Wildlife disease biology comes of age

Infectious diseases are of growing concern among wildlife conservationists. Although the potentially devastating impact of introduced infectious disease on wildlife populations was first realized in the latter part of the 19th century following the introduction of rinderpest into Africa (Metzler, 1993), the extent by which wildlife diseases can undermine conservation efforts is still underestimated (Scott, 1988; McCallum and Dobson, 1995).

Disease is a particular risk for endangered animals with reduced population size and restricted range, and for animals that are part of managed conservation programmes where ecological factors are artificially manipulated (Cunningham, 1996). This reflects the delicate nature of the dynamic equilibrium that exists between host and parasite populations (here we use the term parasite in its broadest sense to include bacteria, viruses and other infectious agents) and this balance is often the product of millions of years of competitive coevolution (Anderson and May, 1978; Lyles and Dobson, 1993). Parasites are a major selective force on the evolution of animal populations, probably important enough to drive the evolution of sex itself (Hamilton *et al.*, 1990). If parasites can exert such an influence under natural conditions, what are the effects of this influence on populations under pressure from habitat destruction and fragmentation, or on animals in manipulated environments or in captive breeding and release programmes?

Two recently published papers demonstrate the alarming extent of the influence of parasites on animal populations in the modern world. The first deals with amphibians, which are undergoing population declines in Europe, Australia, Central America and North America. Hypotheses abound for the cause of these declines (Wake, 1991); however, these remain unproved. A new disease has recently been reported, which causes amphibian mortality in epidemic proportions in rain-forest species in both Australia and Central America, and in association with population declines (Berger *et al.*, 1998). This new epidemic disease is caused by a new genus of chytrid fungus, a primitive member of the fungal kingdom. The parasite infects the superficial, keratinised layer of skin in a range of frog and toad species and has been shown to cause the death of the host following experimental transmission.

The organism was first noted in 1993 by researchers working on a project funded by the Australian Government at James Cook University and the CSIRO and was then found in amphibians from Central America in 1997. This relatively contemporaneous appearance of chytridiomycosis on two continents is striking. Even if the organism has been missed for a couple of decades (and this is quite possible because gross lesions are often not apparent) the disease is a recent and rapidly spreading phenomenon.

The second report concerns snails of the genus *Partula*, which are endemic to islands in the South Pacific. Predation of these molluscs by the introduced snail *Euglandina rosea* (released to control previously introduced *Achatina* sp.) has led to a series of *Partula* extinctions across a number of these islands. Captive breeding has become a crucial part of the conservation programme for the genus and 15 species now occur solely in captivity (P. Pearce-Kelly, pers. comm.). Captive populations, however, are subject to periodic crashes, which have led to species becoming extinct in captivity (and therefore globally). Results of post mortem examinations of *P. turgida* (including the last individual of the species), the most recent partulid to become extinct, are reported in the October edition of the journal, *Conservation Biology (Cunningham and Daszak, in press)*. The cause of death of each individual examined was extensive destruction of the digestive gland by a protozoan parasite of the microsporidian genus *Steinhausia*. Previously, authors have proposed that infectious diseases may have caused historical extinctions (for example Hawaiian birds, see Van Riper *et al.*, 1986; the thylacine, Guiler, 1961) but these remain unsubstantiated (McCallum and Dobson, 1995). The description of the extinction of *P. turgida* is therefore the first definitive account of an infectious agent causing the extinction of a species (albeit that the original decline was due to other causes).

What do these reports tell us about the impact of disease on endangered and threatened species? Because the nature of the amphibian epidemics are consistent with the introduction of a pathogen into a naive population, the findings suggest that a new pathogen introduced to a previously unexposed and fragmented population (factors augmented by a shrinking habitat) can lead to decimation from which the species cannot recover. Perhaps the lesson to be learnt here is that in the modern world, with the movement of humans into once pristine habitats and the introduction of alien parasites (a form of 'pathogen pollution'), local outbreaks of disease can become epidemic or even pandemic (Halliday, 1998), leading to local or perhaps global extinction.

Both papers provide evidence to suggest that tipping the balance in the parasite–host dynamic equilibrium can have serious consequences for wild and captive populations. In the case of amphibians, we have evidence for multi-species mortality forming part of a network of global population declines possibly threatening a class of animals. However, perhaps the most important message comes from the *Partula* study – that in this altered world, there may be no limit to a parasite's impact on the population of a host species. The precedent has now been set: extinction by infection.

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Extinction by assumption; or, the Romeo Error on Cebu

One of the most challenging of all species conservation projects is currently being taken on by FFI on the Philippine island of Cebu: the target is a tiny remnant patch of forest (3 sq km) called Tabunan, the only currently known locality for the Cebu or four-coloured flower-