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Unraveling the Morphological and Genetic Diversity in the Western Shovel-nosed Snake

Understanding the geographic distribution of genetic variation within a species can provide valuable information on the evolutionary and ecological history of that species. Gathering this information can also inform conservation decisions because effective management efforts often first require that distinct units of conservation are identified. Recent arguments support continued recognition of subspecies under the Endangered Species Act (ESA) as long as these designations meet the "discreteness" and "significance" criteria of conservation units defined under the ESA. However, many studies (especially in snakes) have shown previously defined subspecies to be problematic once additional lines of genetic evidence have been examined. To address these concerns, USGS scientists Dustin Wood, Drs. Amy Vandergast and Robert Fisher, and their coauthors at the University of Texas and Arizona State University examined the population genetic structure and morphological diversity in the small, desert-dwelling western shovel-nosed snake. Their study has been published in *Conservation Genetics*.

Management Implications:

- Population genetic analyses reveal historical isolation and independent evolutionary trajectories for two genetic lineages that likely comprise distinct units of conservation within the western shovel-nosed snake.
- Neither genetic nor morphological data were concordant with the traditional subspecies taxonomy. Therefore, using the traditional subspecies taxonomy as a surrogate for conservation and management purposes is not recommended.
- If translocations are proposed for reintroduction of snakes where populations have declined dramatically (e.g., Avra Valley populations in Arizona), then harvesting from the most geographically proximate populations is recommended. However, prior to undertaking interpopulation translocations, further investigation and restoration of the habitat are likely needed.

The western shovel-nosed snake inhabits the arid valley floors and bajadas of the Mojave, Colorado, and Sonoran deserts. Past morphological assessments of taxonomy based mainly on banding patterns recognized four subspecies: Mojave shovel-nosed snake, Colorado shovel-nosed snake, Nevada shovel-nosed snake, and Tucson shovel-nosed snake. Population sizes and range for the Tucson shovel-nosed snake have declined significantly over the past 25 years due to substantial habitat loss (through agriculture and urbanization), and existing populations are further threatened by expansion of the Tucson and Phoenix metropolitan areas. These factors have prompted recent conservation attention. However, the taxonomic validity of the Tucson shovel-nosed snake is complicated by a possible zone of intergradation with another subspecies across central Arizona.

Mitochondrial DNA sequences were analyzed from snakes collected throughout the entire range. Using the maternally inherited nature of mitochondrial DNA, the scientists were able to trace the ancestry and estimate relatedness among populations. In addition, 14 morphological characters were analyzed, providing a more up-to-date geographic assessment of morphological variation and facilitating general comparisons between the morphological and genetic patterns.

Coloration and banding pattern differences have traditionally been used to separate the two snakes above into two subspecies, Colorado shovel-nosed snake (left) and Tucson shovel-nosed snake (right). However, this study indicates these two subspecies exhibit broad overlap in both morphological and genetic variation and instead represent morphological endpoints of clinal variation. Photo (left): Dustin A. Wood, USGS. Photo (right): courtesy of Thomas C. Brennan.

Genetic analyses indicated that diversification within the western shovel-nosed snake developed as a result of both historical and environmental isolating mechanisms, resulting in two main lineages (Northwestern desert and Southeastern desert). These lineages may have initially developed due to the breadth and duration of pluvial-interpluvial periods of the Pleistocene epoch by repeatedly forcing snakes into isolated areas of nonglaciated refugia. Genetic results suggest that geographically proximate populations are more genetically similar to each other than to more distant populations. However, study results also showed that desert basin (i.e., Mojave, Sonoran, and Colorado), temperature, and elevation were strongly associated with genetic divergence, after correcting for geographic distance. Thus, current ecological differences and elevation barriers among desert basins may be equally sufficient to maintain the observed genetic differentiation.

Lastly, the study results indicated that both genetic and morphological analyses do not unequivocally support current subspecies designations. The genetic results revealed significant geographical structuring, but with different geographical limits than established by traditional subspecies taxonomy. Morphological analyses exhibited broad overlap of character variation, and did not provide strong evidence for differentiation of subspecies. In regard to the Tucson shovel-nosed snake, the genetic variation exhibited in this putative subspecies is largely shared with individuals identified as the Colorado shovel-nosed snake. Together these snakes form a larger geographic group whose range has recently expanded from western Arizona populations. These results indicate that gene flow is ongoing or has been until very recently between these two putative subspecies in this region. Based on the collective consideration of morphological results, the accumulation of past knowledge, and mitochondrial sequence data, the authors suggest that the Tucson shovel-nosed snake is better understood as a morphological endpoint of clinal variation rather than a distinct subspecies. If management of this variation is deemed necessary, the authors recommend treating the two putative subspecies in central Arizona as a single population with focus on restoring population structure to its historical condition.

Wood, D. A., J. M. Meik, A. T. Holycross, R. N. Fisher, A. G. Vandergast. 2008. Molecular and phenotypic diversity in Chionactis occipitalis *(Western Shovel-nosed Snake), with emphasis on the status of* C. o. klauberi *(Tucson Shovel-nosed Snake). Conservation Genetics 9:1489–1507. DOI 10.1007/s10592-007-9482-0.*