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Evolution on Islands

A model for contemporary preservation

Since Darwin's observations on the Galapagos, islands have long been recognized as "laboratories" for the study of evolution. The isolation of species sometimes results in very peculiar morphologies and often in drastic size changes. Among insular mammals, there is a general tendency for small mammals to evolve towards a larger size and larger species to evolve toward a smaller size, tendency known as the "island rule". For example, the trend of increased body size ("gigantism") has been documented in numerous rodent taxa on islands (one of the biggest rats on the world are from New Guinea and islands of Indonesia). Giant tortoises still inhabit the Galápagos (foto) and Aldabra, giant monitor lizards inhabit Komodo. On the other hand, fossils of dwarf dinosaurs in Europe, mammoths (in islands of California), elephants, hippopotami, and deer (in islands of Mediterranean and Indonesia), living dwarf deer in the Philippines, reindeer (in Svalbard), boa snakes of the Antilles or the extirpated dwarf Japanese wolf, Bali tiger, giant birds of New Zealand and Madagascar are classic cases of island evolution in the field of vertebrate palaeontology. The restricted scale, isolation, and sharp boundaries of islands create unique selective pressures. The reduced diversity of species on islands results in a reorganization of species interactions within island communities, and island species are generally subjected to reduced predation and competition between species that constrained size growth on mainland. Resource limitation may also explain dwarfism of the large species from mainland. The strength of the island effect on body size evolution is usually inversely proportional to the size of the island and positively related to the degree of isolation from the mainland source of the island population. The fossil record suggests that island species adapt to their new environment rapidly following isolation, through conspicuous changes in size and morphology. However, most of the time, it is assumed that the rate of evolution in island species is accelerated, simply because similar dramatic changes are not observed in their mainland relatives. However, not all island evolution has been rapid: many thousands of years (between 200,000 and 400,000 years) were required for Sicilian elephants, *Elephas falconeri*, to reach a height of less than 1 m and a body mass of 100 kg - about 1% of the mass of their mainland ancestor. The absolute changes in size are substantial, but the time span involved is relatively long. Some authors recently pointed out the ambiguity of the exact meaning of "rapid" when dealing with evolutionary rates. Evolution seems to happen so rapidly that, in most cases, we do not see the intermediate between the mainland ancestor and the island endemics in the fossil record; the small likelihood of fossilization of these intermediate forms may also be due in part to the small size of the founding population. Island species are often so distinct that we are unable to identify their specific mainland ancestor. For example, the phylogenetic relationships among dwarf elephants in the Mediterranean are still unclear. The character size of the ancestor population from the mainland increases by a small amount on the mainland. After the isolation of the population, there is a large and rapid increase of the size of this character. The rate of evolution on the island then decreases to values comparable to the rate values for the mainland population. Now, in a new study published in PLoS Biology, Virginie Millien of McGill University in Montreal, Canada, confirms that island species undergo accelerated evolutionary changes over relatively short time frames, between decades and several thousand years. She compared data from past studies on how fast the body sizes of 88 species of mammal have changed, based on differences in the size of fossils or living descendants. She found that mammals on islands evolve around three times as fast as their continental counterparts. From these datasets, she calculated a total of 826 evolutionary rates for 170 populations.

(Rates of evolutionary change are measured in units called, appropriately enough, "darwins"). Rates of evolutionary change, she found, decreased over time for both island and mainland species, with a slower rate of decrease for island species. The differences in the evolutionary rates between island and mainland pairs also decreased over time, becoming statistically insignificant for intervals over 45,000 years. Overall, island species evolved faster than mainland species--a phenomenon that was most pronounced for intervals between 21 years through 20,000 years. (One can imagine rats of horror movie proportions if such rates persisted for millions of years, but this really happened the Antilles islands of Anguilla and St. Martin, with a 200 kg fossil rodent (Amblyrhiza) !)"The size, isolation and boundaries of islands combine to create selective pressures that are quite distinct from those that act on the mainland. Also, these species often evolve from very small populations that are subject to genetic bottlenecks, which spur change", Millien says. Measuring rates of evolutionary change has proven difficult because the fossil record rarely captures every morphological shift in a lineage, precise dating isn't always possible, and it's often not clear when the ancestral form first appeared on the island. The finding that mammals evolve faster on islands, Millien argues, comports with the island evolution theory prediction that mammals respond to their new island homes with rapid morphological and size adaptations. The brisk pace of these changes may explain why the fossil record harbors few examples of intermediate forms between the mainland ancestor and island descendant. Millien found that evolutionary rates for different populations of the same species varied with island locale. Thus, the rate of evolution does not appear to be an evolutionarily conserved trait, like metabolic rate or whiskers."If island species can evolve quickly it stands to reason that mainland species retain a similar capacity". Mammal species have the intrinsic capacity to evolve faster when confronted with a rapid change in their environment. Because rodents make up nearly half of the world's mammalian species--and over 70% of taxa on some islands in this study--Millien repeated her analysis on a subset of the data with equal numbers of rodent and non-rodent taxa. The over representation of rodents had no effect on the results, which still revealed significant differences between island and mainland evolution rates for the same species or populations. As habitat destruction continues to pose the number one threat to biodiversity, many mainland habitats are beginning to resemble true island habitats, with isolated pockets of wildlife separated by degraded or developed lands. Most species are currently confronted with an extensive deterioration, reduction and fragmentation of natural, undisturbed habitats. Moreover, these habitat changes are accentuated by accelerated change in the global climate. One may suspect that morphological changes in response to fragmentation are similar to changes in island species. Thus, island species may serve as a model for understanding how mainland species will adapt to the rapidly changing environmental conditions brought on by habitat destruction and global warming. It appears that some mainland species are already responding like island species: a 1989 study followed the island rule in linking fragmented habitat to body size changes in 25 Danish mammals over the past 200 years. How long animals can continue to evolve in the face of these changes, however, remains to be seen.