Susceptibility Of Lycaenid Butterflies To Endangerment

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Millions of dollars have been spent in efforts to protect bears, whales, owls, condors, and other charismatic species that have caught the American public's limited attention. By comparison, imperiled invertebrates have been given short shrift, both in terms of allocation of funds and amount of public recognition. For example, insects constitute at least 90 percent of Earth's biota, yet they are represented by just 28 of the more than 1,000 taxa conferred protection under the federal Endangered Species Act. Moreover, those 28 protected taxa are hardly representative of the insects as a whole; 14 of them are butterflies, one of the very few insect groups for which studies have adequately documented distributions and abundances.

Nested within these otherwise dismal statistics is a potentially more hopeful one, a pattern that we think may help us to identify the hundreds, if not thousands, of other invertebrates that are in need of protection. Half of the butterfly species currently listed as threatened or endangered are lycaenids – the blue, copper, hairstreak, and metalmark butterflies – and lycaenids constitute just under half of the butterflies that are candidates for listing as endangered or threatened species.

Why are these numbers so important? They are surprising given that lycaenids represent just 20 percent of the butterflies in the United States. We suspect that lycaenids possess biological characteristics that put them at special risk, and may predispose them to local extinction. Understanding these characteristics may give us insight into the process of invertebrate extinction in general. In turn, these insights may assist in the identification and selection of other invertebrate taxa that may require protection in the future. We also believe that ongoing efforts to preserve lycaenid populations can serve as models to help land managers meet the many challenges posed by other invertebrate groups.

Subspecific differentiation. Not one of the lycaenid butterflies currently protected under the Endangered Species Act, and fewer than 20 percent of the candidates for this status, are full species. They are in fact subspecies, groups of populations that are physically distinct from other such groups. Indeed, lycaenids exhibit high degrees of physical variation: the ratio of subspecies to species in North America is more than twice as great for lycaenids than for other butterflies. Hence, more subspecies with limited geographic ranges will be at risk of extinction and available for protection. Clearly, invertebrate groups that exhibit high levels of variation may need extra conservation attention.

Dispersal abilities. While pertinent field data on butterfly dispersal are lacking for most species, the very few studies available suggest that lycaenids do not move great distances and that they are quite sedentary when compared to other butterflies. This observation is important because dispersal is essential for the persistence of isolated populations. Input of individuals from neighboring areas can bolster populations whose numbers are dwindling, thereby preventing local extinction. Dispersal also allows for the exchange of genetically distinct individuals between populations, increasing genetic diversity and contributing to the ability of populations to adapt to changing environments. Thus, we can expect invertebrates with limited dispersal abilities – like lycaenid butterflies – to be far more prone to local extinction than those with well-developed dispersal abilities.

Hostplant specificity and successional stages. Many butterfly species are very closely tied to one or a few larval hostplant species. All lycaenids currently protected in the United States not only have this characteristic, but they also use hostplants that tend to be found in early successional communities – habitats that are short-lived, transitional, and may arise unpredictably. Butterflies that specialize on such plants must track an ephemeral resource that itself may be dependent on unpredictable and perhaps infrequent ecosystem disturbances. Because of such specific associations, many lycaenids appear to be at great risk of local and regional extinction.

The endangered Karner blue (*Lycaeides melissa samuelis*) illustrates the costs associated with such specialization. Larvae of this subspecies feed exclusively on a lupine plant that is an early successional species restricted to pine-barren habitats. The existence of these habitats is highly dependent on the occurrence of intermittent fires. However, in New York state, fire suppression and habitat loss have significantly reduced the size and number of this butterfly's populations. A butterfly that was once widespread across much of the eastern United States, the Karner blue is now restricted to a dwindling handful of highly isolated habitats of rapidly diminishing quality.

Association with ants. The larvae of about half of the world's lycaenid species associate with ants, and the majority of these associations appear to be mutualistic – that is, both lycaenids and ants benefit. In such interactions, ants serve as pugnacious bodyguards by protecting lycaenid larvae from their many predators and parasites. Individual larvae commonly attract large bands of ants that aggressively patrol and swarm over the larvae and surrounding area. In return for this frenzied protection, lycaenid larvae provide ants with nutritional food rewards in the form of sugar- and protein-rich secretions. Ant-tended butterfly species are likely to be far more sensitive to environmental changes, and more prone to

Mission blue butterfly (Icaricia icarioides missionensis). *Photographed on Twin Peaks in San Francisco, California by Edward S. Ross.*

endangerment and extinction, than untended species. This is because such tended species simultaneously require the right larval food plant and a particular ant species – a combination that occurs infrequently and results in distributions of ant-tended lycaenids that are patchier than those for untended species. As a result, ant-tended lycaenids often exhibit especially reduced dispersal and may express traits associated with inbreeding, such as low levels of genetic variation.

The large blue butterfly (*Maculinea arion*) in Britain provides a sobering example of the consequences associated with a dependence on ants. During early larval stages, large blue larvae fed on wild thyme and, at the fourth instar, were carried by *Myrmica* ants into their nests, where the lycaenids fed on ant brood. Starting around 1950, the level of livestock grazing in the blue's grassland habitats was progressively reduced, due to changing agricultural practices and attempts to protect the habitat of this species (endangered even then). However, these altered grazing regimes had drastic effects on the lycaenid populations. The primary ant-species host persisted only in meadows that were closely cropped by livestock. Even slight reductions in grazing allowed a second ant species to exclude the primary ant host from the area, thereby leading to the butterfly's demise. Despite last-ditch efforts to manage habitat effectively, the large blue had declined to a point at which recovery was impossible, and it became extinct in 1979.

Conservation planning in North America. Subspecific differentiation, limited dispersal capacity, hostplant specificity, and dependencies on ant mutualists seem to have earned lycaenid butterflies their substantial representation on the endangered species list. We would venture to guess that other invertebrates that share these characteristics should be among those that become priority candidates for future study and perhaps their own listing. Furthermore, recent efforts to protect imperiled lycaenids might serve as models for future programs in invertebrate conservation.

Reflecting their dire circumstances, lycaenids have played central roles in the development of conservation policy and science in the United States. Three blue butterflies have been particularly visible in highly contentious land-use debates between developers and environmentalists. The mission blue butterfly (*Plebejus icarioides missionensis*) and San Bruno elfin (*Incisalia mossii bayensis*) were both conferred protection under the Endangered Species Act (ESA) in 1976, when the U.S. Fish and Wildlife Service recognized that encroaching urbanization had virtually encircled the known distribution of these subspecies. More than half of the habitat of the largest remaining known San Bruno elfin population on California's San Bruno Mountain had been lost during the 50 years preceding the listings, and half of the remaining grassland habitat of the mission blue (a quarter of the historical total) had been overtaken by invasive shrub and tree species.

Given that the mission blue occurred primarily on private land and the ESA only offered remedies for taxa on public lands, there was a pressing need for an innovative plan that would balance both biological and economic concerns. Such an approach was engineered by a committee comprising developers, environmentalists, government officials, and biological consultants. Using size estimates of mission blue populations, distribution records for larval hostplants, and information concerning the butterfly's natural history, the committee designed the first Habitat Conservation Plan (HCP). The plan protected 80 percent of remaining habitat on San Bruno Mountain, provided funds for the management and restoration of this habitat, and allowed for the development of the remaining land, which involved "take" of endangered mission blues. In 1982, the U.S. Congress amended the ESA to institutionalize habitat conservation planning, pointing to the mission blue conservation program as the model for this new process. Several dozen HCPs (many of them controversial) have been initiated in the ensuing decade.

In a second noteworthy case, a similar impasse between developers and environmentalists has arisen around the Karner blue butterfly in upstate New York. This federally listed subspecies, restricted to fire-maintained gaps in early successional habitats, exists as a handful of metapopulations (suites of neighboring local populations) that are dependent on a shifting mosaic of suitable habitat. The precarious state of the Karner blue has led to an extensive, broad-based effort to conserve the few populations that remain. Primarily through the joint efforts of The Nature Conservancy and the New York State Department of Environmental Conservation, approximately 800 hect-

San Bruno elfin butterfly (Incisalia mossi bayensis *Brown*). *Photographed on San Bruno Mountain by Edward S. Ross.*

ares of Karner blue habitat have been protected in the Albany Pine Bush Preserve. In addition, the New York State Legislature established the Albany Pine Bush Commission, charged with managing the remaining habitat. These and other programs have involved prescribed burning, host-plant propagation, and creation of effective corridors that promote butterfly dispersal. This innovative, multi-faceted program has set an important example for cooperative conservation and management.

Conclusion. A long history of human-induced habitat alteration and destruction is undoubtedly responsible for the decline and extinction of lycaenids worldwide. Pressure to develop and disturb lycaenid habitat in North America is likely to intensify in coming decades, and more listings of endangered and threatened species should be expected. Only an increase in the already considerable efforts to conserve lycaenids, and invertebrates in general, will prevent more of them from suffering the fate of the Palos Verdes blue, whose extinction in Southern California was recently documented. Establishment in 1971 of the Xerces Society, itself named for an extinct lycaenid, was an important step, as it has greatly increased the attention paid to insects and their conservation. The Endangered Species Act of 1973 and the use of Habitat Conservation Plans have been instrumental in facilitating the protection of threatened and endangered lycaenids on both public and private lands. Unfortunately, the U.S. government has added just a handful of insects to its list since 1981 – despite the fact that both habitat degradation and the list of invertebrate candidates for protection have increased considerably.

Although the ESA and the HCPs have proven to be powerful tools for conservation planning and management for lycaenids, they are nevertheless stop-gap measures designed to take effect usually well after species are in trouble. As attention continues to focus on these essential management efforts, considerable effort must also be directed toward dramatically reducing the wholesale environmental degradation that is responsible for the endangerment and extinction of lycaenids and the myriad species that co-exist with them. As many scientists and environmentalists have implored in this and previous issues of *Wings*, these long-term objectives must include stabilizing and then reducing the growth of human populations, rapid development and deployment of environmentally appropriate technologies, comprehensive changes in the system of economic accounting so as to accurately reflect the effects of our actions on the environment, and a detailed scheme for environmental education and research.

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San Bruno Mountain, overlooking San Francisco. Photograph by Gen Gurcar.