Asymmetric boundary shifts of tropical montane Lepidoptera over four decades of climate warming

Abstract

Aim To estimate whether species have shifted at equal rates at their leading edges (cool boundaries) and trailing edges (warm boundaries) in response to climate change. We provide the first such evidence for tropical insects, here examining elevation shifts for the upper and lower boundaries shifts of montane moths. Threats to species on tropical mountains are considered.Location Mount Kinabalu, Sabah, Malaysia.Methods We surveyed Lepidoptera (Geometridae) on Mount Kinabalu in 2007, 42 years after the previous surveys in 1965. Changes in species upper and lower boundaries, elevational extents and range areas were assessed. We randomly subsampled the data to ensure comparable datasets between years. Estimated shifts were compared for endemic versus more widespread species, and for species that reached their range limits at different elevations.Results Species that reached their upper limits at 2500-2700 m (n= 28 species, 20% of those considered) retreated at both their lower and upper boundaries, and hence showed substantial average range contractions (-300 m in elevational extent and -45 km2 in estimated range area). These declines may be associated with changes in cloud cover and the presence of ecological barriers (geological and vegetation transitions) which impede uphill movement. Other than this group, most species (n= 109, 80% of the species considered) expanded their upper boundaries upwards (by an average of 152 m) more than they retreated at their lower boundaries (77 m).Main conclusions Without constraints, leading margins shifted uphill faster than trailing margins retreated, such that many species increased their elevational extents. However, this did not result in increases in range area because the area of land available declines with increasing elevation. Species close to a major ecological/geological transition zone on the mountain flank declined in their range

areas. Extinction risk may increase long before species reach the summit, even when undisturbed habitats are available.