Impact of *Ranavirus* on garden amphibian populations

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ABSTRACT - Many species of amphibians have bred in a Woodingdean garden pond for more than 30 years. In summer 2007 an outbreak of *Ranavirus* occurred and this paper describes its impact on three species of anurans living wild in the garden and two species kept in an outdoor vivarium. Common frog *Rana temporaria* numbers were reduced by >80%. Common toads *Bufo bufo* decreased by perhaps 20% whereas pool frogs *Pelophylax lessonae* were scarcely affected. A single natterjack *B. calamita* died in the vivarium where at least five survived, but all midwife toads *Alytes obstetricans* (adults and larvae) in the same enclosure perished. There was no sign of recovery of the common frog population over the ensuing five years.

Ranavirus infections have been decimating frog populations in southern and eastern England for several decades (Cunningham et al., 1996). The disease mostly affects *Rana temporaria* in the UK, though there are reports of common toad *Bufo bufo* mortality as well. Unlike North America where vulnerable species are often killed at the tadpole stage (Gray et al., 2009) common frogs mainly die as adults during the summer months. Garden ponds at Woodingdean in Sussex, England have supported several species of amphibians for more than 30 years (Beebee, 2007). In the summer of 2007 *Ranavirus* arrived. Here I describe the consequences of this infection in that year and in the five years following. Numbers of common frogs and toads assembling to breed were best estimated by counting spawn clumps or peak numbers of adults respectively, in early spring. Water frogs were the largest number of individuals seen basking on one occasion each year, usually in April. Dead animals were the sum of those observed in the garden and outdoor vivarium throughout the mortality period.

RESULTS AND DISCUSSION

At total of 32 dead and dying *R. temporaria* including adults of both sexes, and immatures, turned up in the garden between June and September 2007 with a peak after midsummer (Fig. 1). No dying tadpoles were observed but a metamorph was found expiring at the pond edge. This was among several individuals collected by Amanda Duffus from the Institute of Zoology, London who later confirmed *Ranavirus* as the pathological agent. Three common toads were also found dead but water frogs (mostly *Pelophylax lessonae*) were apparently unaffected. On two occasions male pool frogs were separated from amplexus with dead common frogs but no sick or dead pool frogs were ever seen. Similarly, no newt corpses were found in the ponds. However, the disease somehow entered an outdoor vivarium sustaining small breeding populations of *Bufo calamita* and *Alytes obstetricans*. A single natterjack died in August, presumably from *Ranavirus* infection though that was not confirmed. There was no other obvious cause and natterjack deaths have not otherwise been seen in the vivarium before or since. The remaining natterjacks (five adults) survived without sign of infection. Unfortunately the consequences for midwife toads were devastating. Their tadpoles in the vivarium pond all died early in August and soon afterwards so did every adult (nine altogether), including one which had escaped into the garden and in which *Ranavirus* was confirmed. High susceptibility of

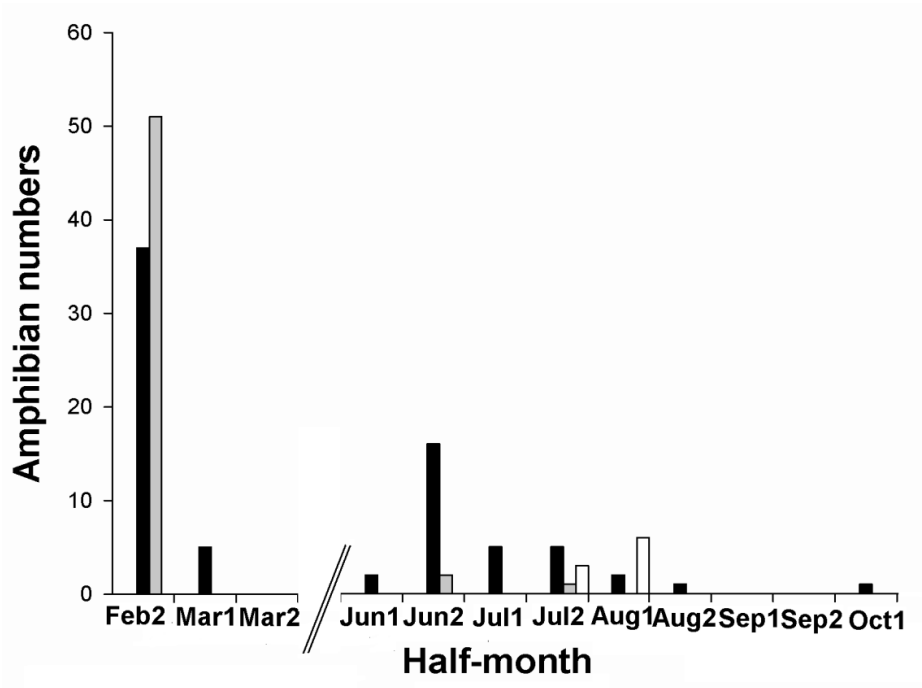

Figure 1. Amphibian breeding and mortality during 2007. Dark bars: *Rana temporaria* spawn clumps (spring) or dead animals (June onwards). Pale grey bars: Numbers of *Bufo bufo* breeding in spring or found dead in summer. White bars: Numbers of *Alytes obstetricans* dying in the vivarium.

midwife toads to this pathogen has also been observed in Spain (Balseiro et al., 2009). A common symptom in all species when suffering from late-stage disease was emergence from cover and an attempt to reach water. Overall the pattern of susceptibility could not have been predicted on the basis of taxonomic relationships among amphibians in the garden. *Rana* is much more closely related to *Pelophylax* than it is to *Bufo* and *Alytes* is phylogenetically distant from all the rest.

Fig. 2 shows numbers of common frogs, pool frogs and common toads assembling to breed in the Woodingdean ponds for several years before and after the *Ranavirus* outbreak. These numbers confirmed the impression of events seen during summer 2007. Common frogs were badly hit with numbers declining by just over 80%. This decrease, based on counts over 2008-2012 compared with 2003-2007, was highly significant (Wilcoxon rank sum test, U = 25.0, exact P = 0.008). On that basis about 40% of the frogs presumed to have died were actually found in the garden during summer 2007. Frogs have continued to breed every year since but with, as yet, no sign of recovery to their previous population size. This mortality rate was similar to the average declines reported in a wide-ranging study of *Ranavirus* effects in England (Teacher et al., 2010). Toad numbers were fewer, on average, after the outbreak but only by about 20% (an insignificant difference, P = 0.389) and water frogs also did not decline substantially although there were insufficient pre-2007 data for formal testing. No dead amphibians were found in the garden in any year subsequent to 2007. The mechanism by which *Ranavirus* causes mortality in summer remains mysterious. Deaths began several months after the animals congregated together for spawning and then extended over many weeks. Frogs and toads are solitary after the breeding season and live mostly away from water. Two midwife toads given to a friend just before the outbreak began survived for two weeks in a vivarium and then both died on the same day. Evidently there is a period of latency during which

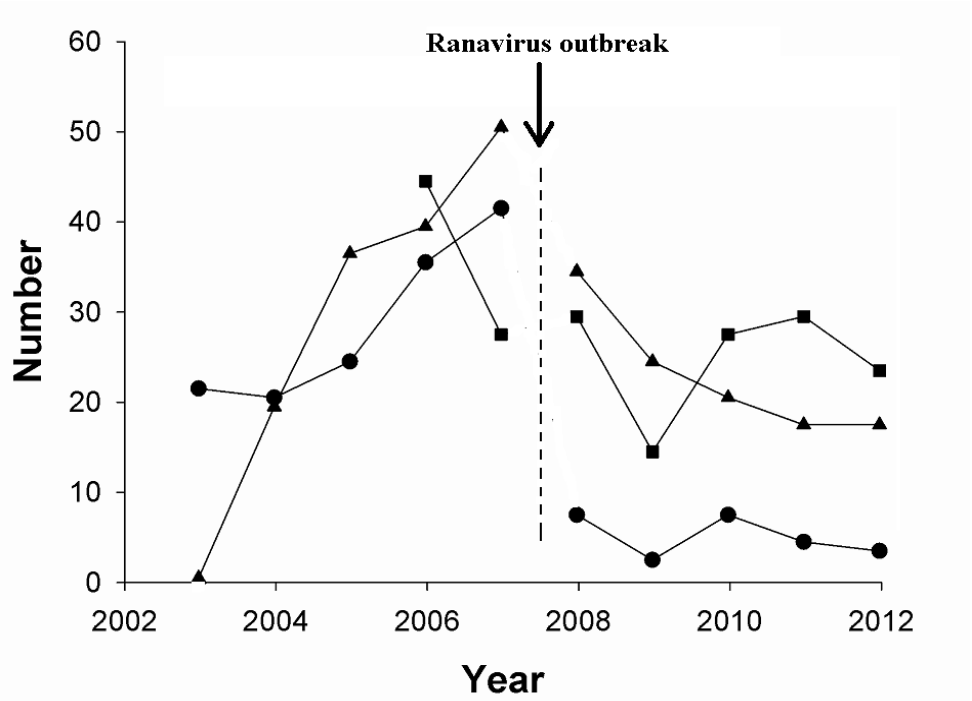

Figure 2. Amphibian numbers in the Woodingdean ponds, 2003-2012. ●, *R. temporaria* spawn clumps; ▲, *B. bufo*, largest number seen on single night; ■ , *P. lessonae*, largest number seen at one time basking in spring (no counts before 2006).

the infection develops but surely not long enough to explain the twelve week gap between spawning and the first dying as seen in Woodingdean. However, *Ranaviruses* may survive for long periods in water or on soil and have a fairly wide host spectrum so either or both of these properties may facilitate delayed infection.

ACKNOWLEDGEMENTS

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