Characterization of Habitats and Haplochromine Diversity to Guide Conservation of Biodiversity amidst Hydropower Developments along the Upper Victoria Nile

A Report

Prepared for the Ministry of Energy and Mineral Development

By

National Fisheries Resources Research Institute (NaFIRRI), Jinja (Uganda)

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Neochromissimotes caught at Isimba falls

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Executive summary

Dams are usually constructed along water courses for various economic uses, but conservation of important organisms and services originally in the area have to be considered. This study was undertaken between October and November 2016 to characterise the habitats to guide conservation of fish species, especially haplochromines of conservation importance, amidst development of dams along the Upper Victoria Nile (UVN). The aim of the study was to provide information on the relationship between habitat characteristics and the diversity of fish, especially haplochromines, and the changes that are likely to occur following construction especially of Isimba Hydropower Plant (IHP)).

The changes expected after construction of IHP were determined by examining the changes that have taken place following construction of Nalubale/Kiira dams in 1954 over sixty years ago, Bujagali Hydropower dam (BHD) completed in 2012 (about four years ago) and the situation around and below the site where IHP was being constructed. These were designated into Zones I, II and III respectively. Each of these zones was divided into two categories, the first representing the changes that are likely to occur in the flooded areas above each dam and those that may occur below the dam. Fish were sampled at different stations in the two categories in each zone based on habitat type such rocky, macrophyte, sandy habitats to which the fish were adapted to survive.

Sixty two haplochromines species, some previously unknown species and seemingly endemic to the Victoria Nile, were observed in the different habitats. There were faunal changes from the Rippon falls area in Zone I, which mainly had inshore Lake Victoria species, to the middle section of the UVN in Zone II, which was dominated by endemic species some of which have adaptations to living in rocky rapids. These unique species included the endemic *Neochromis simotes*, a species of conservation importance, a new species that was assigned cheironym *Neochromis* sp. "Labeo" (because of its mouth similar to that of *Labeo* spp., an adaptation to grazing on the rocks in strong currents), and a new red breasted *Paralabidochromis* sp. with yellow pelvic fins. These unique taxa were common in the middle parts of the river starting from Busowoko in Zone II downstream. These habitats, which have been less disrupted, harboured the highest number of haplochromine species with no known counterparts in either lakes Victoria or Kyoga. Given that some of the species are undescribed, they can disappear unnoticed due to multiple anthropogenic activities, including dams and other habitat changes such as destruction of marginal vegetation, and there is need for concerted efforts to protect them. This will require conservation of the unique habitats, to which the species are adapted to live, such as rocky shores with strong currents and vegetated areas.

In Zone III, where IHP is located, *N. simotes* was found at Kirindi, Isimba, Mbulamuti and Kakindu. This species has historically been known to be extant in these localities. Populations that compareto *N. simotes* have also been reported in rocky areas in Busowoko and Itanda Island in Zone II. During this study, *N. simotes* was however found in only four major sites, two of which (Mbulamuti and Kakindu) will not be extremely affected by upstream flooding by IHP. These areas could potentially form an offset area for conservation of the fishes affected by IHP. The upstream populations in Isimba and Kirindi might be

affected through a reduction in flow current to which these fishes are adapted to live and feed, and through increased predation by Nile perch whose populationis expected to increase in the flooded reservoir. Available data shows that Nile perch, which contributed to decimation of >300 haplochromine cichlids in lakes Victoria and Kyoga, occurs along the entire stretch of the UVN, but many haplochromines which are its preferred prey have been able to persist due to availability of rocky and macrophyte refugia. Similar survival of rocky and macrophyte-dwelling haplochromines have occurred in the main lakes Victoria and Kyoga, and elsewhere in African Great lakes, including Malawi and Tanganyika, which emphasises the importance of protecting rocky and macrophyte habitats in conservation of haplochromine cichlids. Creating more open waters in the reservoir is likely to open more hunting ground for Nile perch and contribute to reduction of haplochromine abundance as has been observed following commissioning of BHD.

The other potential threat to biodiversity noted during the study is that most of the marginal areas along the river banks are under intense pressure from rapidly changing land use practices. There is extensive cultivation of river banks which will accelerates siltation and this is not only a major threat to aquatic biodiversity (including haplochromine abundance) but to the dams themselves. Although water transparency and other water quality parameters in the areas were still good, apparently due to constant flushing, siltation is expected to increase, especially in the reservoir areas. This is likely to negatively affect the abundance of endemic haplochromine genera that depend on light for feeding and breeding as has been the case in Lake Victoria and its satellite lakes, especially in the River Kagera catchment. This should, as a priority, be addressed.

Large expanses of a noxious aquatic weed, *Salvinia molesta*, commonly known as Kariba weed, were encountered in the construction area around Isimba. This is a highly invasive weed and should be carefully removed before the area is flooded; otherwise, it may cause a major threat to the dam after flooding as was the case on Lake Kariba. Sporadic infestations of the weed were also observed in Busowoko. This weed clogs waterways and blocks sunlight needed by aquatic plants and especially algae to carry out photosynthesis. Decomposition of the weed uses up the oxygen causing de-oxygenation and suffocating aquatic organisms and can kill any organism, including fish, trapped underneath. Its presence around Isimba is therefore a threat to biodiversity. This weed will cost the Government of Uganda billions of shillings to control in Lake Kyoga, where it has successfully colonised, and its proliferation around Isimba will complicate its control and affect dam operations.

We recommend as follows:

a) A baseline survey including all aspects of fisheries (biological, environmental, and socio-economic) should, as a priority, be undertaken around Isimba, before dam construction is well advanced (and the area is flooded), followed by systematic monitoring of biodiversity, similar to what was done and is continuing for BHD.
b) Kariba weed around Isimba should be removed before the area is flooded, and measures put in place to control its proliferation. Biological control of the weed has been observed

to work using the Salvinia weevil (*Cyrtobagous salviniae*) but this has not yet been tried out in Uganda.

c) Cultivation of river banks along the UVN should be regulated in line with the National Environmental Management Authority (NEMA) regulation of 2000 regarding wetlands, river banks and lake shores.

d) The live bait fishery, especially upstream Kalange, is threatening fish biodiversity, and should be regulated,especially for the juvenile Elephant-snout fish (Kasulubana).

e) The area below Isimba, starting from Mbulamuti, through Namasagali downstream to Lake Kyoga, should be designated a conservation area to protect fish species diversity which may be affected by flooding of Isimba dam and in that regard, the area downstream of Kakindu should be surveyed to determine the extent of species of conservation importance, such as *N. simotes*.

f) KAO should be extended further upstream to Busowoko to compensate for the expected flooding due to Isimba.

1. Introduction

The demand by the increasing human population has led to environmental changes resulting from infrastructure developments such as conversion of land for agriculture, urban development, communication structures, and hydropower generation and distribution. These change the natural environment into other land forms including farmlands and cities. These have been enhanced other stressors such as over-exploitation of the resources, proliferation of invasive species, environmental degradation, eutrophication, habitat alteration and loss, and climate change, which threatens biodiversity.

Lake Victoria is among the most important economic assets of the East African region. The lake provides water for industrial and domestic use, modulates local climate, has the most productive inland lake fishery in the world (estimated at about one million tons per year),and has been a main subject of study for conservation biologists for its >500 haplochrominespecies, 99% of them endemic, which used to dominate the fish stocks before 1980. Lake Victoria is a main water reservoir and source of the Nile, which is important in hydropower generation and irrigation, not only in Uganda but many countries downstream. However, over exploitation of the resources, introduction of non-native fish species, such as the Nile perch, and land use change have contributed to reduction in fish stocks and drastically reduced fish species diversity.

Haplochromine cichlids are among the most abundant and diverse fishes in freshwaters in the world with most of them being endemic to individual lakes. The majority of haplochromine cichlids are found in the East African Great Lakes, which have a total of ca. 2000 species most of them endemic to specific water bodies (Danley et al. 2012). Among the most species-rich lakes, Lake Tanganyika has ca. 250 endemic haplochromines species (Coulter 1991), Lake Victoria ca. 500 species (Witte et al. 2007), and Lake Malawi >800 endemic haplochromines (Fryer and Iles 1972). The diversity and endemism of haplochromines has been due to availability of unique habitats, such as rocky areas, marginal wetlands, sandy and muddy bottoms, to which individual species adapted spatially, morphologically, nutritionally and behaviorally to evolve into numerous endemic species. Consequently, haplochromine species have been important in ecological and evolutionary studies, and in the stability of ecosystems in which they are found as they are specialized to occupy virtually all habitats and to feed on most materials found in different ecosystems. Because of the high level of specialization, they have been affected by anthropogenic stressors including over exploitation, introduction of invasive species, habitat degradation, pollution, and more recently climate change. Lake Victoria lost about 60% of the 500+ mostly endemic haplochromine species, due to environmental degradation, predation by the introduced Nile perch, and climate variability and change in less than half a century (Witte et al., 1992; Seehausen et al., 1997; van Zwieten et al., 2016). However, some haplochromine species especially those that live among macrophyte and rock-refugia, have survived, amidst the different stressors. This suggests some highly vulnerable fish species can survive amidst stressors when specific habitats are protected. These species need to be identified and the habitats, which contribute to their survival, characterised, mapped and managed to conserve these fishes.

River Nile is one of the longest rivers in the world stretching over about 6,800 km through eleven countries from Lake Victoria to the Mediterranean Sea. In Uganda, the river flows over diverse habitats including rocky areas, falls and rapids, with marginal macrophytes from an altitude of 1,134 m a.s.l. on Lake Victoria, to 1,034 m a.s.l. on Lake Kyoga, and 615 m a.s.l. on Lake Albert. These attributes provide great potential for hydropower generation. However, the Upper Victoria Nile (UVN), which connects lakes Victoria and Kyoga has these unique habitats that include rocky areas, falls and rapids and marginal macrophytes that provide suitable habitats for evolution of unique haplochromine taxa and which serve os refugia for endangered species, and are important in conservation of fishes that might be endangered in the main lake, or those which exist exclusively in the region. The UVN has been reported to have some species that do not appear anywhere else in the World such as *Neochromis simotes* and are of conservation importance.

The Government of Uganda has, and is still constructing dams along the UNV to provide hydropower, which is critically required for national development. Three dam (Nalubale, Kiira, and Bujagali) have been constructed and are already operational along the UVN (**Figure 1**). Two other dams (Isimba and Karuma) are under construction, and five others areas along the Nile in Uganda (Kalagala, Oriang, Ayago, Murchison and Kiba) have been identified as potential areas for dam construction. Damming of the river is accompanied by alterations in habitat that can result into decline and/or loss of biodiversity and critical riverine fisheries. River damming can, however, be beneficial through creation of new fisheries especially in flooded areas. There is, therefore, need for information to guide interventions to ensure that dam construction puts into consideration issues of biodiversity and to ensure conservations of fish species diversity and management of emerging fisheries. Measures need to be put in place to protect fishes and other organisms that may be affected by development of hydropower projects.

Construction of Bujagali Hydropower Plant (BHP) culminated into an Indemnity Agreement between the Government of Uganda and the World Bank in 2007, which required the former to protect and conserve the natural habitat, environment and spiritual values of the downstream Kalagala Offset Area (KOA) to compensate for the loss of biodiversity and other values arising from flooding effects of the BHP. However, the Government of Uganda is constructing Isimba Hydropower Plant (IHP), a 183 megawatts project, 20 km downstream the KOA. There are concerns that IHP may impact biodiversity and various ecosystem services, including disturbance of habitats for fish species of conservation importance such as the haplochromine cichlids, and more specifically *N. simotes*, which is so far known to occur exclusively along the UVN.

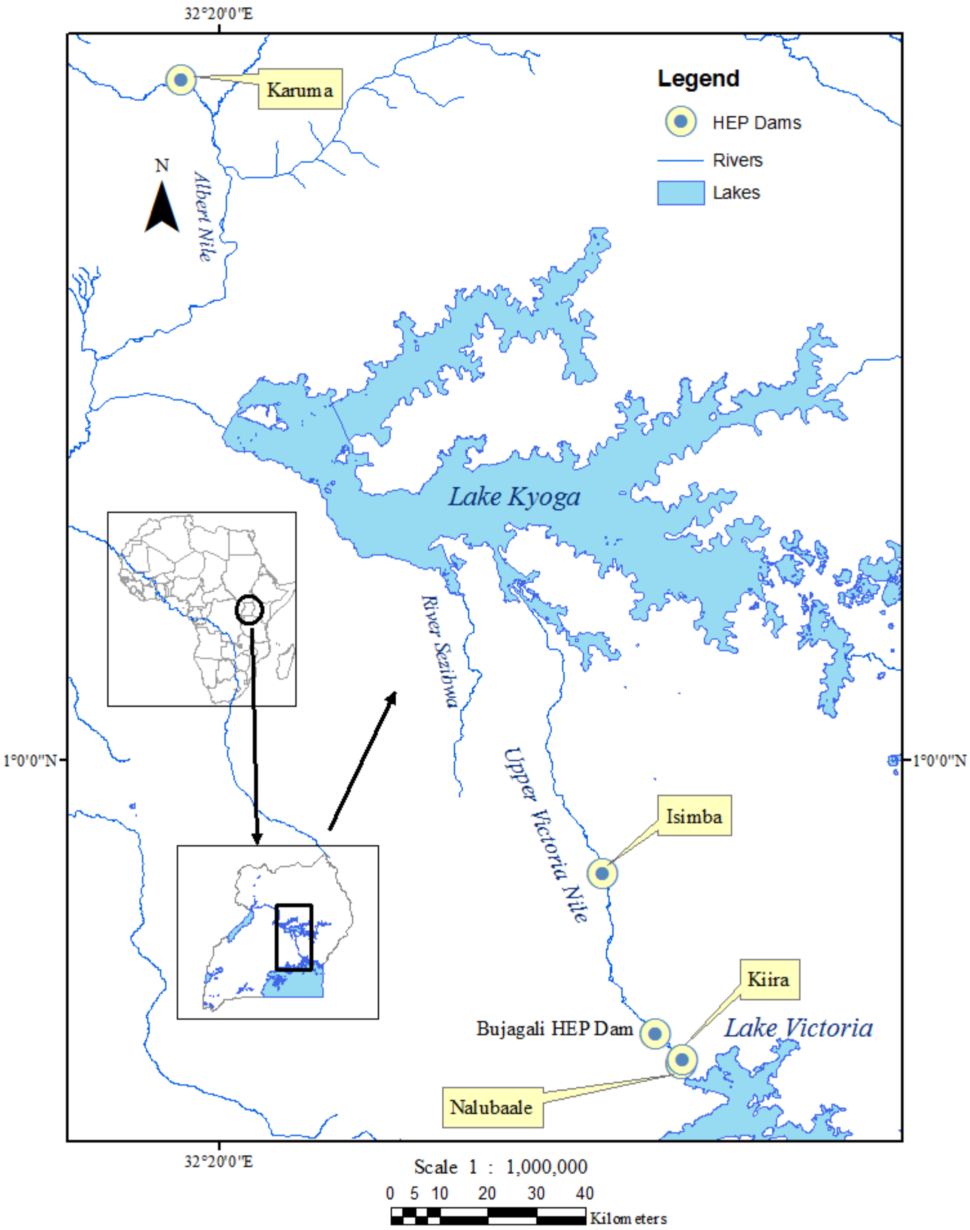

Figure 1. Location of the Hydro Electric Power dams along the Victoria Nile and Albert Nile. Note that Isimba and Karuma are currently under construction

A systematic assessment and monitoring of aquatic biodiversity and environmental factors, including quantitative data on occurrences of fish species, especially haplochromine species, was undertaken in 2000 by the National Fisheries Resources Research Institute (NaFIRRI) before construction of the BHP to act as baseline for future monitoring to infer influence of the dam and guide conservation of the fishes that may be affected, but no similar assessment was undertaken for IHP. Consequently, NaFIRRI was requested to provide information on habitat characteristics and the diversity of fish species, especially haplochromines, associated with the different habitats to strengthen the Environmental and Social Impact Assessment (ESIA) for the IHP. NaFIRRI was specifically requested to:

a) Review available information to determine the extent to which IHP would impact the habitat and fish species diversity, with emphasis on haplochromines of conservation importance;
b) Characterize the habitats between Lakes Victoria and Kyoga and isolate the unique attributes contributing to haplochromine occurrence in the specific areas, and the changes that are likely to occur as a result of the IHP;
c) Provide a list of fish species occurring in the UVN with emphasis on haplochromine cichlids and assess their extinction threat in accordance with international designations (e.g. IUCN);
d) Evaluate the possibility that the cited species of conservation importance occur outside the area to be affected by IHP;
e) Indicate the extent to which the initial concerns of the Indemnity Agreement can be met;
f) Prepare a long-term monitoring programme for areas around the established and on-going hydro-power projects along the UVN and Lower Victoria Nile (LVN); and
g) Provide recommendations on a monitoring programme for aquatic biodiversity and fisheries in light of dam constructions along the UVN and LVN.

2. Methodology

2.1 Selection of sampling areas

Reconnaissance field surveys were undertaken between 5th and 10th October 2016, and 13th to 15th October 2016 to characterize the habitats along the Upper Victoria Nile (UVN), identify and select the sites to be sampled during the survey and logistical needs such as boats, fishing gear, and personnel to assist in the survey.

The selection of the sites for generating information to guide conservation of biodiversity in light of development of hydropower projects along the UVN was based on two major assumptions. The first assumption was that the changes that had taken place following construction of Nalubale/Kiira dams (over sixty years ago), those that had started taking place following completion Bujagali Hydropower dam (BHD) (about four years ago), would provide information on the changes that would be expected to take place around IHP that is being constructed, and subsequent constructions. The second assumption was based on the fact that dams are normally constructed downstream of the falls and, although they submerge the falls in their immediate vicinity upstream, the rocky areas in the area of the falls which are important habitats for fish normally remains intact. It was noted, in addition that the area above the dam is transformed into a lake-like habitat while that below the dam remains relatively turbulent even after construction of the dam and maintains some riverine conditions that may have existed before dam construction. Based on these assumptions, stations were chosen for sampling above and below existing dams and those under construction. In this regard, above and below dams sites, respectively were Ripon falls area, which has Bukaya and Lower Nava as representative zone of Nalubale and Kiira that was completed around 1954, Kalange and Buyala as representative a zone of Bujagali dam completed in 2012, and Kirindi, Isimba, Mbulamuti as a representative zone of Isimba, the dam that was under construction at the time of the survey in 2016. These were designated as Zones I, II and III, respectively. Each of the zones was classified into two categories with the first representing the changes that are likely to occur or had occurred in the flooded areas above each dam, and those that may occur below the dam. Sampling stations were selected under each category of the different zones based on habitat characteristics. In areas where there were major falls with no dam such as Itanda/Kalagala, efforts were made to choose stations above and below the falls for sampling. The stations were based on uniqueness in relation to the known habitat preferences for the fishes such as rocky, sandy, muddy, vegetated areas and fish species composition and abundance based on information from previous surveys especially that of 2000-2001. Figure 2 shows the zones and the locations of the sites that selected for the sampling in each zone. The actual stations sampled in each zone are indicated on Figures 3, 4 and 5.

It was anticipated that the areas, especially below existing dams and those under construction could be designated to serve as potential areas for conservation of riverine species affected by construction of the dams, similar to what was expected of KOA that was set up following construction of BHP if they were found to contain those fishes of conservation importance.

They would, therefore, provide information on the extent to which the initial concerns of the Indemnity Agreement can be met.

The specific habitats chosen for sampling also guided the choice of the fishing method employed. Stations with rocky habitats were sampled using hooks, while those with vegetated shores were sampled using gillnets. In some instances, a combination of hooks and gillnets were used.

2.2. Description of the zones

Zone I represented the area of Nalubale and Kiira dams where flooding was done in 1954, about sixty years ago. This zone is located in an urban setting of Jinja town and there are many developments to the shores of the river. Four stations were selected for sampling in the reservoir around Rippon falls, and two stations downstream of the existing dams around Naava **(Figure 3)**.

Zone II represented the areas of Bujagali dam that was flooded in 2012, about four years ago. This zone extended from Kalange above and Buyala below the dam, to downstream areas, including Busowoko and Itanda/Kalagala **(Figure 4)**. It was anticipated that Busowoko will not be affected due to flooding by Isimba dam. These areas were reported in the 2000-2001 survey to harbour populations of *N. simotes*a haplochromine cichlid species of international interest and could serve as conservation areas for this species.

Zone III **(Figure 5)** comprised of the area above and below the ongoing dam construction at Isimba. Sampling stations in this zone were selected both in what was expected to be the reservoir after the flooding, and below the dam. Kirindi was assumed to be in the area to be flooded, while Mbulamuti and Kakindu were representatives of stations downstream of Isimba dam. These stations were also reported in the 2001 report to harbour *N. simotes*.

2.2. Field sampling

Fish sampling was carried out in three phases, between 29th October and 09th, 12th and 18th, and 26th and 28th November 2016.

Habitat characteristics at each sampling point, including depth, substrate, water transparency, conductivity, temperature, dissolved oxygen, shoreline vegetation and, in some instances, aquatic macrophytes and activities along the river were recorded. The sampling points were marked using a GARMIN Global Positioning System (GPS). Depth was measured using a portable echo sounder, transparency using secchi disc. Conductivity, temperature, dissolved oxygen, and pH were measured using WTW multi-parameter probe.

Fish sampling was carried out using monofilament gillnets of stretched mesh sizes 1 to 6 inches in increments of 0.5 inches. In habitats where gillnets could not be used, especially rocky areas, hooks of sizes number 18 and 20 were used. In a few cases, a beach seine was used. Since the emphasis of the study was on haplochromine cichlids, the fish had to be caught, examined, and photographed when still alive. Consequently, gillnets were set during daytime for one hour to facilitate identification of haplochromine species with their live colours. Setting was repeated at stations where the catch was not representative of local diversity, but the soaking time was maintained at a standard of one hour to facilitate estimation of catch rates.

After hauling, individual fish specimens were photographed alive in a cuvette, using a digital camera and identified to the lowest possible taxon. Because the majority of the species endemic to the Nile River are un-described, those fishes that could not be identified to species level were given cheironyms. After taking the photographs, the right pectoral fin of each photographed fish was clipped and preserved in 95% analytical ethanol for genomic analysis. The fishes were then preserved in 4% formalin for further examination at the NaFIRRI laboratory. Photographs of the fish were sent to Ole Seehausen, at the Eawag Swiss Federal Institute of Aquatic Science and Technology, Centre for Ecology, Evolution and Biogeochemistry for final identification. Additional verification of identification of the fishes from the photographs and preserved samples was provided by Mr. Wandera Sylvester (a former NaFIRRI scientist who participated in the survey of 2000 AES Nile power haplochromine survey). The fin fish samples collected were later also sent to Eawag for genomic analysis to facilitate more detailed description of the fishes.

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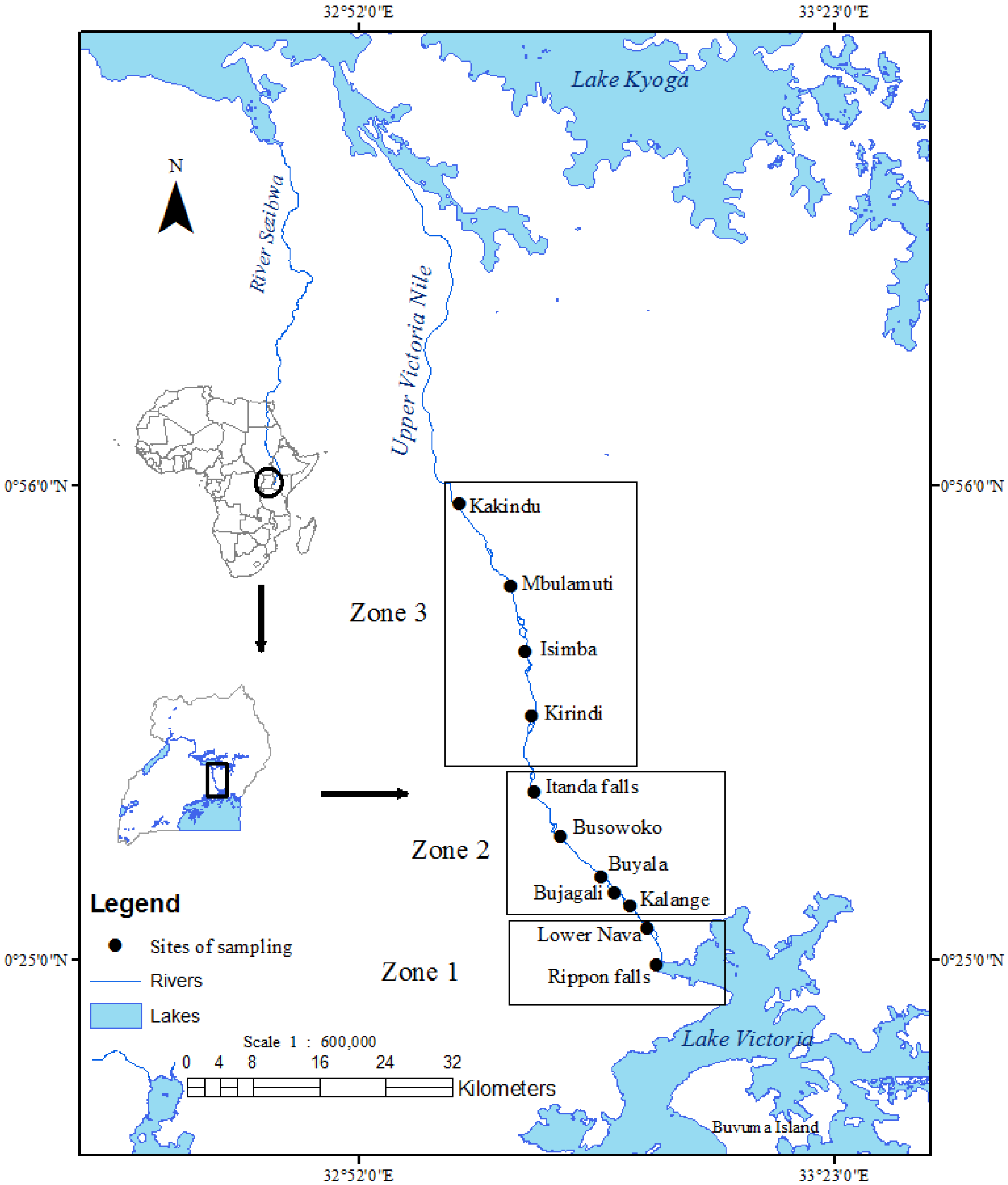

Figure 2. The zones and sites sampled along the Upper Victoria Nile

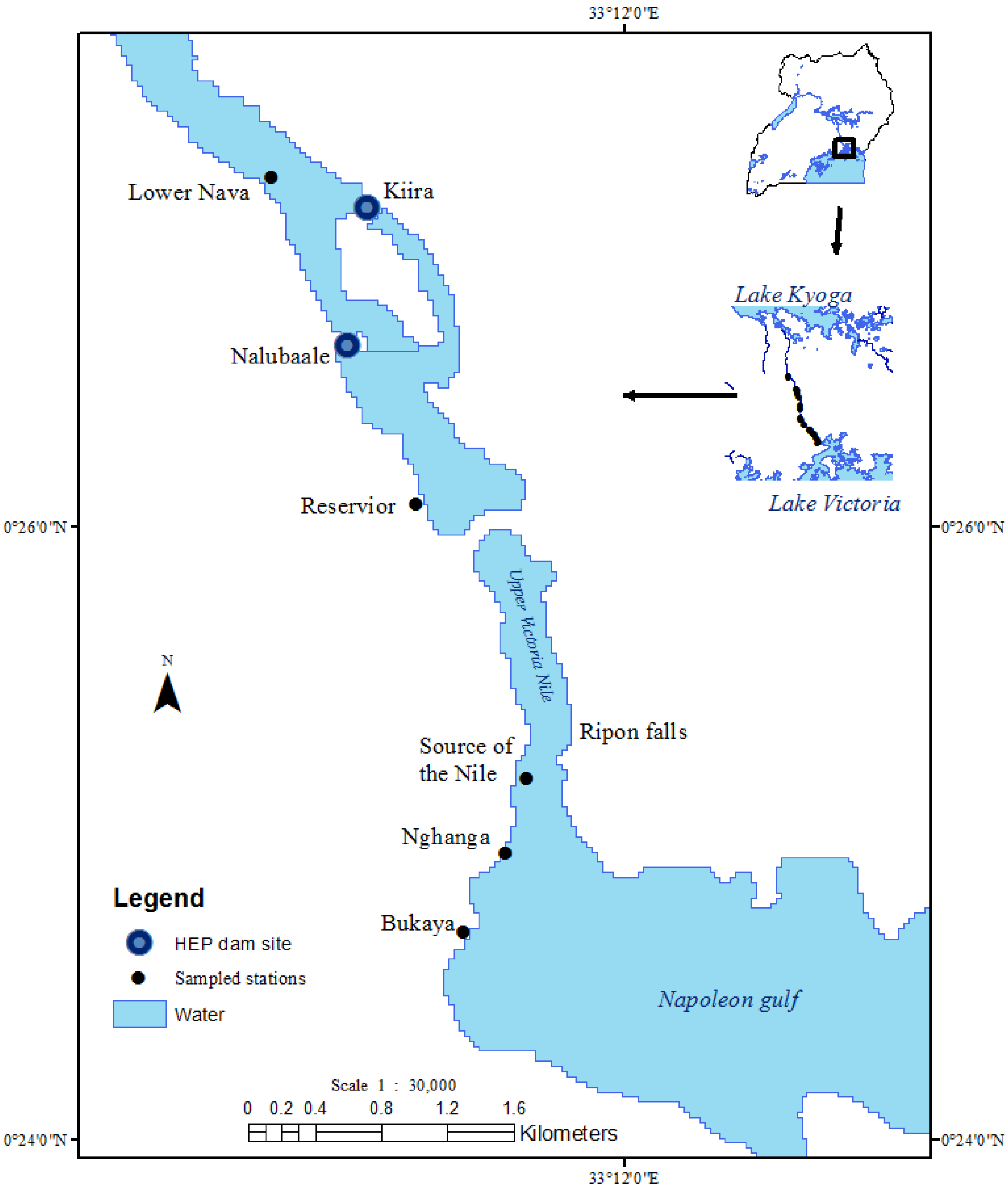

Figure 3. The stations samples in Zone I of Nabubale and Kiira dams first flooded in 1954 about sixty years ago

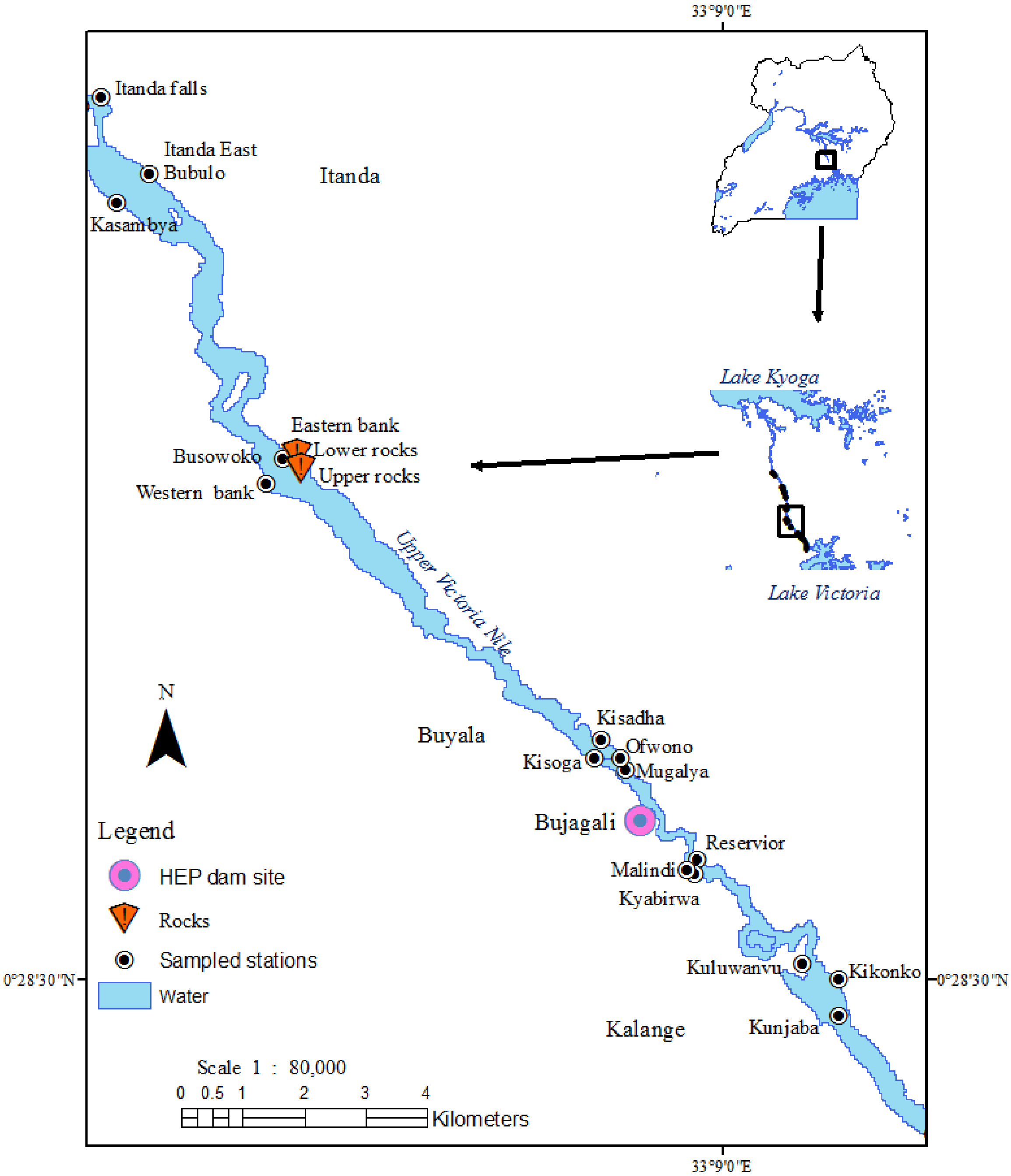

Figure 4. The stations sampled in Zone II around Bujagali dam first flooded in 2012 about four years ago

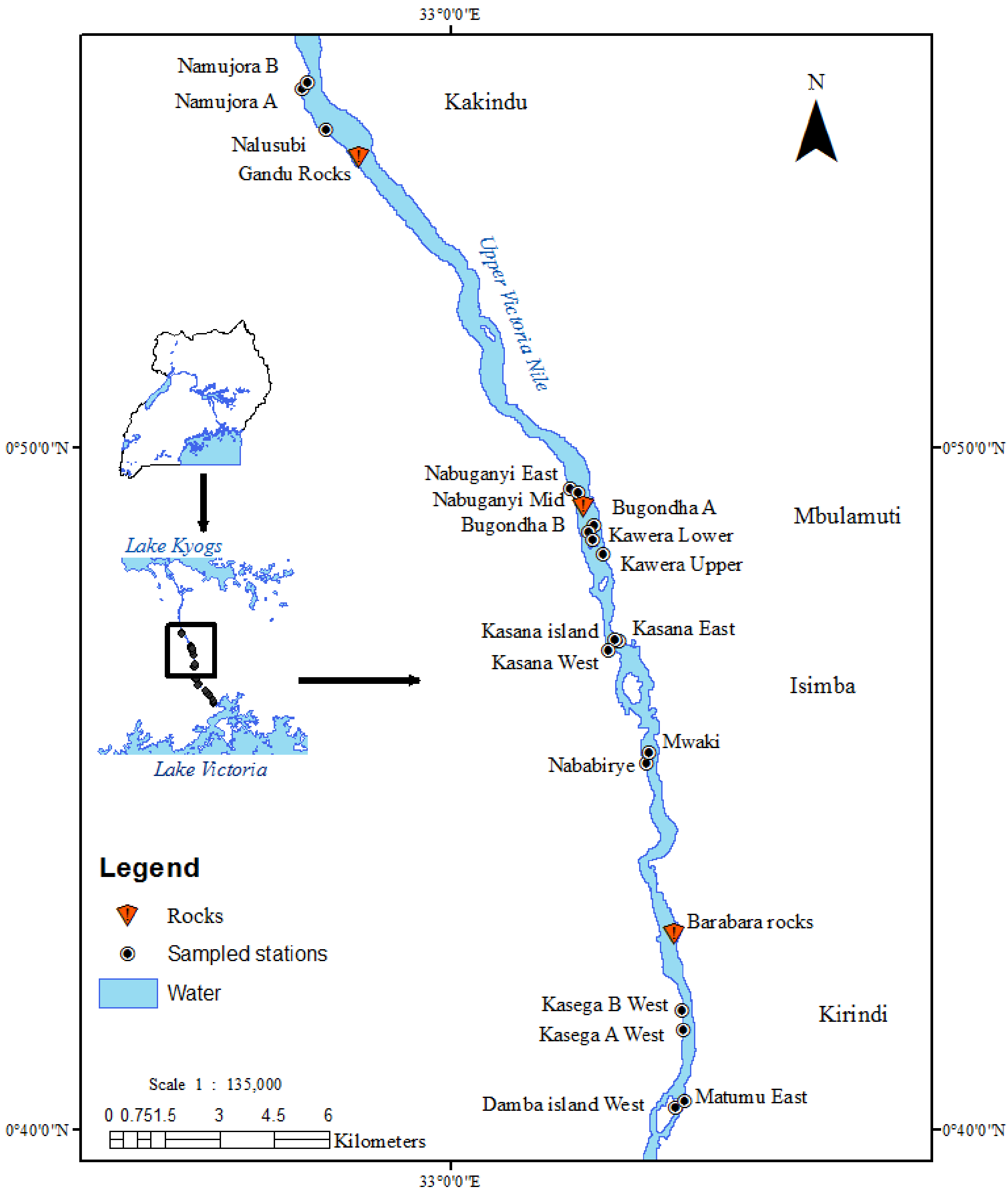

Figure 5. The stations sampled in Zone III above and below the ongoing Isimba dam construction

3. Results

3.1 Review of available information on the extent to which IHP is expected to impact the habitat and fish species diversity, with emphasis on haplochromines of conservation importance

The specialization of haplochromine cichlid fishes to different habitat types have been a major contribution to their evolution into a high diversify of species. Many of the species are restricted in distribution based on ecological specialization, and are only found in specific areas such as shallow inshore areas, macrophyte fringes, rocky shores, sandy/muddy bottoms, or along the water column at different times (Greenwood 1974). This is apparently the reason why the UVN has haplochromine cichlids that are not shared by lakes Victoria and Kyoga. The UVN haplochromine cichlids seem to have evolved in this system due to characteristics of specific habitat in this area especially the existence of rocky areas with fast flowing water currents. Because of these adaptations, any changes in habitat conditions under which specific species evolved and are adapted to survive will affect abundance and diversity of individual species.

Data collected on the UVN during and after construction of Bujagali hydropower plant (BHP) can be used to infer the changes in fish species diversity that may occur following construction of IHP. A baseline study was conducted in 2001 to document fish species occurrence especially of haplochromines along the UVN before flooding of BHP and this has been monitored in 2006 and 2007 following construction and flooding of the dam, both in the upstream (Kalange area) and downstream (Buyala area) of BHP. Some of the changes that took place include the following (NaFIRRI 2013;Tazibirwa 2016).

i. The overall rate of recovery of haplochromine fishes in gillnets set overnight has decreased from 15-16 species during 2006/2007 to 3-4 in 2012/2013, suggesting that diversity has declined since inception of dam construction. Some haplochromines such as *Harpagochromis serranus*, *Lithochromis* spp., and *Labrochromis* spp., which were previously recorded in this area have not been recovered either from downstream, upstream or the reservoir, during the last seven surveys since 2009. And yet, the distribution of these groups is somehow restricted to the Lake Victoria region (Lake Victoria, Victoria Nile, and Lake Kyoga) but are data deficient and their extinction status is not known.
ii. Fish species diversity was higher in the downstream area of Buyala than Kalange before dam construction, but the diversity index dropped to <1.0 in Buyala and increased to ~1.4 in Kalange after commencement of dam construction.
iii. Catch rates of fish increased in the reservoir and upstream of the dam (Kalange area) but decreased in the downstream (Buyala area) after dam construction. For instance, the weight of Nile perch caught per net per night increased in the upstream waters from 15.75 to 141g between 2006 and 2013, and decreased in the downstream from 108 to 36g over the same period. The increase in Nile perch is a threats to haplochromine diversity and abundance since they are its preferred prey. The survey of 2001 showed that Nile perch occurs along the entire stretch of the UVN. However,

availability of rocky and macrophyte refugia along the UVN has facilitated survival especially of rocky dwelling haplochromine as has been the case in lakes Victoria, Malawi and Tanganyika. Creating more open waters in the reservoir expands hunting ground for Nile perch and seems to contribute to reduction of haplochromine abundance as has been the case around Bujagali where catch rate of haplochromines in the reservoir are low (22.5g/net/night in 2013) compared to 226 g/net/net in the downstream Buyala area.

iv. Certain fishes such as the Ripon barbell (*Labeobarbus altianalis*), locally known as Kisinja, have become rare, and contracted in size, while the catfishes and momyrids increased in the upstream areas of the dam, apparently due to existence of a "lake-like" reservoir adjoining to a riverine environment. The changed fisheries in the upstream Kalange area, up to Lower Naava, have initiated a live bait fishery of Elephant-snout fish (*Mormyrus kannume*), locally called Kasulubana, which has put sustainability of this fish into question. This booming fishery is going on unregulated. Kasulubana is one of the fishes that are threatened in their natural habits elsewhere and the Nile River would serve as refugia of its depleted stocks in the main lakes.

The impact of dams on riverine ecological processes can either be immediate or manifest after a long time. The above observations may therefore not provide an exhaustive list of effects of BHP dam, but give some illustration of what should be expected from the IHP. Dams can have a number of effects such as: blocking migratory fishes, such as Kisinja, which swims upstream in swift and rocky upper reaches of rivers to spawn; enhancing eutrophication of reservoirs leading to plankton blooms; decreasing flow volumes in tail waters (see **Figure 6**); stabilizing flow regimes by flood peak cut; changing the thermal regimes of river water; degrading the river bed and increasing in substrate grain size by sediment trapping; changing the composition and abundance of organisms; and disrupting peoples' livelihoods. These impacts, need to be closely monitored with an aim of providing workable mitigation measures.

Potential effects of changes in flow regimes on fish habitat arising from regulation of water flow at the dams are illustrated in **Figure 6**. The left panel shows a photo taken during the current survey at Buyala (below Bujagali dam) at 08:00 am, while the right panel shows a photograph taken two hours later at the same location, the same day. If this depicts a situation where water starts to refill at dawn; then, for most part of the night, the shallow inshore areas, which are most suitable for fish feeding and spawning, may be reduced which affects feeding and recruitment. It is therefore not surprising that fish diversity in Buyala, the immediate vicinity of the BHP, where these photos were taken, has decreased since BHP became operational. This change in habitat condition, to which fishes can adapt, is exacerbated by land use practices, with people cultivating along the river banks almost to the edge of water (**Figure 7**). This increases sedimentation and siltation that can affect fish reproduction, especially haplochromine cichlids and the dam itself.

Figure 6. Fluctuations in water levels at Buyala (downstream BHP) arising from control of water release at BHP dam illustrated by photographs taken at 8.00 am (left) and 10.00 am (right) on the same day.

Figure 7. Crops being grown at the edge of the river at Buyala, posing a threat of siltation and increased turbidity

It should be noted the results and their interpretation can be affected by the extent of the investigations and this seems to apply to the UVN. For instance, the survey of 2001recorded twelve haplochromine cichlids in Isimba area namely: *Psamochromis riponianus, Astatotilapia nubila*, *Pyxichromis orthostoma*, *Astatoreochromis alluaudi*, *Neochromis rufocaudalis, Xystichromis phytophagus*, *Mbipia mbipi*, *Neochromis gigas*, *Neochromis greenwoodii, Paralabidochromis rockkribensis*, *X. nuchisquamulatus*, and *X. bayoni* (Atkins, 2001). Apart from *N.gigas, P.rockkribensis,* and *P.orthostoma*,which are listed on the IUCN red list as vulnerable (in different sub-categories) and *X. bayoni*, which is listed as extinct, all other species are listed in the IUCN red list under ‘Least Concern’ category. A taxon is listed as of “Least Concern” when it has been evaluated against all categories and found to be widespread and abundant, and as "Extinct" where there is no reasonable doubt that the last individual has died. *X. bayoni* has been listed as "Extinct" according to the classification of

IUCN without sufficient evidence that the last individual of *X. bayoni* has died. IUCN used information from Kaufman (1996) to arrive at this status. This species was, however, recovered along the UVN during the 2001 survey, which renders its status on the IUCN red list questionable. Similar intuition applies to *N. gigas*, *P. rockkribensis*, and *P. orthostoma* whose status is based on old literature, citing restricted distribution of these taxa, but where recent surveys have recorded these species in a wide range of localities. These misinterpretations call for frequent and more detailed surveys of fishes of the UVN, especially in the face of multiple dam constructions to guide their conservation and avoid speculative interpretations.

The above observations do not, however, imply that flooding of upstream waters by IHP will not have any effect on other haplochromine cichlids of international interest. If, for instance, Kirindi area, which is located upstream of IHP, is flooded, the population of *N. simotes*, a species of great conservation concern, which was recorded in Bukweya rocks, may be affected. However, in previous surveys along the UVN, this species was also found in two other locations, Itanda Island and Mbulamuti, which may not be severely affected by IHP and other populations which compare to *N. simotes* were found in rocky areas in Busowoko. The specimens from which this species was described were collected from Kakindu, downstream of Isimba, and suspicious specimens of *N. simotes* were collected from Rippon falls around Jinja (Seehausen et al., 1998). This study was partly intended to establish whether this species exists in other locations other than their known range so as to set plans for its conservation amidst dam construction. The population of *N. simotes* in Kirindi, Busowoko, and Itanda, will certainly be disconnected from that of Mbulamuti and Kakindu by IHP. This is why it is necessary to have a devoted study on its biology, including aspects of migration and feeding, which could not be covered in the current rapid assessment. This will help to map the movement and home range of the species as well as determining whether or not fish ladders are necessary on the dams to facilitate its migration.

3.2 The habitats of the UVN and the unique attributes that contribute to occurrence of fishes of conservation importance especially haplochromines, and the changes that are likely to occur as a result of the IHP

Depth of all the areas sampled (**Table 1**), with exception of deep points within reservoirs, ranged between 0.5 and 7.0 m. In majority of the stations, especially shallow areas <2.0 m, water visibility was high, and secchi depth was equal to depth. This is an important attribute with regard to haplochromine cichlid abundance, survival and reproduction. In general, cichlids exhibit high level of territoriality during breeding, with males having specific colours to enable their female mates to recognise them to avoid breeding with wrong mates (Seehausen et al. 1997; Seehausen and van Alphen 1998). This depends on light and if light conditions change, as may be the case following siltation and environmental degradation, which is likely to result from damming and unsustainable land use practices, reproduction will be affected. The relatively high haplochromine diversity in the Nile River, especially from Busowoko downwards towards Lake Kyoga, which are not shared by the main Lake Victoria, seems to be due to adaptable water quality conditions and favourable micro-habitats to which most haplochromine cichlids are specialised to live. All selected water quality parameters, i.e. temperature (25-29.9^{o}C), dissolved oxygen (>6.5 mg/L), conductivity (95-111 µ*S*/cm)and pH (6.8-9) (**Table 1**) were within the range suitable for fish survival in freshwater systems.

With regard to micro-habitat quality, the substrate in the majority of areas sampled was rocky, except in bays with either back flowing waters or slow running water, which had sandy and muddy bottoms, plus *Vossia*, which was the predominant fringing vegetation **(Table 1)**. This aspect, too, is highly vital for fish diversity especially cichlids. As stated earlier, cichlid fishes have evolved into so many species because of their capacity to undergo adaptive radiation to utilize different habitats and resources in aquatic ecosystems to reduce competition (Wagner et al. 2012). The high diversity of haplochromines along the UVN, therefore, is contributed by haplochromine species that are adapted to shallow inshore areas of back-flowing waters, macrophyte fringes, rocky shores, and sandy/muddy bottoms, which are the common habitat types along the UVN. Because IHP dam will be constructed downstream the falls, submerging the falls in the nearby upstream waters, the rocky habitats within Nababirye, Bukasa, and Mwaki areas will likely remain intact, and haplochromine members of rocky-shore clade, which dominate haplochromine species of the UVN, may not be severely affected, although the open water reservoir could increase predation by Nile perch and affect other factors like water currents, light penetration under which these fish are adapted to live. Whereas the area below the dam will remains relatively turbulent, maintaining some riverine conditions, the shoreline habitat conditions will change, depending on how water is released from the dam, and fishes in the vicinity will likely be affected in a way similar to what has been discussed above for Buyala below BHP. However, as discussed above, many of the haplochromine cichlids found in the area below IHP dam are found in other localities, and majority are listed as of Least Concern on the IUCN red list and most of them are restricted to rocky habitats. It is therefore expected that many of the haplochromine communities of rocky habitats, especially below Isimba dam will not be severely affected as was the case following flooding of Owen Falls.

Cichlid fishes are highly adaptive and partition resources through differential distribution, feeding, and reproductive specialization. Degradation of environmental quality will compromise their reproductive success and survival as was the case in Lake Victoria following eutrophication of the lake (Seehausen et al., 1997; van Zwieten et al., 2016). During this survey, we observed that most of the areas along the UVN were under intense pressure due to rapidly changing land use practices. This is not only dangerous to aquatic biodiversity, but will also put the huge investments in hydropower generation along the UVN at risk as sedimentation can negatively affect water flow and the overall capacity of the reservoir. The areas with planted forests along the river were highly sporadic and need to be scaled up if hydropower development on this river has to coexist with biodiversity conservation and environmental quality. Cultivation of river banks and the associated habitat destruction and siltation are of a major concern for aquatic biodiversity and haplochromine cichlid abundance as are the dams, and their impact is exacerbated by the fact that they are more widespread along the riverbank. Busowoko is one of the few sites along the UVN that still maintains natural riparian vegetation (**Figure 8**), and the importance of habitat integrity for haplochromine abundance is manifested by higher catch rates of haplochromines observed during this survey at Busowoko compared to the highly-degraded sites near Kalange, Buyala, Lower Naava, and Isimba that had lower catch rates. Although water transparency and other water quality parameters in all the areas sampled were still reasonably good for fish survival and reproduction (due to constant flushing) **(Table 1)**, we are highly convinced that siltation will build up, especially in the flooded reservoirs, as human activities continue and dams continue to be erected, which will drive abundance of endemic haplochromine genera to very low numbers. This has happened elsewhere, including Lake Victoria and its satellite lakes, especially in the Kagera region (Seehausen et al., 2016), which are outside the protection range, and is likely to happen on the Nile River. Unfortunately, sediment transported from Lake Victoria through the river may also accumulate at unprecedented rates due to reduced water flow rates, worsening the changes in abundance of haplochromines. Measures should, therefore be put in place to address this problem for dams to potentially coexist with biodiversity.

Figure 8. Shoreline vegetation enhanced by planting trees along the river bank at Busowoko. This area has a high diversity of seemingly endemic haplochromines

Large expenses of a noxious aquatic weed, *Salvinia molesta*, commonly called Kariba weed was encountered in the dam construction area around Isimba (**Figure 9**). We were told by people around the construction site that this weed was intentionally introduced around the construction site purportedly for biological water purification from the construction site, an action we consider environmentally disastrous. This is a highly invasive aquatic weed which should be carefully removed before the area is flooded. There was also sporadic infestations of Kariba weed in Busowoko, upstream of Isimba, which could have been propagated from Isimba by fishing boats, fishing gear, and tourist activities. This weed clogs waterways and blocks sunlight needed by other aquatic plants, especially algae to carry out photosynthesis. As it dies and decays, it decomposes uses up the oxygen and deoxygenated the water. It prevents the natural exchange of gases between the air and the body of water which can suffocate and kill any organism, including fish. Its presence around Isimba is therefore a threat to biodiversity and the dam. This weed has already invaded Lake Kyoga, with potential devastating ecological and socio-economic impacts, and is expected to cost the Government of Uganda billions of shillings to control. The presence of this weed around Isimba is a big threat to the Nile River and biodiversity as it can spread to the entire stretch of the river in a short time and possibly end up in Lake Victoria as was the case with water hyacinth with devastating effects. Intentional introduction of this weed around Isimba contravene environmental laws about invasive species, particularly the National Environment Act Cap 153 (1995), which prohibits the introduction of invasive species to water bodies including riverbank or wetland, unless guidelines are issued by NEMA in consultation of lead agencies for controlled introduction. It should, therefore be removed as a matter of priority. The weed can also be effectively controlled through biological control (Pieterse et al, 2003) using Salvenia weevil (*Cyrtobagous salviniae*). This will however require importation of the weevil as was the case following invasion of water hyacinth that preceded it.

Figure 9. Floating mats of Kariba weed, *Salvenia molesta* at the dam construction site at Isimba

Figure 10. Degraded river banks around Buyala, with most of the area converted into horticultural crops.

Figure 11. Degraded river banks around Isimba, with most of the area converted into horticultural crops.

Table 1. Habitat characteristics and selected water quality parameters of the sampled stations along the Upper Victoria Nile. Stations labelled as N/A show that; either, the sites could not be accessed for water testing because of rapid water current or the conditions could not permit testing for a specific parameter. However, fish angling was done in these areas by experienced local fishermen.

Site	Name of station	GPS Coordinates in water	Dominant Vegetation	Bottom type	Notes	Depth(m)	Secchi depth (m)	DO (mg/L)	Temp(◦C)	Cond(μS/cm)	pH
Ripon falls	Bukaya/reservoir (above Nalubale dam)	0.40474N; 33.19262E	Papyrus	Muddy Organic matter	Slow running water	1.6	1.6	7.8	26.8-26.9	105.9	7.26
	Nghanga	0.41561N; 33.19355E	Shrubs	Rocky	Slow running water	1.2	1.2	8.2-8.4	25.5	96.3	7.33
	Source of the Nile	0.41967N; 33.19470E	Site was in the middle of the river so no vegetation	Rocky	Fast running water	4.2	N/A	8.6-8.7	26.6-26.9	100	7.7
	Reservoir	0.43456N; 33.18868E	shrubs	Rocky	Back flowing water, submerged logs	5.7	2.13	7.9-8.8	26.6-26.7	99.3-101.3	7.26
Lower Naava (Below dams)	East bank	0.45237N; 33.18085	Shrubs and *Vossia* in the fore ground	Rocky	Fast moving water	2.2	1.89	8.2-8.9	25.7	100.3-105.3	7.44-7.42
	Lower Naava rocks	N/A	Mid river,no vegetation	Rocky	Exposed rocks near the island	N/A	N/A	N/A	N/A	N/A	N/A
	Kiira dam out let	N/A		Rocky	Fast running water	N/A	N/A	N/A	N/A	N/A	N/A
Kalange	Kunjaba	0.46977N; 33.16697E	Site near an island with *Vossia*, and water hyacinth	Rocky	Fast running water	7	1.95	8.2-8.5	25.8-26.4	99.8-102.5	6.8-7.32
	Kikonko	0.47502N; 33.16698E	*Vossia*, and water hyacinth	Sandy	Slow running water	4	1.81	7.8-8.8	26.5-26.6	99.8-100.3	6.83-7.83
	Kuluwanvu	0.47735N; 33.16160E	*Vossia*, and water hyacinth	Dark organic mud	Site close to island	2.8	1.99	6.9-7.5	26.0-26.2	97.1-102	7.08-7.27
Bujagali falls	Kyabirwa	0.49250N; 33.14624E	*Vossia*	Sandy/organic material	Slow running	3.3	2	7.0-8.7	26.0-26.1	101-101.8	7.25-8.15
	Malindi	0.49103N;	*Vossia*	Organic mud	Slow	3.7	1.73	8.8-	26.2-	100.7-102.3	7.91-

Site	Name of station	GPS Coordinates in water	Dominant Vegetation	Bottom type	Notes	Depth(m)	Secchi depth (m)	DO (mg/L)	Temp(◦C)	Cond(µS/cm)	pH
		33.14467˚E			running			9.0	26.3		8.83
	Mugalya	0.50573˚N; 33.13580˚E	*Vossia*	Sandy with rocks	Fast running	3.3	1.3	8.2	26.5	96.1-98	7.3-7.32
	Kisadha	0.51000˚N; 33.13209˚E	*Vossia*, and water hyacinth	Sandy/organic material	Fast running	1.7	1	6.8-6.7	26.4	98.5-100.3	7.27-7.27
	Ofwono	0.50741˚N; 33.13479˚E	*Vossia*	Sandy/organic material	Fast running	2	1	8.0	26.0	95.8	7.8
Busowoko	Lower rocks	0.55118˚N; 33.08553˚E	Under water plants (*Lagarosiphon*)	Rocks /Sandy	Fast running	0.9	0.9	7.8-7.9	26.1-26.2	100.2-101.5	7.3-7.31
	Upper rocks	0.54994˚N; 33.08819˚E	No vegetation	Rocky	Fast running	4.8	2	7.7	26.0	94.5-95.6	7.47-7.5
	Western bank	0.54969˚N; 33.08629˚E	Shrubs on the rocky islands near by	Rocky	Fast running	1	1	7.5	26.3	97.4-100.8	7.31-7.33
Itanda	Kulwazi	0.60413˚N 33.05880˚E	Shrubs	Rocky	Fast running water	0.7	0.7	8.8-8.9	27.1	93.2-95.2	7.32
	Island	0.60282˚N 33.05586˚E	Shrubs	Rocky	Fast running water	1.7	1.7	8.7	26.7	99.3	7.32-7.33
	Kasambya	0.58877˚N 33.06115˚E	*Vossia*and water hyacinth	Muddy	Slow running water	1.5	1.5	9.2-9	26.8-27.0	92-100	7.31
	Itanda east bubugo	0.59299˚N 33.06580˚E	*Vossia*and reeds	Organic material& sand	Slow running water	1.6	1.6	8.8-9	26.6-26.8	104-104.8	7.4-7.42
Kirindi	Damba island west	0.67239˚N 33.05521˚E	Vossia, shrubs,under Water plants (*Lagarosiphon & Ceratophyllum*)	Rocky	Fast running water	0.6	0.6	8.2	26.4-26.5	101-102	8.5-8.7
	Matumu East	0.67392˚N 33.05725E	*Vossia*, shrubs and under water plants (*Ceratophyllum)*	Sandy	Fast running water	1	1	7.5-7.8	26.4-26.5	113	7.35
	Kasega B West	0.69619˚N 33.05656E	*Vossia* and water hyacinth	Exposed rocks and partly sandy	Fast running water	1.6	1	7.7-7.8	26.6-26.8	97-99	7.89-8.22
	Kasega A West	0.69134˚N 33.05708˚E	*Vossia*	Sandy and organic matter	Fast running water	1.3	1.3	7.8-7.9	27.1-29.9	97.8	7.38
Isimba	Nababirye	0.75638˚N 33.04813˚E	*Vossia* and shrubs	Rocky	Slow running	1.6	1	8.7-8.8	26.9-27.1	100-100.2	7.2-7.4

Site	Name of station	GPS Coordinates in water	Dominant Vegetation	Bottom type	Notes	Depth(m)	Secchi depth (m)	DO (mg/L)	Temp(◦C)	Cond(μS/cm)	pH
	Mwaki	0.75913°N 33.4874°E	*Vossia*	Rocky	Slow running	1	1	8-8.2	26.8-26.9	101.6-104.2	7.5
	Kasana East	0.78638°N 33.04120°E	*Vossia*	Partly sandy and rocky	Fast running water	2	1	7.5	26.0-26.1	107	7.24
	Kasana island in mid river	0.78678°N 33.04018°E	*Vossia*	Rocky	Fast running water	1.6	1.6	7.8	26.2	110.4	7.2
	Kasana west	0.78408°N 33.03880°E	Vossiaand shrubs	Sandy	Fast running water	2.3	2	7.7	26.0	109.3	7.8
Mbulamuti	Nabuganyi east	0.82362°N 33.02930°E	*Vossia* and under water plants *Ceratophyllum*	Sandy	Fast running water	0.5	0.5	8.2	26.7	97.3-101	7.3-7.32
	Nabuganyi mid	0.82253°N 33.03116°E	*Vossia*	Rocky	Fast running water	1.6	1.6	7.8	26.5-26.6	103.2-103	7.8-7.9
	Bugondha A	0.81456°N 33.03521°E	shrubs	Rocky	Fast running water	1.9	N/A	8.8-8.9	26.5	107.4-107.3	7.3-7.4
	Bugondha B	0.81297°N 33.03399°E	*Vossia* and water hyacinth	Rocky	Fast running water	2.1	1.5	8.4-8.7	26.5-26.6	105.3-106.6	7.52-7.6
	Kaweraa lower	0.81091°N 33.03474°E	*Vossia* and shrubs	Rocky	Fast running water	0.9	0.9	8.7	26.9-27	104.9-105.7	7.37-7.41
	Kawera upper	0.80763°N 33.03746°E	*Vossia*	Rocky	Fast running water	0.9	0.9	8.5-8.8	26.9-27	101-104	7.4-7.49
Kakindu	Gandu rocks	0.90457°N 32.97753°E	*Vossia*,Waterhyacinth,*Lagorosiphon, Ceratophyllum*	Sandy	slow running water	2.6	2.6	7.5-7.9	26.0-26.8	104.9-106.6	8.32-8.03
	Namujora A	0.92128°N 32.96398°E	shrubs	Rocky	slow running water	1.1	1.1	7.6-7.7	27.3	100.3-101.7	7.32-8.92
	Namujora B	0.92290°N 32.96508°E	*Vossia* and shrubs	Rocky	Fast running water	1.9	1.9	8.7	27.3-27.4	99.3-101.7	7.44-7.65
	Nalusubi	0.91136°N 32.96966°E	*Vossia*,Papyrus and under water plants (*potamogetoncrispus*)	Organic mad	Fast running water	0.8	0.8	7.0-7.2	27.3-27.5	102.4-104.4	8.01-8.42

3.3 Abundance and occurrence of fish species, with emphasis on haplochromine cichlids and their conservation status

The catch rates for haplochromine fishes, expressed as number of fishes per haul per hour for gillnets and number of fishes per hook per hour for the anglers are summarised in **Table 2**. Abundance of haplochromines in the lower reaches of the UVN was higher, starting from Busowoko downwards. In terms of species diversity, sixty two haplochromine species were recovered at different location of the UVN during this survey, plus other unidentified fishes, and their conservation status as per IUCN red list of threatened species is summarised in **Table 3**, and an illustrated species list on each site is given in **Appendix 1**. The Haplochromine species were distributed in three main zones. There were species mainly found between Ripon Fall and Buyala on the Lake Victoria side of the river and those between Kirindi and Kakindu on the Lake Kyoga side and those that occurred in both zones with an apparent zone of transition around Busowoko and Itanda. This suggested that there was a haplochromine community linked to Lake Victoria and another to Lake Kyoga along the UVN with an intermediate community. A great array of new haplochromine species, some previously unknown and seemingly endemic to the Victoria Nile, were recovered during this study. There was, with exception of Rippon, Kalange and Buyala, areas with relatively high species richness in the middle and lower reaches of the UVN, such as Busowoko, Kirindi, and Kakindu compared to upstream stations such as Bujagali and Lower Naava. The low species diversity in the upper reaches such as Bujagali and Lower Naava could be due to high concentration of dams, and high levels of degradation of marginal areas by farming activities.

There was clear faunal turnover from the Ripon Falls area, consisting mainly of inshore Lake Victoria species to the middle section of the UVN, which is completely dominated by endemic species some of which are adapted to living in the rapids. These unique species include the endemic *N. simotes*, plus a new species that we assigned cheironym *Neochromis* sp. "*Labeo*" (because of its under-slung mouth, an adaptation to grazing the rocks in strong currents), and a new red breasted *Paralabidochromis* sp. with yellow pelvic fins. These unique taxa were common in the middle reaches of the river starting from Busowoko to Mbulamuti. Conservation of unique habitats to which most of these endemic haplochromines are adapted such as rocky shores with strong currents and marginal macrophytes is vital.

Some of the new species, especially in Busowoko, Mbulamuti and Kakindu are out of the area to be impounded by IHP, and may not be severely affected by the dam. These areas, should be protected to conserve these species and effort should be made to describe the new species to create a robust baseline information that will be essential in monitoring the impacts of the dams.

3.4. Occurrence of species of conservation importance outside the area affected by IHP

The endemic fish species of very high conservation importance, *N. simotes*, was found at Kirindi, Isimba, Mbulamuti and Kakindu. This species has historically been known to be extant in these localities. Specimens similar to *N. simotes* have been collected from Rippon Falls but their identity is unconfirmed. Populations which compare to *N. simotes* have been reported in Itanda Island and Busowoko rocky shores. In this study *N. simotes* was found only in four major sites, two of which will not be affected by upstream flooding by IHP. These include Mbulamuti and Kakindu. These areas could potentially form an offset area for IHP and the area beyond Kakindu needs to be surveyed to determine whether *N. simotes* occurs beyond Kakindu.

The extent to which flooding of Kirindi will affect the population of *N. simotes* is not known because less is known about its ecology. However, the species may be affected by the a reduction in flow current to which it is adapted to live and feed, as well as possible increased predation by Nile perch. The population of *N. simotes* in Kirindi, and those previously reported during the 2001 survey in Busowoko, and Itanda will certainly be disconnected from those of Mbulamuti and Kakindu by IHP. A study of the ecology of this species, including aspects of migration pattern and feeding, which could not be covered in this rapid assessment, to succinctly map the home range is recommended.

3.5 The extent to which the initial concerns of the Indemnity Agreement can be met

The Indemnity Agreement between the Government of Uganda and the World Bank of 2007, which required the former to protect and conserve the natural habitat, environment and spiritual values of the downstream Kalagala Offset Area (KOA) to compensate for the loss of biodiversity and other values arising from flooding effects of the BHP, was based on survey findings in 2000-2001 which showed high haplochromine species richness in the middle reaches of UVN, downstream of the BHP site, especially Busowoko, which had the highest haplochromine species richness (15 species), followed by Itanda (14 species), and Kirindi and Isimba (13 species). Only Isimba and Kirindi are expected to be affected by IHP. Busowoko and Itanda (upstream), and Mbulamuti and Kakindu (downstream), according to the construction design, are not expected to be affected by IHP and will compensate for any reduction in habitat and species richness around Isimba and Kirindi. The current KAO should be extended to include Busowoko to improve conservation of fish species diversity. Another offset area should be set up below IHP site, starting from Mbulamuti down to Kakindu, Namasagali and the inflow into Lake Kyoga. There is also need to determine the haplochromine community on the Kyoga side to find out the extent of these species on the Kyoga side of the UVN.

Table 2 Catch rates expressed as number of haplochromines per gillnet haul per hour a (mean ± standard deviation) and number of haplochromines per hook per fisherman per hour. Note: In Lower Nava, only one site was sampled using gillnets due to high water current in most of the areas

Sampling site	Haplochromines per gillnet haul per hour	Haplochromines per hook per angler per hour
Rippon falls	10.0±7.2	19.0
Lower Nava	3.0	14.0
Kalange	10.5±13.4	15.0
Bujagali	6.5±6.3	1.0
Buyala	9.0±5.5	5.0
Busowoko	53.3±17.3	19.0
Itanda	30.0±9.6	7.0
Kirindi	21.0±10.8	12.0
Isimba	12.75±9.7	4.0
Mbulamuti	13.6±4.15	
Kakindu	10.0±4.2	6.0

Table 3 Fish species composition and within site relative abundance (%) along the Upper Victoria Nile.

		ZONE I		ZONE II					ZONE III			
Species	IUCN red list status	Ripon falls	Lower Naava	Kalange	Bujagali	Buyala	Busowoko	Itanda	Kirindi	Isimba	Mbulamuti	Kakindu
Mbipia mbipi	Least Concern	22.5					5.4	0.78	1.2			
Mbipia sp.			5.2	0.85		5.1	0.4	10.2				
Mbipia sp. golden		12.5										
Mbipia sp. Uganda blue scraper				5.9								
Neochromis simotes	Data Deficient								5.9	5.1	43.9	1.8
Neochromis greenwoodi	Least Concern	20	57.8	12.8		13.7	15	3.9	2.4		2.4	1.8
*Neochromis*sp. red pelvic							1.6		3.5	7.6		
*Neochromis*sp. *Labeo* new									1.2	2.5	8.5	
Neochromis cf. large scale nigricans		2.5										
*Neochromis*sp. new species 1		5										
*Neochromis*sp.							1.6		3.5			
Lithochromis xanthopteryx	Vulnerable D2							2.3	27.3	35.8	3.6	3.6
Lithochromis sp. yellow chin												
*Lithochromis*sp.						3.4	0.4	2.3	2.3			
Psammochromis riponianus	Least Concern			0.85								
Psammocromis cf. *acidens*				0.85								
Psammochromis sp.				6.8		1.7	1.6	0.78				
*Ptyochromis*sp.										2.5	24.3	18.1
Astatotilapia nubila	Not assessed	2.5		2.5			2.1					5.4

	ZONE I			ZONE II					ZONE III			
Species	IUCN red list status	Ripon falls	Lower Naava	Kalange	Bujagali	Buyala	Busowoko	Itanda	Kirindi	Isimba	Mbulamuti	Kakindu
Astatotilapia cf. *brownae*								0.78				
Astatotilapia sp				6.83			2.5					
Astatoreochromis alluaudi	Least Concern							3.9	3.5	15.3		1.8
Paralabidochromis flavus						1.7						
Paralabidochromis sp. Nile			5.2	4.2				0.78				
Paralabidochromis sp. 1		5										
Paralabidochromis sp.				14.5		15.5	9.1	6.2				16.3
Paralabidochromis sp. yellow multispot							1.6					
Paralabidochromis sp. red breast new							38.3					
Paralabidochromis sauvagei (*rockkribensis*)		10										
*Ptyochromis*sp 2									5.9			
*Paralabidochromi*sp. short snout scraper			23.6				2.0					1.8
Pyxichromis orthostsoma	Vulnerable A1ace; B1+2ce								1.2			1.8
Haplochromis sp. purple yellow		2.5					0.4					
Haplochromis sp. flameback					18.1	1.7	0.4	18.8	8.3			3.6
*Haplochromis*s p.						17.2						7.2
Haplochromis sp. cf. red back scraper				1.7								
Haplochromis sp. thick skin like							0.4					
Pundamilia pundamilia	Least			6.8				4.7	3.5			

	ZONE I			ZONE II					ZONE III			
Species	IUCN red list status	Ripon falls	Lower Naava	Kalange	Bujagali	Buyala	Busowoko	Itanda	Kirindi	Isimba	Mbulamuti	Kakindu
	Concern											
*Pundamiliaigneopinis*_Nile	Not assessed			3.4			0.4					
*Pundamilia*cf.*macrocephala*	Vulnerable D2					1.72						
Pundamilia cf. *azurea*		2.5										
Pundamilia sp. big blue						3.4						
Pundamilia sp. blue lip							2.0					
Pundamilia sp. Redrim anal fin				6.8								
Pundamilia sp. lemon fin like												
*Pundamilia*sp.				4.2		8.6	2.5	13.3				
Pundamilia sp. 1												
Harpagochromis sp. *guiarti* complex	NA		2.6			1.72		1.5			1.2	
Harpagochromi sp.				0.85	18.1	6.8						
Harpagochromi sp. 2												5.4
Lipochromis sp		2.5										
*Xystichromis*sp. flameback				7.6			7.1			17.9	9.7	
Xystichromis phytophagus												5.4
Xystichromis/Haplochromis sp												7.2
Ptyochromis xenognathus red pelvic												1.8
*Ptyochromis*sp							0.4					
Unknown species 1				1.7								
Unknown species 2					18.1							
Unknown species 3					36.3							
Unknown species 4									1.2			

		ZONE I		ZONE II					ZONE III			
Species	IUCN red list status	Ripon falls	Lower Naava	Kalange	Bujagali	Buyala	Busowoko	Itanda	Kirindi	Isimba	Mbulamuti	Kakindu
Unknown species 5									1.2			
Unknown species 6									3.5			
Unidentified				9.4	9	17.2	3.3	29.1	23.8	12.8	3.6	16.3
Total No of species (2016)		**11**	**5**	**18**	**4**	**13**	**22**	**14**	**16**	**7**	**7**	**14**
Total No of species (2001)		**12**	**-**	**11**	**6**	**10**	**18**	**12**	**14**	**12**	**9**	**8**

3.6 Plan for a long-term monitoring for conservation and management of aquatic biodiversity of the Victoria Nile amidst hydro-power projects

Sustainable development emphasises a need for meeting development goals such as those derived from dam construction while sustaining the ability of natural systems to continue to provide the natural resources and ecosystem services. This requires embracing economic and social development with environmental protection and envisions a desirable future state for human societies in which living conditions and resource-use continue to meet human needs without undermining the integrity, stability and beauty of natural ecosystems. There are enormous developmental benefits that accrue from dam constructions. However, the benefits from damming rivers may, sometimes, not offer sufficient trade-offs for the negative socio-ecological outcomes. There is therefore need to closely monitor the impacts of dams with an aim of providing workable mitigation measures to sustain other services through Environmental and Social Impact Assessment (ESIA) and monitoring to guide mitigation measures.

Development of dams requires an ESIA before dam construction and monitoring after dam construction. This has in part been achieved for some of the dams constructed along the UVN. For instance, NaFIRRI previously conducted an EIA, including the one for the AES Nile power in the early 2000s for BHP, and has been involved in long-term environmental monitoring of BHP to guide mitigation measures. Given the rapid developments of these hydropower projects on the Victoria Nile, and their potential impacts, there is need for a comprehensive assessment and long-term monitoring of environmental and social impacts of these dams along the entire stretch of the Victoria Nile. It is therefore recommend that a long-term monitoring for conservation and management of aquatic biodiversity of the Victoria Nile amidst hydro-power projects should be done to include the following:

a) Physico-chemical parameters, including total suspended solids, water clarity, conductivity, temperature, dissolved oxygen, turbidity, water current, organic carbon and organic matter;
b) Nutrients, especially nitrogen and phosphorous;
c) Pollutants due to dam construction such as oils;
d) Occurrence of aquatic weeds especially the Kariba weed and Water hyacinth;
e) Biological diversity including macrophytes, algae, micro and macro invertebrates; and fish;
f) Endemism, distribution, and life history characteristics including home ranges of fishes;
g) The impact of predation by Nile perch especially on haplochromines;
h) Waterborne diseases such as bilharzia;
i) Land use, land use change and sustainable land management practices; and
j) The effects of dam construction on fishing activities, livelihoods of riparian communities, and livelihood options that can be promoted among fisher communities whose fishery based livelihoods have been affected.

The budget for collecting of baseline information where this does not exist an long-term monitoring will depend upon the extent of the work to be done but in the immediate term there is need for:

i. A baseline survey around Isimba estimates at US$ 20,000 to be done on a quarterly basis over a period of one year;
ii. An exhaustive quarterly survey of the area areas beyond Kakindu to Lake Kyoga with further validation of the area up to Isimba estimated at US$ 15,000;
iii. Once the above baseline data is available there should be at least a bi-annual monitoring estimated at about US$ 30,000 per year.

However long-term monitoring of the entire stretch of the UVN from the Ripon Falls to Lake Kyoga will need preparation of a more comprehensive budget. It should also be noted that in the current survey, it had been envisaged to have some expert input and although this was provided at the cost of our collaborator, this will need to be inbuilt into a comprehensive survey to facilitate analysis which cannot be done locally and to build local capacity to sustainably undertake the work.

4. Conclusions and key recommendations

Majority of the haplochromine species in the UVN are those that are adapted to rocky habitats. Although flow velocities will reduce in the impounded areas, the rocky habitats will remain intact, except that the reservoir will create an open water environment and increase the hunting efficiency of Nile perch which can reduce stocks of haplochromine.

With exception of new un-described species, such as *Neochromis* sp. Red pelvics, which was only found in Isimba area, the majority of haplochromine species are found in other localities that will likely not be severely affected by IHP.

The area below the dam will remain relatively turbulent, maintaining some riverine conditions but the shoreline habitat is likely to be affected, depending on how water is released from the dam which will affect composition and diversity of fishes. But, with exception of new and possibly endemic haplochromines, whose biology is less known to precisely infer the impacts of IHP, most of the other haplochromine cichlids found in the area below the IHP site are found in many other localities.

Neochromis simotes, the endemic haplochromines species of very high conservation importance, was found in four major sites, two of which, Mbulamuti and Kakindu, will not be extremely affected by upstream flooding by IHP. However, the population of *N. simotes* in Kirindi, Busowoko, and Itanda will be disconnected from that of Mbulamuti and Kakindu by IHP, and the effect, can only be quantified through movement and home range studies.

N. simotes was, during the 2001 survey observed to be most abundant in Mbulamuti - Kakindu area. It is strongly recommended that the area from Mbulamuti to Lake Kyoga be designated and offset area to conserve this haplochromine species of high conservation importance. A survey of the area between Kakindu and Lake Kyoga should be undertaken to determine the extent of UVN haplochromines below Kakindu.

The effect of IHP on riverine fisheries will be exacerbated by land use activities along the river. Although some areas along the river have some planted forests, they are highly sporadic, and majority of the areas are under intense pressure by farming activities. Cultivation of river banks and siltation are a major concern for haplochromine cichlid abundance, and a danger to the dams themselves. Although water transparency and other selected water quality parameters along the UVN were good, siltation is expected to build up, especially in the impounded areas. This will affect abundance of endemic haplochromines. Cultivation of river banks should rigorously be managed, and aforestation of river banks should be scaled up if development and biodiversity have to co-exist and the dams protected from siltation. The billions of dollars spent on construction of the dams and the socio-economic development derived out of the power generated far outweigh any investment into conserving the river bank and this should be treated as a priority.

Flooding and formation of reservoirs will change fisheries. For instance, the flooding of Bujagali falls changed fisheries both in the upstream and downstream waters, especially in the upstream Kalange area, up to Lower Naava. This initiated a live bait fishery, especially for the juvenile Elephant-snout fish (Kasulubana), and this activity, which is unregulated, is threatening local fish biodiversity. Fishing activities in the reservoirs and along the river should be regulated.

There was no baseline aquatic and biodiversity survey to guide management and subsequent monitoring in the dam construction area around IHP. A dedicated baseline survey including all environmental, biological and fisheries aspects, similar to what was done before construction of BHP should be undertaken before the area is flooded.

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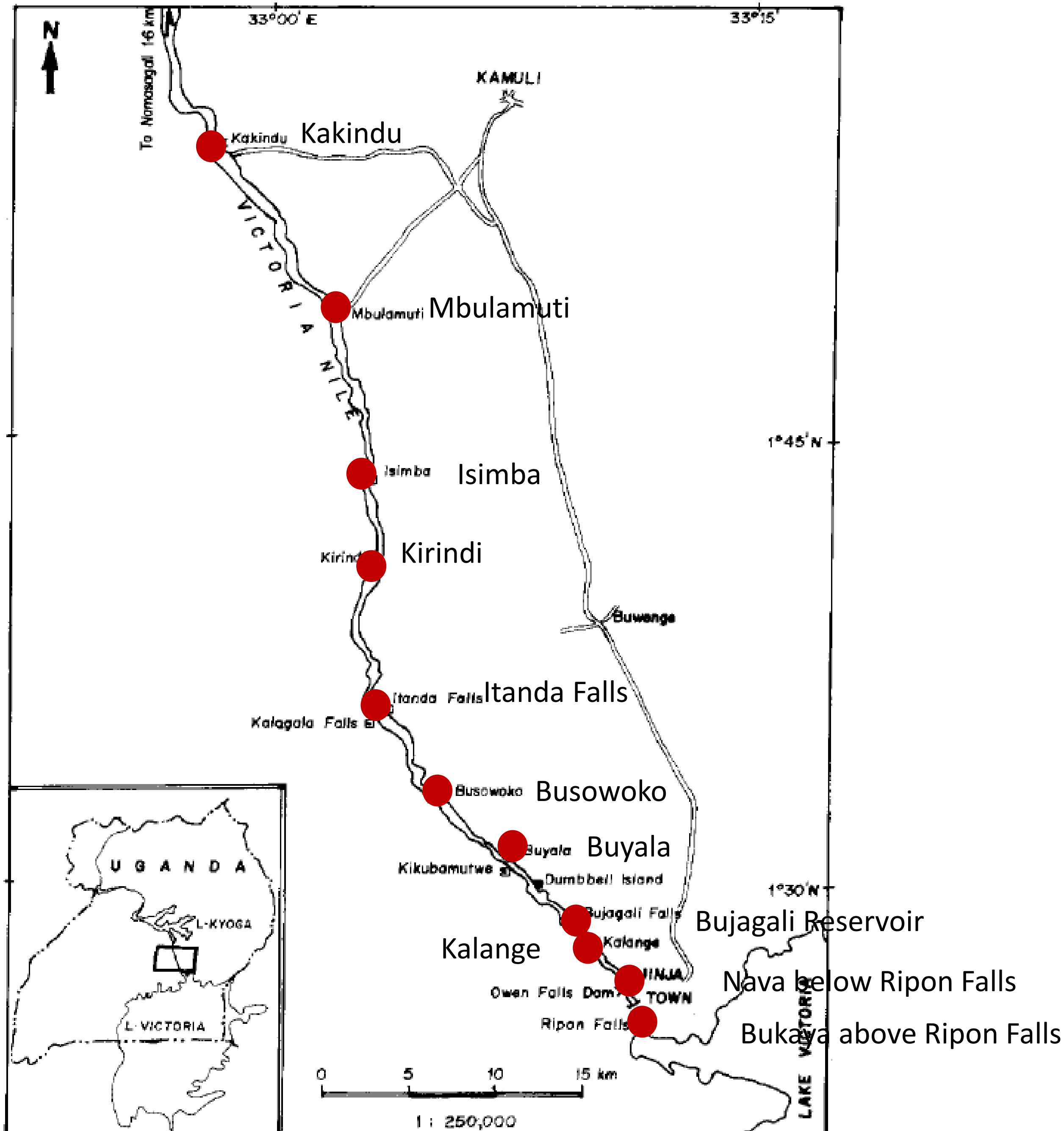
Victoria Nile Haplochromine survey 2016

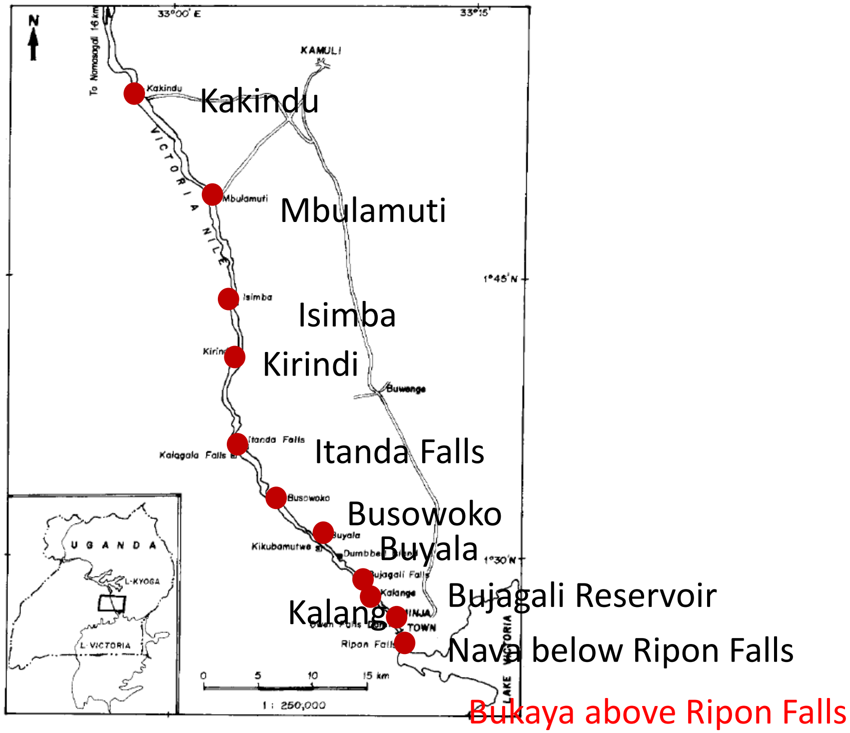
First compilation of species

Ole Seehausen

9.12.2016



N
33°00' E
33°15'
To Namasagali 16 km
KAMULI
Kakindu
Kakindu
VICTORIA NILE
Mbulamuti
Mbulamuti
1°45' N
Isimba
Isimba
Kirindi
Kirindi
Buwenge
Itanda Falls
Itanda Falls
Kalagala Falls
Busowoko
Busowoko
Buyala
Buyala
Kikubamutwe
Dumbbell Island
1°30' N
Bujagali Falls
Bujagali Reservoir
Kalange
Kalange
JINJA TOWN
Nava below Ripon Falls
Owen Falls Dam
Ripon Falls
Bukaya above Ripon Falls
LAKE VICTORIA
UGANDA
L. KYOGA
L. VICTORIA
0 5 10 15 km
1 : 250,000




Astatotilapia nubila


Haplochromis cf. «purple yellow»


Mbipia mbipi


Mbipia sp. «golden» new


Neochromis grenwoodi


Neochromis sp. new


Lipochromis sp.

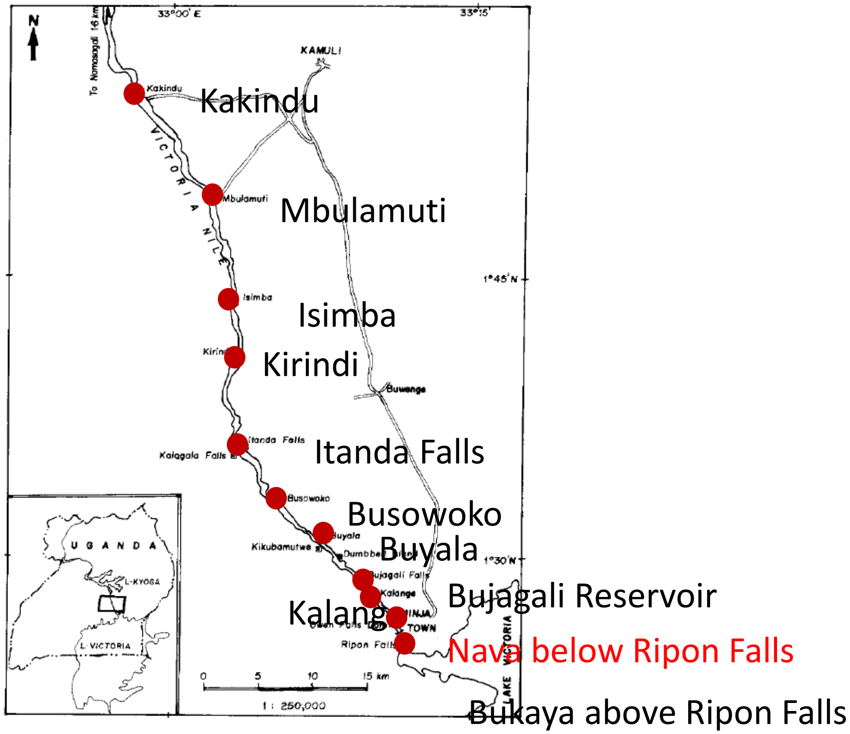

Neo. sp. «large scale nigricans»


Pundamilia cf. azurea


Sp. open water

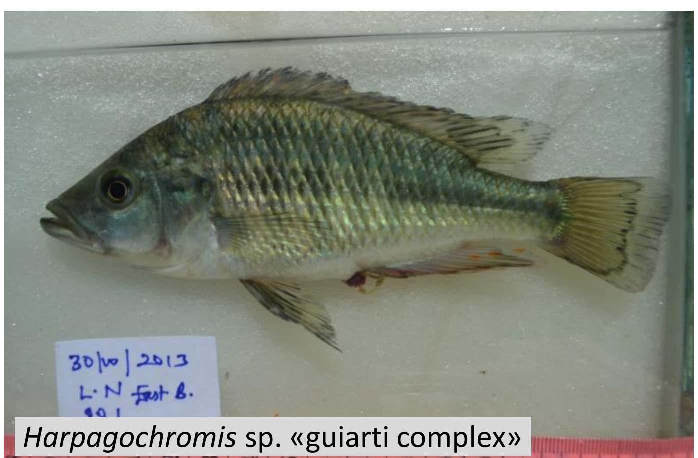

Paralabidochromis sauvagei


Paralabidochromis sp. 1



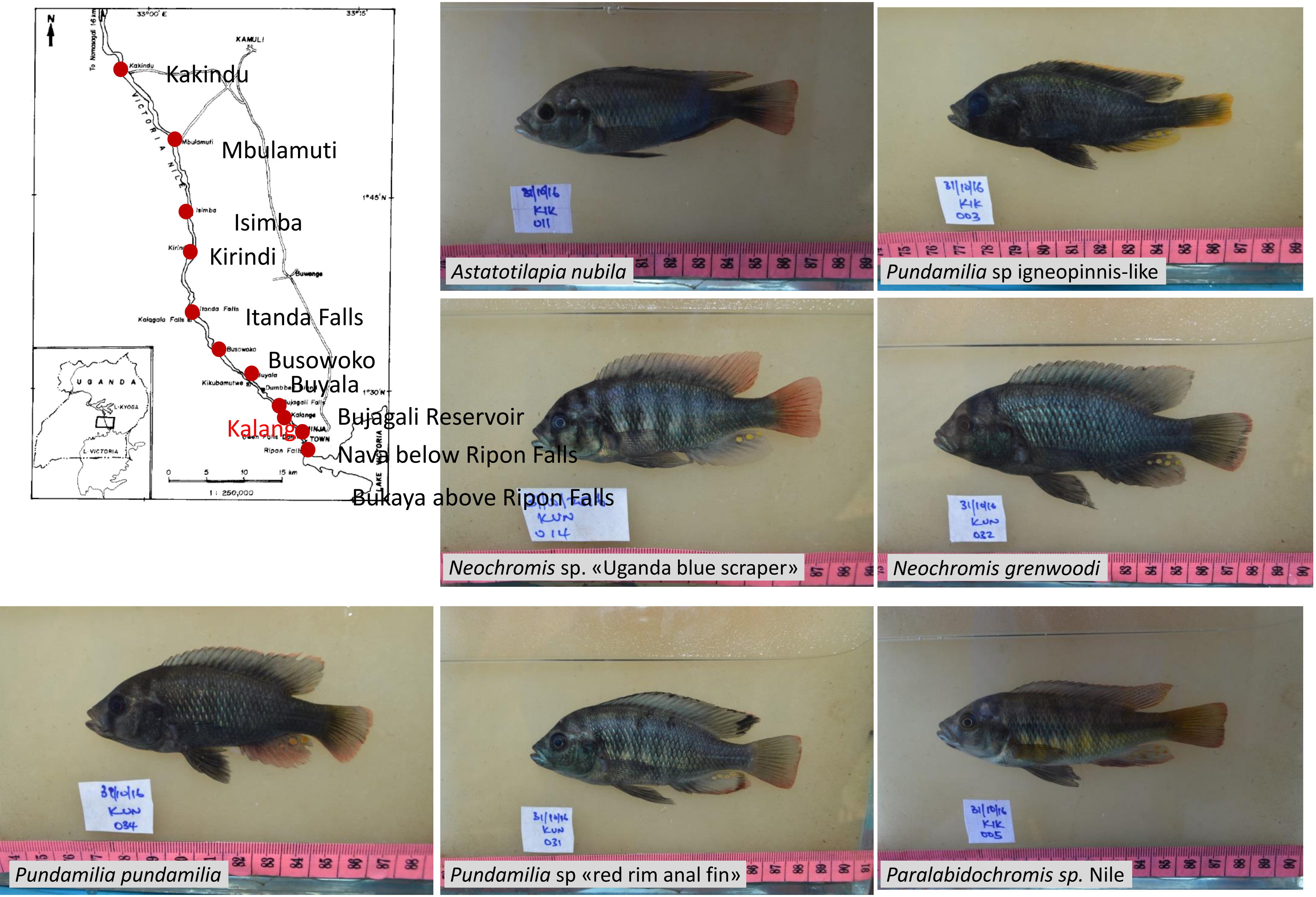
Neochromis grenwoodi

Paralabidochromis sp. «short snout scraper»

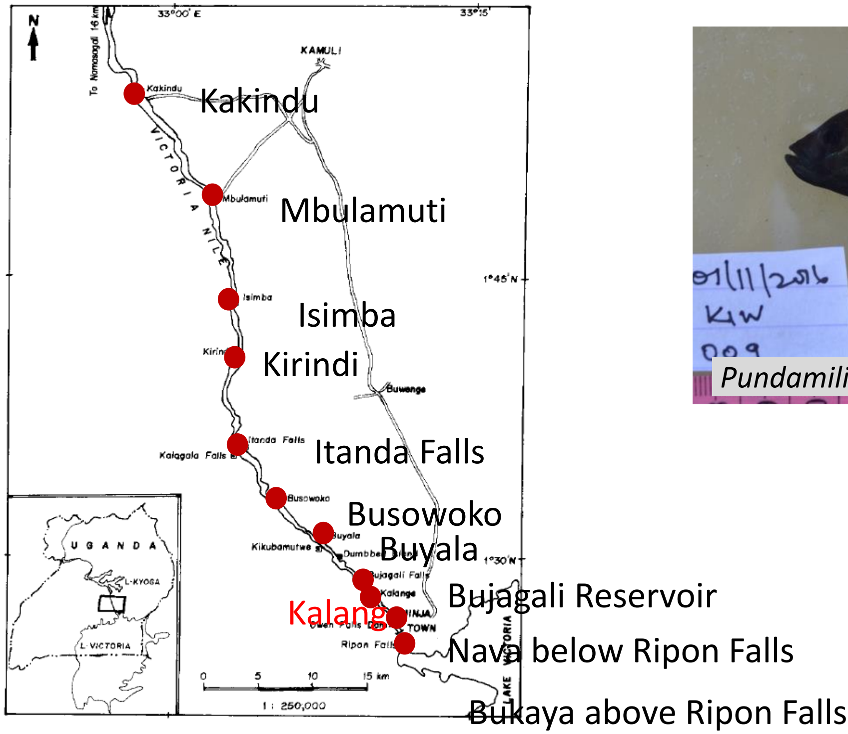


Harpagochromis sp. «guiarti complex»

Paralabidochromis sp. Nile



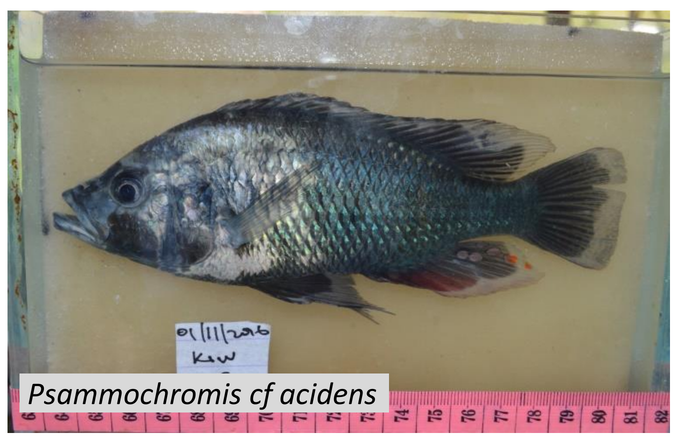
Kakindu
Mbulamuti
Isimba
Kirindi
Itanda Falls
Busowoko
Buyala
Kalange
Bujagali Reservoir
Nava below Ripon Falls
Bukaya above Ripon Falls
KAMULI
33°00' E
UGANDA
L. KYOGA
L. VICTORIA
1 : 250,000
Astatotilapia nubila
Pundamilia sp igneopinnis-like
Neochromis sp. «Uganda blue scraper»
Neochromis grenwoodi
Pundamilia pundamilia
Pundamilia sp «red rim anal fin»
Paralabidochromis sp. Nile



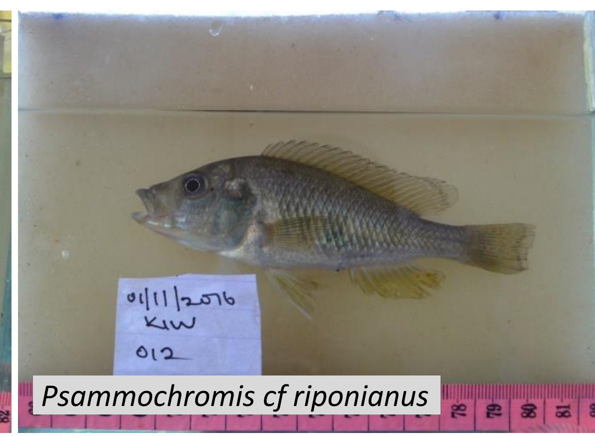
Pundamilia pundamilia


Unknown species 1

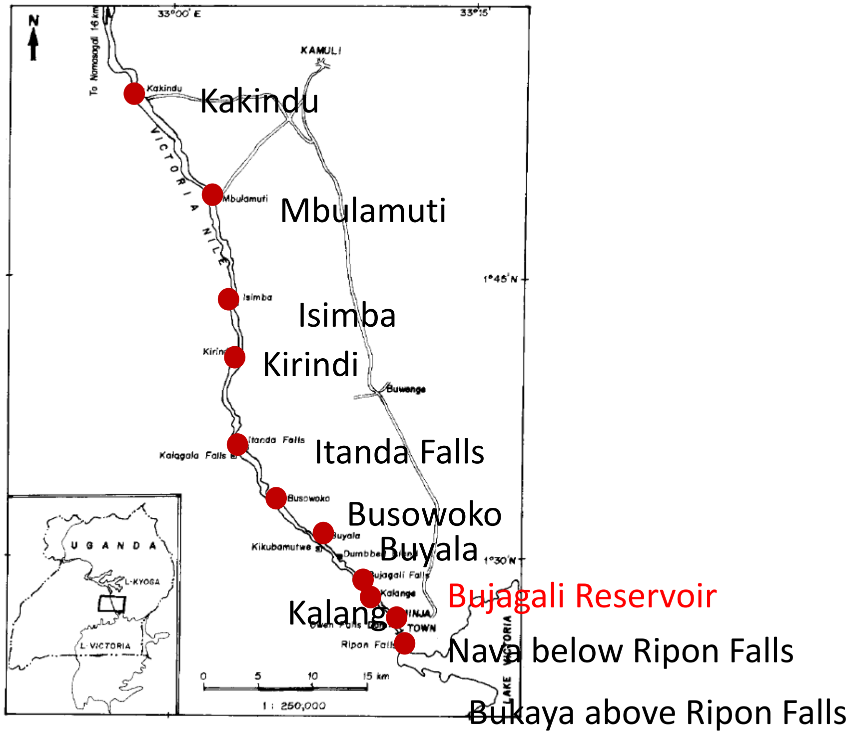
Haplochromis cf «red back scraper»

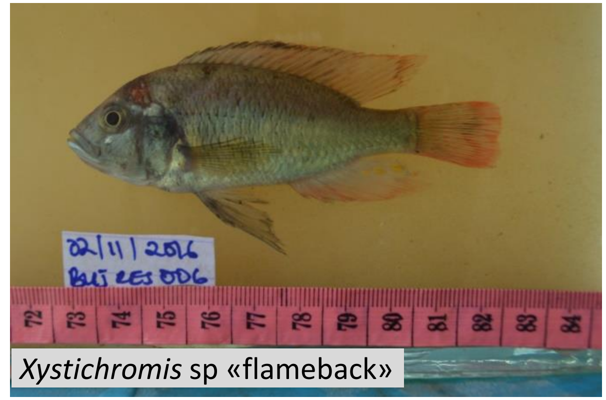


Psammochromis cf acidens



Psammochromis cf riponianus

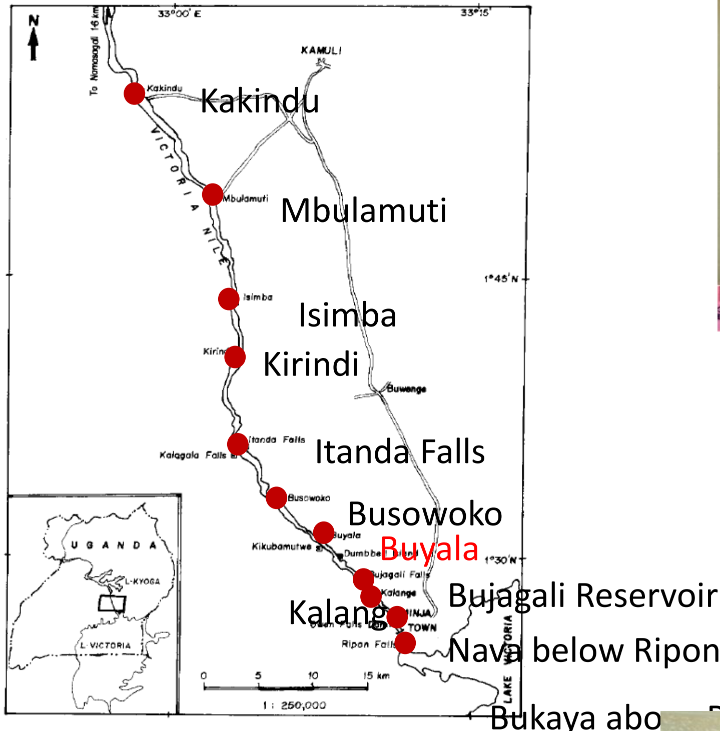




Xystichromis sp «flameback»

Unknown species 2

Unknown species 3

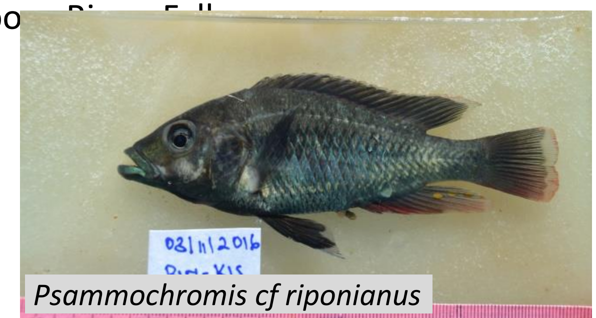

N
33°00'E
33°15'
KAMULI
To Namasagali 16 km
VICTORIA NILE
1°45'N
1°30'N
Buwenge
Kalagala Falls
Kikubamutwe
U G A N D A
L. KYOGA
L. VICTORIA
JINJA TOWN
Ripon Falls
LAKE VICTORIA
0 5 10 15 km
1 : 250,000
Kakindu
Mbulamuti
Isimba
Kirindi
Itanda Falls
Busowoko
Buyala
Bujagali Reservoir
Kalang
Nava below Ripon
Bukaya abo


04/11/2016
Buy-OFN
007
Mbipia mbipi


03/11/2016
Buy-KLS
018
Lithochromis sp


03/11/2016
Buy-LSL-R
Neochromis grenwoodi


04/11/2016
Buy-MG
Paralabidochromis flavus

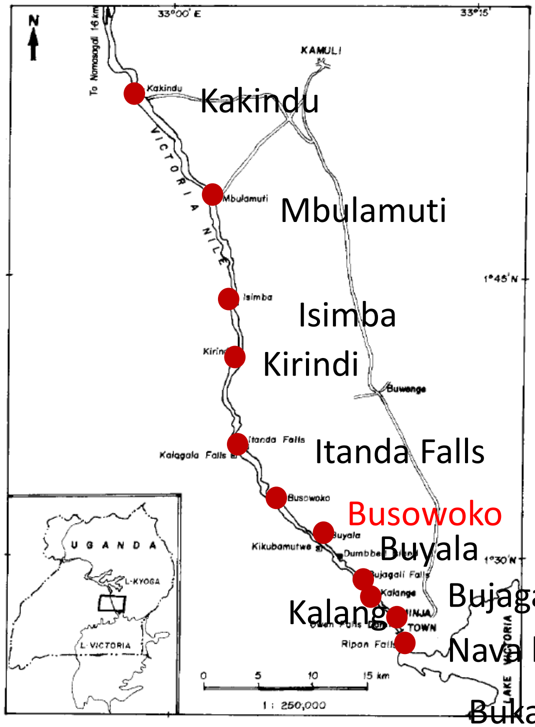

03/11/2016
Psammochromis cf riponianus


03/11/2016
Paralabidochromis sp. Nile

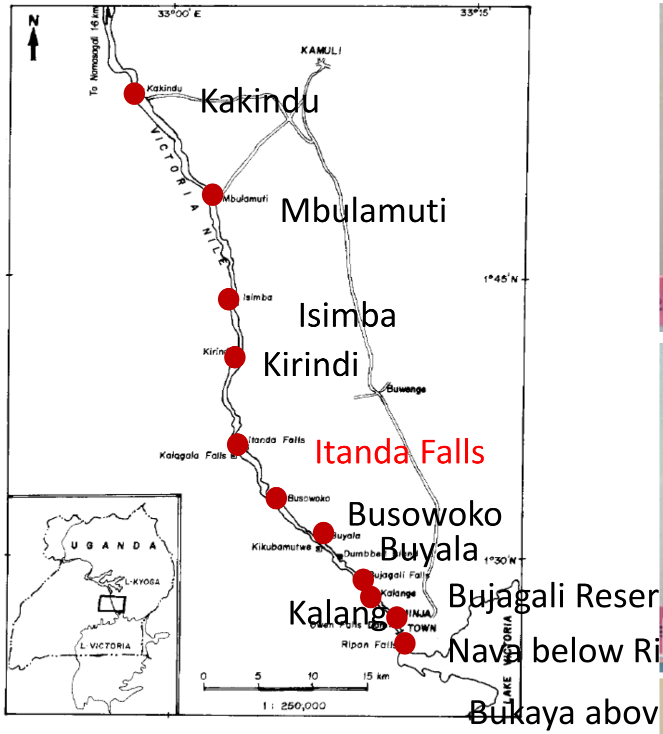

04/11/2016
Buy-OFN
001
Harpagochromis sp. «guiarti complex»


03/11/2016
Buy-KLS
014
Pundamilia cf. macrocephala


03/11/2016
Buy-KLS
Pundamilia sp. «big blue»


N
33°00' E
33°15'
KAMULI
To Namasagali 16 km
Kakindu
VICTORIA NILE
Mbulamuti
1°45'N
Isimba
Kirindi
Buwenge
Itanda Falls
Kalagala Falls
Busowoko
Buyala
Kikubamutwe
Bujagali Falls
Kalange
JINJA TOWN
Ripon Falls
1°30'N
UGANDA
L. KYOGA
L. VICTORIA
LAKE VICTORIA
0 5 10 15 km
1 : 250,000
Kakindu
Mbulamuti
Isimba
Kirindi
Itanda Falls
Busowoko
Buyala
Bujaga
Kalang
Nava
Buka


Astatotilapia nubila
«H». Sp. «thick skin» like
Haplochromis cf «purple yellow»
Lithochromis sp
Mbipia mbipi
Neochromis grenwoodi
Neochromis sp
Sp. «blue lip»
Xystichromis sp «flameback»
Para. sp. «red breast» new
Para. sp. «yellow multispot»
Pundamilia sp. 1



Astatotilapia cf. brownae

Xystichromis sp «flameback»

Lithochromis sp «yellow chin»

Mbipia mbipi

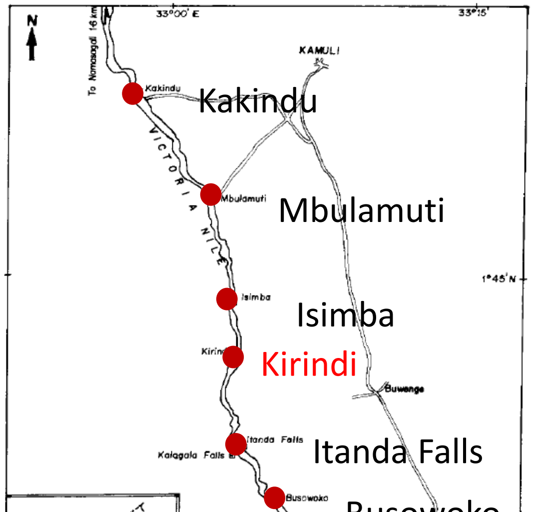
Neochromis grenwoodi

Paralabidochromis sp. Nile

Astatoreochromis alluaudi

Pundamilia cf pundamilia

Pundamilia sp. 1



Xystichromis sp «flameback»

Lithochromis sp «yellow chin»

Astatoreochromis alluaudi

Neochromis simotes

Mbipia mbipi

Unknown species 5

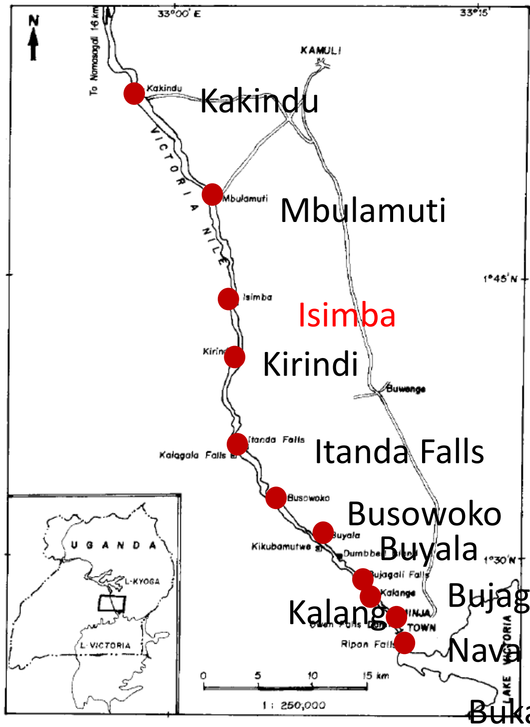
Neochromis grenwoodi

Unknown species 6

Pyxichromis orthostoma

Ptyochromis sp. 2

Unknown species 4



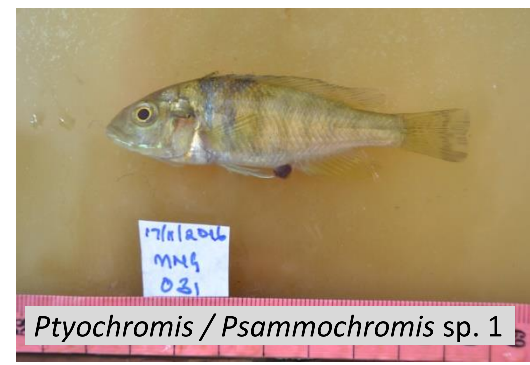
Xystichromis sp «flameback»

Lithochromis sp «yellow chin»

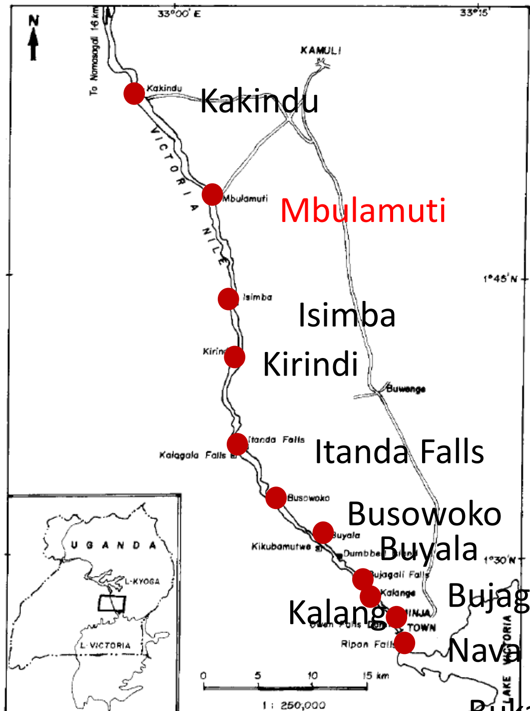
Neochromis simotes

Neochromis sp. «red pelvic» new

Astatoreochromis alluaudi



Ptyochromis / Psammochromis sp. 1



Xystichromis sp «flameback»

Lithochromis sp «yellow chin»

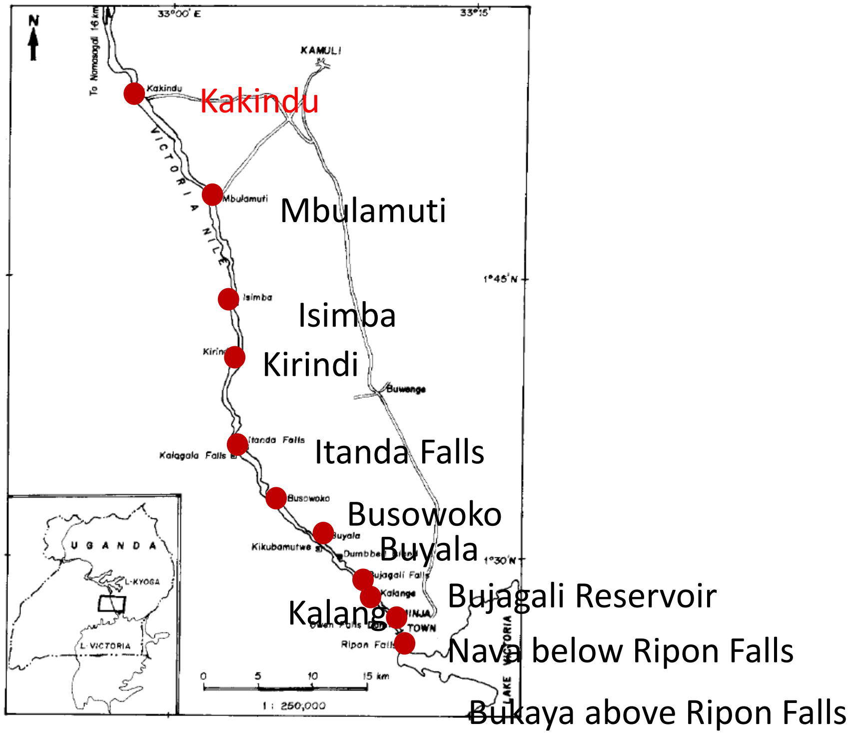
Neochromis simotes

Neochromis sp. «Labeo» new

Harpagochromis sp. «guiarti complex»

Neochromis grenwoodi

Ptyochromis / Psammochromis sp. 1




Astatotilapia nubila


Xystichromis sp «flameback»

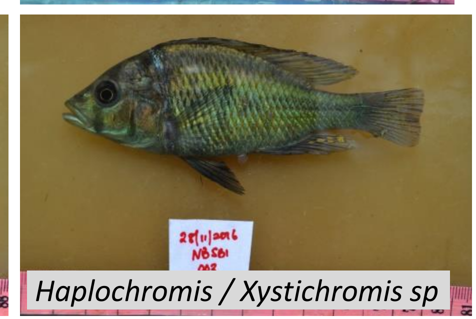

Neochromis simotes


Para. sp. «short snout scraper»


Ptyochr. xenognathus red pelvic


Ptyochromis / Psammochromis sp. 1


Xystichromis cf. phytophagus


Haplochromis / Xystichromis sp


Harpagochromis sp. 2


Harpagochromis sp. 2


Pyxichromis orthostoma