Recovery of the Endangered Mauritius Kestrel from an Extreme Population Bottleneck

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The Mauritius Kestrel (*Falco punctatus*) is a severely endangered species (King 1981) whose entire population in the wild reached a low of only 2 pairs in 1974 (Temple 1974, 1977). Temple (1978) speculated that a spontaneous "tradition-shift" (*sensu* Wilson 1975: 13) in nest-site selection may have been initiated in the kestrel population in 1974. This shift from nesting primarily in tree cavities to nesting in holes and niches on cliffs was initiated by the single successfully breeding pair in 1974 and seems to have permitted the kestrels to reproduce more successfully. They had previously suffered heavy nest losses (most likely to introduced macaques, *Macaca fascicularis*). All young kestrels fledged since 1974 were from sites on cliffs and subsequently adopted cliffs for nesting when they established their own breeding territories. There are no records of tree nests since 1976 (Collar and Stuart 1985). The overall improvement in reproductive success that seems to have resulted from cliff-nesting has allowed the kestrel population to experience a recovery from the severe bottleneck of 1974.

There has been much interest and concern among conservation biologists over the ability of extremely depleted populations to rebound from major bottlenecks (e.g. Schonewald-Cox et al. 1983), but there has been relatively little documentation of the fates of natural populations during the courses of their recoveries. Here, I discuss the recovery of the Mauritius Kestrel population from a major bottleneck and show that its subsequent growth seems to have followed a pattern that approximates a logistic growth curve.

The Mauritius Kestrel population is now restricted to a potential range of approximately 4,000 ha of remnant forest habitat surrounding the Black River Gorges in the southwest of the island of Mauritius in the Indian Ocean (Temple 1977). The ecological basis for this habitat restriction is the kestrel's highly specialized foraging ecology, which allows it to hunt successfully only in certain types of forests (Temple 1986).

By plotting repeated sightings of the 7 individually recognizable kestrels that comprised the wild population from 1973 to 1975 and creating everted polygons enclosing sighting points, I was able to determine the approximate sizes of kestrel home ranges and territories. Three pairs of kestrels had annual home ranges that averaged approximately 120 ha (range 97–142 ha), and adjacent pairs appeared to tolerate about a 50% overlap (range 42–70%) in their home ranges. All observed territorial disputes occurred within a 300-m radius of nest sites, suggesting that a circular area of about 28 ha approximately describes a kestrel's territory size.

By systematically inspecting the remaining habitat for all potential nesting cliffs (based on characteristics of 1974–1977 nests) and plotting nonoverlapping, circular 28-ha territories around each usable site, I estimated that only about 18 cliff-nesting pairs could be accommodated in the available habitat. If nonbreeders, whose 120-ha home ranges overlapped by 50%, filled in all areas not occupied by breeders, the carrying capacity of the remaining habitat around the Black River Gorges would be approximately 66 kestrels.

Between 1973 and 1977 the size of the kestrel population was monitored closely. Because of the small population size, total counts of individuals were possible. I counted 4 birds at the end of the 1973 breeding season, 7 in 1974, 7 in 1975, and, with the help of S. D. McKelvey, 11 birds in 1976. In 1977, P. Trefrey (pers. comm.) counted 15 birds. Between 1978 and 1983 no systematic counts of the total population were made, but in 1984 a thorough census of the population resulted in an estimated population size of about 50 kestrels (N. C. Fox pers. comm.).

Using only the population data from 1973 to 1977 and the methods described by Caughley (1977), I calculated an annual population growth rate (r) of 0.35 for the kestrel. Given this population parameter and an estimated carrying capacity of 66 birds, it was possible to construct a population-growth model that predicted the population's size in each year since 1973. Similar approaches have been used to model the recoveries of other endangered species (e.g. Miller et al. 1974, Barclay and Cade 1983). I used the logistic model of population growth, as described by Tanner (1978),

$$N_t = \frac{K}{1 + Ae^{-rt}}$$

where N_t is the population size in year t, K is the carrying capacity of the available habitat, A is the value $[(K - N_o)/N_o]$, e is the base of natural logarithms, r is the population growth rate, and t is the number of years since 1974 (Fig. 1). Fox's 1984 estimate of 50 birds suggests that the population's growth is, indeed, following a pattern that approximates the logistic growth model generated from the 1973–1977 population data.

The wild population of the Mauritius Kestrel has survived an extreme reduction in population size and is recovering its numbers at a rate that suggests it will reach the carrying capacity of its habitat within 20 yr of emerging from a major bottleneck. The wild population is now substantially inbred, with an in-

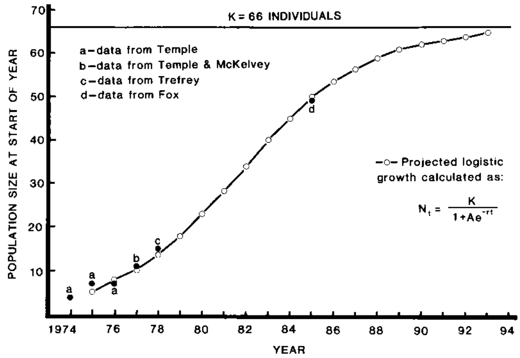

Fig. 1. Observed and predicted size of the Mauritius Kestrel population following a severe population bottleneck in 1974.

breeding coefficient, F (Wright 1922), of at least 0.125, where $F = 1/2N_e$ and N_e was the number of breeders in the 1974 bottleneck population. Inbreeding depression is commonly encountered in populations that have passed through such a severe bottleneck (Schonewald-Cox et al. 1983), and Cooper (1979) and Cooper et al. (1981) have wondered whether mortality rates in a small captive population of Mauritius Kestrels may have been elevated because of inbreeding depression.

At present any reduction that may have occurred in the fitness of individuals in the wild population apparently has not interfered with a relatively robust rate of population growth. This growth is an encouraging indication that the Mauritius Kestrel may have survived a severe population bottleneck without acquiring the potentially heavy genetic loads that can lead to extinction in such situations. Lovejoy (1978) speculated that populations that have survived previous bottlenecks may be in better condition to survive subsequent ones because they have eliminated many deleterious alleles during each successful passage through a bottleneck. Species like the Mauritius Kestrel that colonized remote oceanic islands almost certainly have passed through bottlenecks in the course of their evolution on the island. Nonetheless, with a potential wild population of only 66 individuals, the Mauritius Kestrel will remain an endangered species until conservation measures, such as translocations of birds to areas of new habitat on Mauritius or elsewhere (Temple 1981), allow the population to reach a larger size.

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