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Towards understanding the presence of abundant fish in running *iishana*

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Abstract

Although the *iishana* (seasonal watercourses) deltaic system in northern Namibia and southern Angola is usually dry, millions of fish populate the more than 100 000 km² area during high floods that occur irregularly about once in three years. The origin of the fish has been a topic of debate for a long time, including suggestions of refugia for breeding fish in the upper parts of the Mui and Cuvelai catchments, deep dams in both Angola and Namibia and fish arriving with flood water from the Kunene River. This paper discusses fish collections made during a major *efundja* (large flood with plenty of fish) in 2017 and a medium flood in 2020. The bulk of fish during major *efundja* comprise two species that were also collected in the flooding Cuvelai and in *iishana* fed from deep dams in 2020. The source of fish during medium floods is therefore ascribed to fish surviving in refugia and then breeding successfully. The fish occurring in abundance in *iishana* during major *efundja*, however, come from tributaries of the Kunene along the divide with the western *iishana*, where spawners and young fish cross the divide and migrate into the headwaters of the *iishana*. Plentiful fish during *efundja* relies on unhindered access into the *iishana*. The Cuvelai system is threatened by environmental degradation in the *iishana* region and inappropriate road infrastructure is a constraint. Fisheries activities should be regulated and cooperation between the Angolan and Namibian authorities is required to ensure the survival and continuation of fish resources.

Introduction

The *iishana* (Oshiwambo, plural of *oshana*, shallow seasonally flowing grassy channel) of southern Angola and northern Namibia are part of the Cuvelai Drainage, a seasonal drainage wedged between the Kunene and Okavango Rivers (Figure 1). In ancient times, the upper Kunene did not flow westwards to the Atlantic Ocean but drained southwards into a former Lake Kunene, a much larger precursor of modern day Etosha Pan (Hipondoka *et al.* 2006). The upper Kunene was captured near present day Calueque by a smaller river to the west, leaving only the present Cuvelai and some branches to feed the *iishana* and Etosha (Mendelsohn and Weber 2011, Mendelsohn *et al.* 2013). Consequently, *iishana* are usually dry and only receive substantial floodwaters on average every third year in summer. Then usually bone-dry channels suddenly teem with small and some larger fish, all moving south with the slow water current. Such *efundja* (Oshiwambo, floods) are a welcome source of fish to local people; they use traditional traps and baskets and also modern nets, fykes and line and hooks to trap and catch mainly small barbs (Figure 2) and young catfish (Figure 3). During good *efundja* large numbers of fish are caught and offered for sale along roads or dried for later use (Figures 3 and 4), providing a valuable protein addition for residents.

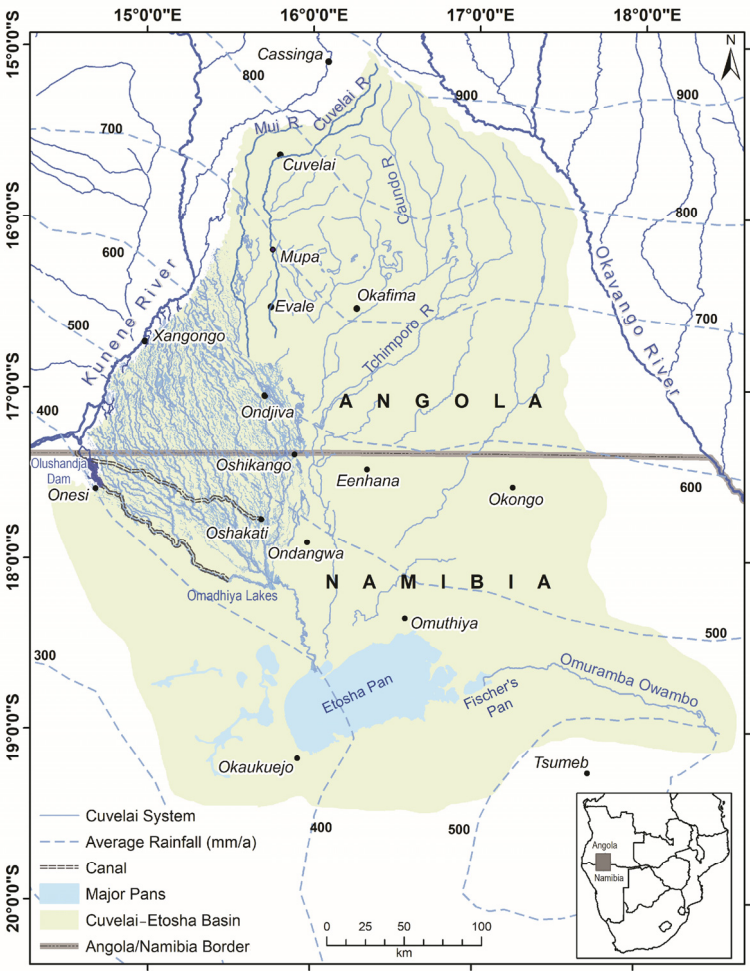

Figure 1: *The Cuvelai catchment with adjacent river systems.*

Figure 2: *Two barb species (*Enteromius *spp.) or* oontangu *(Oshiwambo) that form the main composition of the* efundja *catch together with catfish. These barbs are also the reason for the extremely fast growth of catfish that feed on them, reaching a length of 30 cm from December (when they hatched) to April.*

Figure 3: *Catfish (*Clarias gariepinus*) or* ehepala *(Oshiwambo) from the 2020 small* efundja*, for sale along the road near Oshakati, April 2020.*

The Cuvelai is zoogeographically not completely separated from the Kunene due to a man-made canal linking the two rivers (Figure 1) (Hay *et al*. 1997, van der Waal 1991). Of the 46 fish species collected in the Cuvelai, *iishana* and canals supplying water from the Kunene to the *iishana* system, 17 are considered migrants from the Kunene via the canal (van der Waal 1991). In the southern Cuvelai the environment is saltier, drier and harsher, and there only 9 fish species are regularly found, dominated by catfish and barbs. The Cuvelai does not have any unique or endemic fish species.

It was previously assumed that the suddenly appearing fish in flooding *iishana* all come from almost permanent pools higher up in the Cuvelai River, with possible contributions by other rivers, e.g. the Mui and Chimporo in southern Angola (Figure 1), but it was difficult to understand how all *iishana* can become so quickly populated. The more than 100 *omatele* (Oshiwambo, livestock watering dams) that were built in the 1960s were then assumed to act as refugia and reservoirs for breeding fish. However *efundja* with plenty of fish also happened before these deep dams were built, and the very large numbers of fish caught during major *efundja* (Figure 4) cannot have originated from the relatively small pools and dams.

In 2017, new information was gathered of mass fish migrations upstream into small tributaries of the Kunene, originating on the divide between the Kunene and westerly *iishana* (Hipondoka *et al*. 2018). It is now understood that whereas water does not actually flow from the Kunene into the Cuvelai or its *iishana* (Stengel 1963), surface water connections are established during heavy rain and flood conditions and this facilitates the crossing of breeders and small fish from the Kunene tributaries into the headwaters of western *iishana* (Hipondoka *et al*. 2018). Because the steep tributaries of the Kunene dry up very quickly, once fish have crossed the divide they have no option of returning and follow the slow current southwards.

In February 2020 after good rain had fallen and the Cuvelai was reported to be flooding in southern Angola, an investigation was made by visiting *iishana*, tributaries on the divide between the Kunene and Cuvelai north of Ruacana, and the lower part of the Cuvelai at Mupa and Evale. A large scoop net with deep bag and 8 mm mesh size and a small seine net were used to collect fish specimens. Catches by local fishers using traditional traps and seine nets were also recorded.

Figure 4: *Mass fishing activities during the large* efundja *in 2008 resulted in large scale fish sales along roads.*

Results and discussion

Sites where surface water connections between the two river systems were possible were found (Figure 5) but due to the lack of follow-up rains no active fish migration was observed on the divide. An important find was the collection of the dominant fish species of the *efundja* (*Enteromius paludinosus*, *Clarias gariepinus* (Ekandjo 2009, van der Waal 1991)) in the flooding Cuvelai in southern Angola. *Iishana* further south in Namibia were also sampled and some fish were collected in running *iishana* that had connections with deep dams, but where the Cuvelai floods from Angola had not yet reached. Additionally, fish escaping from the overflowing Olushandja–Oshakati canal were collected. During this medium *efundja*, low numbers of fish were collected, assumed to have originated from the canal, pools and dams in which fish populations had remained after the good 2017 *efundja*.

It can now be seen that the abundant fish life of the *iishana* during efundja has multiple origins:

1. Permanent pools in the Cuvelai River in southern Angola (above Evale).
2. Semi-permanent deep livestock drinking dams (*omatale*) in southern Angola and northern Namibia.
3. The Olushandja–Oshakati canal and the canal from Olushandja down the Oshana Etaka, when they are overflowing or leaking (see Figure 1).
4. The divide area where the Kunene tributaries originate close to the top end of *iishana*. During floods and good rain periods, Kunene fish migrate upstream in tributaries to breed and disperse and they and their offspring can then reach the *iishana* and migrate downstream.

As soon as the *iishana* have filled from local rainwater, the connecting drainage lines spill their overflowing water southwards and a general southward flow starts. This flood is reinforced by floodwaters from the Cuvelai and Mui Rivers, causing stronger flows at constrictions in the channels, culverts and smaller bridges. Fishing is concentrated here and the many long fine-meshed funnel nets often completely block the passage of fish (Figure 6). During major *efundja* abundant water from upstream as well as from within the *iishana* region itself causes general overflowing and then all *iishana* become interconnected enabling fish to disperse over the entire *iishana* region.

This observed downstream migration is the opposite of the general tendency of fish to migrate upstream. There are two general upstream migration types: breeding migrations to reach the shallow vegetated inundated spawning sites of many freshwater fish species, and expansion migration, usually upstream by mainly young fish in an attempt to distribute the species higher up in the system. One of the driving forces behind the observed downstream migration in the current case is the plentiful availability of food in newly inundated areas, providing for both the smaller insect and plankton eating barbs and larger predatory catfish that also feed on them.

The Cuvelai *iishana* system is a unique ecosystem that is driven by cycles of rain and flood water. While the ancient connection with the Kunene remains intact, fish can enter the system. Fish are a valuable benefit of *efundja*. The whole system is however threatened by environmental degradation in the *iishana* region and inappropriate road infrastructure is a constraint (Figure 7).

Figure 5: *On the divide between the Kunene and Cuvelai catchments, facing the Kunene, February 2020. Fish can reach these shallow standing pools if there is enough rain, and thus move into the* iishana, *breed and populate them.*

Figure 6: *Nine funnel nets just below a culvert intercept fish migration, with a second and third row behind them,* efundja *2008.*

Figure 7: *Two examples of inappropriately designed and seriously eroded culverts on the road near the divide, that actually overtopped during a flash flood early in the 2020 rainy season. All smaller fish and most larger fish would have great difficulty getting across these obstacles*

Furthermore, the Cuvelai drainage presents a good example of the need of cooperation between neighbouring states. The survival and continuation of fish resources in the interior of the *iishana* system in both southern Angola and northern Namibia is dependent on the protection and conservation of fish refugia populations in the Cuvelai River itself, the existence of deep dams and pools and especially on the maintenance of connectivity between the Kunene and *iishana*. It is of utmost importance that these shared water and fish resources are jointly conserved and that harvesting of the fish resources is planned and regulated.

Some suggestions that may help to promote increased fish presence in the *iishana* during floods include:

1. Modifying the road running on and near the divide between the Kunene and headwaters of the *iishana* by inserting suitable fish-friendly culverts and bridges at every drainage and stream (Figure 7).
2. Placing a ban or restrictions on netting directly at and near any man-made constriction of *iishana* and streams, including bridges and culverts. The Namibian Inland Fisheries Act of 2003 states that no fishing is allowed within 100 m of bridges and culverts; however, we have not observed its enforcement in the Cuvelai. Traditional bunds with fish traps placed in openings can however still be allowed as their effect is limited. Traditionally, local chiefs decided when fish in the *iishana* had grown big enough to be harvested. Traditional authorities and communities should again become involved in conservation of local fish life.
3. Designation of all deep dams and ponds in both countries as fish refugia, allowing fish to survive and breed early in the next rainy season.
4. Developing extensive fish farm projects through fish breeding facilities that can breed fingerlings for release in local *iishana* every year that water is present (about 2 in 3 years). In order to prevent any introduction of parasites and genetic deterioration, only locally occurring fish should be used in breeding programmes.
5. Regular monitoring for the presence of fish and managing the fish migrations so that accumulating fish life in the drainage pans of the Omadhiya wetlands can also be harvested optimally.
6. Initiating a study on the economic value of local fish in the region to motivate active management of this resource.

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