FLUOROSIS IN FROGS: A RED FLAG FROM NEW ZEALAND

SUMMARY: Osteofluorosis developed in New Zealand native frogs (*Leiopelma* spp) from reduced ultraviolet B (UVB) light exposure and a diet low in the Ca:P ratio after the use of fluoridated water with 0.94 ppm F. The frogs recovered with increased UVB light exposure, a diet with a higher Ca:P ratio, and the use of defluoridated water with 0.06 ppm F. New Zealand native frogs give a red flag warning that fluoridated water may not be safe for humans.

Keywords: Ca:P ratio in diet; Fluorosis in frogs; *Leiopelma* spp; New Zealand; New Zealand native frogs; Osteofluorosis in frogs; Red flag warning; Ultraviolet B light; Water fluoridation.

Just as canaries, chirping and singing on their perches without swaying, once gave coal miners a reassurance that the air was safe and lacking toxic levels of methane and carbon monoxide, healthy frog populations are today a marker of an unpolluted environment. With permeable skin that is able to absorb chemicals and pollutants, frogs are accurate bioindicators providing us with an early-response system that can tell us when something is wrong in the environment.[1] The recent finding by Shaw et al. (Abstracted in this issue of *Fluoride* on p. 307) that fluorosis from fluoridated water was a probable factor in metabolic bone disease in captive New Zealand native frogs (*Leiopelma* species) is not only important for understanding factors that affect the health of amphibians but also for providing a red flag that fluoridated water may not be safe for humans.[2]

The diagnosis of osteofluorosis in *Leipelma archeyi* frogs at Auckland Zoo was strongly suggested by microcomputer tomography scans of femurs that showed, in affected frogs, complete or folding fractures, and greater bone volume, bone surface, cross-sectional thickness, and mean total cross-sectional perimeter together with histological evidence of hyperplasia, periosteal growth, and thickening of trabeculae. A significant rise in the frog mortality at Auckland Zoo occurred when the water used to moisten the soil substrate in the native frog house was changed from reverse-osmosis water with 0.06 ppm F (2005–February 2007) to town water filtered with a charcoal and particle filter with 0.94 ppm F (February 2007–February 2009) ($p=0.00$, odds ratio=15.4, 95% CI 5–47). The mortality fell again after a change was made back to the use of reverse osmosis water in February 2009 ($p=0.000$, odds ratio=43.8, 95% CI 9–266). The annual mortality rates were: 2005, 9.4%; 2006, 17.9%, 2007, 6.2%; 2008, 31.2%; 2009, 52.1%, 2010, 7.8%, and 2011, 4.1%.

Comparison of the native and captive habitats showed wild *Leiopelma* had a diet including woodlice, snails, millipedes, and silverfish, with a higher Ca:P ratio than the commercially available invertebrates and more exposure, from basking in early-morning dappled light, to ultraviolet B (UVB) light which enables vitamin D_3 (cholecalciferol) to be produced photochemically in the skin from 7-dehydrocholesterol. No new fractures or tetanic spasms suggesting metabolic bone disease occurred in the Auckland Zoo frogs after eliminating most of the F, adding UVB light, and increasing the inherent calcium of the captive diet. Similar problems and results occurred with native frogs at Hamilton Zoo (*L. hochstetteri*) and the Zoology Department, University of Otago, Dunedin, (*L. pakeka*) but the evidence for the diagnosis of osteofluorosis was weaker because histological and micro-CT examinations were not done.

The study by Shaw et al. might be considered irrelevant to water fluoridation for two reasons: the frogs studied were had less UVB light exposure and a diet with a low Ca:P ratio, and humans are not frogs. However, 5% of New Zealand adults have been found to have vitamin D deficiency[3] and a screening test for teratogenicity, the Frog Embryo Teratogenesis Assay-*Xenopus* (FETAX) involving the effects of sodium fluoride on the development of frog embryos has had a high degree of success identifying mammalian teratogens.[4] Ultrastructural studies have also shown that F has the ability induce cell ultrastructure changes in both plants and many species of animals including humans, mice, rats, rabbits, guinea pigs, pigs, and chickens.[5] The appropriate response to this study, together with previous research on fluoride in drinking water,[6-14] would be to implement the Precautionary Principle and halt the fluoridation of community water supplies.[15]

However, history indicates that paradigm change can be a slow process that I have called “tardive photopsia.”[16] The lessons of the canary in the coal mine appeared to be forgotten prior to the underground coal mine explosion on 19 November 2010, when twenty-nine men died underground at Pike River in the Paparoa Range on the West Coast of the South Island of New Zealand.[17] The monitoring system had shown there was a serious methane management problem with high readings—many dangerously high—being recorded on most days. The information was not properly assessed, and the response to warning signs of an explosion risk was inadequate.

I was unable to find a report in the New Zealand press of the study on osteofluorosis in New Zealand native frogs. A letter to the editor of the *Otago Daily Times* resulted in the contents being noted but not selected for publication. The Ministry of Health, New Zealand, continues to support water fluoridation as a proven and safe public health measure to reduce dental caries.[18] We ignore the red flag of the New Zealand native frogs at our peril.

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