Even a small cane toad can provide a fatally poisonous meal for a large predator like this Mitchell's Water Monitor. Photo: Michelle Gray

Controlling Cane Toads Ecologically

BY RICK SHINE

Although physical removal of the cane toads that are plaguing northern Australia has failed to slow the invasion, some promising new approaches to toad control are emerging from research into the invaders' basic biology.

With their strong physical resemblance to a mobile cowpat, cane toads are the giant frogs that most Australians love to hate. Brought from their native South America to coastal Queensland in 1935, these large warty invaders have since spread across more than a million square kilometres of northern Australia.

Many millions of taxpayer dollars, and thousands of hours of community effort, have gone into attempts to control the expanding toad population. But basically, it hasn't worked: indeed, the toads are spreading more and more rapidly.

Why has all this effort failed to slow down the toad invasion and are there better ways to attack the problem? New ecological research is suggesting some answers to these questions.

People want to eliminate cane toads for lots of reasons, ranging from revulsion at the toads' appearance through to concern for their impact on biodiversity. And there's no doubt that the toads have exacted a huge toll on native animals. Many Australian predators that consume frogs also try to eat the newly-arrived toads, and are killed by the toad's powerful poison. In particular, toad invasion has massively impacted populations of northern quolls (cat-sized carnivorous marsupials), large varanid lizards (goannas) and snakes (such as king browns and death adders).

So far, most of the effort into controlling toads has gone into two approaches: one very simple and one very high-tech. The simple approach has focused on community-based attempts to catch and kill toads by hand-collection ("toad musters"), traps, fences and the like. Volunteers go out at night, catch as many toads as they can, and then kill them (usually by gassing or freezing).

Lots of toads have been captured and killed in this way. For example, a recent "Stop The Toad" muster killed 68,000 toads within a month, and the Kimberley Toad-Busters have accounted for more than 250,000 adult toads. These are huge numbers, so why hasn't the toad invasion front been slowed down?

The answer lies in toad biology. A female toad can reach sexual maturity at a few months of age, and can produce up to 30,000 eggs in a single clutch. So, all of those massive toad-kills by the community groups equate to only about 10 clutches of eggs!

Unfortunately, the high reproductive rate of toads means that it's almost impossible to remove them faster than they can replace the losses – in effect, the challenge is more like trying to control an insect than a vertebrate. Mathematical models by Hamish MacCallum of the University of Tasmania show that the toad-catchers would have to remove 25% of the entire population every month to seriously reduce toad numbers. It's just not possible, even with the enormous effort and enthusiasm shown by the community groups to date.

If we can't control toads by simple physical removal, can high-tech methods work? The CSIRO tried to develop a genetically-engineered toad-killing virus, but work on this project has now concluded without any useable weapon. Part of the problem was the potential for collateral damage: even if a suitable virus could have been constructed (and the technical challenges were immense), it might then pose a threat to toads of other species. Toads occur almost worldwide, including in areas of Asia very close to the cane toad's Australian range. The risks simply outweigh the benefits.

Fresh Leads to Vulnerabilities

Some more encouraging news about toad control has emerged more recently from an unexpected direction. My research group ("Team Bufo") at the University of Sydney has been funded by the Australian Research Council to investigate toad biology and impact. This is "blue sky" research designed to help us understand the dynamics of a biological invasion rather than to develop new methods for control. But, as we have accumulated more and more information on toad biology, potential vulnerabilities of the cane toad have become obvious – setting the scene for a novel approach to toad control based upon a detailed understanding of the invader's biology.

One fundamental problem with any program to control an invasive species is collateral damage. Whatever we do to stop the invader must have little or no effect on native species (like native frogs, which are similar to cane toads in many ways). This means that characteristics distinctive to the cane toad – not seen in Australian frogs – offer vulnerabilities that we might exploit for toad control.

The first of these emerged from Mattias Hagman's PhD research in the Northern Territory, and Mark Semeniuk's Honours work in northern New South Wales. In both of these places we found that cane toads select very specific kinds of ponds for spawning – ponds that are ignored by most Australian frogs.

The toads like shallow pools with gently sloping edges and very little vegetation on the bank, whereas many frogs prefer just the opposite. So, we might be able to modify the landscape to make ponds unsuitable for toads, in which case we can concentrate their breeding in a smaller number of water bodies. This would help us to use the toads to control themselves, because toad tadpoles

Meat-ants (*Iridomyrmex reburrus*) attacking a metamorph cane toad beside a tropical billabong. Photo: Georgia Ward-Fear

compete with each other, toadlets eat each other, and so forth. Therefore convincing many of the local toads to breed together in the same place could greatly reduce the number of adult toads recruited into the population the following year.

The second breakthrough also came from Hagman's work. He found that cane toad tadpoles communicate with each other with special pheromones that are ignored by native tadpoles. Basically, the South American toads speak a different language than the Australian frogs. For example, cane toad tadpoles signal the presence of a predator by releasing alarm pheromones from glands in their skin, and those chemicals cause other toad tadpoles to flee.

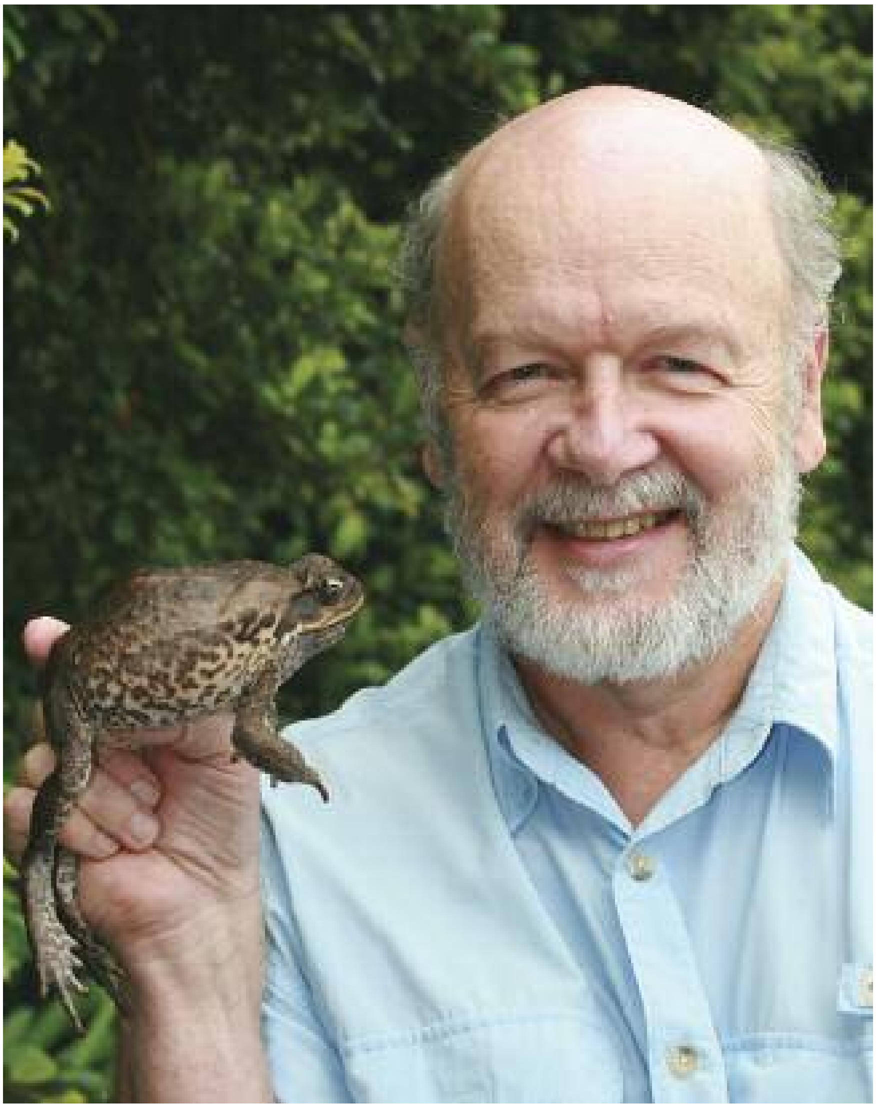
The ferocious looking head of an Australian meat-ant.
Photo: April Nobile / www.antweb.org

In our trials in outdoor ponds, consistent exposure to these alarm chemicals stresses the toad tadpoles so that up to one-third of them die before they complete development. Native tadpoles simply ignore the chemical – they probably don't even detect it – so we have a toad-specific weapon to kill tadpoles. Furthermore, the toad tadpoles that do survive long enough turn into miniaturised toadlets that are much more vulnerable to other risks, such as drying out or being eaten by a local predator (the toads have very little poison at this stage of their life).

More recently, Michael Crossland has found another toad pheromone that seems to be equally useful, but in this case it attracts toad tadpoles instead of repelling and stressing them.

Fresh Leads to Parasites and Meat-Ants

The next toad-specific weapon is a parasite: a nematode worm that lives in the



A cane toad confronts Prof Shine. Photo: Terri Shine

toad's lungs. Crystal Kelehear's Honours research showed that infection with this parasite is often fatal for small toads.

Analysis of DNA sequence data by Sylvain Dubey showed that the parasite in question is a South American species that was brought to Australia with the cane toad. So far we have never found it in any Australian frogs.

Some populations of Australian cane toads lack the parasite, so we might be able to use the lungworm to help control numbers and sizes of toads by building up lungworm numbers. Ligia Pizzatto is currently running trials to check that doing so would not put any of the local frogs at risk – a critical issue before we can begin trying to use the parasite for toad control.

Our fourth toad-specific weapon is the humble Australian meat-ant. These large ants are common across northern Australia, and anecdotal reports of ants consuming small cane toads have been cropping up for years. Georgia Ward-Fear looked more closely at this topic during her Honours year, and found that cane toads are surprisingly bad at avoiding predatory meat-ants. The native frogs she tested are good at it: either they are active in places and at times when the ants are not, or the frogs keep a wary eye on ants and hop away if one approaches.

In contrast, young cane toads are active in exactly the wrong place (the edge of the water body) at the wrong time (daylight hours) and simply ignore the ants until they attack. Even then, the toad's response is ineffective: they simply cease moving and allow themselves to be dismembered by the foraging ant.

It seems that a few million years of co-evolution have allowed Australian frogs to adapt to the meat-ants' presence, but the newly-arrived South American interlopers have had no opportunity to learn this lesson – there are no such ants in the toad's native range.

Integrating Ecological Knowledge

So can we use this newly-gained ecological knowledge to help with toad control? The answer may lie in an integrated approach, similar to the kinds of systems

A male toad calling. Photo: Matt Greenlees

developed by agricultural scientists to deal with insect pests (remember, the toad has a life-history more like an insect than a typical terrestrial vertebrate). There's still a long way to go before we can implement these new weapons, but the outlines of a possible approach are becoming clear.

First, a change in the landscape – like allowing grass to grow all the way to the water's edge – could be used to concentrate toad breeding and thus intensify competition and cannibalism (it's a toad-eat-toad world out there!). If we can work out the chemical identity of the toad's alarm pheromone we could spread synthetic pheromone in breeding ponds to kill toad tadpoles but leave the natives unaffected. Similarly, we could use the attractant pheromone to bring toad tadpoles into traps.

If the lungworm parasite turns out to be toad-specific (and our data so far are very encouraging) we could build up parasite numbers to infect and kill small toads and stunt the growth of the survivors.

And we can probably make life a little better for the meat-ants, and a lot worse for the toads, by laying baits to encourage meat-ants to forage down near the water's edge at the times and places that young toads are emerging.

Clearly we can't just jump in and start applying these methods. The history of the cane toad itself – and many other horror stories about other species – tell us that biocontrol is a tricky business, and that any proposal to manipulate complex native ecosystems needs to be approached carefully.

Most importantly we need to assess the potential for collateral damage – it would be a hollow victory indeed if our new approach reduced the numbers not only of toads but of some native species as well. But such issues are fairly easy to evaluate with small-scale controlled experiments, and these are already underway with promising results.

The ecological approach will never give us a "silver bullet" to eradicate cane toads from the Australian landscape, but it promises to give us methods to reduce toad numbers without harming other species. If this ongoing research program ultimately does yield an effective set of strategies to control the hated cane toad it will be a striking example of the advantage of "knowing your enemy"; that is, of understanding the nature of the problem before you invest too heavily in single-minded and ultimately ineffective solutions.

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