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Research poster: Quaternary biogeography of Neotoma cinerea: Linking genetic patterns with environmental change

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Quaternary biogeography of Neotoma cinerea: Linking genetic patterns with environmental change

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Introduction

Our understanding of the development and maintenance of phylogeographical structure is aided by integrating information from genetics, subfossil assemblages, and models of ecological niche distributions through the late Quaternary. The bushy-tailed woodrat, Neotoma cinerea, offers an interesting study case for several reasons:

• Molecular work in Neotoma has prompted the elevation of several groups to species status in recent years, given the wide range of occupied environments and morphological variation in this species. It is plausible that divisions in N. cinerea are similarly deeper than currently reflected by taxonomy.

• Parts of the current N. cinerea range were previously restricted to Pleistocene glaciers and glacial lakes, offering the potential for different regional histories and patterns of colonization since the last glacial maximum (c. 21,000 years ago (21 ka).

• Subtribal palaeoanthropologists have provided extensive historical information for Neotoma taxa, as one of the primary builders of these middens, N. cinerea has an almost unparalleled Quaternary record which has made it a model species for investigating species’ reactions to past climate change and has helped form and assess hypotheses regarding Great Basin biogeographic history.

Objectives

• Determine the major phylogeographic divisions of N. cinerea and their geographical distributions.

• Combine genetic and fossil information to estimate the timing of major clade divergence, and assess evidence of recent ecological and geographical trends in major clades.

• Model current and palaeoecological distributions of major clades in and around the Great Basin, and integrate with genetic patterns to form hypotheses of the biogeographical history of N. cinerea.

Phylogenetic inference

Neotoma diversity and phylogeographic divisions of N. cinerea characterized by haplotypes. Mitochondrial DNA sequences labeled with Bayesian posterior probability (BPP) and maximum parsimony (MP) were used. Five major clades are labeled by color: yellow (yellow Phase), green (Pacific Northwest Phase), blue (Northern Phase), red (Western Phase), and orange (Southeastern Phase). The divergences are shown in yellow at the top of the cladogram and the phylogenetic relationships between the clades are shown in the phylogram.

Divergence dating

Methods

We estimated divergence time of the 2 major clades using BEAST v.1.4.8. Unique N. cinerea haplotypes and Cricetid outgroup taxa were analyzed assuming the GTR+I+F model, an intraspecific tree prior, and uncorrelated lognormal clock. Tribe Neotomini (woodrats and relatives to genera Neotoma, Hapalomys, and Xenosciurus) was restricted to monophyly with a uniform divergence age prior of 8.6 ± 0.8 million years ago (Ma) representing the oldest known woodrat fossil.

Results

The divergence time between the 2 major clades was estimated at a mean 1.82 Ma with a 95% highest posterior density interval of 1.29 to 2.37 Ma.

Ecological niche modeling

Methods

We used 30 arc-second resolution grid files for 19 bioclimatic variables representing current (WorldClim*) and 21 ka (ECHAM*) time periods. Neotoma cinerea records were acquired through MegaBase, ArcGIS, and individual museum databases, and clade identities were determined genetically or by proximity to characterized samples. Bioclimatic values were checked for correlation and discarded if no relationships exceeded R² = 0.7. Models of the current ecological niche distribution were developed in Maxent v.3.3.1 and projected onto the 21 ka climate grids.

Results

Ecological niche models for 2 clades and subclades at 21 ka and current time periods. Dark gray represents low model presence of N. cinerea (0.000), while light gray indicates lower model presence (0.001-0.500). Pale colors are shown as dark gray. Pleistocene glaciers are shown in light gray, and the Thane and Virginia Rivers are shown in a yellow-black gradient.

Demographic tests

Methods

We performed 3 tests in Arlequin 3.1 to assess evidence of recent population expansion. Tajima’s D, Fu’s Fs and 1,000 simulated samples, and mismatch distribution analyses with 500 bootstraps. These tests were conducted for each of the 5 major clades.

Results

Significant negative values of D and Fs for the Northern and Intermountain subclades indicate recent population expansion, supported by non-significant deviations from the mismatch distribution null model of population expansion. In contrast, the Middle Rockies distribution differed significantly from the null, indicating population stability or contraction.

Future work

The estimated divergence time of the 2 major N. cinerea clades is consistent with the onset of the Pleistocene glacial epoch c. 1.8 Ma. The current phylogeographical distribution additionally suggests that the Green and Colorado Rivers may be sufficient barriers to dispersal. Only one point of symmetry (western South Dakota) was detected between the 2 major clades, likely representing a secondary contact zone.

Despite the Eastern clade’s wide predicted niche area in the Great Basin at 21 ka, this group may have never inhabited this region due to river barriers. Great Basin populations of N. cinerea may instead have been comprised of Northern clade members in the late Pleistocene, and later Intermountain clade members in the Holocene. This potentially recent colonization of the Great Basin by the Intermountain clade is supported by strong demographic evidence suggesting population expansion.

Reasons for potential clade replacement are speculative but may be related to hypothesized local extinctions in the arid mid-Holocene*. The Northern clade may have been supplanted by the Intermountain clade through chance, competition, or otherwise; whether, when, and why this occurred has yet to be determined, but holds implications for understanding the reaction of this species to past and future climate changes.

References


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