The Influence of Inbreeding Depression and Immigration on the Stability of a Small Insular Population: Modeling Inbreeding-Stress Interactions

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Abstract: We investigated the potential for inbreeding to increase variability in the population trajectory of a small insular population. Increased stochastic variability in population size increases extinction risk, especially in small populations, and is, therefore, of interest in conservation biology. Inbreeding depression may vary with severity of environmental stress. We explored three main inbreeding-stress interaction scenarios: 'no interaction', a 'linear interaction', and a 'threshold interaction' in which the survival rates of inbred individuals were greatly reduced above a stress threshold. Due to uncertainty in parentage, the severity of inbreeding depression in wild populations is rarely known. We therefore explored a wide range of inbreeding depression in annual survival rate from 0 to 80%. We also explored the influence of immigration rate on population variability and extinction rate. We investigated these scenarios using an individual-based population model that traced a pedigree and determined an inbreeding coefficient for each individual. The model was parameterized using data from an island population of song sparrows (*Melospiza melodia*), monitored closely since 1975, with a continuous social pedigree from 1981. The population has varied from 4 to 72 adult females (mean = 42) and immigration has averaged about one bird per year. Most mortality in this population (and all mortality in our model) occurred in winter and appeared to be influenced by external stresses such as periods of extreme cold. Given constant immigration, little increase in variability in the population trajectory occurred as inbreeding depression increased from 0 to 80% with 'no interaction' between stress and inbreeding depression, and only slightly more with a 'linear interaction'. However, imposing a 'threshold interaction' between stress and inbreeding increased extinction rate markedly and led to regular crashes averaging 83% ± 11% (mean ± SD) of population size at a mean interval of 11 ± 5 years. The immigration rate required to reduce the extinction rate to less than 5% in 230 years increased with inbreeding depression and with the level of the inbreeding-stress interaction. With inbreeding depression of 50%, an immigration rate of 1.25, or 5 immigrants in 4 years, was required given the 'threshold interaction'. By comparison, immigration rates of only 0.50 given a 'linear interaction' and 0.38 given 'no interaction' were required to reduce extinction rates to 5%. Under the 'threshold interaction', the

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highest extinction rates occurred when there was no inbreeding depression at low stress and high inbreeding depression at high stress. Moderate inbreeding depression with low external stress resulted in the gradual removal of inbred individuals from the population, thus reducing extinction. These results suggest that inbreeding-stress interactions have the potential to increase stochastic variability in a population trajectory and that higher levels of immigration may be required to reduce the risk of extinction if inbreeding depression is high or if inbreeding-stress interactions occur in nature.