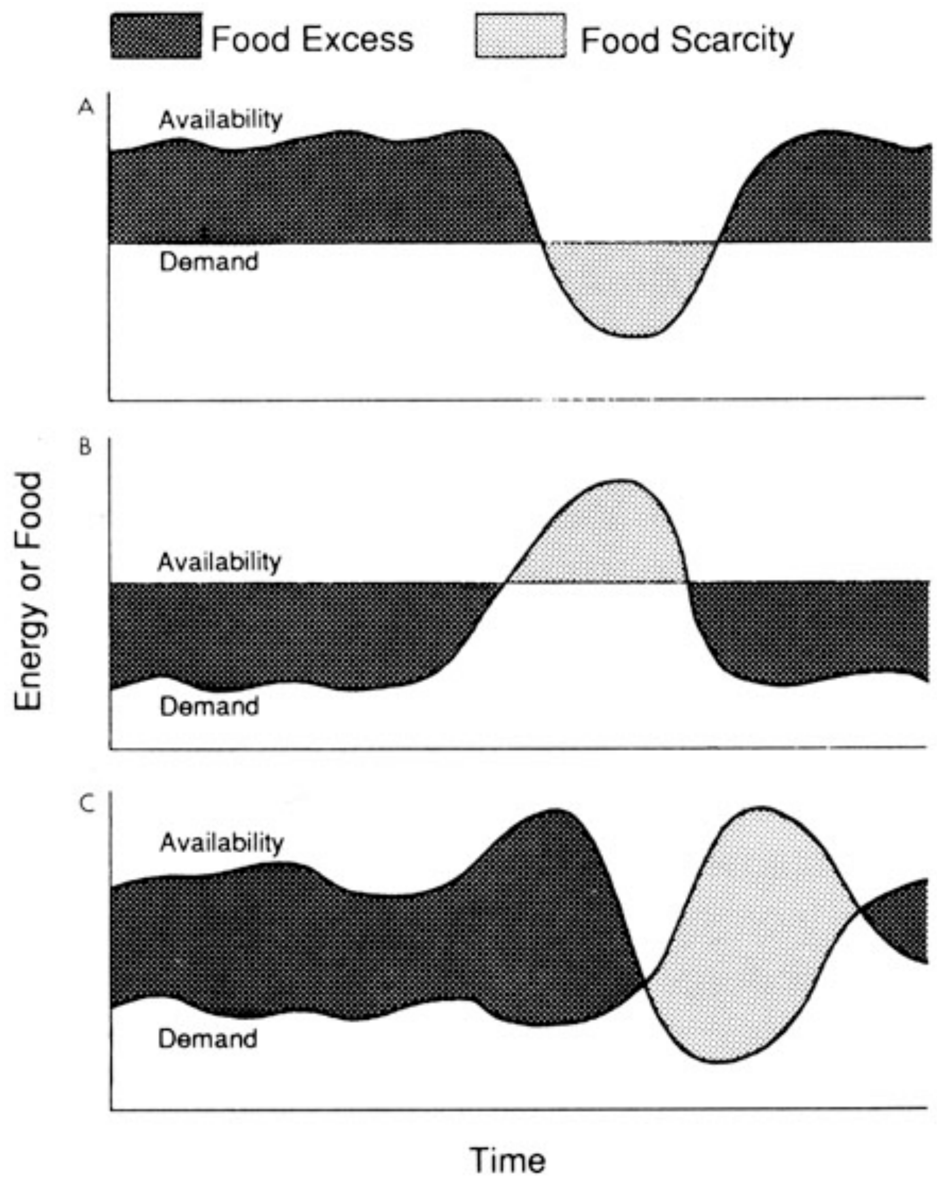


Nonflying eutherian mammals

Diet influences metabolic rate



Reasons for energy budget fluctuations

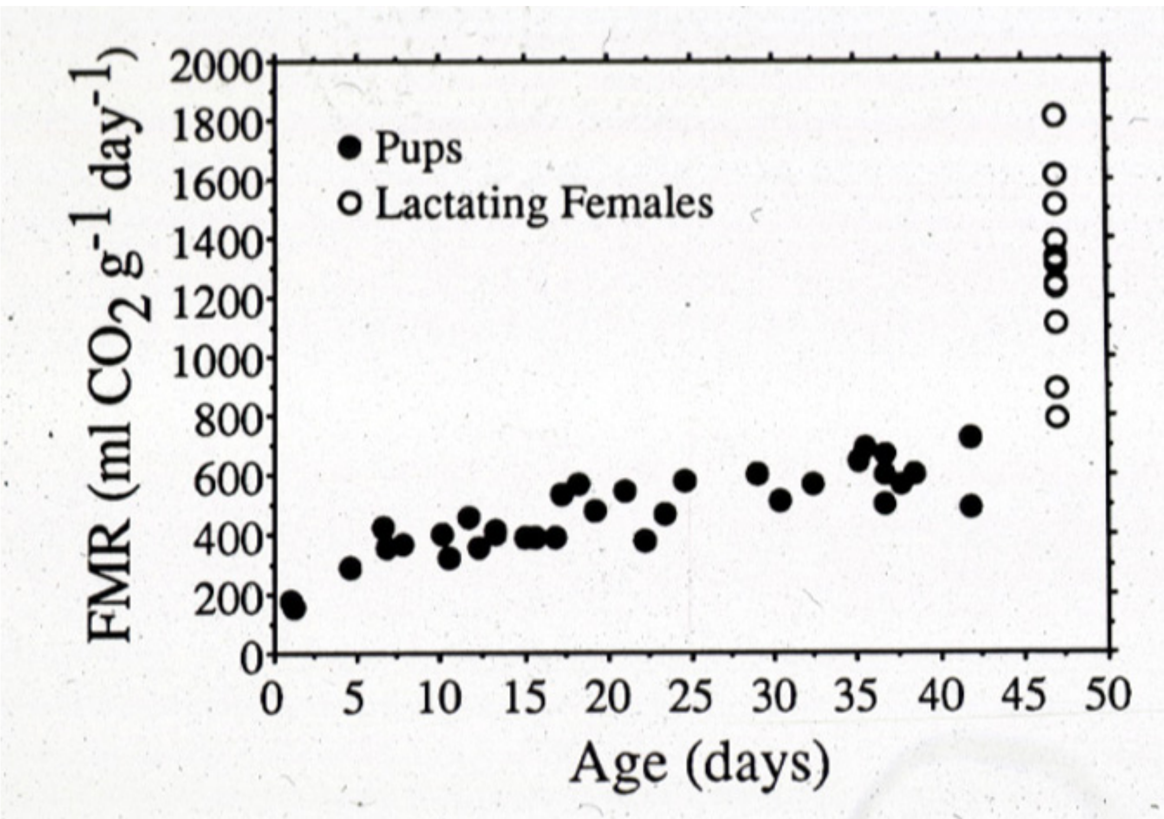


Availability - e.g. seasonality

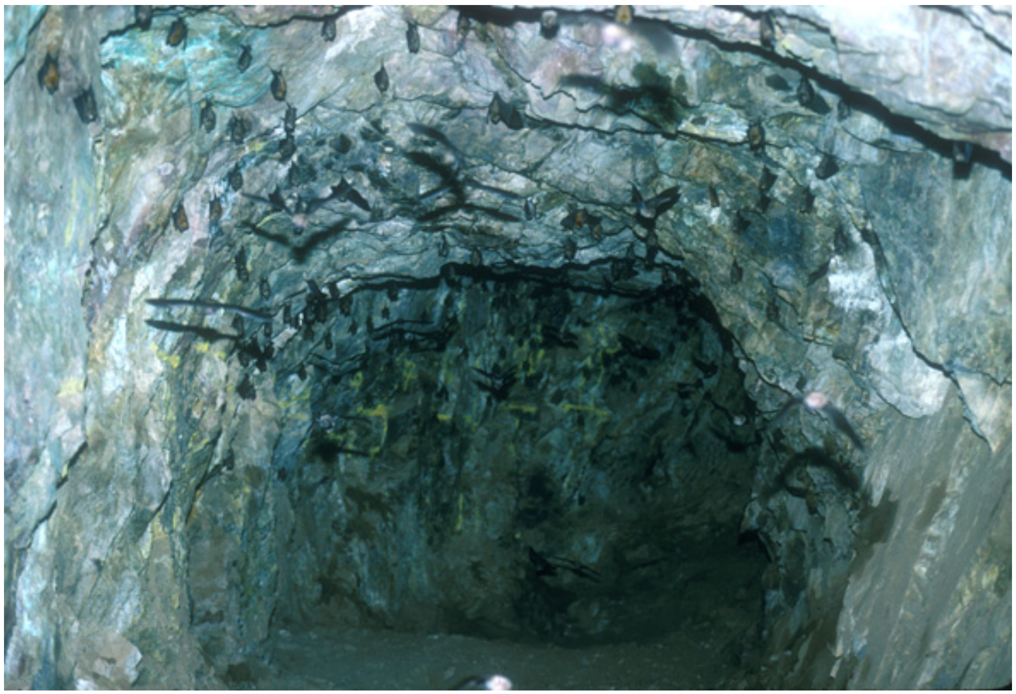
Demand - e.g. pregnancy

Both - e.g. winter, night

Lactation is costly

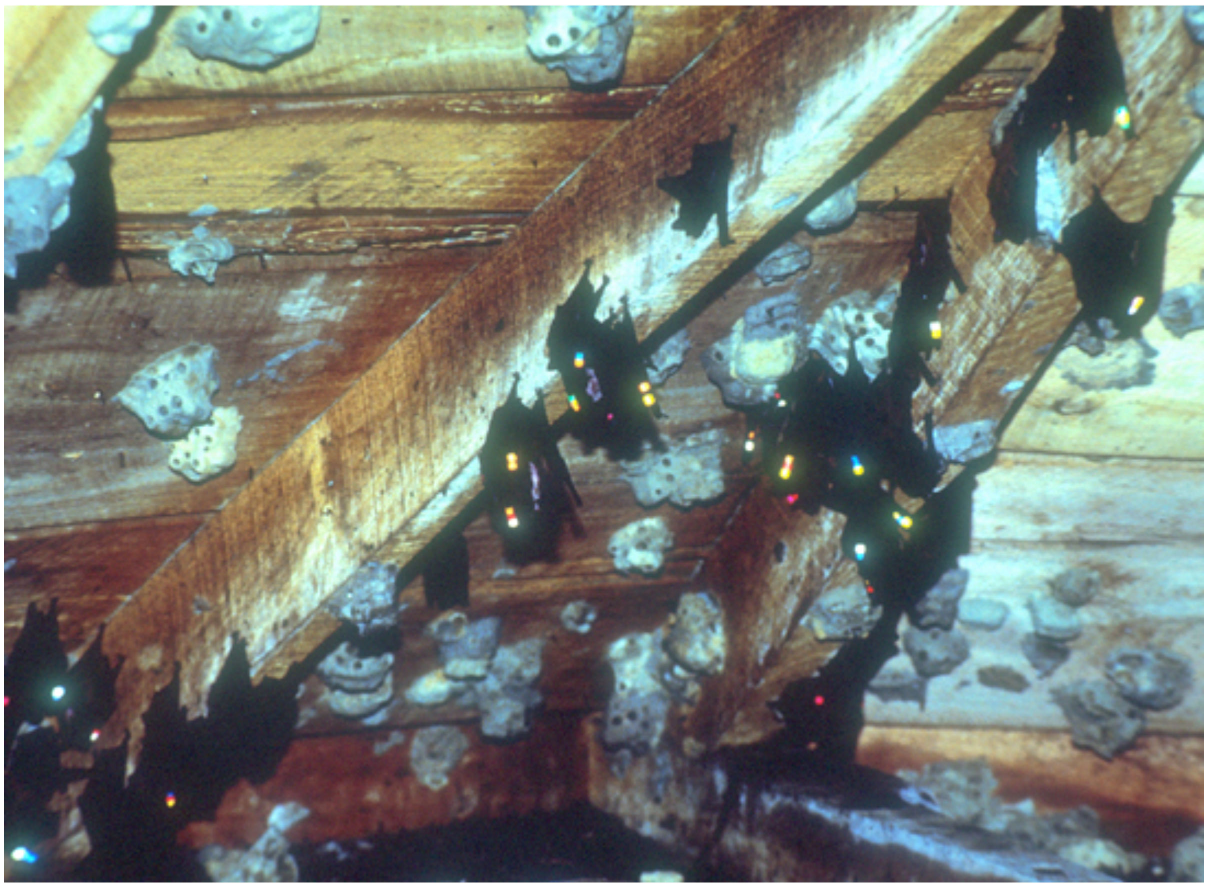


Roost selection

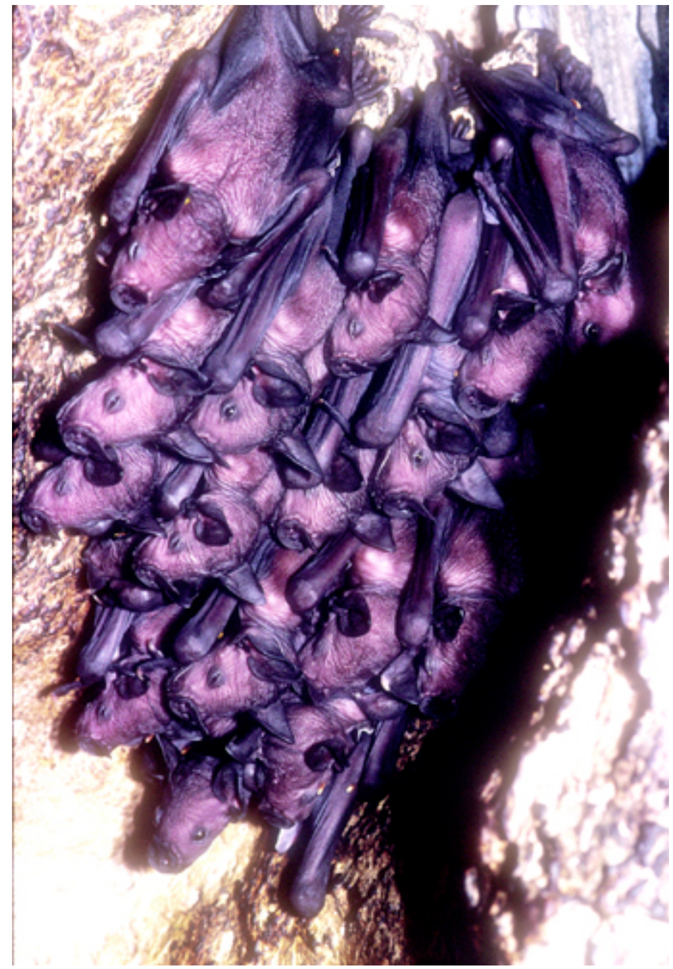


Behavioral thermoregulation

Nycticeius humeralis
Evening bats

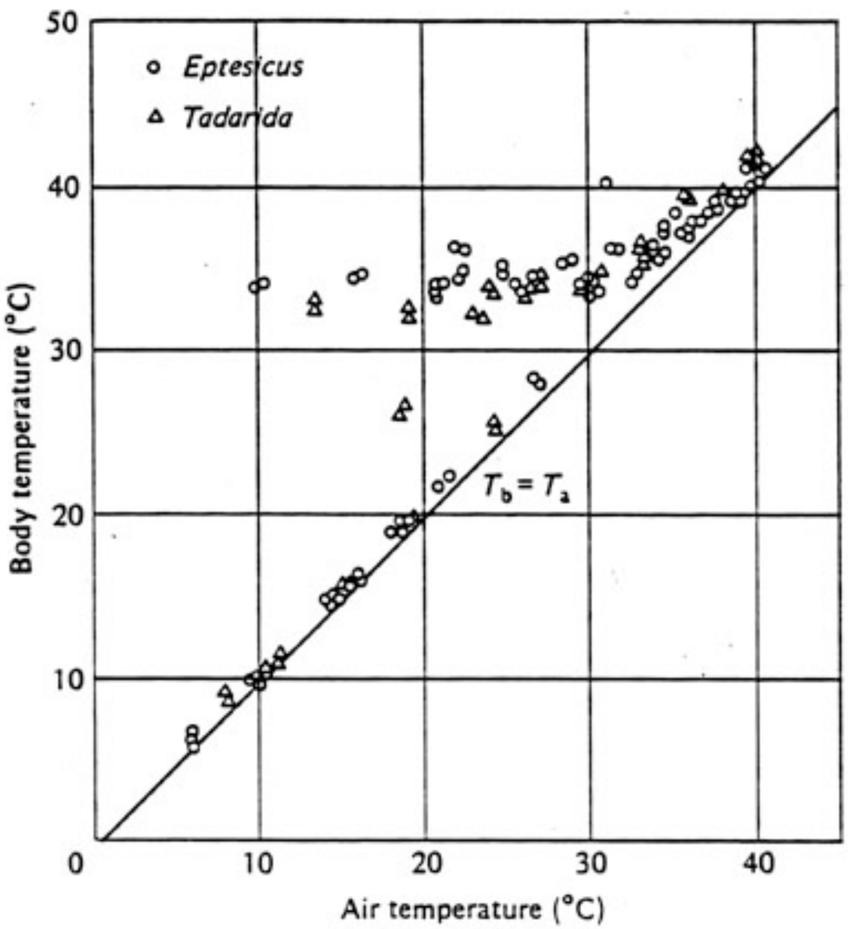


Phyllostomus hastatus
Greater spear-nosed bats



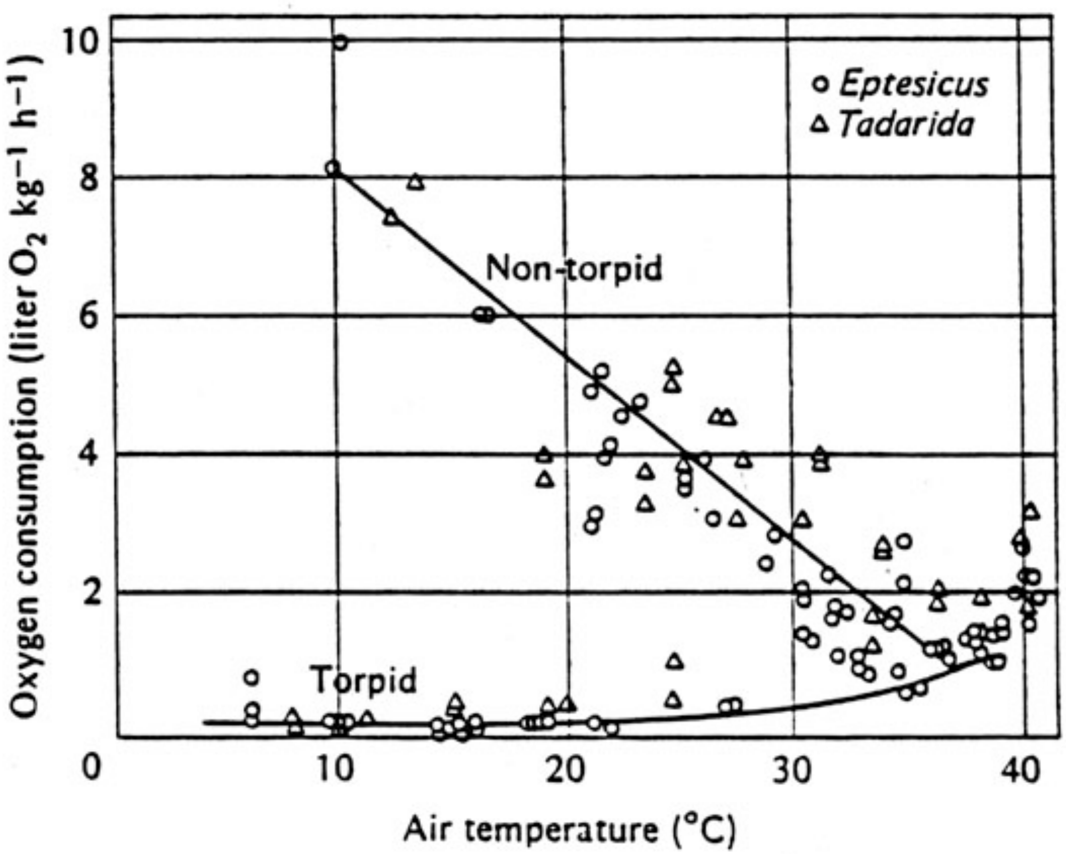
Torpor is a reduction in body temperature

FIGURE 8.24 The body temperatures of two species of North American bats. At low air temperature these bats may be either active with normal body temperatures about 34 °C or torpid with body temperatures near the air temperature. [Herreid and Schmidt-Nielsen 1966]



Torpor saves energy

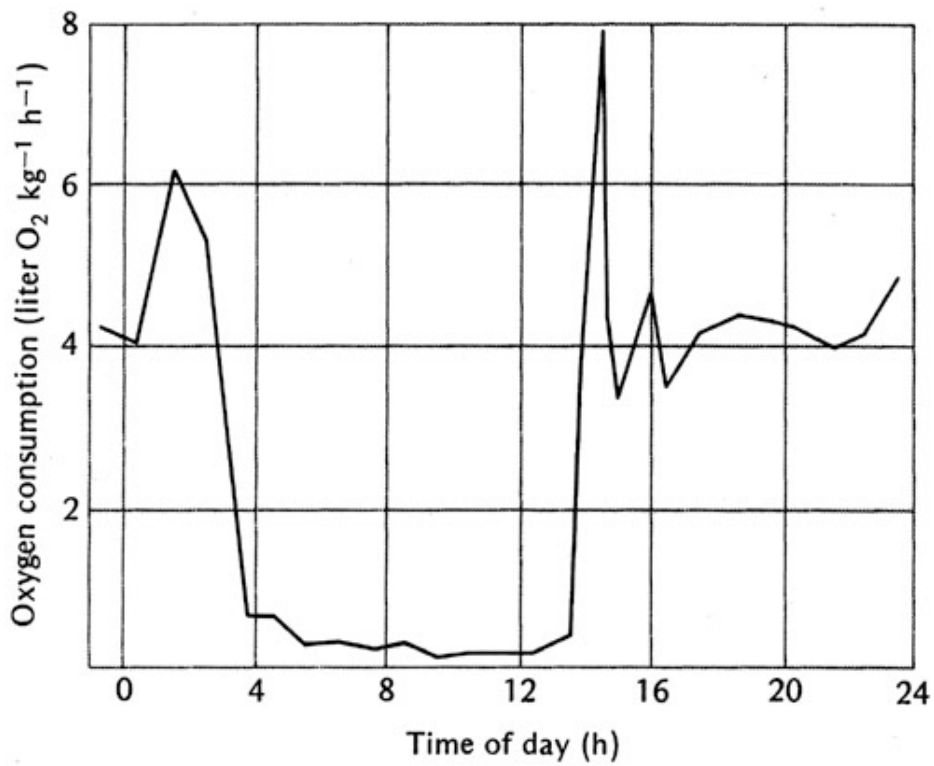
FIGURE 8.25 The oxygen consumption of active bats increases with decreasing air temperature; the oxygen consumption of torpid bats drops to a small fraction of the active rate (same bat species as in Figure 8.24). [Herreid and Schmidt-Nielsen 1966]



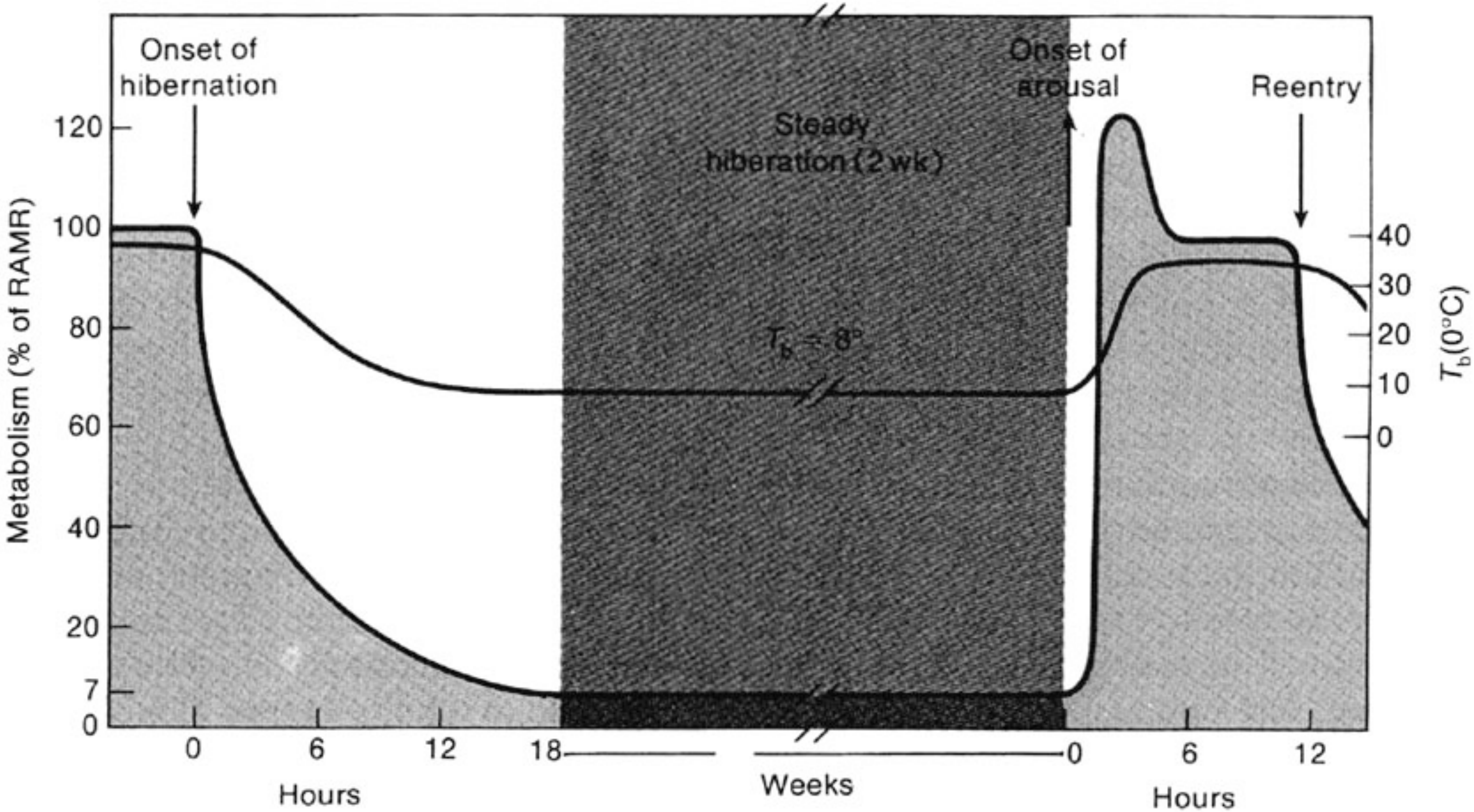
Energy use increases linearly as ambient temperature decreases for an active animal that maintains a constant body temperature

Arousal from torpor can be expensive

FIGURE 8.26 Oxygen consumption over a 24-hour period of a pocket mouse kept on a restricted food ration of 1.5 g seeds per day. During 9 hours the animal was torpid and had a very low rate of oxygen consumption followed by a peak as it returned to the active state. Air temperature was 15 °C. [Tucker 1965a]

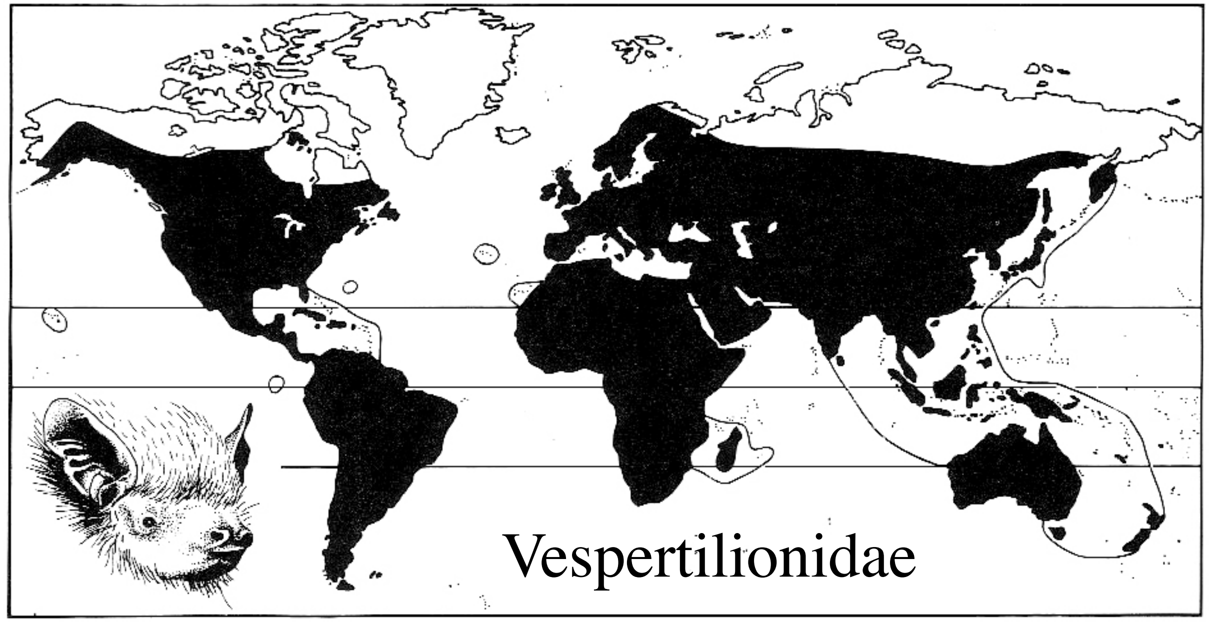


Hibernation = long torpor



Ground squirrel maintained at 4°C

Hibernation has evolved twice in bats and has allowed some species to occupy cold climates



Hibernacula temperature preferences

During hibernation bats maintain body temperature about 1^{o}C above ambient, but rarely below 6^{o}C

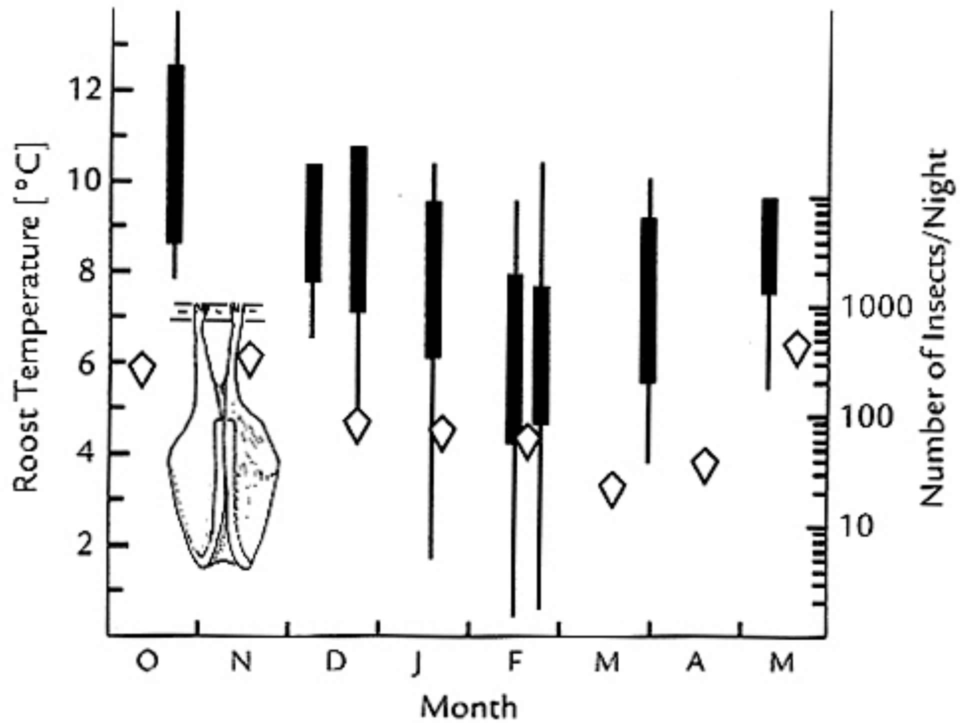
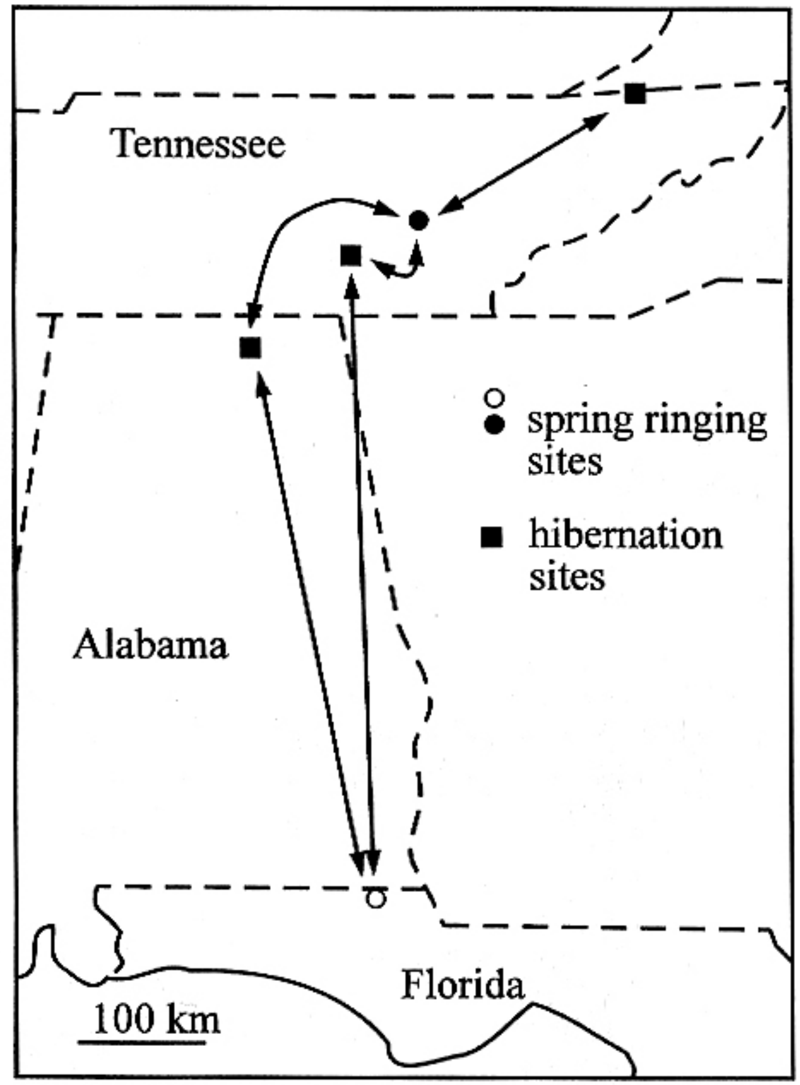


Figure 3.6 Choice of roosting place during the hibernation period depends on the outside temperature and availability of insects. This figure illustrates temperatures in the winter quarters of the horseshoe bat, *Rhinolophus ferrumequinum*, in England. Thin vertical lines = temperature range within the winter quarters; thick bars = temperature range preferred by the bats. In autumn and spring, the bats move to warmer roosting places. Open diamonds = number of insects caught in light traps per night. From Yalden and Morris (1975).

Some bats move north to hibernate

Gray bat (*Myotis sodalis*)

Bats rarely roost deep in caves because the temperature is too warm. Consequently, they have to move when it gets cold or warm outside. This makes them vulnerable to disturbance during hibernation.



Body weight during hibernation

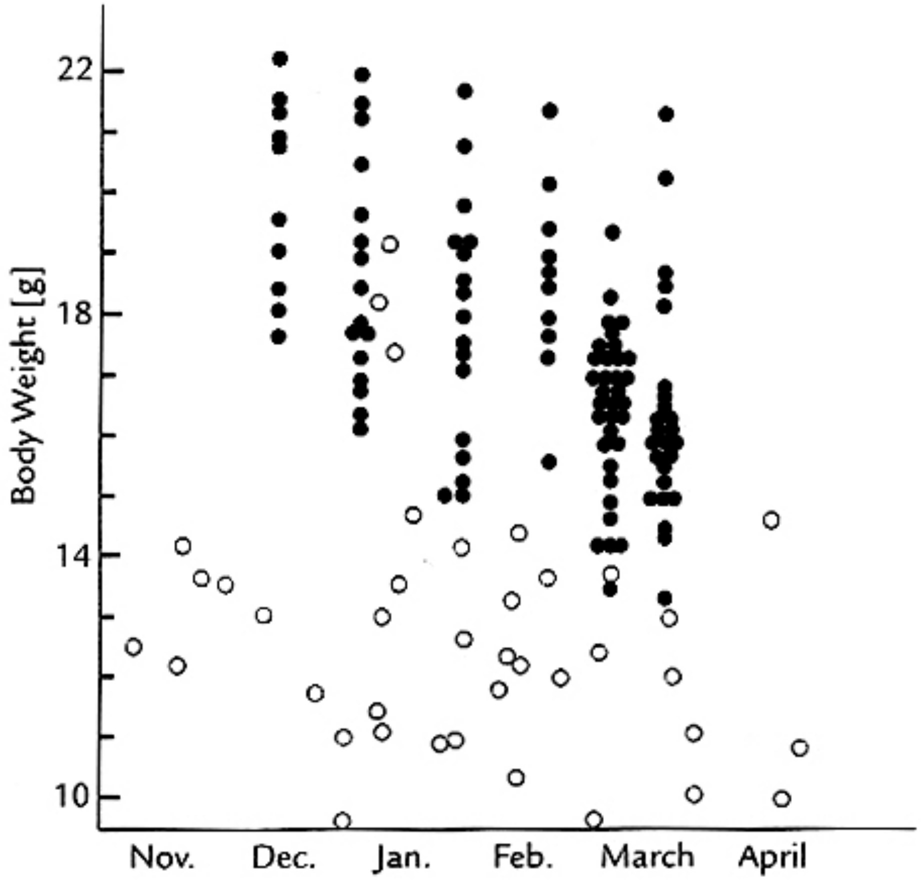
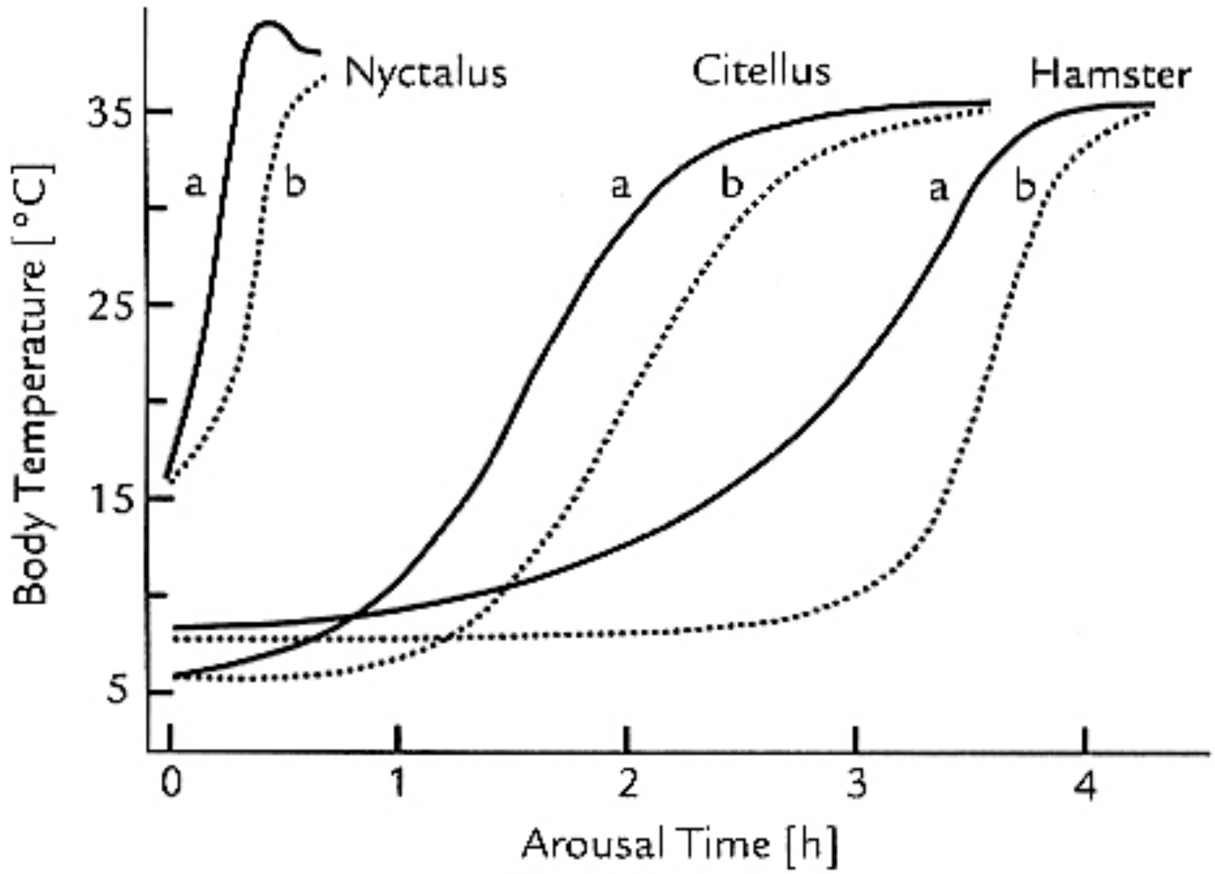


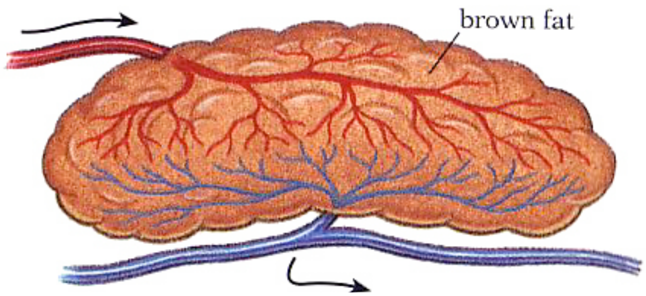
Figure 3.7 Difference between the body weight of hibernating *Eptesicus fuscus* (filled circles) and that of animals found actively moving about in the winter quarters (open circles). The clear boundary between active and hibernating bats at 14 g suggests that exhaustion of fat reserves acts as a stimulus for arousal. From Brigham (1987).

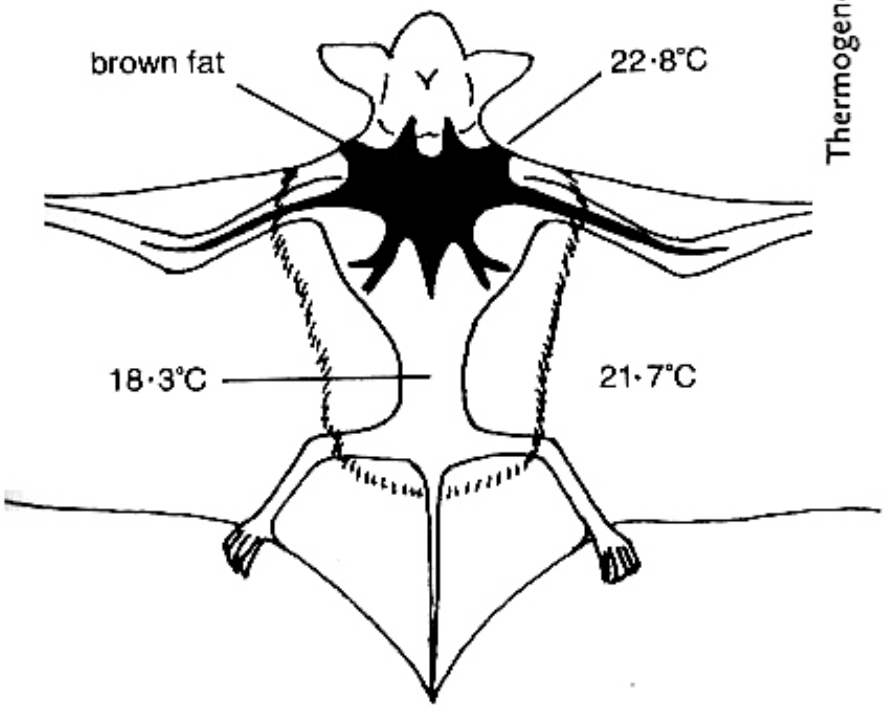
Bats can arouse faster than other hibernators



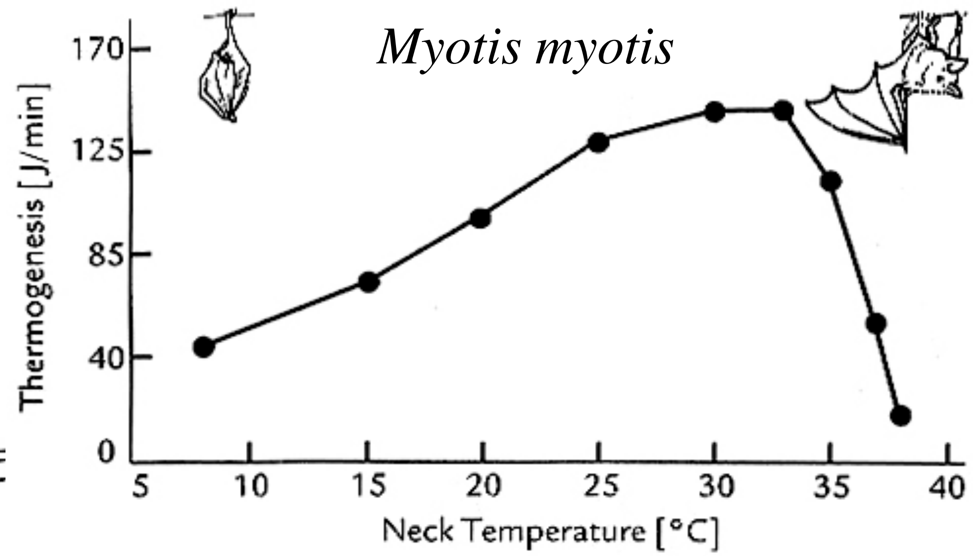
a =ventral temperature, b = rectal temperature

Due to nonshivering thermogenesis





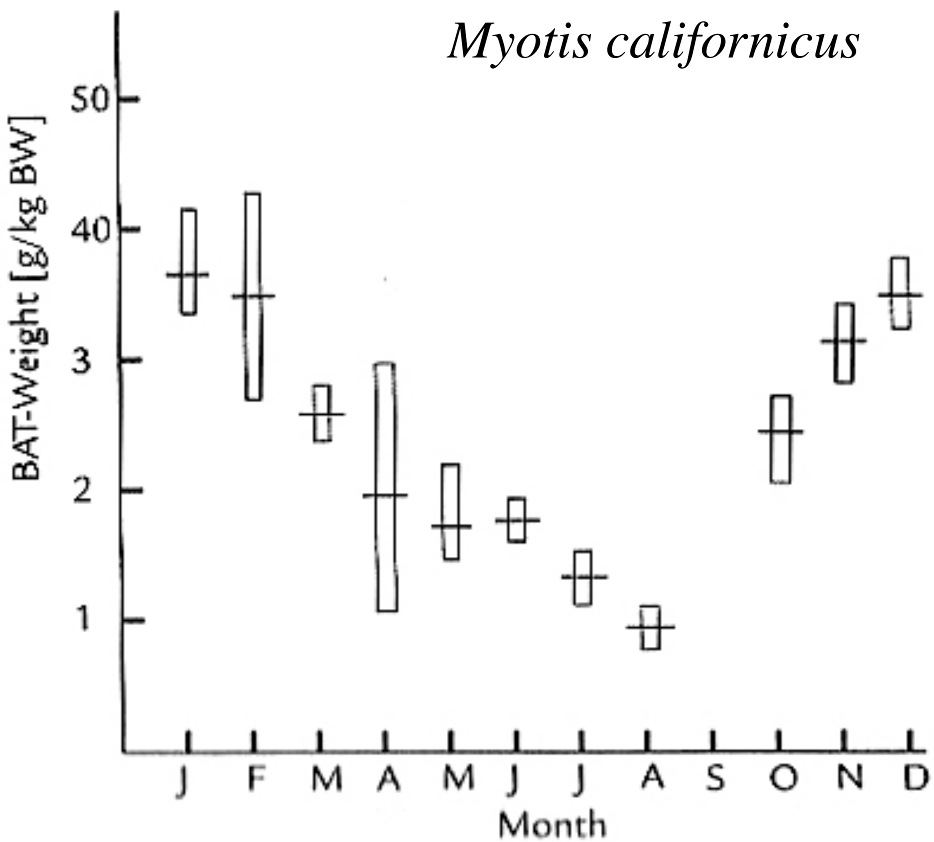
Brown fat deposit on the back of a Big Brown bat (Eptesicus fuscus–*Vespertilionidae*). *Note differences in temperatures of the fat mass, lower body, and wing membrane.*

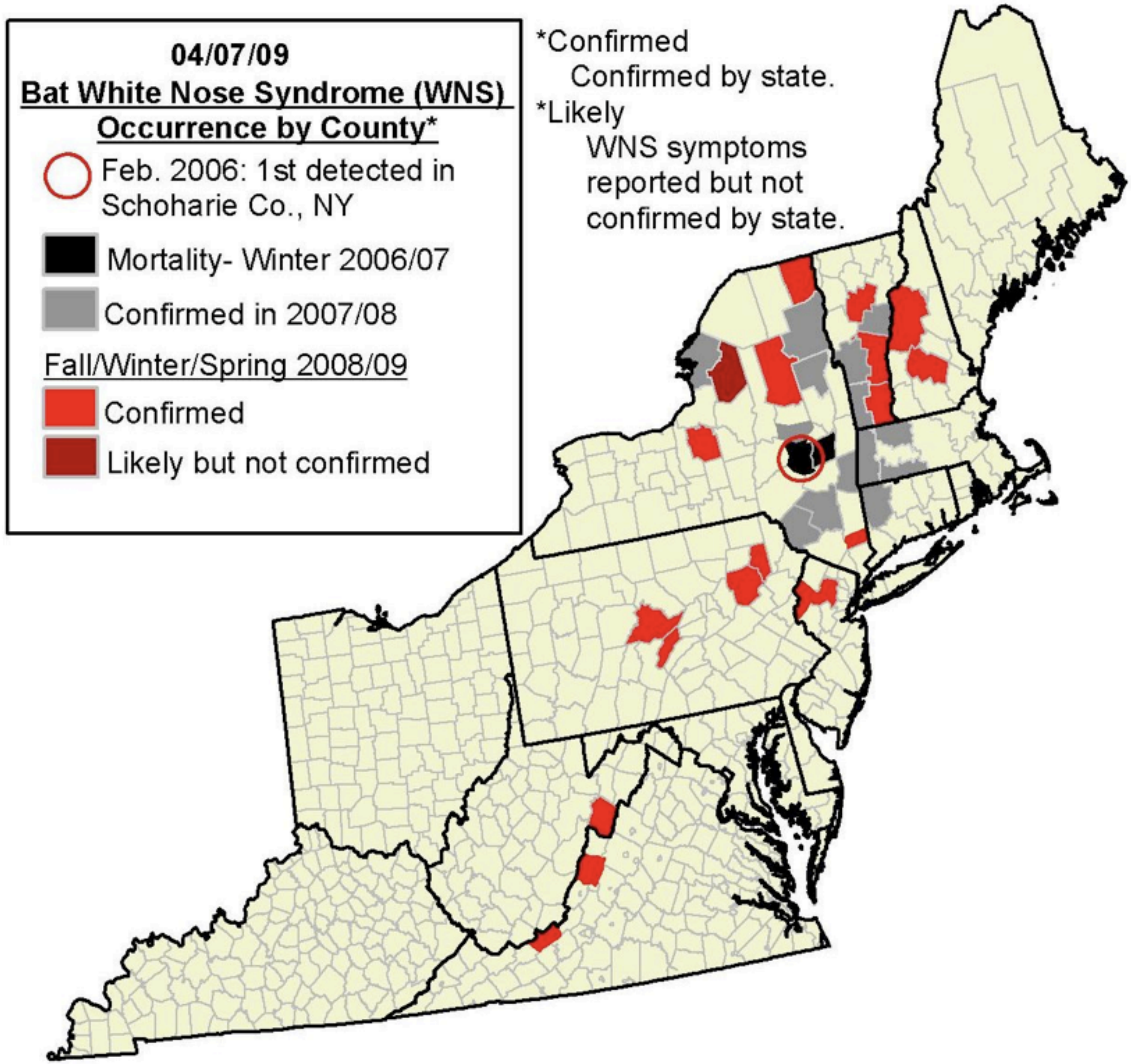


Brown adipose tissue (BAT) contains fat cells with many blood vessels and mitochondria which gives the tissue a brown color.

When BAT is oxidized, the blood is heated quickly.

BAT seasonal accumulation




04/07/09
Bat White Nose Syndrome (WNS)
Occurrence by County*
Feb. 2006: 1st detected in Schoharie Co., NY
Mortality- Winter 2006/07
Confirmed in 2007/08
Fall/Winter/Spring 2008/09
Confirmed
Likely but not confirmed
*Confirmed
Confirmed by state.
*Likely
WNS symptoms reported but not confirmed by state.

Monday,
April 13, 2009

ABOUT THE NORTHEAST REGION

WILDLIFE AND HABITAT
Coastal Zones
Environmental Contaminants
Endangered Animals and Plants
Wetlands
Wildlife In Refuges
Mammals
Amphibians
Birds
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Invertebrates

RECREATION
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Fishing
Hiking
Hunting
Wildlife Viewing

NEWSROOM
Nationwide News
For the Media
Pictures In the News
Publications
Federal Register

White-Nose Syndrome in bats: Something is killing our bats

Credit: Nancy Heaslip, New York Dept. of Environmental Conservation

Little brown bats with white-nose syndrome, New York

Cave advisory: Service recommends suspending activities in caves to protect bats from white-nose syndrome

FAQs

News release

Return to main WNS page
Report unusual bat behavior or deaths
Photos
Audio and video
State information
About WNS
Research and monitoring
Protocols
Bats are cool
What can you do to help?
For cavers
For kids & educators
Partners in the WNS search
Personal notes

White-Nose Syndrome Threatens the Survival of Hibernating Bats in North America

History of White-Nose Syndrome and Diseases in Hibernating Bats

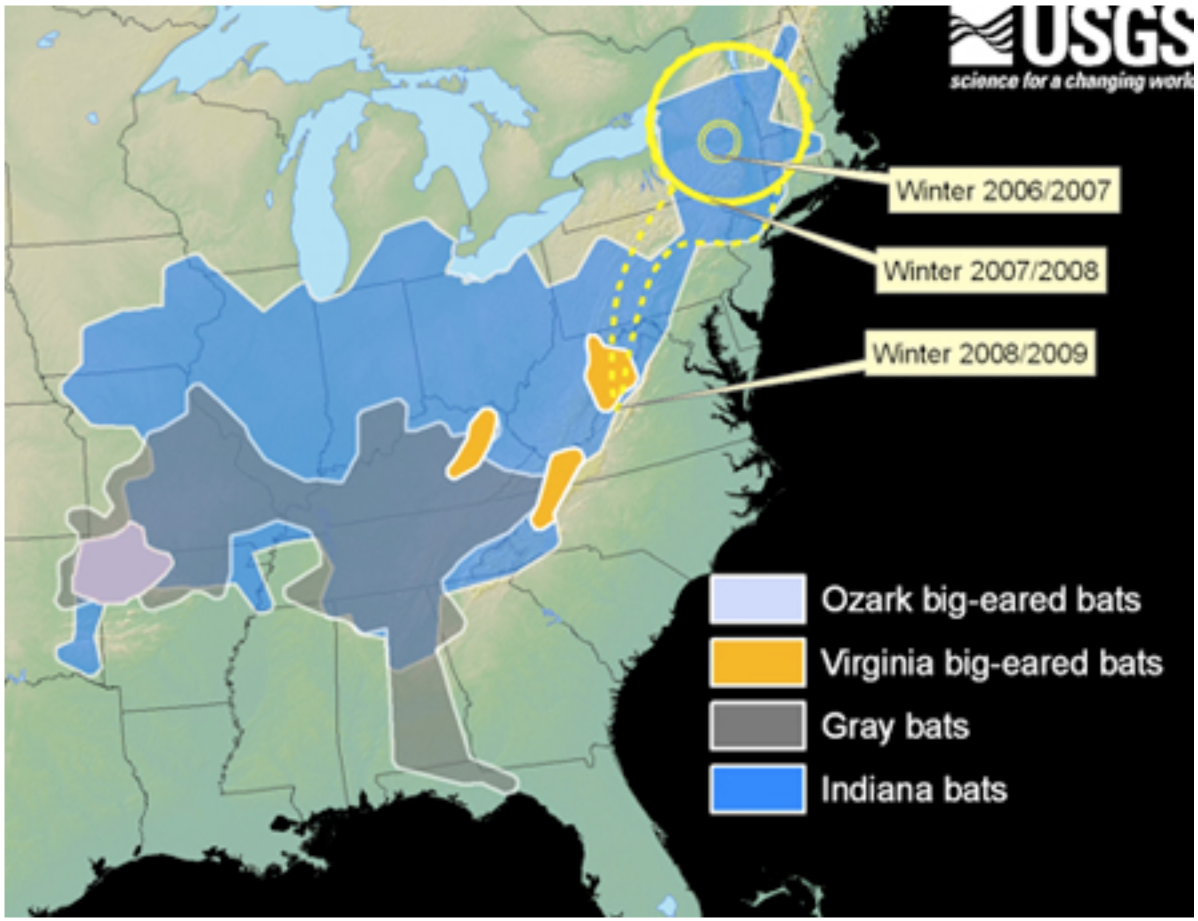
During the winter of 2006/2007, an affliction of unknown origin dubbed "White-Nose Syndrome" (WNS) began devastating colonies of hibernating bats in a small area around Albany, New York. Colonies of hibernating bats were reduced 81-97% at the affected caves and mines that were surveyed. Since then, White-Nose Syndrome has been detected more than 700 kilometers (450 mi) away from the original site, and has infected bats in eight surrounding states. Most species of bats that hibernate in the region are now known to be affected and little brown bats (*Myotis lucifugus*), northern long-eared bats (*M. septentrionalis*), and federally listed (endangered) Indiana bats (*M. sodalis*) have been hit particularly hard. The sudden and widespread mortality associated with White-Nose Syndrome is unprecedented in hibernating bats, which differ from most other small mammals in that their survival strategy is to live **life in the slow lane**—their life history adaptations include high rates of survival and low fecundity, resulting in low potential for population growth. Most of the affected species are long lived (~5-15 years or more) and have only one offspring per year. Subsequently, bat numbers do not fluctuate widely over time, and populations of bats affected by White-Nose Syndrome will not recover quickly. Epizootic disease outbreaks have never been previously documented in hibernating bats.

An Emerging Disease of Hibernating Bats

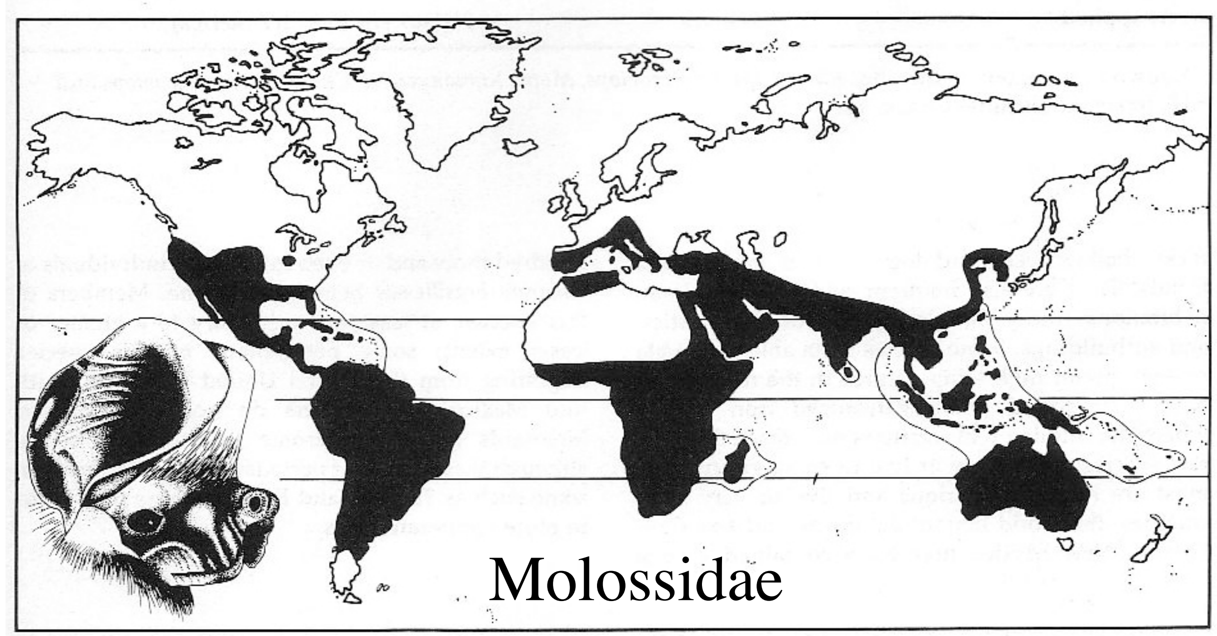
White-Nose Syndrome was named for the visible presence of a white fungus around the muzzles, ears, and wing membranes of affected bats. Based upon what is known about typical fungal pathogens of typical mammals, this fungal growth was initially thought to be a secondary infection of bats with compromised immune systems. However, bats are anything but "typical" mammals (see below). Since then, a **previously unreported species of cold-loving fungus (*Geomyces* sp.) has been identified as a consistent pathogen among affected animals and sites**. This fungus, now widely considered to be the causal agent of WNS, thrives in the darkness, low temperatures (5-10°C; 40-50°F), and high levels of humidity (>90%) characteristic of bat hibernacula. Unlike typical fungi, this species of *Geomyces* cannot grow above 20°C (68°F), and therefore appears to be exquisitely adapted to persist in caves and mines and to colonize the skin of hibernating bats. A consistent pattern of fungal skin penetration has been observed in over 90% of bats from the WNS-affected region that were submitted for disease investigation.

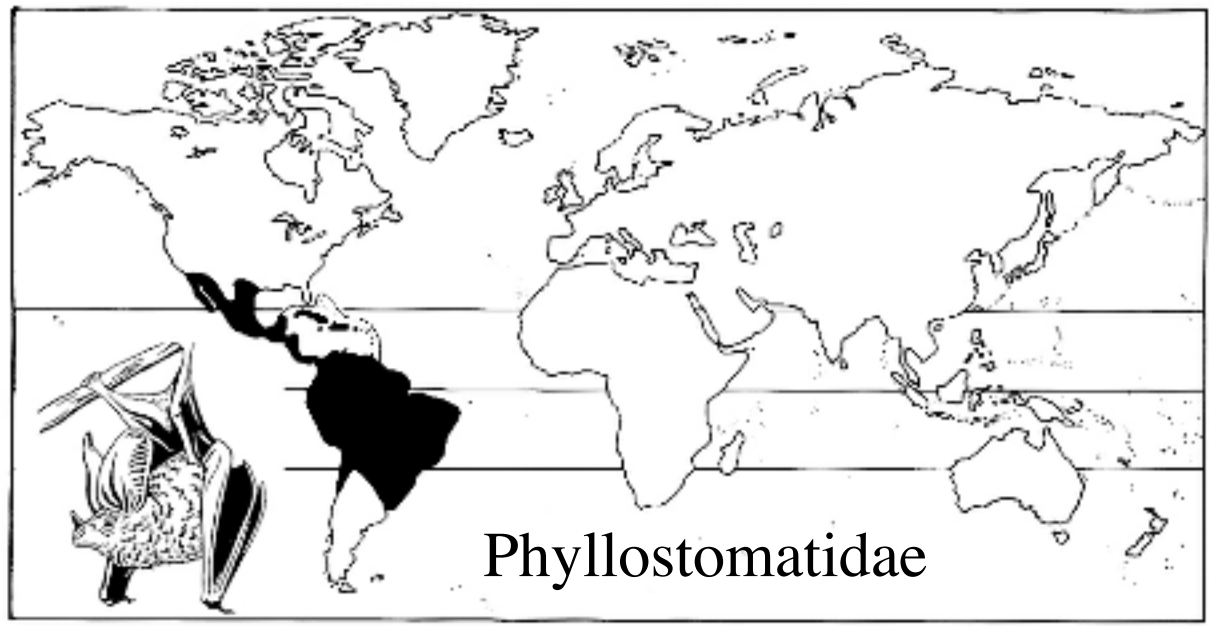
White-Nose Syndrome was named for the white fungus around the muzzles, ears, and wing membranes of affected bats. Photo: Meteyer et al. July 2009 [In Press]. JVDI Vol 21 No. 4.

WNS and distribution of endangered species



Migration permits other species to occupy temperate regions



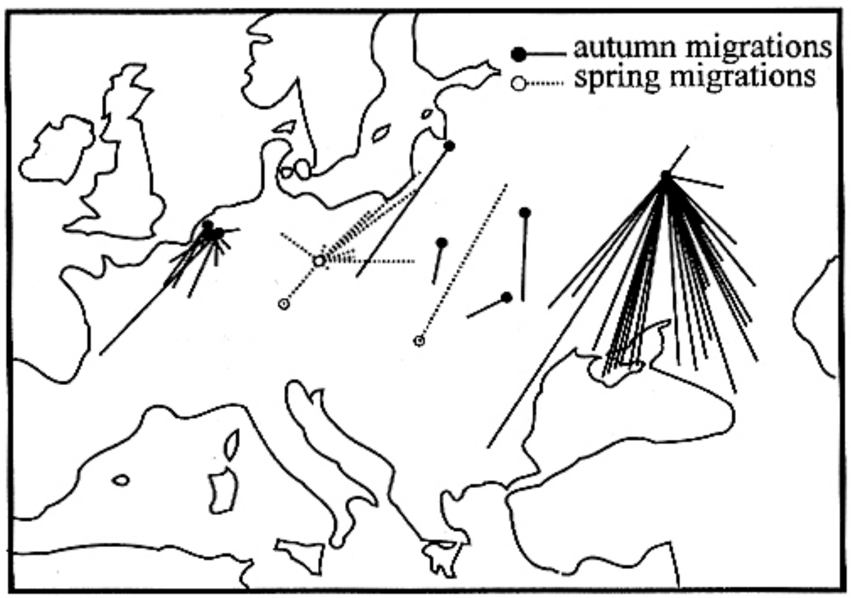


Migration routes of lesser long-nosed bats (*Leptonycteris curasoae*)

Feed on cactus going north, agave going south

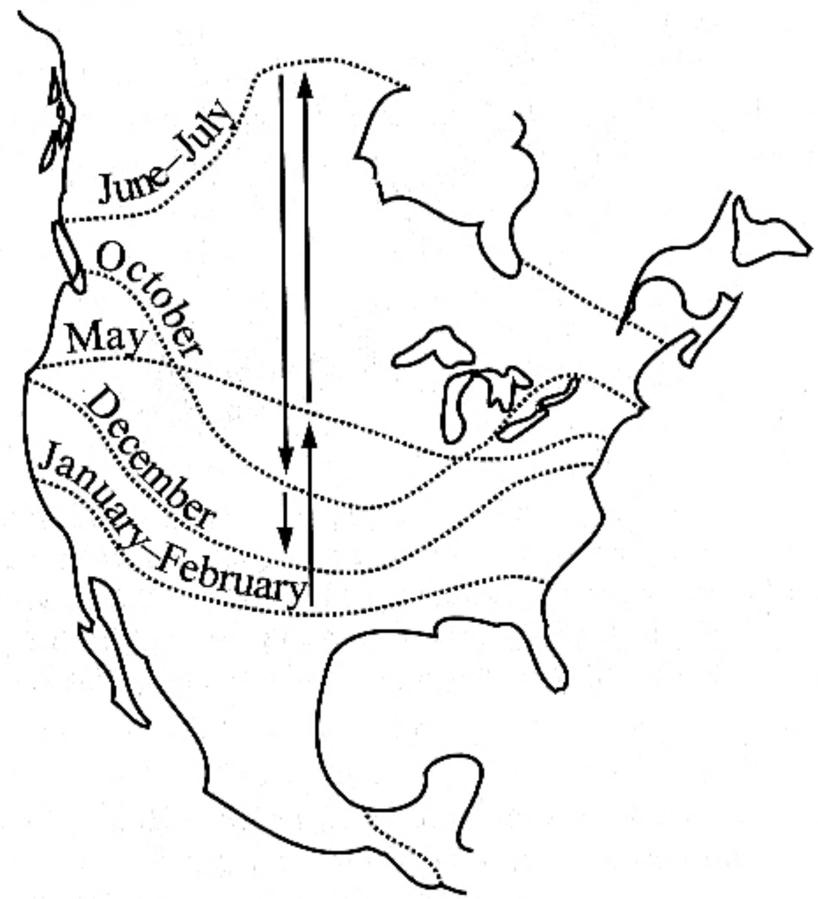
Temperate migration patterns

Nyctalus noctula
Noctule

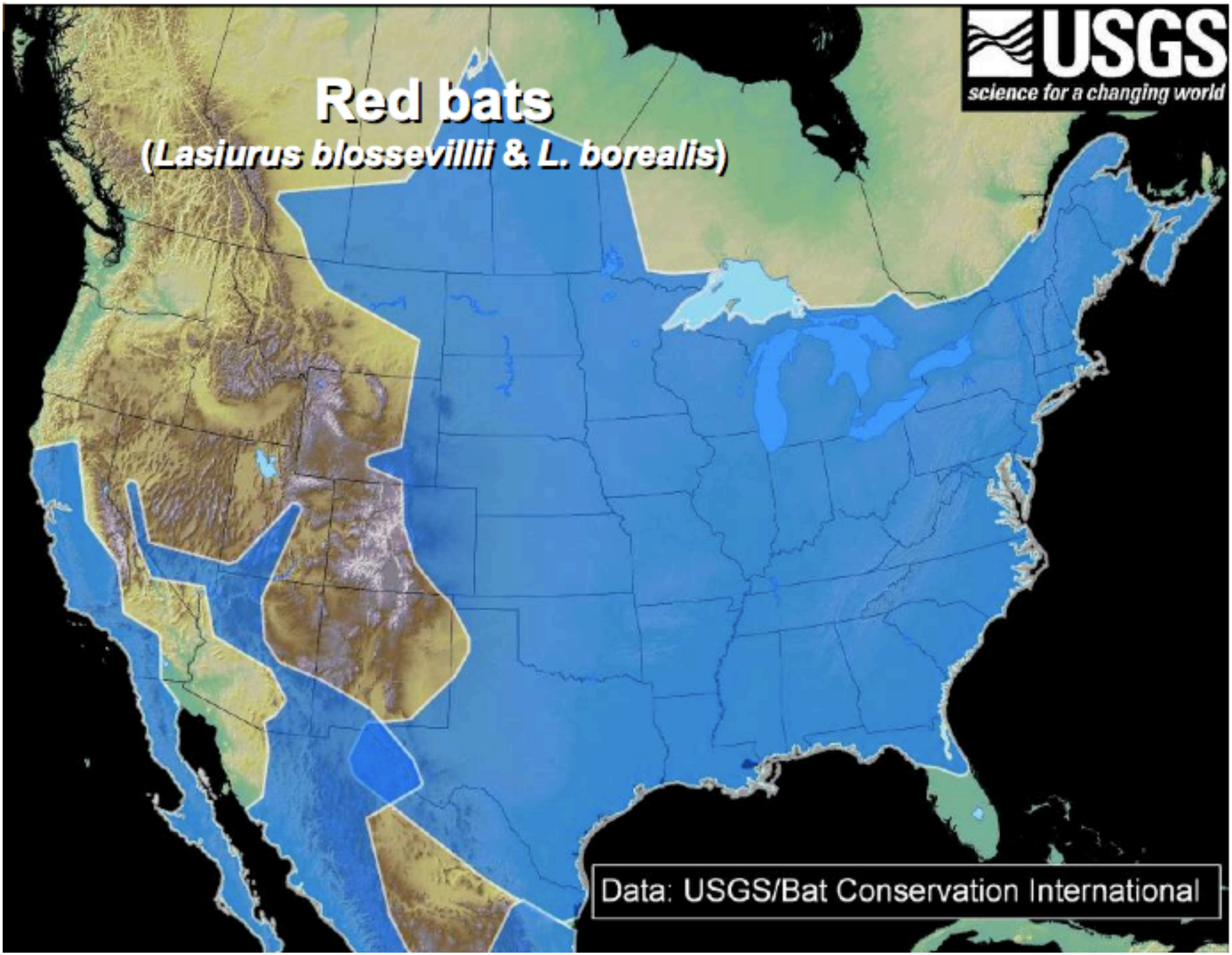


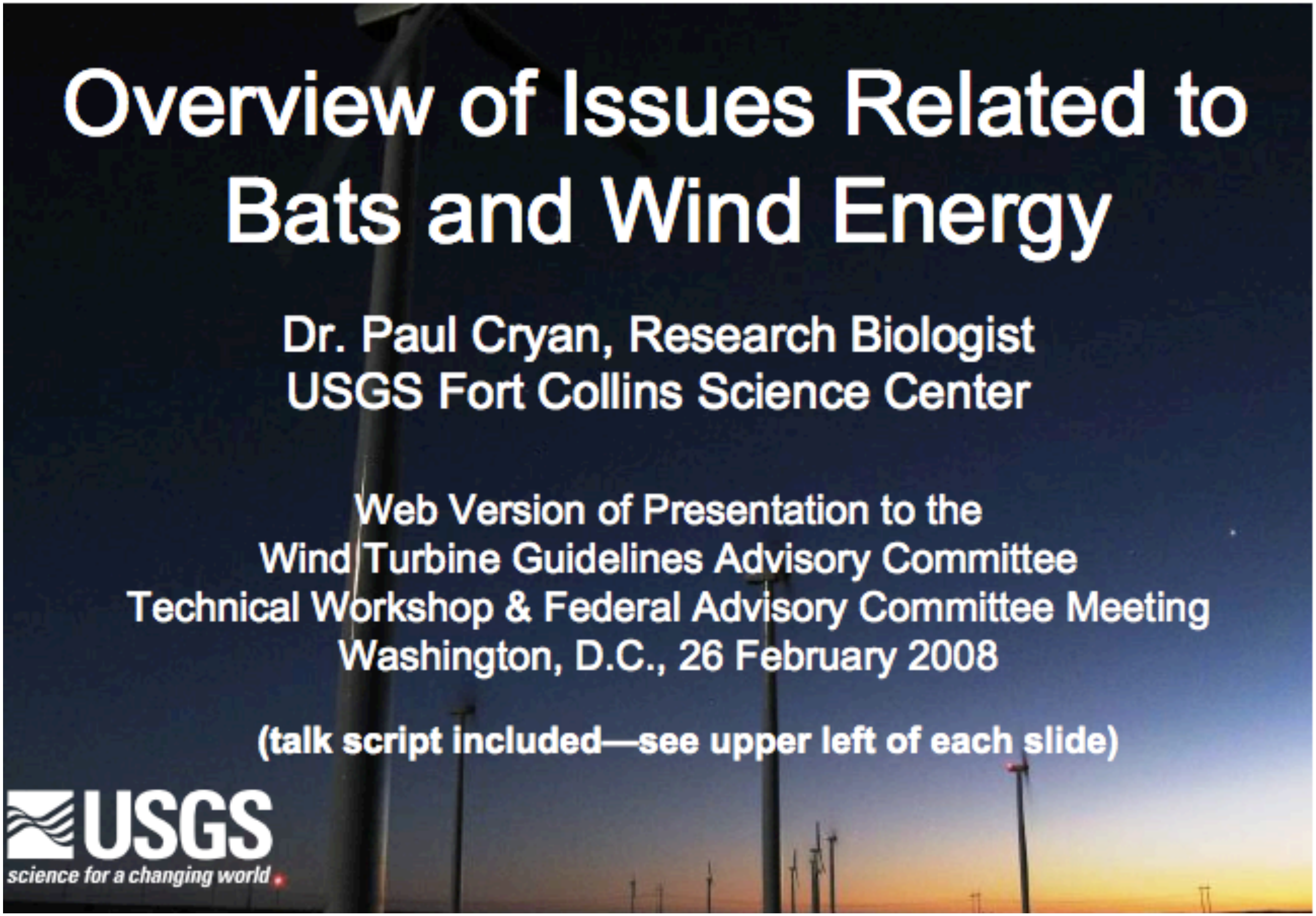
Temperate migration patterns

Lasiurus cinereus
Hoary bat



Animated maps available for viewing at:
http://www.mesc.usgs.gov/BatsWindmills/_animations/HoaryBat_Migration.wmv


Red bats
(Lasiurus blossevillii & L. borealis)
USGS
science for a changing world
Data: USGS/Bat Conservation International


Overview of Issues Related to Bats and Wind Energy
Dr. Paul Cryan, Research Biologist
USGS Fort Collins Science Center
Web Version of Presentation to the
Wind Turbine Guidelines Advisory Committee
Technical Workshop & Federal Advisory Committee Meeting
Washington, D.C., 26 February 2008
(talk script included—see upper left of each slide)
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