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LETTER TO THE EDITOR

Recovery and genetics of Mexican wolves: a comment on Clement et al.

Clement et al. (2024) recently published an invited article about potential inbreeding depression in wild populations of Mexican wolves (*Canis lupus baileyi*), a gray wolf subspecies historically distributed in northern Mexico and the southwestern United States. We appreciate their effort to examine this topic, but there are several aspects of this analysis that should be further discussed and some related aspects of Mexican wolf recovery that need to be emphasized.

BACKGROUND ON MEXICAN WOLF GENETICS

All Mexican wolves (around 260 in the wild and around 380 in captivity) descend from 7 founders from 3 captive lineages (Hedrick et al. 1997, Fredrickson et al. 2007) that made very unequal contributions to the present-day population. Specifically, the 3 founders from the McBride lineage contributed about 77% of the ancestry, the 2 founders from the Ghost Ranch lineage contributed only about 16%, and the 2 founders from the Aragon lineage contributed only about 7%. As a result, the estimated number of remaining Founder Genome Equivalents (FGE), which also includes the impact of inbreeding, in the wild population is only about 2.1 and in the captive population is only about 2.85. In other words, the Mexican wolf population descends from one of smallest effective founder numbers of any reintroduced endangered species, a fact that portends severe genetic problems.

INBREEDING AND INBREEDING DEPRESSION IN MEXICAN WOLVES

Clement et al. (2024) reported that the average inbreeding coefficients in the wild Mexican wolf population was very high (0.227), there was extremely high variation in inbreeding among individuals, and that there was no increase in the inbreeding level from 2010 to 2022. This period overlaps with the introduction of 83 fostered pups from 2016 to the present from the captive population with a 36% higher FGE, suggesting that this lack of increase in inbreeding is primarily the result of these introductions keeping the inbreeding from increasing in the short-term. When (and if) these foster pup introductions are reduced or stopped, the inbreeding coefficient in the wild population will inevitably increase, an effect that can be mitigated by allowing interbreeding with northern gray wolves (*C. l. occidentalis*).

Clement et al. (2024) also found no evidence of inbreeding depression in the wild population for pup recruitment to age 9 months. As they discussed, demonstrating inbreeding depression in a wild population can be difficult, partly because accurately measuring components of fitness such as survival to reproduction, male reproductive success, age of first reproduction, and adult survival are often difficult. However, earlier reports found significant impacts of inbreeding depression in Mexican wolves for body size (Fredrickson and Hedrick 2002), male infertility (Asa et al. 2007), and litter size (Fredrickson et al. 2007), effects that are unlikely to have disappeared with time.

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It is possible that historical low population numbers, as with the captive population of Mexican wolves, might have resulted in fixation of some deleterious alleles such that further inbreeding might not result in further reduction in fitness, that is, inbreeding depression. Fixation of deleterious variants could result in a lower population fitness, which could be identified and restored by outcrossing with other unrelated populations. In fact, crosses between the Mexican wolf lineages showed increased fitness, a further confirmation of inbreeding depression. In addition, there have been recent unpublished reports of syndactyly, a congenital, generally genetic, deformity where the soft tissue between digits is fused in 2 different Mexican wolves in the wild population.

It is possible that the lack of evidence of inbreeding depression found by Clement et al. (2024) was also influenced by 2 other factors. First, many of the denning wolves have been supplementally fed 4.4 kg of carnivore logs per wolf every 2 to 3 days since 2009. This management action is designed to make wolves less predatory on livestock but makes the wild environment more benign. As a result, it could have greatly reduced the observed impact of inbreeding on several components of fitness, an impact that would be evident if supplemental feeding is discontinued. In addition, it appears that the artificial supplemental feeding of denning wolves that has greatly increased the survival of pups has consequently resulted in much of the population increase from 2009 to the present. As has been noted previously by Carroll et al. (2019), statistical analysis of the effects of inbreeding needs to independently assess effects on litters that received supplemental feeding and those that did not.

Second, in their analysis Clement et al. (2024) only considered inbreeding in litters when there was one or more offspring. To determine the impact of inbreeding on offspring numbers, the category of zero offspring for appropriate mating pairs should also be included in this analysis using the estimated inbreeding coefficients for the potential parents and offspring. This category of no successful reproduction is likely to provide strong evidence of inbreeding depression.

GENETICS AND RECOVERY IN MEXICAN WOLVES

Although inbreeding depression is extremely important when considering genetic factors in endangered species, the amount of genetic variation is also of great importance. Using genomic analysis, Mexican wolves were found to have only 55% of the variation found in northern gray wolves, making the level the lowest genetic variation of any wolves (vonHoldt et al. 2011). In addition, genomic analysis in Mexican wolves (Taron et al. 2021) has demonstrated that the current population has reduced genetic variation and increased inbreeding compared to the historical population.

Overall, the conclusion by Clement et al. (2024) that there is no inbreeding depression in Mexican wolves is not supported. Because Mexican wolves are so low in genetic variation and have shown inbreeding depression, they are in need of genetic rescue. Expansion northward resulting in crosses with northern gray wolves, such as those currently being established in Colorado, would provide an appropriate cross to further ameliorate the negative effects of inbreeding depression and increase genetic variation. To guard against the negative impacts of inbreeding in Mexican wolves, successful recovery is essential for the long-term survival of Mexican wolves.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

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