Is this the last stand of wild lungfish?

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Wild lungfish are survivors. Droughts, floods, habitat loss, environmental contamination, human interference, the black market in Europe and Asia, they have seen it all since they first became known to science in 1870. All the same, the Australian lungfish, *Neoceratodus forsteri*, is the last survivor of many kinds of lungfish in Australia. The lungfish is now found in only three, possibly four, natural environments in southeast Queensland, as well as a few lakes and rivers to which the species has been introduced, all in the same limited area.

Wild lungfish are under threat from many aspects of human activity, notably from conversion of the natural riverine environments into large reservoirs for water conservation where conditions are not ideal for adults or for eggs, embryos and hatchling lungfish. Two large reservoirs block parts of the Burnett River, most of the Brisbane River has been turned into water impoundments, and even the small North Pine River consists almost entirely of Lake Samsonvale.

Three major problems, one partly a natural effect and two the result of human interference, are damaging lungfish populations. The population of adult lungfish may have suffered during the recent prolonged drought in southeast Queensland (2001-2008), but the floods that have followed since the drought ended have killed many hundreds of adult lungfish. This has happened because floods have caused water impoundments to overflow, and lungfish have been washed over the reservoir walls and smashed into the spillways below the wall. Any lungfish that survive a fall over the reservoir wall may be carried into unsuitable environments below the dam, or taken out to sea where they cannot survive. Spillway pools have been closed to the public since 2011, and the number of lungfish destroyed in spillway pools is unknown.

Other threats are purely man made. Eggs and newly hatched lungfish depend on submerged water plants for survival. Eggs are laid on the plants, and hatchlings hide there. In a natural flowing river, water plants and hiding places are plentiful, and young fish can find food amongst them. These refuges for young fish do not exist in reservoirs because the water level fluctuates, especially in spring when lungfish are spawning, and the plants and little food animals cannot survive around the margins of the reservoir. This is well known as a possible danger to recruitment of young lungfish to the adult population, as Bancroft, one of the first lungfish researchers, discovered many years ago. Without refuges and food, recruitment of young to the adult population will be reduced or may cease altogether.

Now there is a new threat to lungfish survival. This has been identified by scanning electron microscope analyses of young lungfish, using a JEOL 6460LA in the facilities of AMMRF at the University of Queensland. Embryos and hatchlings from two environments in Lake Wivenhoe and one in Lake Samsonvale, where lungfish were trapped when the reservoirs were built, were compared with embryos and hatchlings from parts of the Brisbane River. In the river environment, refuges and food supplies were as they should be, and the young were normal. Not one of the eggs collected from reservoir environments and reared by identical methods, produced normal juveniles, possibly because the level of nutrition for parent fish in this lake was so poor that they were unable to produce healthy eggs.

Young fish raised from eggs collected in River environments had healthy skins, with ciliated cells to keep the fish clean, and sense organs to help the fish find food (Figure 1). Embryos and hatchlings from the reservoir environments had many faults, particularly in the skin and skin sense organs, and were unable to feed and grow (Figure 2). If this result is repeated in the wild in more water impoundments, recruitment of young to the adult population in reservoir environments could fail catastrophically. So far, it has happened in 2009, 2010 and 2012, in two different reservoirs, Lake Wivenhoe and Lake Samsonvale.

Methods of rearing the eggs have been in use for many years, using material from the river and from reservoirs. Eggs from river environments grow to be large, normal fish. Eggs from reservoir environments die, often before they start to feed. The problem is not the method of raising the young fish. The same results arise when late stage embryos, about to hatch, or young that have actually hatched, are taken to the laboratory. If they come from water impoundments, they die like the little fish that came from young eggs. If they come from the river, they survive and do well.

The problem does not result from pollution. River lungfish have been exposed to pollution from agriculture and factories near the river for many years, and have survived. The reservoirs are usually protected from such sources of pollution because they are water catchments. But their young are not normal. The cause may be genetic, or it may result from a lack of appropriate food for adult lungfish. There has been a decline in the numbers of small clams and snails in the places where lungfish live, and the adult fish need this food material to make strong and viable eggs.

Sadly, the river environments have been spoiled by drought and floods in the last fifteen years, and lungfish have not spawned in these sites for at least ten years.

What can be done about the plight of lungfish? It could be possible to use the suggestion of a friend from New Zealand. Parts of the Mary River, and perhaps the Brisbane River, now degraded by clear felling of the river banks, and urban development, could be restored and fenced off to prevent the access of cattle. Trees could be planted along the banks, shading the river and allowing submerged plants and small animals to colonise the habitat. This would create living spaces for lungfish and other water animals, such as turtles and the Mary

River cod. The area could be turned into an aquatic national park, with walking tracks and access for kayakers.

If nothing is done, we could be looking at the last stand of wild lungfish.

References

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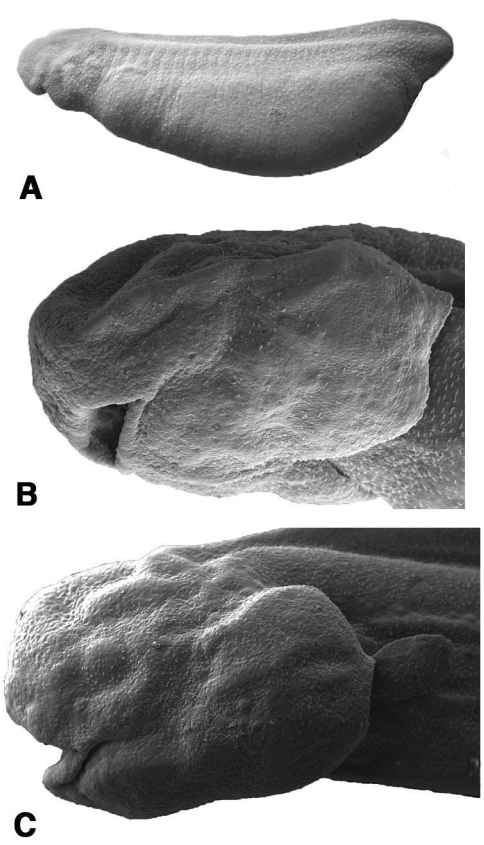

Figure 1. Young fish from Lowood on the Brisbane River below Lake Wivenhoe, collected before spawning ceased in this site. A. An embryo that is developing well, with a perfect skin and head and tail of normal proportions in relation to the endodermal mass. B. A young fish approaching the stage of hatching. C. Head of a hatchling with a normal mouth and gill covers, and healthy skin. Sense organs are as they should be for the stage of development.

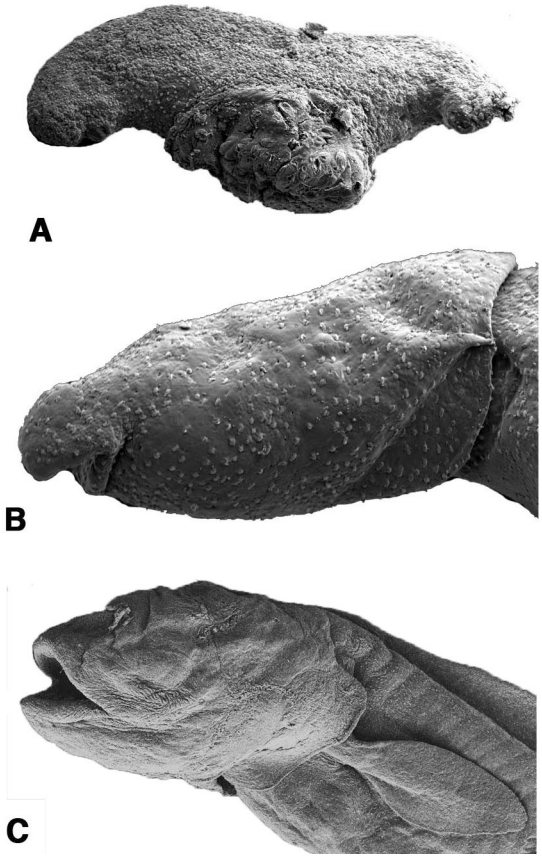

Figure 2. A. An embryo from Lake Samsonvale. The head and tail are small and poorly formed, and the endoderm has split. This embryo could not have survived. B. The head of a hatchling from lake Samsonvale. Skin cells have cilia, but the head has no normal structure except for a small terminal mouth. C. The head of a hatchling from Logan's Inlet in Lake Wivenhoe. The mouth and the gill covers are fixed in open positions, and there are no skin sense organs. Thios is the wrong one!