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Epidemic Disease and Amphibian Declines in Australia

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Introduction

The recent article in *Conservation Biology* by Laurance et al. (1996), proposing that "epidemic disease is the most likely agent" responsible for amphibian declines in Australian rain forests, is of great concern to the many amphibian biologists currently involved in research on "declining" frog populations throughout Australia. The notion that the amphibian declines in Queensland have been caused by a pathogen is an untested hypothesis with little empirical data. The following points regarding the evidence for epidemic disease should be considered before the disease hypothesis is adopted as the explanation.

Ecological Similarities of Vulnerable Species

The ecological similarities of the declining species discussed by Laurance et al. (1996) are also shared by additional species of frogs with stream-dwelling larvae that have not declined. Three species (*Mixophyes schevilli*, *Litoria lesueuri*, and *L. genimaculata*) have stream-dwelling larvae and are still found at high altitudes throughout the wet tropics region. This notion of a waterborne virus affecting only lotic species is therefore tenuous. Laurance et al. (1996) have not considered other high-altitude species in southern Australia (*Pseudophryne corroborree*, *Philoria frosti*, and *Litoria verreauxi alpina*) that have declined throughout the same time period (Gillespie et al. 1995). These alpine and subalpine species are not associated with stream environments and, accordingly, their declines are not directly explained by the virus theory. Furthermore, population declines have occurred primarily at high altitudes, but not all populations of high altitude amphibians have declined (Richards et al. 1993; Gillespie et al. 1995).

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The Extinction Wave Pattern

The hypothetical virus is discussed as having been transported up the Queensland coast by an unknown host or vector. The calculation of a northward spread at 100 km per year is based on three samples from southeast Qld, central Queensland, and the wet tropics, not on the number of points presented in the accompanying figure (Fig. 2 in Laurance et al. 1996). When the ignored data point in that figure is included, the use of regression is questionable. In the absence of any consistent or rigorous population monitoring in Queensland during this period, the perceived northward spread may be an artifact of the time at which each report of decline was made. Furthermore, the declining frogs of southern Australia were not included in the predicted spread of the hypothetical disease. For example, the decline of Corroborree Frogs in southern New South Wales since 1979 has been well documented (Osborne 1989). This seems too coincidental to be overlooked when the pattern of the declines is determined.

Rapid Decline of Affected Frog Populations

Although there is evidence that some frog declines have been rapid (e.g., *Rheobatrachus* spp.), this has not always been the case. The perceived pace of the decline in the wet tropics may be an artifact of sampling design because declines have been reported, albeit anecdotally, since 1985. In other parts of Australia the decline of *Pseudophryne corroborree* has been continuous since 1979 (Gillespie et al. 1995), and the decline of *Philoria frosti* in Victoria has been recorded over many years: 1985–1996 (Hollis 1995).

Pathological Evidence

Laurance et al. (1996) have focused on a virus as the pathogen likely affecting the animals that were collected

from the declining populations in 1994. The natural occurrence of viruses in native Australian frogs is not well known. Although the pathology of the dying frogs suggests a viral infection, no virus has yet been isolated from the sick and dying frogs examined. It is important to consider that, if a virus is isolated, it does not automatically explain the observed declines. Many questions need to be answered. Do all of the species of sick and dying frogs harbor a virus? Is it one virus? Are the virus or antibodies to the virus still found in the species that persist in the upland streams?

Our field experience suggests that it is not unusual to encounter small numbers of sick or dying frogs in the wild. The discovery of a small number of dead or dying frogs at one location, at one time, may not suggest widespread epidemic disease but rather a more localized phenomenon. It may have been a secondary infection from another agent or an opportunistic infection; the frogs may be susceptible to disease because of another environmental stress. The susceptibility of amphibians under environmental stress to secondary infections has been suggested for North American amphibians (Carey 1993).

Persistence of Lowland Populations

Although frogs have declined primarily in high-altitude sites, this has not been consistent across all sites. When the alarm was raised in 1993, several populations of "declining" frogs were still found at higher altitudes (Richards et al. 1993). Since then, new populations of *Litoria nannotis* and *L. rheocola* continue to be found at high altitudes (Hero 1996). Clearly, the declining frogs in the wet tropics have not disappeared from all high-altitude sites and are not excluded from them. Further research is required to investigate the high-altitude sites where these species are still found and to compare them with the sites where they have not been found for many years.

Absence of Plausible Alternatives

The lack of alternative hypotheses is the major strength of the conclusions in Laurance et al. (1996). Rather than test a hypothesis, they suggest it as the only plausible explanation. The disease hypothesis is based on weak evidence and, as we have indicated here, is no more compelling than alternative hypotheses. Alternative hypotheses for global declines have been suggested and discussed extensively (Blaustein & Wake 1995). Laurance et al. (1996) do not discuss the relevance of their hypothesis in a national or global context. This disease hypothesis requires rigorous experimentation and investigative research before it should be accepted. Automatic dismissal of alternative hypotheses without this research is a matter of concern.

Potential Vectors

The suggestion that a hypothetical iridovirus was introduced by an ornamental fish is purely speculative. Fish and amphibians are known to have iridoviruses of similar structure and function, but no fish iridovirus has been known to infect a frog. It should be noted, however, that an amphibian virus has been shown to infect fish under laboratory conditions. Introduced freshwater fish are few and are usually specific to either the tropics (tropical aquarium fish) or the temperate regions (trout species), although some species may be widespread (e.g., carp and mosquito fish). The movement of these species from one catchment to another is not known. Many introduced fish are spread by humans into farm dams and lakes, primarily at low altitudes, yet there is no evidence of widespread decline among pond-dwelling amphibians.

In addition to these problems, a suitable vector that could facilitate the transmission of a pathogen from one high-altitude stream to another has not been identified. The hypothetical virus is clearly only effective at high altitudes, but the infected potential vector must have traversed thousands of kilometers through lowland terrain, where, it is suggested, the virus is less virulent. Furthermore, if a virus was spread by a tropical organism (fish, toad, or insect), then it is not reasonable to conclude that it would be less virulent in lowland areas. A tropical pathogen is predicted to be less virulent in upland areas and lower latitudes where the temperatures are cooler and hence subtropical in climate.

Exotic Pathogens and Amphibian Declines

The article by Laurance et al. suggests that the problem of declining frog populations in Australia is now understood. This is far from the truth, and only an enormous amount of research by amphibian biologists, in conjunction with epidemiologists, will enable us to test the epidemic disease hypothesis. The evidence presented by Laurance et al. (1996) to explain the amphibian declines in eastern Australia is consistent with the expected effects of a highly virulent pathogen only when a significant amount of information is ignored. Like all proposed hypotheses, the pathogen theory may be valid. But it too must be tested thoroughly before any conclusion can be reached.

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