

The Meadow Jumping Mouse as a Laboratory Model of Hibernation

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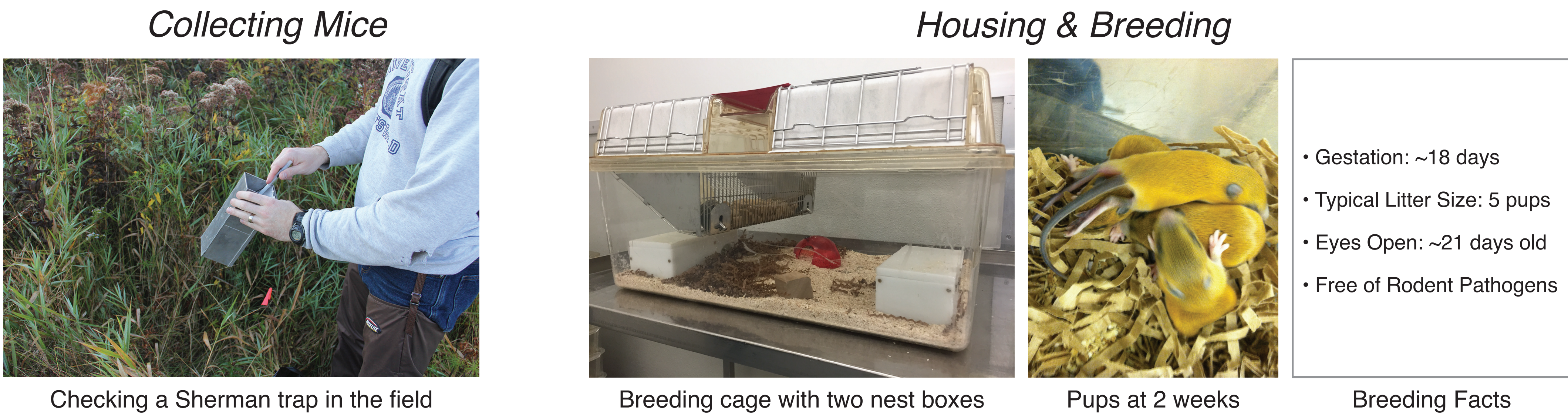
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ABSTRACT

Hibernating mammals exhibit great metabolic flexibility. They experience seasonal obesity and employ heterothermy as a survival strategy. During hibernation in cold climates, small mammalian hibernators enter a state of metabolic torpor and profound hypothermia. The significant (>95%) reduction of metabolic rate during torpor allows the hibernator to subsist on body fat for up to six months. The physiological flexibility of hibernators and their ability to suppress metabolic rate and survive hypothermia are of interest to human medicine; however, the molecular mechanisms underlying these phenotypes are not well understood and most current hibernating model organisms are not conducive to genetic approaches due to long generation times. The goal of this research has been to establish the meadow jumping mouse (*Zapus hudsonius*) as a convenient laboratory model of hibernation. Meadow jumping mice are small North American rodents with a ‘true’ hibernation phenotype: they fatten prior to hibernation and undergo multi-day bouts of torpor that are interrupted by short interbout arousals. Crucially, meadow jumping mice breed multiple times per summer in the wild, and they cue their transition from summer reproduction to fall fattening and hibernation largely on day length. We established a breeding colony using wild-caught animals that were trapped in Massachusetts in the summers of 2014 and 2015. The animals remain in a lean breeding condition year-round when housed at long photoperiod (16 hours light, 8 hours dark). Obesity and torpor can be induced by exposure to short photoperiod (8 hours light, 16 hours dark) and reduced temperature. We have generated the first meadow jumping mouse transcriptome data and expect that completion of ongoing genome sequencing efforts will increase the utility of this model. The meadow jumping mouse appears to be suitable for investigation of hibernation metabolism in the laboratory, and its short generation time may open the door to future genetic studies of hibernation phenotypes.

2. Establishing a Breeding Colony and Husbandry

Because there were no current breeding colonies of meadow jumping mice, we collected wild mice in Massachusetts to found a permanent colony. We have determined the health status of the mice and optimized housing and breeding conditions to suit the natural history of this unique species.



3. Inducing Hibernation in the Lab: Day Length & Temperature

Meadow jumping mice prepare for hibernation based on environmental cues – primarily day length. The mice fatten up and hibernate during simulated fall and winter conditions, but remain reproductively active as long as they are housed in simulated summer conditions.



5. Ongoing Genome Sequencing Work

We are in the process of sequencing and annotating the *Zapus hudsonius* genome in collaboration with the Broad Institute. The strategy is to generate a reference genome and perform gene annotation using mRNAseq data and computational methods. This *Zapus* genome will provide a foundation for comparative genomics and future genetic experiments.

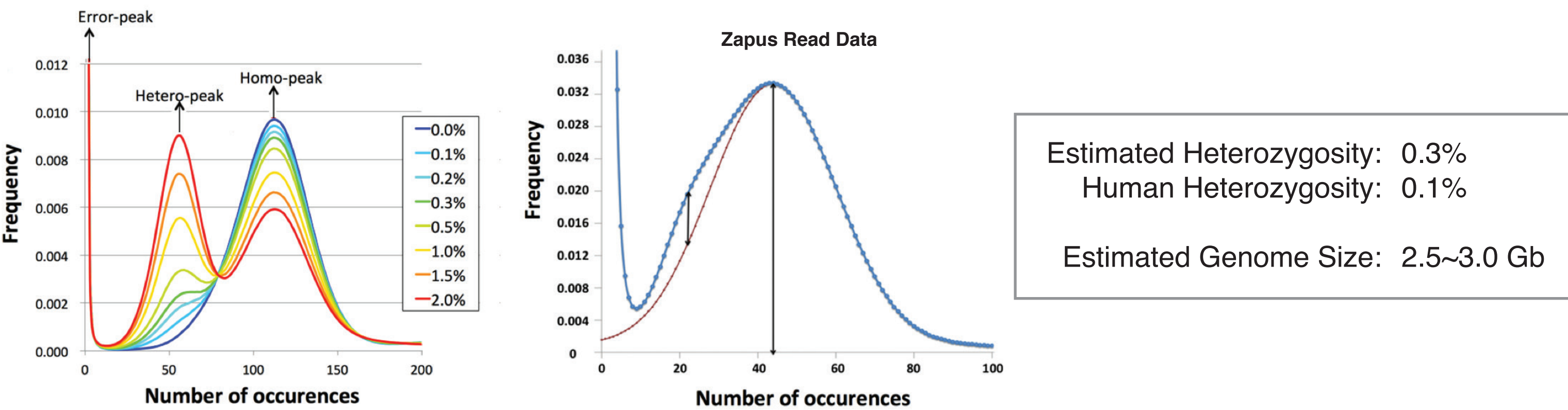
Status of Current Assembly

Library	Current coverage	Needed coverage
Paired-end	45	80
3K Mate pair	4.5	10
6K Mate pair	1.7	6
15K Mate pair	0.9	4

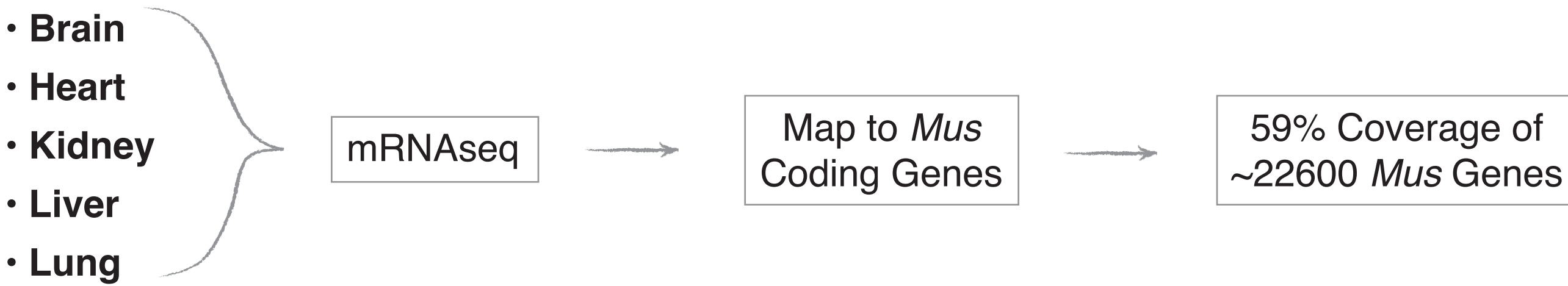
Genome Size: 2.63 Gb

Contig N50: 28.7 kb
Scaffold N50: 53.3 kb

Estimated Genome Size and Heterozygosity



Current Transcriptome Data

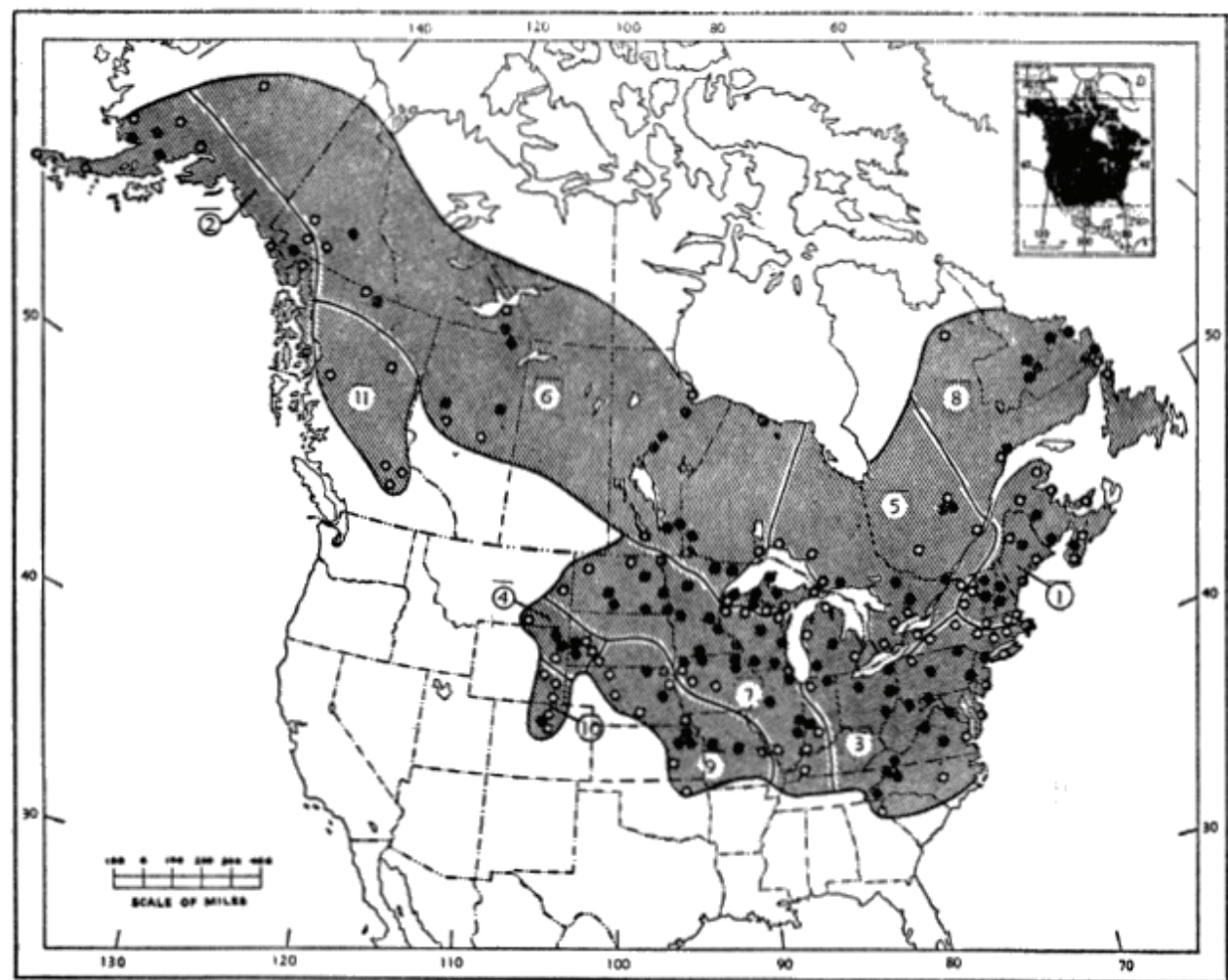


1. The Meadow Jumping Mouse

Zapus hudsonius

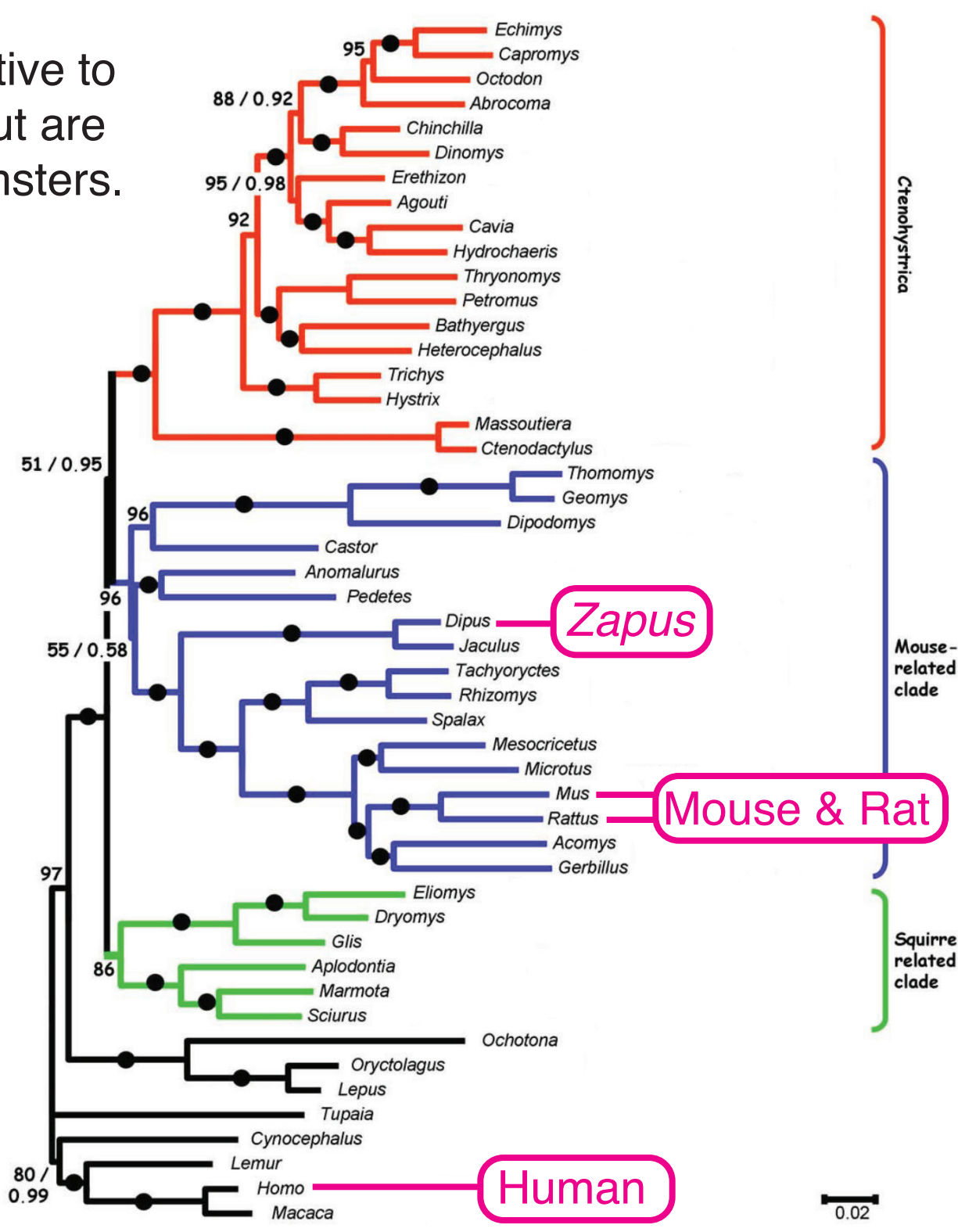
The meadow jumping mouse is a small hibernating rodent native to North America. *Zapus* are related to laboratory mice (*Mus*), but are evolutionarily more distant from *Mus* than are gerbils and hamsters.

Range ¹



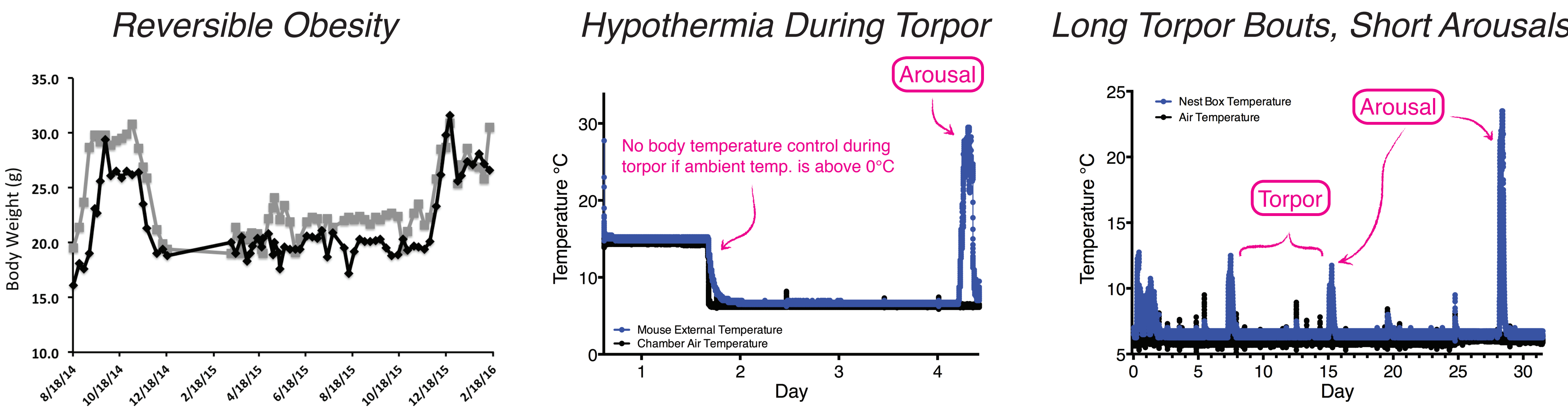
1. Krutzsch (1954) University of Kansas Museum of Natural History Publication 7:349-472.
2. Blanga-Kanfi, et al. (2009) BMC Evolutionary Biology, 9(1):71.

Phylogeny ²



4. The Hibernation Phenotype of *Zapus hudsonius*

Meadow jumping mice have a hibernation phenotype similar to ground squirrels – once prepared with sufficient fat stores, the animals experience week-long bouts of torpor that are interrupted by short arousals. Body temperature falls to near freezing during torpor. Meadow jumping mice fast during hibernation and do not cache food.



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