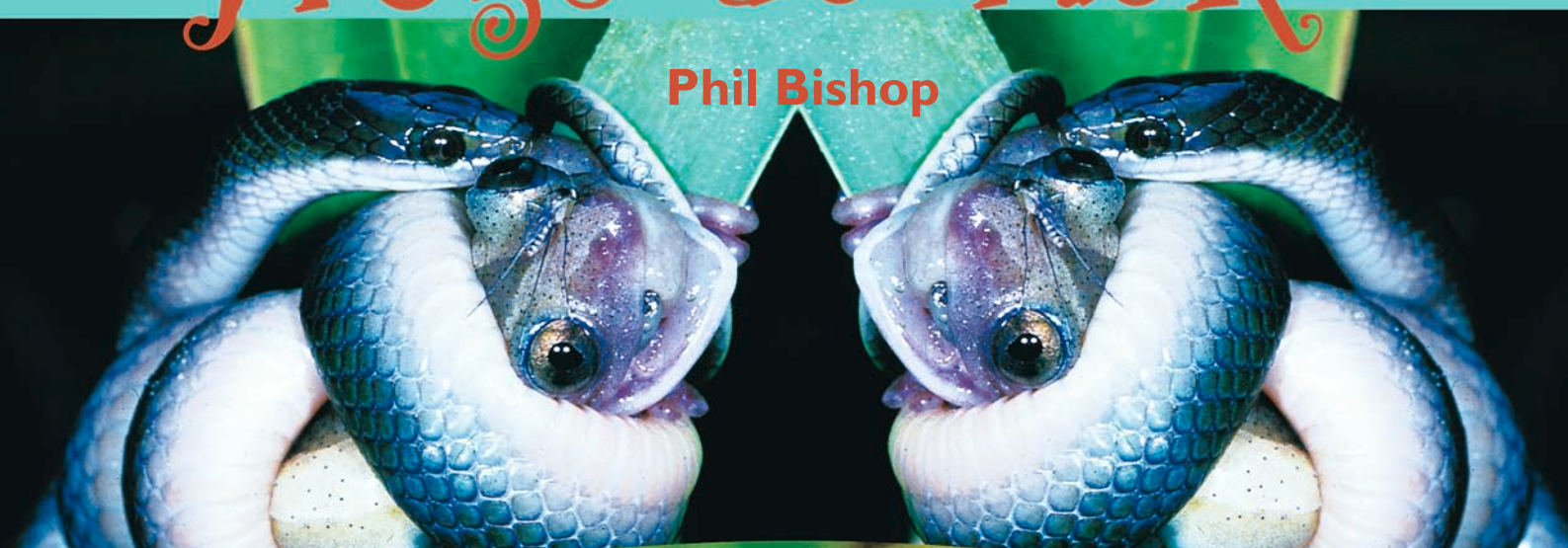
ALPHA

125

frogs at risk

Phil Bishop



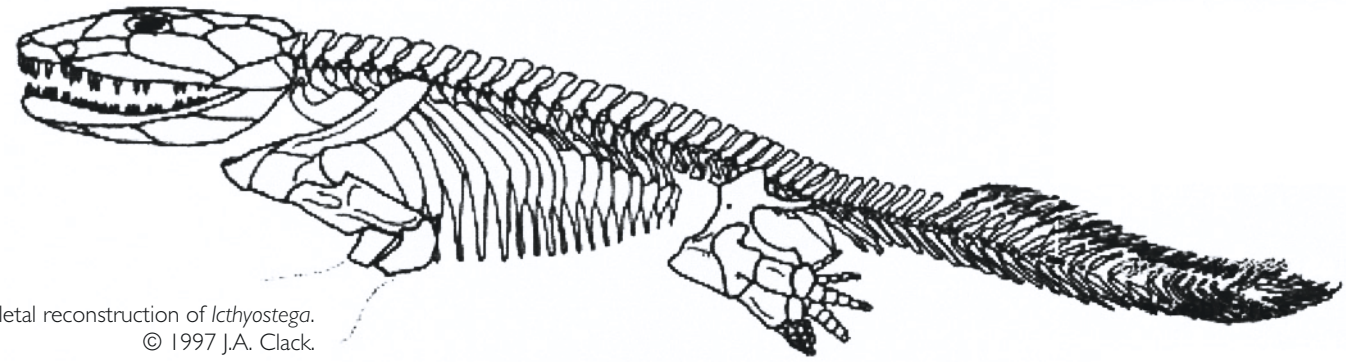
the ROYAL SOCIETY of NEW ZEALAND

Frogs were once thought of as "lower forms" of life. In the 18th century, Scandinavian biologist Linnaeus stated that, "These foul and loathsome animals are abhorrent because of their cold body ... filthy skin ... harsh voice, squalid habitation, and terrible venom ...". This statement reflected the western world's repulsion of amphibians, as the common toad was associatied with witchcraft and many common ailments such as warts. We now know that Linnaeus was sadly mistaken – amphibians comprise a beautiful array of varied, colourful, harmless and often comical creatures.

Amphibians are **terrestrial vertebrates**. They were the first vertebrates to walk on land and probably evolved from the lobe-finned fishes. The *Icthyostega* – one of the earliest amphibian fossils – was discovered in Greenland in 1932 from late Devonian deposits (about 370 million years ago). Amphibians first became common during the Carboniferous period when they were nearly all aquatic or semi-aquatic. By the mid-Permian there were over 40 families with more than 60% of these being completely terrestrial. This was the peak of the "Age of Amphibians". However during the late Permian, reptiles became more common and amphibians began to decline.

Amphibians represent a strange group of animals with most having been extinct for the last 150 million years. During the Triassic they became virtually extinct on land with only a few aquatic families left, including the first frogs. Only two groups survived from the Jurassic period (frogs and salamanders). Today there are more amphibian species than there are mammals and they represent key components in terrestrial food chains. There are 5771 described species of amphibians (*see* AmphibiaWeb 2005) and many new species are still being discovered.

So frogs have been around for a long time. They have survived where many other species have not. But can they survive the 21st century?



Skeletal reconstruction of *Icthyostega*.

Frogs are friends

Herpetology (from the Greek *herpeton*, meaning "crawling things") is the study of amphibians and reptiles, so somebody who studies them is called a herpetologist.

Amphibians can be divided into three distinct groups (or Orders) known as the:

- Urodela – salamanders, newts and mudpuppies (535 species)
- Gymnophiona – caecilians (170 species)
- Anura – frogs and toads (5066 species).

In Australia and New Zealand our only amphibians are anurans (frogs and toads). They can often be found under rocks and logs, or on the ground, and are important environmental **biomonitors**. So, we can therefore think of them as our friends.

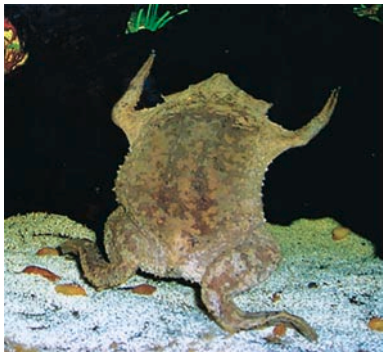
Anuran life histories

Many of us have been fascinated by rearing tadpoles and we know the common life cycle of the frog. Males and females come together at a breeding site and lay frog spawn, which develops into tadpoles that finally **metamorphose** into miniature adults. However, there are many species of anurans in other countries that have a different life history. Here are some unusual examples.

The scientific name of a species (often of Latin or Greek origin) is always written in italics. It contains two parts: first the **Genus**, which always begins with a capital letter; then the **Specific** name (unique to that species), which is always written with a small letter, e.g. *Leiopelma hochstetteri*, *Leiopelma hamiltoni*. Species placed in the same genus are closely related.

Surinam toad (*Pipa pipa*)

This toad is entirely aquatic and spends all its life in the muddy bottoms of tropical rivers and canals throughout South America. It has special adaptations on the ends of its fingertips that can detect small invertebrates, which it then lunges at and stuffs into its mouth. During mating the pair do a somersault, and the eggs are laid and fertilised as they reach the top of the somersault. The eggs sink slowly, coming to rest on the female's back where the skin slowly engulfs the eggs, forming a protective barrier. The female carries these developing eggs around with her for several months until the fully metamorphosed toadlets break out through the skin of her back.



Surinam toad. © Patrick Morgan.

Greater leaf-folding frog (*Afrixalus fornasinii*)

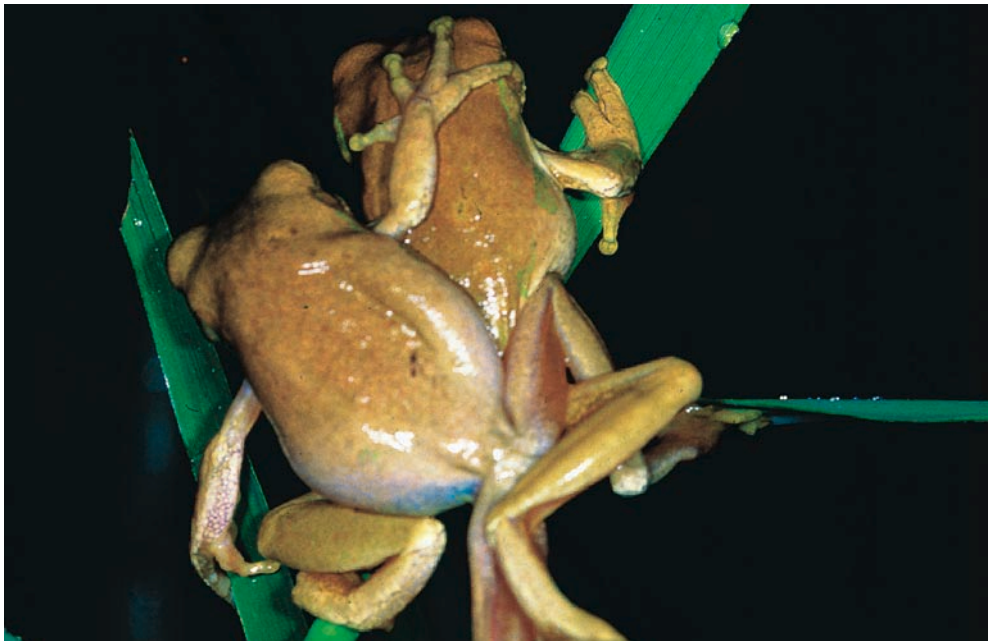
These frogs are very common in the African savanna. They have the unusual habit of eating other frogs' eggs and larvae by raiding frog nests, particularly those of the foam nest tree frog. During mating they climb up a leaf, laying eggs as they go. Both male and female stick the edges of the leaf together, producing an incubation chamber for the developing eggs. After about five days the eggs have formed into tadpoles that wriggle their way out of the leaf nest into the pond below.

Leaf-folding frogs.

Foam nest tree frog (*Chiromantis xerampelina*)

These frogs also inhabit the African savanna. In summer, males call from branches of trees which overhang temporary rain puddles. Their calls attract both males and females and often a breeding party forms with 1 female and up to 20 males. The female churns her hind legs and her secretions are turned into a large white foam nest (like a large meringue) where her eggs are deposited. Many males fertilise the eggs. The nest hardens (just like a meringue) and the eggs develop into tadpoles inside it. After about five days the tadpoles become very active and they break out into the pond below.

Foam nest tree frog.



Fighting tree frogs in Africa.

To listen to the calls of introduced frogs in New Zealand, visit the DOC herpetofauna website (http://www.doc.govt.nz/Conservation/001~Plants-and-Animals/001~Native-Animals/Herpetofauna/004~Frog-Identifier.asp) or AmphibiaWeb (http://elib.cs.berkeley.edu/aw/).

New Zealand frogs

In New Zealand there are seven species of frogs, three of which were introduced from Australia and have survived to produce self-sustaining populations. All native New Zealand frogs are protected and two of the introduced ones are currently endangered in their native country, Australia.

Introduced frogs

Although many species of amphibians were deliberately liberated into the New Zealand environment over the years, there have only been three species (all within the genus *Litoria*) that have been successful colonisers.

Brown tree frog showing its orange legs.

Common name	Scientific name	Released	Distribution	Colour
Introduced frogs				
Brown tree frog (sometimes called whistling frog)	*Litoria ewingii*	Greymouth, 1875 (from Tasmania)	South Island; southern and central North Island	Mainly light brown with white stripe along jawline from armpit. Lighter patch on top of head. Belly and throat white/cream. Underside of thighs bright orange
Green and golden bell frog	*Litoria aurea*	Auckland area, late 1860s (from Sydney)	Upper North Island north of Gisborne	Mainly green with gold or bronze patches. Back of the thighs and groin bright blue. Belly smooth and white
Southern bell frog (called growling grass frog in Australia)	*Litoria raniformis*	Canterbury late 1860s (from Tasmania)	Throughout NZ	Similar to green and golden bell frog, but often has warty back. More dark brown or black blotches. Pale green stripe down mid back. Thighs and groin bright blue
Native frogs				
Archey's frog	*Leiopelma archeyi*		Coromandel Peninsula Whareorino forest (near Te Kuiti)	Mainly brown; some have patterns of orange, green and red with black zigzags
Hamilton's frog	*Leiopelma hamiltoni*		Stephens Island	Mainly brown (ranging from light tan to almost black), with black patterns on their backs and faces
Maud Island frog	*Leiopelma pakeka*		Maud Island (19,000 individuals)	Similar to Hamilton's frogs. Up until 1998 they were thought to be the same species
Hochstetter's frog	*Leiopelma hochstetteri*		East Cape to Northland (just south of Whangarei) Native forests up to 800 m above sea level	Mainly brown, but with occasional green blotches

Native frogs

Our native frogs in the genus *Leiopelma* are very unusual. They are unique in the frog world because they have long pieces of cartilage in the abdominal muscles, lack eardrums (tympani), have an abnormally high number of vertebrae (with a characteristic shape) and have tail-wagging muscles (even though they do not have a tail!). All *Leiopelma* frogs have round pupils, broad heads, and smooth skin on the "soles" of their feet. They are nocturnal and catch their prey by grabbing it with their mouth (they do not flick their tongues out like most other frogs). They do not have loud mating calls but can make faint squeaks when harassed. Although the largest *Leiopelma* (Hamilton's frog) can reach 50 mm in length, we once had a much larger species (*Leiopelma waitomoensis*) in New Zealand that was 100 mm long. It is now extinct. We have four native species (*see next page for more native frog photos*).

Maud Island frog.

	Webbing/suckers	Size (nose to rear)	Call	Breeding
	Not usually	30–50 mm	"weeeeep-eeep-eeep-eeep-eeep-eeep" (like a cricket – nothing like a whistle!)	All year (even in frosty conditions). External fertilisation with clumps of eggs laid under water. Tadpoles black, turning brown as they get older
	Webbing on toes	Females: 90 mm Males 60 mm	"craaaaaaaaawk, craaawk, crok, crok, crok" (large choruses can sound like motorbikes from a distance)	Summer, in shallow temporary ponds in full sunlight. Between 3000 and 10,000 eggs laid in floating mat, which sinks after 6–12 hours. Tadpoles black. Can interbreed with southern bell frog
	Webbing on toes. No suckers	Females: 100 mm	"crawcrocrocrocrok"	Similar to the green and golden bell frog but prefers permanent lakes, swamps and dams with still water
	None	Less than 40 mm	 Southern bell frog.	Summer. They lay eggs in October under logs or stones away from water. Eggs hatch after 6–10 weeks into tailed froglets (tails are gradually absorbed). Froglets climb onto male's back where they stay until fully developed
	None	Females: up to 50 mm		Probably around December with similar behaviour to Maud Island frog (below)
	None	48 mm		Captive frogs lay 1–19 eggs in December in moist depressions under logs, rocks or vegetation. Eggs are guarded by the male and young develop while on male's back
	Toes partly webbed	Females: up to 47 mm		10–22 eggs are laid in wet areas next to streams: under logs, rocks and vegetation. Larvae have a small yolk sac and well-developed tail. They can flip in and out of water – the closest to true tadpoles of any of our native frogs

Archey's frogs have recently suffered a major decline in numbers and are now listed as Nationally Critical with a high risk of extinction. A captive breeding facility for this species was opened at Auckland Zoo in October 2004.

Hamilton's frogs are the rarest in New Zealand and perhaps the world, with less than 500 individuals left. In May 2004, a small number were moved from Stephens Island to another predator-free island in the Marlborough Sounds. Their continued existence depends on the conservation measures we put in place.

Hochstetter's frog is our only semi-aquatic native frog and the only native species in which males and females are easy to tell apart – males have broader and more muscular forearms.

Photos

1, Male Archey's frog guarding eggs. © Rod Morris

2, Male Archey's frog with juveniles on his back. © Rod Morris

3, Hochstetter's frog with juvenile on its back. © Rod Morris

4, Hamilton's frog, Stephens Island.

Global amphibian declines

Over 200 amphibian species worldwide have experienced recent population declines, with reports of at least 32 species' extinctions. The possible causes of amphibian declines can be grouped into seven broad categories.

Habitat destruction

It is now estimated that humans have altered between one third and one half of the Earth's land surface. Forestry and agriculture have major effects on frog populations. Roads and paddocks are significant barriers to terrestrial **arthropods** and small mammals, and the same is probably true for amphibians. Mining is also a major threat, by polluting water and by mechanical destruction of frogs and their habitat.

Pollution

Aluminium, cadmium, copper, zinc and iron are all toxic to amphibians. Nickel, lead, and manganese have damaging effects on fish, so frog populations will probably be similarly affected. Organic herbicides and pesticides often cause developmental abnormalities or fatalities. A report in 1997 showed that Roundup was extremely toxic to tadpoles and adult frogs. This herbicide (in its new and apparently safe form) is still widely used in New Zealand.

African bull frogs which are deformed as a result of pollution.

Climate change

Direct effects– the timing of breeding by amphibians is governed by environmental factors such as temperature. It is thought that if global warming occurs, frogs will start breeding earlier in the season. This is already happening, with frogs coming out of hibernation earlier and being more susceptible to sudden changes in the weather. There are also predictions that in the second half of this century, carbon dioxide levels will double, which may increase the Earth's mean surface temperature by 4°C. The sea level could then rise by over 2 m, inundating most of the world's coastal wetlands – there will be an alteration of rainfall patterns and more frequent and intense droughts.

Indirect effects– such as depression of immune function causing the frogs to become more susceptible to disease. There may be more complex subtle effects where the lower pond-water levels will expose the embryos to more ultra-violet (UV) light from the sun, causing them to be even more susceptible to fungal attacks.

UV radiation

The widespread decline of amphibians may be linked to an increase in UV radiation (in particular UVB at a wavelength of 300 nm). UVB radiation is harmful to many species of amphibians, however the literature surrounding the effects of UV on frog populations is highly controversial and we are not yet sure UV is a serious threat.

Predators and disease

In the United States, Australia and New Zealand there have been several populations of amphibians that have declined as a direct result of predation by freshwater crayfish, bullfrogs, cane toads, and rats. In New Zealand, mosquito fish (which can survive in salty, acidic or hot conditions) are major predators of tadpoles and native fish. Mammalian predators such as kiore, mice and the mustelids (stoats, weasels, etc) are probably the major culprits in the decline of our native frogs.

Viral, bacterial and fungal diseases are responsible for the decline of many amphibian species. In New Zealand, a recent outbreak of the chytrid (pronounced *kit-rid*) fungus was thought to have caused a mass die-off of Archey's frog in the Coromandel, resulting in an emergency meeting of the Native Frog Recovery Group. Archey's frog is now listed as Nationally Critical and steps are in place to try and prevent its extinction.

Overexploitation

Another possible cause of global decline is the collection of frogs as a food source. People in Africa, the United States, Germany, France and the Netherlands eat millions of frogs every year. For example, the United States imports more than 3 million kg of frog meat a year – approximately 26 million frogs! The main exporters of frogs are India, Indonesia and Bangladesh. When frogs are captured on such a large scale, it upsets the food chain and their usual prey multiplies. This results in the extensive use of insecticides and causes considerable damage to the delicate ecosystem, including destruction of further frog populations.

The multi-million dollar pet trade

Generally, the rarer the species the higher the demand and, therefore, the rarer the frog becomes. Frogs caught in the wild are often kept in crowded cages awaiting final shipment to the United States. The ones that do get there alive usually only live a couple of months in captivity before being unceremoniously flushed down the toilet. New Zealand has one of the rarest frogs in the world and the demand for this species by fanatical collectors is very high. It is only because of the hard work of the Department of Conservation and the frogs' inaccessible habitat that it survives today.

The whole picture of declining populations is complex as all these factors are interrelated.

Why should we care?

As major predators of insects, frogs fulfil an important role in the food chain. Without them, insects can multiply out of control causing huge damage to crops and a dramatic increase in insect-borne diseases such as encephalitis and malaria. Because they have a semi-permeable skin, frogs are particularly vulnerable to pollutants and other environmental stresses. Consequently frogs can be used as environmental biomonitors – an early warning system for the quality of the environment and the potential threats to other animals, including ourselves. Frogs throughout the world also provide a valuable source of food for humans and other animals.

The Department of Conservation has a system for classifying species according to the threat of extinction. Any **taxon** that exists in the wild in New Zealand can be listed (e.g. marine, terrestrial and freshwater **biota**). There are categories for both introduced and native **taxa**, as well as for threatened and non-threatened taxa. Taxa with the highest threat of extinction are classified as "nationally critical".

Resources

FROGLOG is the bimonthly newsletter of the Declining Amphibian Populations Task Force (DAPTF). Contact Dr Phil Bishop, University of Otago (email: phil.bishop@stonebow.otago.ac.nz) or view online (http://www.open.ac.uk/daptf/froglog/).

AmphibiaWeb is an online system that allows free access to information on amphibian biology and conservation (http://elib.cs.berkeley.edu/aw/index.html).

Glossary

arthropods – invertebrate animals which have a segmented body, external skeleton and jointed limbs (insects, spiders and crustaceans)
biomonitor – an early warning system for the quality of the environment and the potential threats to other animals
biota – the animal and plant life of a particular region, habitat or geological period
metamorphosis – the process of changing from one form to another during development. In amphibians it is usually associated with a switch from an aquatic larval stage to a terrestrial adult phase
taxonomy – the branch of science concerned with classification, hence taxon is a taxonomic group (plural is taxa)
terrestrial – living on or in the ground
vertebrates – animals which have backbones or spinal columns (mammals, birds, reptiles, amphibians and fishes)

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Front cover photos from top: Brown tree frog tadpoles (© Marion Anstis); Hamilton's frogs; brown house snake eating leaf folding frogs, Africa; green and golden bell frog.
Background photos, page 2: Cape rain frog from Africa (© Les Minter); *pages 4 & 8*: brown tree frog tadpoles.

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