Adaptations to life at high elevation: An introduction to the symposium

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Gradients in altitude represent natural experiments by providing substantial changes in numerous environmental parameters. Across different altitudes, temperature and humidity decrease in a manner similar to changes with increased latitude. However, unlike latitudinal variation, habitats along altitudinal gradients do not differ in day length or solar angle of incidence, but do yield dramatic changes in barometric pressure that influences diverse biological processes such as metabolic rate (Hammond \textit{et al.}, 1999) and aerodynamic performance (Altshuler \textit{et al.}, 2004). Because elevational belts can thus constrain physiological capacity, mountain zones can be functionally isolated habitats acting as islands in a sea of unsuitable habitat (Brown, 1971). When biogeography is combined with elevation-based physiological studies, mountains can serve as a powerful context with which to apply a mechanistic approach to community ecology as well as to evolutionary processes such as speciation. One of the more demonstrable examples of this type of integrated research program concerns the effects of climate change on extinctions of high-elevation taxa (e.g., Pounds \textit{et al.}, 1999).

Although the combined environmental changes across elevation influence physiological performance synergistically, these have nonetheless been mostly investigated in isolation. We organized this symposium with the hopes of stimulating the comparative study of high-elevation biology by including not only mechanistic breadth but also taxonomic diversity. Accordingly, the talks included both physiological and evolutionary impacts of elevational change for a variety of metazoan taxa, including alpine herbs and woody plants, arthropods that are constrained by mostly diffusive pathways for gas exchange, exothermic reptiles and amphibians, metabolically active and volant birds, mammals of varying body mass, and humans, who have often colonized high-elevation habitats.

The program was fully interdisciplinary, uniting otherwise seemingly unrelated themes such as speciation, respiration, aerodynamics, pollination biology, plant morphology, and the evolutionary context of high-elevation physiology.

Many of the presenters have graciously submitted articles to this issue, representing much of the mechanistic and taxonomic diversity present in the symposium. Beall (2005) examines alternative adaptations to hypoxia in separate human populations from the Andes, the Himalayas and the Ethiopian highlands. West (2005) examines human physiological adaptations to high elevation at several temporal scales, including both evolutionary adaptation and short-term acclimation at the highest altitudes where humans reside, as well as the response of climbers to the highest elevations on earth. Adverse effects of high altitude are of course not confined to humans. Monson and colleagues (2005) describe nutrient storage in alpine plants and its influence on growth, desiccation tolerance, and seedling survival. Navas (2005) explores how different responses to altitudinally variable temperatures influence the distribution and abundance of lizards and amphibians. The combined effects of temperature, oxygen, and air density on insect physiology, morphology, and behavior are described by Dillon and colleagues (2005). We took a similar approach for birds that takes into account the additional effects of variable wind speed and humidity, and also examine the consequences of elevational colonization by hummingbirds (Altshuler and Dudley, 2005). The influence of topography in general, and elevation in particular, on avian speciation is further discussed by Fjeldså and Rahbek (2005) for the tanagers, a Neotropical and species-rich family of passerine birds. Finally, in a highly integrative analysis, Ghalambor and colleagues (2005) combine altitudinal and latitudinal processes to test the prediction that...
tropical montane organisms are more limited by elevation than are temperate taxa.

The study of life at high elevation is a discipline that is growing rapidly through technological advances, heightened interest in mountaineering, and conservation concerns related to climate change. In 2000, a new journal entitled “High Altitude Medicine & Biology” was launched, and many new studies are describing how humans can train and climb at altitude, together with the health risks of these behaviors. Consequences of high elevation for the physiology and performance of diverse plants and animals have also been receiving enhanced scientific attention. We accordingly expect that the comparative biology of high elevations will continue to grow as a conceptually unified discipline, and will serve as a model system for further eco-physiological and evolutionary studies that links otherwise seemingly disparate research fields and study organisms.

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References


