Drought In An Evolutionary Context: Molecular Evidence From Endemic Colorado River Fishes In Western North America

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Abstract. Large-scale climatic oscillations can extirpate populations and force survivors through genetic bottlenecks. An arid post-Pleistocene hypsithermal, for example, may be responsible for the shallow genetic architecture of an endemic fish in the Colorado River Basin of western North America. This hypothesis was tested using molecular data and assessing similar basin-wide effects manifested within the endemic fish community. Molecular variation was evaluated for three species with different life history and ecology: an ubiquitous, diminutive minnow (Speckled Dace, Rhinichthys osculus), an abundant, large-bodied sucker (Flannelmouth Sucker, Catostomus latipinnis), and a large-bodied minnow with disjunct and patchy distribution (the endangered Humpback Chub, Gila cypha). Populations from ecologically comparable but distant areas (i.e., lower basin Little Colorado River in Grand Canyon, AZ vs upper basin Yampa River, UT) were contrasted. Molecular analyses revealed low and non-significant levels of divergence amongst populations (0.002--0.125%), thus rejecting hypotheses that molecular variability among these fishes stemmed either from phylogenetic and life history differences, or from anthropogenic effects. Results also suggest upper- and lower-basin communities last shared common ancestors 3,300--9,615 ybp, and juxtapose well with a post-Pleistocene drought scenario. Magnitude of the genetic bottleneck was determined by deriving effective population sizes ($N_e$) for both sucker and minnows in the Little Colorado River. A coalescent approach coupled with a five-year open-population estimator ($N_c$) and a single 1,640 bp sequence representing four combined mtDNA regions (ND2, ATPase 6 and 8, and D-loop). According to the literature, a $N_e/N_c$ ratio of approximately 0.10--0.11 is to be expected, whereas for sucker and chub respectively it was 0.068 and 0.046 (=35% and 56% reductions), thus implicating a rather large bottleneck. Clearly, drought events over evolutionary time have had enormous impacts on communities of fishes that still reverberate today. Interestingly, these events are not considered in the adaptive management of western North American threatened and endangered species.