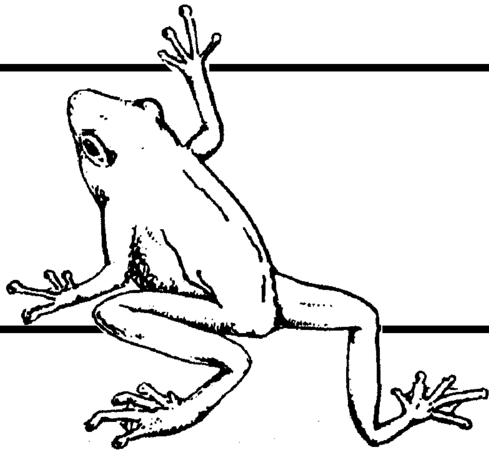
# FROGFACTS
## No. 9


The Frog and Tadpole Study Group of NSW Inc
FATS GROUP

P.O. Box 296
Rockdale 2216

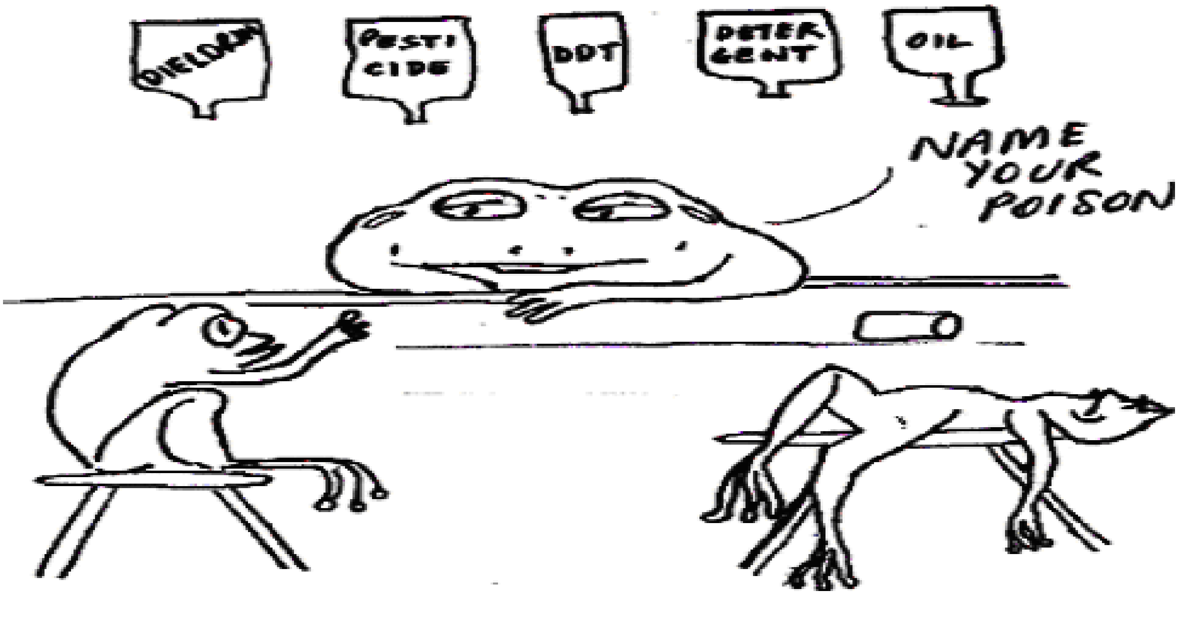

# FROGS AS BIO-INDICATORS

### What are bio-indicators?

Freshwater bio-indicators are animals and plants that can be used to determine the state of health of freshwater habitats. Some creatures are very sensitive to water-borne pollutants while others less so. Changes in the abundance and diversity of these animals can be used as a measuring tool to determine water quality. Bio-indicator organisms typically live in freshwater and so are subject to the changes in pollutant load. They are often more effective than laboratory-based measuring tools as they are unable to escape the effects of the pollutants, are more sensitive than most meters and are cheaper to use. One of the biggest problems in using laboratory probes or taking water samples is that water quality is not static, it changes constantly and pollution loads may vary from high to immeasurably low.  Water meters can only record water quality at one point in time and often fail to assess fluctuations in water quality.

### What creatures are used as bio-indicators?

The most widely used organisms are aquatic insects and other aquatic invertebrates; these soft-bodied animals are collectively referred to as "macro-invertebrates". Many insects have juvenile stages that are fully aquatic. Some of these insects and aquatic arthropods were found to be sensitive to particular pollutants in water. Scientists use this information to rank macro-invertebrates according to their levels of sensitivity. A statistical method (called the Signal Index) has been developed (Chessman *et al.*1997) that enables rapid assessment of water quality based on the ratio and abundance of aquatic animals found (see Gooderham and Tsyrlin 2002 for an introduction to macro-invertebrates).



Frogs have been used as bio-indicators but their use is not widespread. It is known that frogs (and especially tadpoles) are sensitive to a range of water-borne substances making them suitable candidates as bio-indicators. However, unlike macro-invertebrates, relatively few species occur at each freshwater site and so statistical models have not been developed using frogs. Despite this, frogs have been used in Australia to measure environmental pollution.

## What are frogs sensitive to?

Frogs have been shown to be sensitive to a range of environmental pollutants (see Tyler 1989) including agricultural pesticides (such as Chlordane, Kaplan and Overpeck 1964; DDT, Osborn *et al* 1981; Dieldrin, Cooke 1972, Brooks 1981), herbicides (e.g. Defenuron, Paulov 1977); fungicides (such as Maneb, Bancroft and Prahlad 1973) and heavy metals (such as. Mercury, Buirge *et al* 1977; Copper, Bando 1976; Zinc, Byrne *et al* 1975). Rarely have frogs been used to monitor unspecified environmental pollutants. Tyler and Cappo (1983) used frogs to monitor changes in water quality of local streams in the development area of the Ranger Uranium Mine in the Northern Territory. This study was the first in Australia to demonstrate the potential to use frogs as environmental indicators. This study was carried out as radioactive and non-radioactive mineral waste escaping from the mine was known to cause deformities in embryonic vertebrate (backboned) animals. Tadpoles are embryos that are found in all of the creeks around the mining area. Frog abnormalities were recorded and correlated with heavy metal concentrations in the water.

One widespread form of environmental disturbance that is not related to mining or industrial activity is pollution from urban stormwater run-off. In eastern Australia, the development of expansive urban settlements has resulted in polluted stormwater entering many creek and river catchments (Warner 1991). Household chemicals, detergents, grease and various water-soluble compounds are collected by stormwater and transferred to watercourses below the urban interface. This is a particular problem for capital cities such as Sydney where drinking water catchments are surrounded by urban settlements.

In 1998, the Blue Mountains Bio-indicators project was established. This project was devised to establish monitoring procedures for the various catchments in the upper Blue Mountains, to identify catchments with particular water quality problems and to ameliorate these. Community involvement was integral in this project. A detailed bio-indicator study using aquatic macro-invertebrates was pivotal to this study (Chessman 1999), however, the opportunity also existed to trial the use of frogs in this role. In the summer of 1998/1999, a matched-site study was initiated to test the usefulness of frogs as bio-indicators of stormwater pollution in the upper Blue Mountains (White 1999).

## How can frogs be used as bio-indicators?

Three main methods have been trialled using frogs; these include laboratory-based trials where frogs (or tadpoles) are exposed to controlled doses of agent (such as pesticide, fertiliser or pollutant); field-based trials where abnormalities are recorded or field-based trails where changes in frog abundance and behaviour are noted. The third method is most similar to that used for macro-invertebrates. The Blue Mountains Frog Bio-indicator Study (White 1999) is still the only study of this type to be carried out in Australia.

## Blue Mountains Frog Bio-indicators

In order to determine which frog species would be useful as indicators of stormwater pollution in the Blue Mountains, 22 paired sites were selected across the mountains. The sites were paired according to size of watercourse, order of catchment, elevation and aspect; the only obvious difference between each pair of sites was that one was immediately downstream of urban areas while the other was not. Each site was also subject to routine laboratory-based water sampling and assay. Macro-invertebrate surveys were also carried out at most sites as a corroborative study. Thus, 22 equivalent pairs of frog habitats were compared. Surveys were carried out at each pair of sites on the same night as weather can greatly influence frog behaviour. Two habitats were surveyed in each site; namely, perched swamps and first order creeks.

The surveys scored three types of data at each site; these included ground transects, frog call surveys and tadpole surveys. Ten frog species were present in the study sites and frog abundance, diversity and behaviour was recorded for each site. Indices for each survey technique were developed so that a cumulative score could be generated for each site. Differences in the frog data between urban-affected and non urban affected sites were noted and included a reduction of frog diversity, reduction of species calling and calling intensity and a reduction in species breeding at the urban-affected sites.

Using the laboratory and macro-invertebrate data, the water quality in each watercourse (i.e. swamp and creek habitat) were ranked from cleanest to most polluted. Frog data correlated very highly with rankings derived from macro-invertebrate data (which in turn was strongly correlated with physical and chemical measures of water quality). On the basis of the high correlation between methods, the ten frogs species recorded were ranked according to their level of sensitivity and usefulness as bio-indicators. These species were as shown below:

<u>Zero Tolerance Species</u>

| | |
|---|---|
| Red-crowned Toadlets | *Pseudophryne australis* |
| Bibron's Toadlets | *Pseudophryne bibroni* |

Low Tolerance Species

| | |
|---|---|
| Leaf-green Tree Frogs | *Litoria phyllochroa* |
| Red-groined Toadlet | *Uperoliea laevigata* |
| Eastern Banjo Frog | *Limnodynastes dumerilii* |

Medium Tolerance Species

| | |
|---|---|
| Bleating Tree Frog | *Litoria dentata* |
| Peron's Tree Frog | *Litoria peronii* |
| Whistling Tree Frog | *Litoria verreauxii* |

High Tolerance Species

| | |
|---|---|
| Striped Marsh Frog | *Limnodynastes peronii* |
| Common Eastern Froglet | *Crinia signifera* |

Those species that have been grouped as "zero tolerance" species are those that were never detected in urban-affected habitats; either as tadpoles or as adult frogs. Those species grouped as "low tolerance" species are those that may or may not have been detected as adult frogs in urban-affected sites, but have not been observed to breed in these areas. Those species that were grouped as "medium tolerance" species are those often found in urban-affected areas but reproductively restricted through a marked reduction in calling frequency, the number of calling males or the reduction in number or absence of tadpoles. "High tolerance" species are those present in most urban-affected sites and apparently able to breed freely in these sites.

**Specific Pollutants**

The Blue Mountains Frog Bio-indicator Study looked at the cumulative effects of stormwater pollution on frogs and tadpoles. Stormwater contains a mixture of pollutants and this varies from site to site; in urban areas, most stormwater pollutants are typically petro-chemicals, pesticides and solids. Stormwater from industrial areas often contains more detergents, heavy metals and solvents (Sydney Water). Pollutants, such as detergents and some pesticides, will eradicate frogs from most sites regardless of their level of tolerance.

Some pollutants are only a biological hazard at certain concentrations. Atrazine (a widely used pesticide) has been shown to cause malformations and sterility in frogs at extremely low concentrations whereas at higher levels its effects are less pronounced (Johnson 1976).

## Are frogs useful bio-indicators?

The Blue Mountains Frog Bio-indicator Study indicated that frogs are useful bio-indicators. Water pollution causes changes in frog abundance and behaviour. The general principle holds true "if there are plenty of frogs present at a freshwater site, the water quality is likely to be good; if frogs are absent or scarce, be wary of the water".

Before any bio-indicator study can be initiated, it is important that the relative sensitivities of the frogs present be pre-determined. Surveying paired sites simultaneously can control for differences in weather, climate history and habitat. Using a significant number of paired sites reduces the chance fluctuations in individual breeding and predation events. Surveying and comparing site types for frog predators, frog diseases, road kills etc. may be necessary. Evidence of breeding and of recruitment of the next generation of frogs is valuable. Finally, a comparison of this data to water tests by other means adds confidence in the results.

However, using frogs as bio-indicators can be as simple as noticing that a formerly noisy frog habitat has become silent while other nearby habitats are still active. Whether pollution or other causes are responsible can then be investigated further.

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## Further information

The postal address of the FATS Group is: P.O. Box 296, Rockdale NSW 2216. When requesting *FrogFacts*, please send a small donation for photocopying and postage.

*FrogFacts* information sheets of the FATS Group:

- FF1 Keeping Green Tree Frogs
- FF2 Keeping Frogs in Your Garden
- FF3 Establishing Frog Habitats on Your Property
- FF4 Rainforest Frogs
- FF5 Green and Golden Bell Frogs
- FF6 Collecting, Raising and Releasing Tadpoles
- FF7 Frogs of the Sydney Region
- FF8 Frog Hygiene for Captive Frogs
- FF10 Water Quality for Frog and Wildlife Ponds

Other *FrogFacts* are planned.

*FrogCall* **-** Bimonthly newsletters of the FATS Group

FATS Group meetings: Every first Friday of every even month, 7 pm for a 7:30 start, at Newington Armoury, Bldg. 22, northern end of Jamieson St., Homebush Bay. Parking at boom gate. Visitors welcome.

FATS web site (with links to other frog groups): www.fats.org.au

Frog Hygiene Protocol on DEC / NPWS website: www.nationalparks.nsw.gov.au/PDFs/hyprfrog.pdf

DEC/ NPWS frog info sheets: www.nationalparks.nsw.gov.au/npws.nsf/Content/Frogs

Frogwatch Helpline: 0419 249 728, (02)9599 1161, (02)9371 9129

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Author: **Dr. Arthur White**

Reviewed by:
Marion Anstis (FATS Group)
Lothar Voigt (FATS Group)

Illustration: Arthur White

Editor: Lothar Voigt

Supported by funding from NSW Department of Land & Water Conservation / Natural Heritage Trust



ISSN 1037-0617 June 2004. Latest revision April 2006