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- Caprivi *Nothobranchius* Described
- Distribution and Migration of the Caprivi Killifish
- *Nothobranchius* Habitat Classification
- Life History of *Nothobranchius*

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Contents

The Cover: *Nothobranchius capriviensis*, new species; male of the Salambala NA 07-1 population from the Salambala Conservency, Zambezi Region, Namibia. Photograph by Brian Watters (© 2015).

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Distribution and migration of the Caprivi killifish, *Nothobranchius capriviensis* Watters, Wildekamp & Shidlovskiy 2015, an assessment of its conservation status, and a note on other killifish in the same area

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Abstract

Nothobranchius capriviensis occurs in several ephemeral pans in eastern Zambezi Region of Namibia, usually in isolation but rarely in association with other fish species. During flooding episodes, however, *N. capriviensis* has been recorded at two road culverts at opposite ends of its main distribution range centered on the Salambala Conservancy. On one occasion the flow was inland from the Zambezi-Chobe floodplain during a high Zambezi flood. On the other, the flow was in the opposite direction towards Lake Liambezi as a result of very heavy rainfall draining from the Salambala Conservancy woodlands. On both occasions, other small floodplain fish species were also present. *Nothobranchius* species are thus shown to have the capacity to migrate to colonise, or re-colonise, pans that are then isolated when floods subside. The recognition of *N. capriviensis* as a separate species necessitated re-appraisal of its Red List status. Strict interpretation of IUCN Red List categories necessitates placing it under "Near Threatened", but any erosion of Salambala Conservancy's protection status would immediately downgrade its status to "Endangered" under Red List Criteria B2ab(iii). Five other killifish in Zambezi Region are illustrated here.

Introduction

The Caprivi killifish, *Nothobranchius capriviensis* Watters, Wildekamp & Shidlovskiy 2015, is restricted to the eastern Zambezi Region (formerly eastern Caprivi) in Namibia (Watters *et al.*, 2014, this issue). As for other *Nothobranchius* species, the obligatory habitat for *N. capriviensis* is pans with a substratum of fine, soft black mud rich in swelling clays (Watters, 2009); for this species this habitat occurs in low-lying mopane woodland. Mopane, *Colophospermum mopane* (Benth.) J. Léonard, is a tree that occurs in almost pure stands, particularly in areas with heavy clay soils and poor drainage, and is characteristic of the region inland from the Zambezi-Chobe floodplains. In Zambezi high flood years, flood waters extend into low-lying depressions in the woodlands, while heavy local rainfall results in drainage from the super-saturated mopane woodlands towards the floodplains (see Results section below). Since the original discovery collections (Van der Waal and Skelton, 1985; Table 1a), further sampling was carried out by Watters and colleagues (Watters *et al.*, 2014, this issue), on which the species description is based. Collections were made in the same area by Tweddle *et al.* (2004) followed by more extensive surveys in the following decade in the distribution range of the species and also in surrounding areas. The species was found in more pans in its known range, but was not found in extensive pan and swamp systems to the west of its range. Notably, it was found in two separate areas at road culverts during flooding episodes, in association with numerous other small fish species characteristic of floodplain habitats. The distribution and implications for dispersal of *Nothobranchius* species to isolated pan habitats is the subject of this note. In addition, the conservation status of the species is re-assessed.

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Methods

Sampling was carried out on an *ad hoc* basis in association with other research programmes using D-nets, Samus and Deka backpack electric fishers, and, where feasible, a fine-meshed 5 m long seine net, in the months of January to April over a number of years. All fishes caught were identified to species level. Collections are housed in the South African Institute of Aquatic Biodiversity (SAIAB) in Grahamstown, South Africa. The conservation status of *N. capriviensis* was assessed using the IUCN Red List Categories and Criteria (IUCN, 2001) together with the more recent guidelines (IUCN Standards and Petitions Subcommittee, 2014).

Results

The pans in which *N. capriviensis* were caught by the present authors (Table 1a, Figures 1 to 5) all fall within the known range of the species (Watters *et al.*, 2014, this issue). In almost all isolated water bodies, it was the only fish species present. An exception was the Silumbi gravel pit, a site in mopane woodland adjacent to the Bukalo Channel that carries water from the Zambezi-Chobe floodplain to Lake Liambezi on an irregular basis dependent on the height of the annual Zambezi flood. This gravel pit is now mainly artificial, resulting from gravel extraction for road construction, but retains varied habitat including areas suitable for *Nothobranchius* survival. When full, it drains to the Bukalo Channel from which it is colonised by migrating floodplain fish species from the channel. It has also been stocked with indigenous tilapias as part of a community-based fish ranching project. *Nothobranchius* were not, however, found in this pit in 2010 and 2011 rainy season sampling, and may thus have been eliminated by the other species.

To the west of the known range of the species, several pans and extensive shallow swamps were sampled in February 2012 as

Table 1a: Summary of data on sites known to contain populations of *Nothobranchius capriviensis*.

Site	Date	Locality	Coordinates	*N. capriviensis* presence/collected	Habitat description and presence of other fish
1a	1974	Pool south of Bukalo next to road	17°45.067'S 24°33.617'E	6+ adult fish	Pan about 100 m long, up to 70 cm deep, water grey, turbid, covered in water lilies emergent aquatic vegetation and coarse grass tufts. Tadpoles and large insects present, no other fish.
1b	12-04-03	Pool south of Bukalo next to road	17°45.067'S 24°33.617'E	1 juvenile <5 mm TL	Pan about 100 m long, up to 1 m deep, water grey, turbid, covered in water lilies. Tadpoles and large insects present, no other fish.
1c	14-02-08	Pool south of Bukalo next to road	17°45.067'S 24°33.617'E	No fish	No fish. Tadpoles and large insects present. Full, grasses and water plants.
2a	1-02-08	Silumbi gravel pit	17°45.767'S 24°30.650'E	100+ killifish, each ~20 mm TL	Full, overflowing in *mulapo*, water grey/ turbid.
2b	14-02-08	Silumbi gravel pit	17°45.767'S 24°30.650'E	~60 fish along sides, 10–30 cm depth	Full, overflowing in *mulapo*, water still grey/ turbid, vegetation - dead tufts of grass. Other fish species: *Oreochromis macrochir*, *O. andersonii*, *Clarias gariepinus*. Stocked with tilapiines and catfish.
3a	1973	Sakamanduna Pan	17°45.767'S 24°30.650'E	10+ adult fish	Pan on eastern side of road, used for water collection and watering livestock, 60 m long, up to 60 cm deep, fringed by tall grass and extensively covered by grasses and sedges with small open area with water lilies and *Ottelia* sp., no other fish.
3b	12-04-03	Sakamanduna Pan	17°45.767'S 24°30.650'E	41 fish collected, both sexes	Pan 60 m long, up to 60 cm deep, fringed by tall grass and extensively covered by grasses and sedges with small open area with water lilies, no other fish.
3c	27-02-08	Sakamanduna Pan	17°45.767'S 24°30.650'E	3 males and 2 females near tussocks	Full, grass tussocks, *Ottelia* and *Lagarosiphon*. No other fish, insects and tadpoles present
3d	29-03-08	Sakamanduna Pan	17°45.767'S 24°30.650'E	18 males and 1 female	Depth 80 cm, many insects, tadpoles, water lilies.
3e	23-02-12	Sakamanduna Pan	17°45.767'S 24°30.650'E	Abundant in cattle-disturbed shallow, fish small and males not yet fully colored (Figure 3)	Sparse grasses in shallows, grasses, sedges, etc. dense in deeper areas.
4a	10-04-08	Izimwe Pan 1	17°50.167'S 24°41.550'E	No killifish, but reported here earlier (M. Saisai, pers. comm.)	2 m deep but can dry out. *'Barbus' paludinosus*, *Tilapia ruweti* present.
4b	27-01-09	Izimwe Pan 2	17°50.167'S 24°41.550'E	No fish	Connected to site 4b. Full, partly open, covered with *Azolla*, dense grass on edges, no other fish caught but catfish seen rising.

Table continued on facing page....

Site	Date	Locality	Coordinates	*N. capriviensis* presence/collected	Habitat description and presence of other fish
5a	10-04-08	Salambala Pan	17°50.017'S 24°36.050'E	3 pairs in elephant tracks, 1 red-head male	1 km across, full of grass and aquatic plants, water clear, deep pan, full. Fewer plants where *Nothobranchius* were caught, no other fish.
5b	27-01-09	Salambala Pan	17°50.017'S 24°36.050'E	Many young fish	As above, no other fish.
5c	24-04-09	Salambala Pan	17°50.017'S 24°36.050'E	18 females caught, no males	As above, no other fish.
6	10-04-08	Chiri near Dudukabe.	17°50.000'S 24°36.000'E	Few fish	Small drying pool in wetland. No other fish, abundant *Ottelia* on bottom. pH 7.3, Conductivity 120 µS cm^{-1}, temp 32.1°C, DO 136%, 8.82 mg L^{-1}.
7	10-04-08	Sizungwe, cutline Ibbu to Silumbi	17°52.650'S 24°30.300'E	21 fish	Mopane woodland. Large grass pan only 2 small holes left with water, 10cm deep waterlilies, *Ottelia*, no other fish.
8	10-04-08	Large Pan on cutline in woodland	17°52.500'S 24°30.133'E	8 females, no males	Grassy, some small pools with water lilies. One *Tilapia sparrmanii*.
9	27-01-09	Small stream near Sizungwe pan on road to Ibbu	17°52.700'S 24°32.133'E	Many fish of different size groups	All *Nothobranchius* caught in deeper (~50 cm) water near grass tufts, no other fish.
10	27-01-09	1 km S of Site 9		10+ fish	Small pools in mopane woodland, 30 cm deep, open grassland around, no other fish.
11	27-01-09	Satwa Pan, Salambala	17°52.283'S 24°33.217'E	5 fish	Large pan, grass dense, 40 cm max depth, open center, no other fish.
12	27-01-09	Itebe Pan, Salambala	17°51.783'S 24°34.150'E	3 fish in elephant tracks	Very large, ~1 km across, dense grass, 30 cm max, depth, not full, no other fish.
13	27-01-09	Nyete Pan, Salambala	17°51.083'S 24°35.467'E	4 fish	Pan 500 m across, full with grass and sedges, no other fish.
14	27-01-09	Mazibabili Pan, Salambala	17°50.867'S 24°35.867'E	3 fish	1000 x 200 m across, grass-covered but also aquatic plants, 40 cm deep, no other fish.
15a	15-03-11	Swamp near Lake Liambezi	17°52.967'S 24°24.767'E	~20 fish, both sexes	Grass-covered swamp with open water in center, depth unknown, in mulapo several hundred metres long draining to Lake Liambezi. Also caught small juvenile Clarias gariepinus.
15b	4-04-14	Swamp near Lake Liambezi	17°52.967'S 24°24.767'E	1 fish	As above for site15a.
16	1973	Small pool near the Mutwalwizi Channel, Lusese District	17°40.916'S 24°44.030'E	10+ sub-adult specimens, both sexes	Small residual pool in a seasonal channel draining the grassed floodplain near the forest edge, into the permanent Mutwalwizi Channel. ~25 km east-northeast of Bukalo, in the western marginal zone of the Eastern Floodplain. Pool 10 x 6 m and 100 cm deep, muddy water, some floating *Salvinia molesta*. Small floodplain fish also present.

Table 1b: Localities of the two culvert areas at opposite ends of the *Nothobranchius capriviensis* distribution area where migrating fish were caught, with a list of other species collected at the same time.

Site	Date	Locality	Coordinates	*N. capriviensis* presence/collected	Other fish species present
17	7-04-09	Culvert on Katima Mulilo to Ngoma road south of Kalimbeza turnoff	17°34.133'S 24°21.767'E	Fish in vegetation to side of culvert	*Marcusenius altisambesi*, *Pollimyrus marianne*, *'Barbus' paludinosus*, *'B'. multilineatus*, *'B'. haasianus*, *'B'. radiatus*, *'B'. thamalakanensis*, *Micralestes acutidens*, *Rhabdalestes maunensis*, *Clarias gariepinus*, *Schilbe intermedius*, *Micropanchax* spp, *Pseudocrenilabrus philander*, *Tilapia ruweti*, *Tilapia sparrmanii*, *Oreochromis andersonii*.
18	7-03-11	Culvert on Bukalo–Ngoma loop road, near Lake Liambezi	17°53.967'S 24°25.300'E	Several specimens collected on both sides of road	*'Barbus' paludinosus*, *'B'. poechii*, *'B'. multilineatus*, *'B'. bifrenatus*, *'B'. afrovernayi*, *'B'. haasianus*, *Coptostomabarbus wittei*, *Rhabdalestes maunensis*, *Micropanchax johnstoni*, *M. katangae*, *M. hutereaui*, *M.* sp. nov., *Tilapia ruweti*, *Tilapia sparrmanii*, *Coptodon rendalli* *Oreochromis macrochir*, *Pseudocrenilabrus philander.*
19	15-03-11	Culvert on Bukalo–Ngoma loop road, near Lake Liambezi	17°54.233'S 24°25.767'E	Several specimens collected on both sides of road	As above for site 18.

Table 1c: Localities of fish-free sites west of the *Nothobranchius capriviensis* distribution area, all investigated on 23 December, 2012.

Site	Coordinates	Description of site
20	17°50.367'S 24°02.400'E	Small pan 30 m wide and averaging 20 cm deep, grass covered with tall grass in center.
21	17°49.133'S 24°02.400'E	Large pan 60 m wide and up to 35 cm deep, grass covered with tall grass in center with some *Nymphaea*.
22	17°45.500'S 24°02.000'E	Large pan 70 m wide and over 1 m deep, in clear drainage line south of Katima Mulilo-Rundu main road. Grass covered with taller grass near center and area about 5 m wide in center filled with *Nymphaea*.
23	17°43.217'S 24°04.433'E	Extensive swamp covered by grasses with small *Nymphaea* plants, in same drainage line as site 21. Water averaging 20–25 cm deep over area exceeding 1 km in length. This swamp and pans comprise the largest aquatic ecosystem in the area, in a drainage line that extends towards the floodplains in the east.

part of an Environmental Impact Assessment for a proposed irrigation scheme, where the potential presence of this threatened species was a matter for concern (Tweddle, 2012). Preliminary examination using Google Earth of drainage patterns

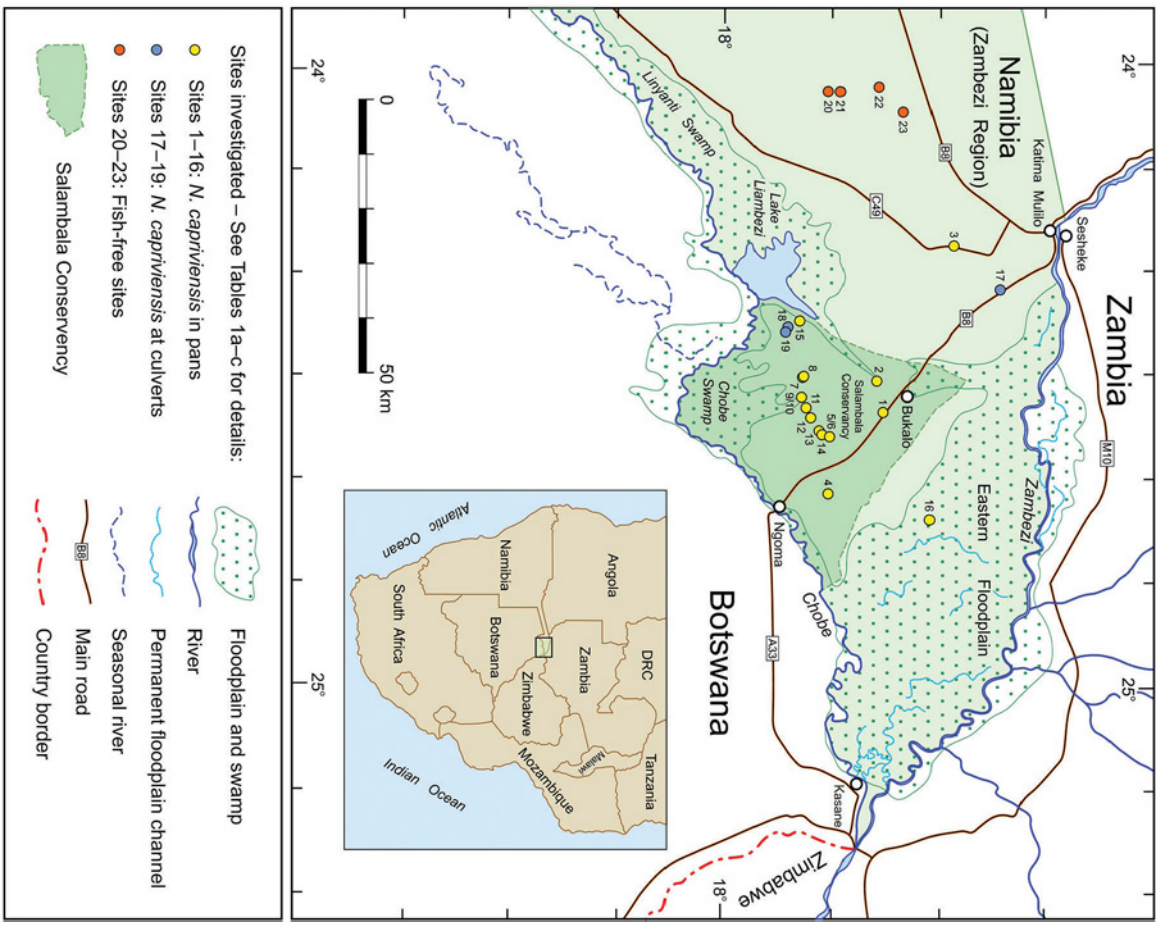

Figure 1: The eastern part of Zambezi Region, Namibia, showing the known distribution range of *Nothobranchius capriviensis*.

and abundance of pans suggested *N. capriviensis* might be present. The pans and extensive shallow swamp channels were, however, found to have unsuitable substrata of sandy beds with some soft silty mud but no black muddy clays (Figures 6 and 7). No fish species were recorded at any site (Table 1c).

The other sites at which *N. capriviensis* was collected were at road culverts. In the first of these, the channel is an established drainage line linking the Zambezi-Chobe floodplain with inland *milapo* in mopane woodlands. *Milapo* (singular = *mulapo*) are northeast-southwest trending shallow depressions probably ancient, that are seasonally flooded from the floodplains and local rainfall. At the time of sampling, the water was flowing strongly from the floodplain inland to the woodlands. Two *N. capriviensis* were caught, one male and one female. Numerous other typical small floodplain fish species were caught at the same time (Table 1b).

The other culvert sites (two culverts a few hundred metres apart) were more unusual as they are not associated with obvious stream beds. The culverts are approximately 4 km from Lake Liambezi on a new gravel loop road from the town of Bukalo to Lake Liambezi, returning via the edge of the Chobe River floodplain to Ngoma town (Figures 8 to 10). The culverts allow drainage of rainfall from the very flat mopane woodlands in the Salambala Conservancy to the lake. Other species caught with the *Nothobranchius* at the culverts are listed in Table 1b.

Figure 2: Sakamanduna Pan, the type locality for *Nothobranchius capriviensis*. Fish were abundant in the cattle hoofprints between the grass tussocks in the shallows in the foreground.

Discussion

Distribution and migrations

Nothobranchius species are characteristic of isolated, seasonal pans. Some species have very limited range, e.g. *N. capriviensis*, whereas others are more widespread but with geographical variation between populations, e.g. *N. kafuensis* Wildekamp and Rosenstock, 1989 (Watters *et al.*, 2014, this issue). The question of how the species disperse was addressed by Watters (2006, 2009). Watters *et al.* (2014, this issue) summarised this as follows: "Dispersal within any particular floodplain or system of linked floodplains will involve the fishes being transported from existing *Nothobranchius* habitats to other parts of the floodplain by flowing water and migration through shallow standing water. This will be a slow process but, over the long term (perhaps millions of years), all suitable sites will become inhabited. Features such as waterfalls, cataracts, rapids and broad strongly flowing permanent rivers can form barriers preventing the spread of a poor-swimming non-riverine fish such as *Nothobranchius* and may, therefore, constitute marked boundaries to the ranges of different species."

In almost all natural pans sampled here that contained *N. capriviensis*, it was

Figure 3: Male (above) and female (below) *Nothobranchius capriviensis* from Sakamanduna Pan in February, 2012. The fish were small and not yet fully mature at that time.

Figure 4: Ben van der Waal sampling Salambala Pan, the most important site for the long-term conservation of *Nothobranchius capriviensis*, in May, 2009. Only female fish were caught on this occasion.

Figure 5: Richard Peel sampling the swamp near Lake Liambezi.

Figure 6: Denis Tweddle sampling a sandy pan devoid of fish to the west of the *Nothobranchius capriviensis* distribution range.

Figure 7: Extensive, fish-free drainage channel to the west of the *Nothobranchius capriviensis* distribution range.

the only fish species present. Existence of other species in pans, such as predatory catfishes, may eliminate or prevent establishment of *Nothobranchius* populations. The pans are all in flat areas of woodland with no major elevation. Shallow *milapo* extend throughout, but in addition the whole area of mopane woodland that forms the distribution range of the species can be very wet and waterlogged during periods of heavy rain. This was the case in February 2011 and also in 2014, when road culverts approximately 4 km from Lake Liambezi were sampled as part of a PhD study by R. Peel on fish species succession in the lake. Lake Liambezi is ephemeral and refilled in 2009 after a period of 25 years when it was generally dry and productive farmland. This led to the rapid development of a high value commercial fishery.

The culverts are not on obvious streams but allow rainfall drainage from the woodlands and numerous pans of the Salambala Conservancy along shallow meandering depressions that can be picked out on satellite imagery. The 2011 sampling was during a period of heavy rainfall when the water level was high in the drainage channels on both sides of the road and there was strong flow towards the lake through the fully submerged culverts (Figure 8). Sampling targeted the fish species attempting to get through the culverts against the very strong flow. The cyprinids *'Barbus' paludinosus* Peters, 1852 and *'B'. poechii* Steindachner, 1911 made up the bulk of the catch (Figure 9), which comprised a multi-species breeding migration up from the lake. In contrast, it is likely that *N. capriviensis* would not be migrating upstream, but instead were being carried passively downstream in the floodwaters coming from the inland pans where they are found during the dry season. With much of the woodlands very wet and the *milapo* and pans flooded by the heavy rains, *Nothobranchius* were able to spread over a wide area, most likely passively by being carried along in the floodwaters.

In 2009, culverts along the Bukalo-Ngoma road were sampled during a flooding event, when Zambezi waters flowed inland through the culverts to the *milapo* in the mopane woodlands. In contrast to the culverts near Lake Liambezi, where the other fish species were actively migrating upstream from the lake to find spawning grounds, the fishes in this case (Table 1b) were all migrating out from the Zambezi/Chobe floodplains, swimming with the floodwaters. This life history strategy is typical of numerous African floodplain species. It is a pioneering strategy that allows small, rapidly growing and prolifically breeding species to move out from the river with the floodwaters to colonise new habitats as they become available. Van der Waal (1996) recorded such migrations in the Caprivi between 1973 and 1975. In the present case, it is uncertain whether the *Nothobranchius* specimens, caught on the inland side of the culvert, were moving with the other fishes from a population on or near the floodplain or had headed from an inland *mulapo* towards the floodplain against the current. The former seems more probable, as there was a population known from near the main floodplain, on a seasonal stream associated with the permanent Mutwalwizi Channel in the 1970s (Watters *et al.*, 2014, this issue). The Mutwalwizi population, although within the apparent floodplain boundary (Figure 1),

Figure 8: Sampling the floodwaters through the culvert near Lake Liambezi. *Nothobranchius* were caught on both sides of the road.

Figure 9: Result of a single scoop of the net at the culvert in Figure 8, catch dominated by *'Barbus' paludinosus*, *'B'. poechii* and *'B'. bifrenatus*.

was in a pool on a small winding channel draining the forested (mopane) edge of the floodplain. They had thus probably migrated, or were carried in receding flood water, from pans in the forest towards Mutwalwizi. To date, no established populations of *Nothobranchius* have been seen in waters on the main floodplain, probably as a result of competitive exclusion by other floodplain-adapted species.

Also in 2009, a year of exceptionally high Zambezi flood, the floodwaters reached well inland and road culverts were also sampled near Gunkwe (and thus close to Sakamanduna Pan), when the direction of water flow was from the Zambezi into the forest. Fishes sampled were characteristic pioneer floodplain species, including *'Barbus' paludinosus* (most abundant) *'B'. haasianus* David, 1936, *'B'. barnardi* Jubb, 1965, '*B*'. *bifrenatus* Fowler, 1935, *'B'. multilineatus* Worthington, 1933, *'B'. poechii*, *'B'. radiatus* Peters, 1853, *Coptostomabarbus wittei* David & Poll, 1937, *Micropanchax hutereaui* (Boulenger, 1913), *Brycinus lateralis* (Boulenger, 1900), *Rhabdalestes maunensis* Fowler, 1935), *Schilbe intermedius* Rüppell, 1832, *Clarias gariepinus* (Burchell, 1822), *C. ngamensis* Castelnau, 1861, *Pseudocrenilabrus philander* (Weber, 1897), *Tilapia sparrmanii* A. Smith, 1840 and *Oreochromis andersonii* (Castelnau, 1861). The drainage system for these culverts can be followed on satellite imagery through the woodlands and links to the culverts along the Bukalo–Ngoma road. There is thus a linkage at high floods between the culvert where *N. capriviensis* was found on the Bukalo–Ngoma road through to the Sakamanduna Pan area.

In conclusion, therefore, despite the apparent restricted distribution of *Nothobranchius* populations in isolated pools, the movements of *N. capriviensis* described here show that the species is able to move freely in periods of heavy rainfall and consequent flooding to colonise new areas. Each *Nothobranchius* species or geographical variety therefore has a range of distribution defined by the rainfall characteristics and flooding potential of that area. In the longer term, ranges can be fragmented by crustal deformation in various forms that can affect drainage patterns, including river capture, leading to the isolation and separation of the species into different populations and the development of different phenotypes (e.g. as with *N. kafuensis*), and eventually separation into distinct species, e.g. *N. kafuensis* and *N. capriviensis* (Watters *et al*., 2014, this issue).

Conservation (Red List) status

Watters *et al*. (2014, this issue) stated that as the species is no longer regarded as a population of *N. kafuensis*, its status of Least Concern in the IUCN Red List (Tweddle, 2007) needed to be re-assessed.

The species has a limited area of occurrence of <150 km^2. Its populations are fragmented but, as described in this note, there is opportunity for movement, links between populations and, during years with high rainfall, re-occupancy of pans in which the species had been eliminated in drier periods. The number of separate locations at which it has been found is >10. Reduction in population size can be inferred based on the current absence of the species from three previous known localities, one (roadside pan near Bukalo) as a probable result of habitat degradation through an increased human population in the general area, and two (Izimwe and Silumbi) as a probable result of predation or competition by other fish species. At one site (Silumbi), this has been exacerbated by artificial fish stocking. Several populations have a degree of protection in the core wildlife protection area of the Salambala Conservancy. Long term viability of this protection is, however, threatened by high human population growth and thus increased disturbance, e.g. by agriculture, livestock, etc. in Zambezi Region.

Assessment of the conservation status depends on the interpretation of definitions in the IUCN Red List Criteria. If the populations are defined as "severely fragmented" because of the annual isolation in pans, the species would qualify as "Endangered" under Criteria B2ab(iii). This results from (B2) an area of occupancy <500 km^2, (2a) severely fragmented populations, and (2biii) continuing decline projected in area, extent and/or quality of habitat. If, however, the migration data presented here over-rule the definition of "severely fragmented" populations, then the species narrowly fails to meet the Criteria for the defined threatened categories as a population size reduction of ≥30% cannot be inferred within the next ten years, but only over a much longer time span. The definition in this case must be "Near Threatened". Should opportunities for recolonisation be reduced in the future however it might then be considered severely fragmented and then qualify as Endangered B2ab(iii).

The guidelines for "Uncertainty" in the IUCN criteria contain a precautionary principle that states a taxon should be classified as threatened unless it is certain that it is not threatened. This has high relevance for *N. capriviensis* because of the increasing pressure on land resources in the area as a result of rapid human population growth. Conservancies do not have equivalent status to national parks and are vulnerable to local political whim. Without the existence of the Salambala Conservancy core area, a continued decline in all five categories under Criterion 2 would be projected, i.e. (i) extent of occurrence, (ii) area of occupancy, (iii) area, extent and /or quality of habitat, (iv) number of locations or subpopulations, and (v) number of mature individuals, thereby downgrading the status to "Endangered". Conservation emphasis is recommended to support Salambala Conservancy in maintaining its wildlife core area in perpetuity.

A note on other killifish species in the Zambezi/Chobe floodplain area

Four *Micropanchax* species (following the 2015 nomenclature of Eschmeyer's Catalog of Fishes (http://researcharchive.calacademy.org)) were previously recorded from the area: *M. johnstoni* (Günther, 1893) (Figure 11), *M. katangae* (Boulenger, 1912) (Figure 12), *M. hutereaui* (Boulenger, 1913) (Figure 13) and an undescribed species known as *Micropanchax* sp. "pigmy" (Skelton, 2001) (Figure 14). Their taxonomy is currently under investigation at SAIAB (R. Bills, personal communication) and on a broader African scale by R. Wildekamp and colleagues, and it is likely that changes in classification will occur with Zambezian species recognised as distinct from those of rivers to the north. Each of these species is well-known in the area. The first three are abundant on the Zambezi/Chobe floodplains and were caught together with *N. capriviensis* at the culverts near Lake Liambezi. The unde-

scribed *M*. "pigmy" has a more restricted distribution, in large swamps and permanent *dambos*. *Dambos* are drainage channels in areas of clay soils and consequently impeded drainage that results in waterlogged soils and inhibited tree growth. *Dambos* are prominent features in the Zambezi landscape at a range of elevations,

Figure 10: *Nothobranchius capriviensis* male from the road culvert near Lake Liambezi.

Figure 11: *Micropanchax johnstoni* male, a common poeciliid in the region.

Figure 12: *Micropanchax katangae* male, a common poeciliid in the region.

which distinguishes them from *milapo* connected to the floodplains.

In addition to these species, a fifth species was caught at the culverts near Lake Liambezi (Figure 15). This species resembles *M. johnstoni* in general appearance and body proportions and may have been misidentified in previous preserved collec-

Figure 13: *Micropanchax hutereaui* male, a common poeciliid in the region.

Figure 14: *Micropanchax* sp. "pigmy" male, an undescribed but well-known species characteristic of swamps and *dambos* in the region.

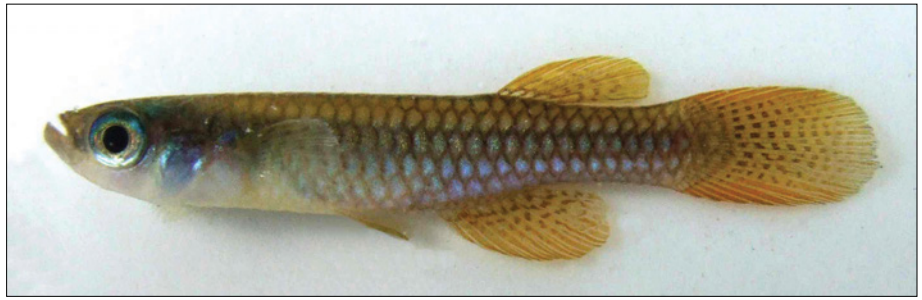

Figure 15: *Micropanchax* sp. "Liambezi" male, an apparently undescribed species found at the road culverts near Lake Liambezi.

tions. The most notable character is that all body scales are outlined with pigment, giving a mesh scale pattern similar to, but not as sharply defined as, that of the mesh-scaled topminnow, *M. hutereaui*, with which the species was caught at the culverts. Preserved specimens of this species have a dark mid-lateral band, a character not seen in *M. johnstoni*. Remarkably, specimens of the same or a very similar species are now being noted in widely separated parts of the Zambezi system. Marshall (2011, p. 196) reported a species from the upper reaches of the Matetsi River, now a tributary of the Middle Zambezi River, that "differ from *M. johnstoni* in having a dark lateral band along the sides and a dark band on the back, while the scales have a more marked mesh-like appearance and there are distinct marks on the caudal fin". This is an accurate description of the Liambezi culvert specimens. Marshall (2011, p. 13) stated that the upper Matetsi and Deka Rivers have species characteristic of the Upper Zambezi and thus are relict populations from the period pre-dating the capture of the Upper Zambezi by the Middle Zambezi in the Batoka Gorge/Victoria Falls area.

More remarkably, Martin Genner (2014, personal communication to D. Tweddle, with photo) collected a similar, probably identical species from a stream flowing into Lake Malawi in Mozambique, about 1 km from the lake. The Lake Malawi streams in Malawi were extensively and intensively sampled by the first author (summarized by Tweddle, 1996), and thus this discovery was completely unexpected. These discoveries show that the rivers of Africa are still capable of producing surprises and many changes and new additions can be expected in poeciliid taxonomy in future.

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References

IUCN. 2001. IUCN Red List Categories and Criteria: version 3.1. IUCN Species Survival Commission. IUCN, Gland, Switzerland and Cambridge, UK. Ii+30 pp.

IUCN Standards and Petitions Subcommittee. 2014. Guidelines for Using the IUCN Red List Categories and Criteria. Version 11. Prepared by the Standards and Petitions Subcommittee. Downloadable from http://www.iucnredlist.org/documents/RedListGuidelines.pdf.

Marshall, B. 2011. The fishes of Zimbabwe and their biology. The South African Institute for Aquatic Biodiversity & the Royal Museum for Central Africa, Smithiana Monograph 3: 290 pp.

Skelton, P.H. 2001. A complete guide to the freshwater fishes of southern Africa, Southern Book Publishers (PTY) LTD, Halfway House: 395 pp.

Tweddle, D. 1996. Fish survey of Nkhotakota Wildlife Reserve. A report to the Japanese International Cooperation Agency on behalf of the Wildlife Society of Malawi. JLB Smith Institute of Ichthyology, Investigational Report 53: 79 pp.

Tweddle, D. 2007. *Nothobranchius kafuensis*. In: IUCN 2013. IUCN Red List of Threatened Species. Version 2013.2.

Tweddle, D. 2012. Namibia Agriculture & Renewables, Caprivi Irrigation Project. Environmental Impact Assessment, Aquatic Ecology Component. Colin Christian & Associates CC: 10 pp.

Tweddle, D., P.H. Skelton, B.C.W. van der Waal, I.R. Bills, A. Chilala and O.T. Lekoko. 2004. Aquatic biodiversity survey for the "Four Corners" Transboundary Natural Resources Management Area. Final Report – July 2004. Report for African Wildlife Foundation, SAIAB Investigational Report 71: xviii+202 pp.

Van der Waal, B.C.W. 1996. Some observations on fish migrations in Caprivi, Namibia. South African Journal of Aquatic Science **22** (1/2): 62–80.

Watters, B.R. 2006. Dispersal of *Nothobranchius* – Fact and Fiction. Journal of the American Killifish Association **39** (3–4): 137–144.

Watters, B.R. 2009. The Ecology and Distribution of *Nothobranchius* Fishes. Journal of the American Killifish Association **42** (2): 37–76.

Watters, B.R., R.H. Wildekamp and K.M. Shidlovskiy. 2014. Description and biogeography of *Nothobranchius capriviensis*, a new species of annual killifish from the Zambezi Region of Namibia (Cyprinodontiformes: Nothobranchiidae). Journal of the American Killifish Association **47** (4–6): 97–133.

International Union for Conservation of Nature (IUCN)

Editorial note by Brian R. Watters

The IUCN is an international organization, a global environmental network, whose mission is to "influence, encourage and assist societies throughout the world to conserve the integrity and diversity of nature and to ensure any use of natural resources is equitable and ecologically sustainable". Through its members (more than 1200 governmental and non-governmental organizations), as well as a very large number of scientists and experts, the IUCN gathers and manages biodiversity data in support of its mission and advocates for free access to such information.

The IUCN Red List of Threatened Species is the "most comprehensive, objective global approach for evaluating the conservation status of plant and animal species". The list and principles involved are the main source of guidance for the conservation activities of governments, non-governmental organizations and scientific institutions. The IUCN Red List aims to: establish a baseline for the monitoring of changes in species status; provide a global context for establishing local conservation priorities; monitor the on-going status of representative species, as biodiversity indicators, in major ecosystems. The assessment of conservation status for a species is carried out through "Red List Authorities" usually a Specialist Group responsible for the species, group of species or a specific geographic area. Only after consideration of supporting information, verification of its scientific accuracy, and consultation, will a species be included on the IUCN Red List.

Reference: IUCN web site at: http://www.iucn.org