

Litoria rheocola, the
armoured mist frog

Frog lore

Too little too late?



*Stream-dwelling frog
species are disappearing
from Queensland
rainforests. John van
Tiggelen discovers that
nobody really knows why.*



Litoria genimaculata, the green-eyed tree frog



VIEWED from the resort town of Port Douglas, the lone blue silhouette of Thornton Peak appears rarely to doff its cap of clouds. On closer inspection, from the banks of north Queensland's Daintree River, the peak's lush slopes rise through the mist toward a saddle said to be studded with massive hunks of orchid-clad granite.

Cape York's highest mountain shelters several animal species not found anywhere else. Its immense conservation value means access is restricted to rangers and researchers in the main, and only the more adventurous ones at that.

Late last year, the peak lured Dr Jean-Marc Hero, a James Cook University zoologist in search of the tropical highlands' four missing rainforest frog species. Elsewhere they had disappeared suddenly, and the towering mountain seemed a

likely last refuge. One of the species, the armoured mist frog (*Litoria lorica*), has only ever been sighted atop Thornton Peak, though not since 1991.

Hero planned a meticulous campaign. After training 38 observers using taped frog calls and a guidebook (both of which he co-produced), Hero split the group into eight teams. Half scaled the peak from four different sides, while the remainder scoured plateaus further north.

The 'spotters' combed hundreds of kilometres of streams for frogs by night and tadpoles by day. But the result was disappointing. They found just one juvenile specimen of the most recent species of the four to go missing: the sharp-snouted day frog (*Taudactylus acutirostris*). The survey confirmed Hero's worst fears. Something was killing Queensland's frogs.

Could a virus be the cause?

The frogs' disappearance has bamboozled scientists for years. In 1988, upland rainforests of north-east Queensland gained World Heritage status. Despite the protected conditions, stream-dwelling frogs have mysteriously declined at altitudes above about 400 metres. Lowland populations, however, appear unaffected.

Dr Bill Laurance, an ecologist with CSIRO's Tropical Forest Research Centre at Atherton, believes he knows the cause. Laurance, together with biologist Keith McDonald and virologist Rick Speare, proposes that a virus is cutting a swathe through frog populations along the east coast.

In support of their hypothesis, the research trio points to an apparent 'extinction wave' travelling through Queensland's montane forests. In south-eastern parts of the state, five frog species declined in number by more than 90% about 15 years ago. Two of them, the southern day frog (*T. diurnus*) and the gastric-brooding frog (*Rheobatrachus silus*), have not been seen since 1979 and 1981 respectively.

The suspected epidemic next struck frogs of the Eungella rainforest, near Mackay. The northern gastric-brooding frog (*R. vitellinus*) vanished in 1985, as did the Eungella torrent frog (*T. eungellensis*), although the latter appears to be recovering since its rediscovery in 1992.

The southern declines sparked fears that frogs of the highland rainforests between Townsville and Cooktown were at risk. Sure enough, scientists were soon documenting their demise in the

early '90s. Even so, for a few years it seemed that the Daintree River might barricade the northward spread of the disease.

But no. As part of a monthly monitoring program on the Big Tableland, the northernmost range of the wet tropics, McDonald, who is a chief ranger with Queensland's Department of Environment and Heritage, watched the frogs die before his very eyes during visits in late 1993.

'The population on the Big Tableland was going great, even as we lost them on Windsor (another tableland to the south),' McDonald says.

McDonald began finding lethargic frogs with discoloured skin and swollen legs. Within three months, a suite of three species had disappeared.

'Places where you could hear frogs calling everywhere were now in dead silence. It's the most eerie feeling you can have,' he says.

McDonald's first-hand observations of sickly frogs, and the general pattern of extinctions, support the view that an epidemic disease is responsible. According to Laurance, several other lines of evidence independently point to an exceedingly virulent pathogen on the move.

Firstly, all affected frog species live near streams. A water-borne infective agent would explain why the declines are so comprehensive. Secondly, the fact that upland rather than lowland species are infected suggests that a lower ambient temperature could be a factor, either by lessening the immune response of the frogs (as has been shown for cane toads), or by providing optimal conditions for a virus.

Thirdly, the research trio has identified a suspect. In 1989, Rick Speare, from James Cook University, isolated a new iridovirus from a frog of the open forest. He called it the Bohle virus, after the region north of Townsville where it was found.

Iridoviruses commonly infect amphibians, fish and insects and can be extremely pathogenic.

Upon examining the moribund frogs sent in by McDonald from the Big Tableland, Speare found himself in familiar territory. His microscope revealed cell changes consistent with the Bohle virus infection that he had described five years earlier.

'So far the Bohle virus fits,' Laurance says. 'When the question of temperature range came up, Rick recalled that when he infected frogs with the Bohle virus, they died in air-conditioned offices, but not outside the lab. This suggests it may thrive in uplands while remaining viable for transmission in lowlands.'

Laurance says that the virtual 100% mortality rate implies that the frog populations are immunologically 'naive' in that they have not acquired any resistance to the virus as a consequence of previous infections. This leads Laurance to believe that the virus has been introduced from overseas, possibly via the trade in aquarium fish. It is not inconceivable that the same virus has been responsible for similar declines of frogs around the world, he says.

Old explanations defied

In the past, researchers have proposed that large-scale environmental changes have been responsible for the frog declines. Due to their permeable skins and aquatic surroundings, frogs have come to be considered as sensitive 'bio-indicators' of subtle environmental changes.

American studies have reported that increased UV-B exposure due to the thinning of the ozone layer above temperate regions can harm otherwise healthy frogs. Global warming, acid rain and so-called 'killer fogs' (mist droplets containing pesticide residues from farmed regions) have all been flagged overseas as possible causes. And less subtle degradation due to habitat destruction, urban development and river pollution continues to have an enormous impact.

But none of the above factors has been shown to play a significant role in the shaded environs of Australia's tropical rainforest. Neither can upsets in natural predator-prey relationships sufficiently explain the declines, because cane toads and feral pigs would be expected to affect lowland populations just as much, if not more.

Laurance recently analysed long-term weather records throughout eastern Queensland to explore whether frog declines could be linked with unusual weather patterns. He found that most weather stations reported less annual rainfall and warmer summers than usual during the five years preceding the frog declines. 'In general, however, the moderate deviations, from long-term averages at each site, appear to be an

The Australian lace lid (*Nyctimystes dayi*): very rare.

Steve Richards

inadequate explanation for the dramatic frog declines,' he says.

Laurance says the absence of plausible alternatives supports the hypothesis that an epidemic is wiping out frogs.

Dr Ross Alford, who heads James Cook University's frog program, is not so sure. He says the wave of extinctions is based on just the loose clusters. 'I have a problem with the idea of a virus epidemic, particularly the idea that it has spread northwards at about 100 km a year,' he says.

Alford says that frog populations at Mount Spec, north of Townsville, declined several years after the demise of populations further north.

'There is a serious lack of evidence for the spatial structure in the timing of tropical declines south of the Daintree,' he says. 'Also, to reach upland areas the virus must have crossed vast tracts of lowlands.'

No potential vector has yet been put forward with any degree of confidence, although candidates include cane toads, fish, mosquitoes and parasitic fly larvae which burrow into the skin of frogs.

According to Alford, the possible link between declining species and their ability to handle dry spells has yet to be discounted. 'If frogs that are good at preventing water loss are not declining, then that would be very interesting,' he says.

But Alford and his colleague Hero agree that the epidemic hypothesis is a legitimate one that needs proper testing. Hero says the virus hypothesis is popular because 'it is the only one we have that vaguely makes sense'.

Alford favours some climatic factor, perhaps combined with an endemic virus. 'It is possible that extreme dry seasons are an environmental stress that could cause normal infections to become more severe,' he says.

But climatic conditions in rainforest can be patchy, and precise data for this patchiness is lacking. Alford is reluctant to rely on the available data for rainfall, for example, because rainfall is regionally variable.

Laurance acknowledges that the virus hypothesis has not won universal acceptance. He says Alford's environmental co-factor idea is plausible, but 'until someone comes up with a

mechanism, an actual smoking gun, then I still have to regard the disease hypothesis as the prime reason for declines'.

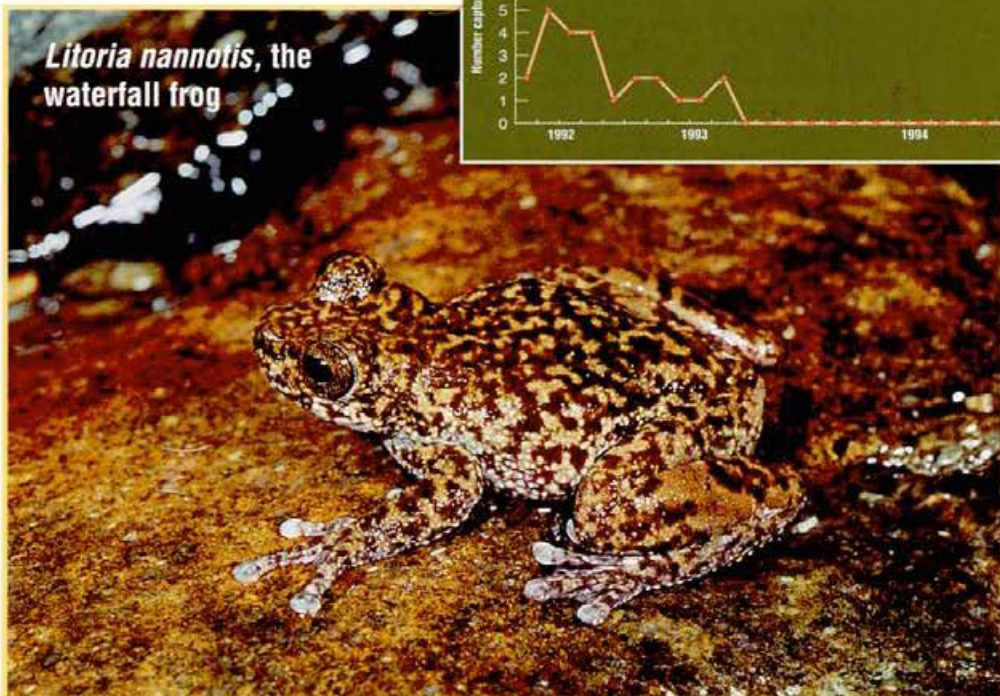
'What's happened is that people who work with diseases are comfortable with the idea of a virus, but ecologists are not too enthused about it,' he says.

What the experts do agree on, is that direct human disturbance can be ruled out as a contributing factor. McDonald's survey sites on the Big Tableland have in the past undergone extensive tin mining.

'This is one of the most invasive practices in the rainforest, involving sluicing the mined sediment through streams,' McDonald says. 'But after 100 years of this the frogs were still there. As for logging, World Heritage listing put a stop to that seven years ago, well before the frogs began disappearing.'

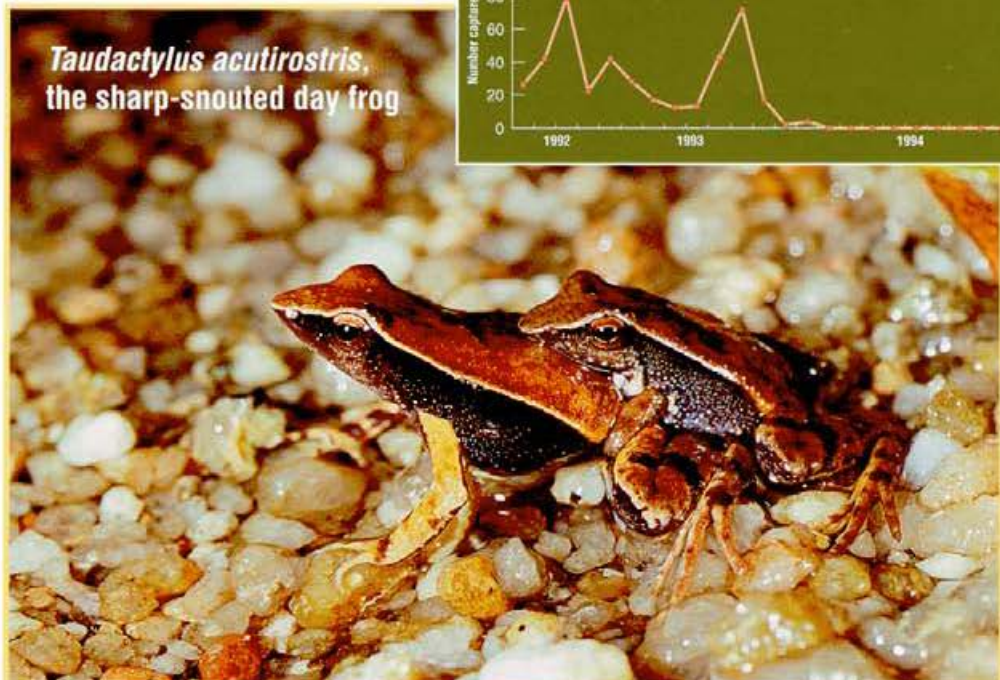
Nonetheless, as Speare, McDonald and Laurance readily admit, so far the evidence for a virus remains largely circumstantial. 'It's got all the characteristics of a disease, but that doesn't yet make it one,' Laurance says.

Litoria nannotis, the waterfall frog



Steve Richards

Taudactylus acutirostris, the sharp-snouted day frog



Steve Richards



John van Tiggelen

Isolating the virus

Work has begun to isolate the putative virus from affected frogs. If successful, virulence transmission and optimal temperature range could be investigated further.

More research is also needed on frog biology and ecology.

'We need to find out where these frogs go during the day and during the dry season, what they do and where they forage,' Alford says.

In addition, frog husbandry is a virtually unexplored field, and rearing frogs in experimental conditions is likely to be a prerequisite for conducting definitive research on the virus.

'We're very much on the back foot,' McDonald says. 'This whole business has caught scientists by surprise because it happened so suddenly.'

'It is quite frightening. Being on the management side of things, unless you know

CSIRO ecologist Dr Bill Laurance: believes a virulent pathogen is cutting a swathe through frog populations on Queensland's east coast.

the causal factor, you cannot manage to conserve something that's disappearing before your eyes. We've got to find out what's going on.'

Meanwhile, Hero's intrepid research methods are becoming almost eponymous. A recent trip involved a helicopter drop-off into the remote headwaters of the South Johnstone River, east of Tully. From there, 11 team members rafted through treacherous rapids to search nightly for the missing frogs.

Despite these efforts, the mountain mist frog (*L. nyakalensis*), the northern tinker frog (*T. rheophilus*), the armoured mist frog (*L. lorica*) and the sharp-snouted day frog (*T. acutirostris*) are still missing. Time to save them is running out, if it hasn't already.

More about frogs

Hero J and Fickling S (1994) *A guide to stream-dwelling frogs of the wet tropics rainforests*. James Cook University.

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Blaustein A and Wake D (1995) The puzzle of declining amphibian populations. *Scientific American* April pp56-61.

Laurance B McDonald K and Speare R (in press) Epidemic disease and the catastrophic decline of Australian rainforest frogs. *Conservation Biology*.

The status of Queensland's stream-dwelling frogs

Common name	Scientific name	Range	Status
southern dayfrog	<i>Taudactylus diurnus</i>	SE Qld	extinct?
southern gastric brooding frog	<i>Rheobatrachus silus</i>	SE Qld	extinct?
cascade tree frog	<i>Litoria pearsoniana</i>	SE Qld	very rare
giant barred-frog	<i>Mixophyes iteratus</i>	SE Qld	very rare
Fleay's barred-frog	<i>M. fleayi</i>	SE Qld	very rare
northern gastric brooding frog	<i>R. vitellinus</i>	Eungella	extinct?
Eungella dayfrog	<i>T. eungellensis</i>	Eungella	very rare
armoured mistfrog	<i>L. lorica</i>	NE Qld	extinct?
mountain mistfrog	<i>L. nyakalensis</i>	NE Qld	extinct?
common mistfrog	<i>L. rheocola</i>	NE Qld	very rare
waterfall frog	<i>L. nanotis</i>	NE Qld	very rare
northern tinkerfrog	<i>T. rheophilus</i>	NE Qld	extinct?
sharp-snouted dayfrog	<i>T. acutirostris</i>	NE Qld	extinct?
Australian lace-lid	<i>Nyctimystes dayi</i>	NE Qld	very rare

Vanishing frogs. At least 14 species of Queensland frogs have disappeared or are becoming extremely rare during the past 15 years. All these frogs breed in small rainforest streams, usually in cool, mountainous areas.