Report to Durrell Wildlife and Conservation International providing advice on conservation of endemic fishes in the Nosivolo River, Madagascar, November 2005.

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Background

During the initial phase of the Nosivolo Endemic Fish Conservation project, conducted by Durrell Wildlife Conservation Trust (DW) and the Department of Animal Biology of the University of Antananarivo (DBA) with funding from Conservation International (CI), approximately two thirds of the 120km long river was surveyed for fish and invertebrates. Surrounding land surveys evaluated the degree of river-bank forest cover. Despite severe deforestation along the majority of the river, it appears that water quality is still good. Out of 19 endemic fishes known from the Nosivolo River 16 were identified during the study. All appear to be in decline including three species, which are endemic to the watershed. One of these, the Songatana (*Oxylapia polli*) is listed as Critically Endangered (CR: B1ab(i,iii), IUCN 2004). The principal threats to fish populations appear to be continuing deforestation, the presence of introduced fish (mostly tilapiine cichlids and poeciliids) and overfishing of the river.

Initial outreach work showed that the local communities are receptive to conservation. They are aware of the decline of their fish populations and reacted positively to the idea of developing conservation strategies to ensure the wise use of the river and watershed. Based on this work DW developed a conservation plan for the Nosivolo watershed, to be implemented from 2005. Within this work, Durrell Wildlife (DW) and Conservation International (CI) identified that there was a need for further capacity development here in Madagascar in terms of developing Madagascar's expertise in fish population ecology and conservation. Durrell Wildlife made contact with the South African Institute for Aquatic Biodiversity (SAIAB) an organisation which has a wide range of experience in this field. SAIAB recommended undertaking an initial survey reconnaisance trip under the direction of the freshwater curator, Mr Roger Bills.

Objectives

To assist DW, CI and DBA to improve the conservation plan for the endemic fish of the Nosivolo River, in particular:-

- To advise on research and monitoring methods
- To advise on effectiveness of proposed conservation actions and suggest other activities as appropriate
- To advise on future research priorities
- To evaluate potential collaborative links between the Nosivolo project and SAIAB

Expected outputs

- Collaboration established between SAIAB and Malagasy partners (DW, CI, DBA).
- Report by Roger Bills outlining :
    - his experiences in Madagascar ;
    - strengths and weaknesses of the Nosivolo work and the Nosivolo team ;
    - advice and recommendations on the current ecological monitoring protocols ;
    - advice and recommendations on the preliminary conservation strategies proposed ; and
    - potential role(s) that SAIAB could play.
- Roger Bills to meet most of the aquatic conservation organisations (gvt. & non-gvt. Based in Tana).
- Roger Bills has a good understanding of Malagasy in-country capacity and Malagasy conservation issues.

Report Observations and recommendations

1. Overall impressions

1.1. During my trip to Madagascar I spent 10 days in the Nosivolo catchment around Marolambo (Itinerary Appendix 1). I accompanied the DW/DBA team and observed their fish data collection methods. We had various meetings with local officials in Marolambo and within the DW/DBA/SAIAB team continuous discussions about the Nosivolo Conservation project being proposed. I have a good understanding of the scope of the project and the methods proposed.

- DW has experienced field conservation officers capable of working independently.
- DW has clear goals and strategies and everyone understands these.
- DW officers have an excellent rapport with the Marolambo community.
- There appear to be gaps in ichthyological reference materials and skills, which make it difficult for certain research tasks (e.g. biodiversity surveys) to be completed by Malagasy scientists and conservationists.
- Future research with foreign organisations should include Malagasy training and infra-structural capacity building.
- Madagascan freshwater systems are severely impacted by farming activities particularly rice cultivation
- Soil erosion and consequently river sedimentation is a serious impact in all systems observed.
- Alien fishes were the dominant species in most areas sampled.
- The Marolambo community has recognised that certain activities are unsustainable and has already introduced some measures to reduce impacts e.g. a four-month fishing ban.
- Due to a closed-season on fishing I have a poor understanding of the scope or magnitude of fisheries in the Nosivolo.
- The proposed programme places a great emphasis on helping communities on the Nosivolo River form fishing associations and formalise wide-ranging fisheries regulations These are a good start at conserving the fishes of the Nosivolo but it should evolve into a broader catchment management programme.
- A successful fisheries programme will result in a relationship of respect and cooperation between DW and communities which will enable DW to influence a variety of broad catchment conservation issues e.g. riparian vegetation conservation

1.2. Importance of considering the broader Mangoro catchment area.

The Nosivolo sub-catchment has been identified as having higher fish diversity than other parts of the Mangoro River system and surrounding regions (Camp 2000, map below) as a high number of Madagascar endemics have been found at the site of which at least three species appear to be endemic to the Nosivolo river system. It is possible that other parts of the Mangoro system have been less well studied and are similarly important for endemic fish. Given the desperate state of aquatic diversity within Madagascar urgent conservation work is needed immediately. Much catchment-wide work is needed to raise awareness of local peoples to the impacts of forest clearing, overfishing and habitat degradation. The broad nature of such conservation actions override issues of micro-endemism. While it makes sense to initiate conservation work in Nosivolo, it is recommended that studies to determine the distributions and taxonomy of species within the greater Mangoro region take place as funding possibilities arise.

2. Monitoring

2.1. During the preliminary fish diversity and abundance assessments there seems to have been a heavy reliance on one or two methods e.g. throw and gill netting used by fishermen. All methods are biased and give varying results. Consequently, additional assessment techniques are suggested.

- Experimental gill nets with variable mesh sizes (5-10 mesh sizes in panels 5-10m each).
- Underwater observations using masks and snorkels.
- Seine netting.
- Trapping.

2.2. Sampling areas. Individual monitoring sites will comprise varied micro-habitats e.g. rapids, pools, overhanging vegetation. Ideally all habitats should to be sampled separately and data from each recorded separately.

2.3. Sampling times. Different types of fishes exhibit different activity patterns e.g. most catfishes and eels will be more active at night. Where feasible assessment techniques should be applied during the day and night.

2.4. Data collection. Monitoring needs to be standardised and effort needs to be recorded. For example snorkel counts can be made in a discrete area such as a pool or a rapid if such features are permanent. Alternatively counts could be done over a period of time such as five minutes, which could be repeated several times at a single site. In addition to counts it is desirable to have a period of time for looking for rare species to note their presence. The results

would therefore produce replicated data on timed counts plus species present but not seen during the timed counts.

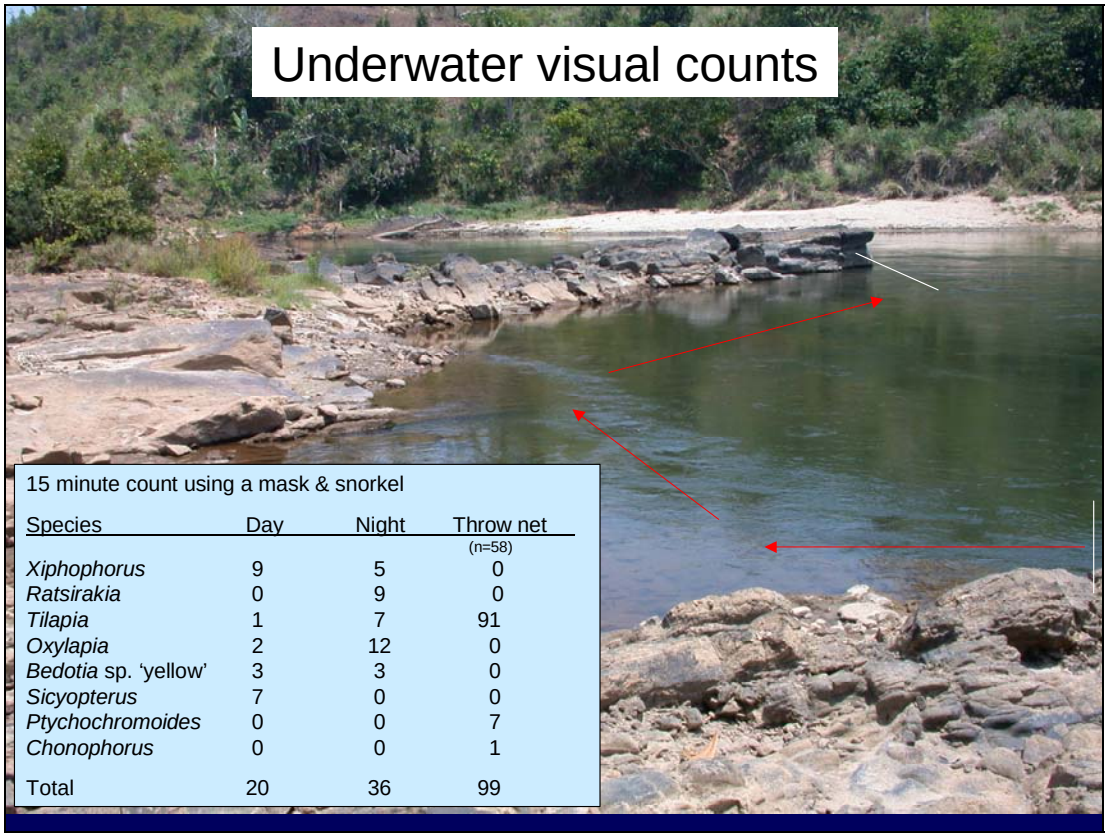

Figure 1. Results from day and night snorkel counts and throw net collections in the Nosivolo River below Marolambo (Site M5)(10/11/2005).

2.5. Monitoring should be broadened to include rapid habitat assessments such as:status of banks;

- riparian vegetation width;
- sedimentation index e.g. sediment grades, rock embeddedness; and
- water turbidity.

2.6. I suggest that where possible monitors should be a mix of DW staff, local fishermen from fishing associations, farmers and local community leaders. Local people could be employed for 2-3 day per month to achieve reliable results.

2.7. Monitoring sites need to be accurately mapped and exact routes and limits for snorkel counts need to be identified. If this is not done different habitats could be surveyed each time resulting in obviously different and uncomparable results.

2.8. Monitoring sites. Long-term monitoring sites need to be identified and accurately described e.g. GPS coordinates taken, photographed from fixed points and sketch maps made showing exact sample points drawn. Criteria for choosing sites should include some of the following:

- Accessibility during most seasons;
- A range of impacts from pristine through to heavily impacted;
- Protected and non-protected fishing areas;
- Varied habitat types; and
- Varied water body size e.g. Nosivolo River through to small streams.

3. Fisheries assessments

3.1. Fisheries assessments. Greater amounts of data need to be gathered for fisheries analysis. The best way to do this is by encouraging reliable fishermen to help with data collection by recording their catches at least some of the time through the season and in different parts of the river system.

3.2. The basic fisheries data needed from fishermen are:

- Date;
- Place where gear was set
- Effort e.g. set overnight or some many hours;
- Number / size of gear e.g. 10 traps, 1 x 10m gill net
- The catch –
    - Species
    - Number
    - Length (total length)

3.3. All fishing methods need to be assessed for their occurrence, frequency of use and seasonality and their catches. A much better understanding of the dynamics and impacts of the fishery is needed before detailed management regulations can be implemented.

3.4. Prawn trapping. In particular, prawn trapping, which is conducted at slightly different times to dedicated fishing methods, needs to be studied. Prawn traps do catch fishes and in many instances they are set within rapid areas. Prawn trapping is also allowed during the fish breeding season. As rapids appear to be the most important habitat for remaining indigenous fishes it is possible prawn traps are having a significant impact upon indigenous stocks. Initially several management options seem possible:

- ban trap fishing during the fish breeding season;
- ask fishermen to return all fishes and only keep prawns; and

- restrict the use of traps to non-rapid areas.

Without any research, the latter two options would seem the most reasonable as this is obviously a critical period of the year for food security.

3.5. Accurate length – weight relationships for all the indigenous fish species in the Nosivolo River can be determined by DBA/DW staff during the course of fisheries monitoring exercises.

3.6. Fish market assessments. The trends in fisheries catches may be reflected in the numbers and sizes of fishes being sold in markets. It is probably worthwhile recording crude information about fishes in markets through a single season e.g. fish species, number and total weight and measuring total lengths of sub-samples for each species of over a 2-3 day period every month.

An example of a data collection sheet.

Nosivolo conservation programme - fishermen's catches monitoring form

Site name: Coordinates:
Recorder: Fisherman:
Date: Time:
Catch method (gill-net, trap, etc.): No. of devices:
Size: length of net: Mesh size: Depth:
Where were fish caught (rapid / pool):

For catch data try to measure everything. If there is too much measure and weigh a portion and then weigh the total catch.

Species	Size (total length in mm)

4. Fish biodiversity

4.1. A checklist of fishes of the Nosivolo River based on previous surveys is given in Appendix 3. Collections sites for the November trip are given in Appendix 4 and notes on the fishes collected in November are in Appendix 5.

4.2. Further exploratory work is clearly needed within the Nosivolo and Mangoro River systems. Aims of such work should be as follows.

- Determine more accurately what is present within these systems.
- Establish species identities and educate all researchers in correct fish identifications.
- Develop a better understanding of the preferred habitats for each of the indigenous species.
- Determine the ranges, upper and lower distribution limits of all species.
- Start estimating population sizes for endangered species using mark recapture and genetic (fin clip) methods.
- Search for possible sites for rehabilitation projects e.g. waterfalls, pristine areas with few exotic species.
- Develop plans for 'core' fish conservation areas based on improved knowledge of key habitats for each species and the state of the rivers.

4.3. Data from all previous fish collections, research conducted and aquarium holdings of species within the Nosivolo/Mangoro catchment is not easily available. This can help with the following.

- Planning future surveys.
- Assessing priority areas for conservation management actions.
- Planning rehabilitation projects.
- Assessing species for IUCN red data status.

I recommend that a database with fish distribution data (from varied sources) be developed and held in Madagascar. I have made a start on putting such a database together but this may take some time as not all collections data appears to be readily accessible and not everyone I have contacted has responded positively. Collections data I have received so far are included on the CD-rom accompanying this report. It is not yet in a database format.

4.4. Fish identification. To help conservation staff and fisheries scientists with accurate fish identification the following are suggested.

- Establish small voucher collections of fishes and good quality photographs in Madagascar in places where fish identifications will be needed e.g. DBA, DW, Marolambo.
- Large fish collections are not recommended as these are costly to maintain and this is not the business of universities or conservation organisations.
- If museum collections are required these should be housed in the Antananarivo Natural History museum. If this institution does not yet have the capacity to o this then a programme leading to this goal is suggested.

- Identification keys can be developed to identify fishes of individual systems or Madagascar. At preset the numbers of undescribed species in certain groups (e.g. Cichlidae & Bedotiidae) will make that a little difficult.

4.5. Species declines. We were informed by some older fishermen that several species had either declined in abundance or had disappeared from certain areas over the last 10-20 years.

- *Oxylapia polli* Kiener & Maugé, 1966 was reported to have disappeared from the Sahanao and Sandranamby Rivers both large tributaries of the Nosivolo near Marolambo.
- *Mesopristes elongatus* (Guichenot, 1866), *Agonostomus telfairi* Bennett, 1832 and *Kuhlia ruperstris* (Lacepède, 1802), probably all estuarine straglers, seem to have almost disappeared from the Nosivolo River. This may well be due to fishing pressure on species that are naturally rare in the upper river.

5. Threats to fishes of the Nosivolo River

5.1. Previous systematic and conservation research, including the preliminary studies for the present Nosivolo Conservation project, have identified threats to aquatic biodiversity and suggested numerous conservation actions. In commenting on the specific DW/CI/DBA Nosivolo project proposal I agree with many of their conclusions.

5.2. The two major threats within the Nosivolo catchment are:

- sedimentation of rivers caused by slash and burn cultivation on steep slopes and rice paddy farming; and
- alien fishes, which at most sites, were both numerically and biomass-wise the dominant fishes present.

5.3. A third potential major threat, which appears to be very low level at present but could easily and rapidly escalate is gold mining. Gold mining has the potential to result in:

- increased turbidity loads within rivers due to washing of alluvial sediments;
- immigration of large numbers of people with at host of environmental and social impacts: and
- the possible use of Mercury in Gold extraction process.

5.4. Fishing pressure is also a potential threat to fish diversity. The period of our visit to Marolambo was during a locally enforced closed fishing season so I have a poor impression of the level of pressure being exerted upon fisheries resources. I suspect that fishing alone would be less of a threat to indigenous fish survival than either sedimentation, alien fishes or the varied impacts of

gold mining. However, as there are multiple impacts, which probably work in synergy, it would be extremely difficult to determine all the interactions and quantify the magnitude of each component.

5.5. Local plants are used as fish poisons to some extent by local people. The magnitude of this is unknown but it is probably an unsustainable activity (see section 6.9. for further discussion).

6. Conservation actions

6.1. Fisheries regulations and DW proposals. The aim of DW to develop fishing associations and through these to develop fisheries regulations is a sound strategy. If this is successful it is likely to have long-term impacts beyond the life and geographical range of the Nosivolo project. Some of the benefits could be as follows.

- You will be helping communities develop something they have already decided they need to do. Consequently, DW can build-up a degree of good-will with local communities.
- This good-will should engender cooperation in a host of other community activities e.g. altering farming practices, alien fish eradication projects and setting aside conservation zones.
- Assessments can be done involving local fishermen-community and they can be part of developing solutions to the problems. If this happens there is much more chance that any regulations will be respected and followed by members of the community.
- Fishermen can help with collecting much more data than DW/CI staff alone can do.

6.2. Implementation of certain conservation actions may be aided by the local water and forests government office. The representative for this office was recently transferred and needs to be replaced urgently. DW/CI could possibly help this process.

6.3. The process of establishing fisheries regulations, monitoring their impact and their subsequent analysis is likely to result in a new set of regulations. Such alterations to regulations could happen several times. It is important for communities to understand this process otherwise DW staff could loose credibility and thus local support. Involving local people in the monitoring, analysis and the development of new regulations will help in explaining this process to the wider community.

6.4. Protected, non-exploitation areas. The idea non-fishing zones should be expanded to no- or low-impact zones. If local people agree reducing as many

of the impacts as possible within ‘conservation zones’ would be best. Restricted activities within conservation zones could be:

- no fishing with gill and throw nets;
- no trapping for fish or prawns;
- no gold mining;
- no farming within 10-50m of river banks; and
- no washing in the river.

6.5. Protected areas could be permanent or rotated every year or two. There needs to perhaps be both initially and these need to be monitored to determine if rotation is satisfactory for fishes..

6.6. Suggested areas that should be considered for protection as low-impact conservation zones are:

- waterfall pools (as fish migrate up rivers and often concentrate and breed at waterfalls);
- river confluences as there is often a great deal of habitat and potential spawning sites;
- rapids as these appear to be the last strong-hold for most of the endemic fishes;
- sections in upper-catchment streams; and
- wetlands / swamps all over the catchment.

6.7. Size of conservation zones needs to be considered. Perhaps there could be a range of sizes of conservation zones. I am not an expert in this field and we will need to get further advice on this. Compromises will probably need to be made with local communities as they may not wish to set aside what would be an ideal area for biological reasons.

6.8. It will be important to monitor the success of conservation zones. Monitoring sites within and outside of conservation zones should be identified and monitoring should commence immediately.

6.9. Banning fish poisoning. Poisoning is widely recognised by local people as being unsustainable and undesirable, however, we found some evidence it had been used in isolated pools around Marolambo. Our fish guides also found the plants used for poisoning with ease further indicating that the method is well known and probably frequently used. It is likely that poisons will have a greater impact on indigenous species than the exotic *Xiphophorus* and tilapiine cichlids so further skewing fish communities towards exotics. The prohibition of poisons needs to be enforced.

Figure 2. Plant used for poisoning still waters around the Marolambo region.

6.10. Riparian vegetation conservation. Erosion is one of the two major impacts in the system. In many instances cultivation goes to the waters edge. Local communities seem to recognise this is a poor policy and have stated they want to stop this. This is a very positive step and should be built upon immediately by DW and local authorities. All farmers need to leave strips of natural vegetation along river all river courses (both banks) as a permanent measure. It is probably best to get the advice of experts in erosion control to determine the extent of the strips although this is probably dependent on the topography of the river banks and thus variable. This is an urgent issue and it needs to be addressed on a catchment-wide scale.

6.11. Protection of forests and wetlands in the catchment. If possible the remaining wetlands and forests should be targeted for protection. When we flew out of Marolambo up the Nosivolo catchment we saw numerous upper catchment wetlands that had not been converted to rice paddies. These are valuable areas for river functioning and biodiversity of aquatic invertebrates, amphibians and birds if not fishes.

6.12. Alien fish control activities. Together with sedimentation alien fishes pose the greatest threat to indigenous fishes. The rice paddies produce vast numbers of *Xiphophorus,* which are constantly 'leaking' back into the Nosivolo system and they are by far the most numerous species, probably outnumbering all other species combined. Some attempts at starting to control

these should be experimented with. This could be run as a student project and involve varied strategies together with monitoring e.g. closing off of rice paddy channels, trapping at in- and out-lets, introductions of indigenous cichlids which may predate upon *Xiphophorus* or rotenoning individual paddies. Working down systems from the upper catchments could result in eradication of aliens from small sub-systems. If this works I would have applications all over Madagascar.

7. Aquarium projects

7.1. Aquarium projects. I have read several articles concerning the breeding of Madagascan fishes for conservation. However, during my visit to Madagascar I got little sense there is much collaboration between aquarium breeders and any Madagascan authorities. Several issues seem relevant.

- Do aquarium breeders have genetically diverse stocks and if not can they get additional wild stocks?
- Are there long-term goals for producing enough stocks to release into rehabilitated areas?
- Are there any present initiatives where certain species are presently being built up for a reintroduction and if so where?
- If not can some Nosivolo fishes but brought to the fore in this respect?
- Can some breeding be done in-situ in port-a-pool facilities near Marolambo under aquarist supervision?
- Can aquarists help fund a river rehabilitation project – e.g. rotenoning of a river above a waterfall?
- There should be greater feedback to Madagascan authorities regarding fish biology and aquarium observations as this could be important in formulating species conservation plans.
- An aquarium in several of the villages in the Nosivolo catchment would raise awareness about both the fishes and their environment.

7.2. It is possible the Pretoria Zoo aquarium (a sister organisation to SAIAB) will be interested in getting involved in a breeding programme as it has recently reviewed operations and is changing to a more scientific and conservation role. If they do agree then Nosivolo fishes could form an initial focus for the zoo. Endangered species, which are endemic to the Nosivolo, e.g. *O. polli*, *P. katria*, *P. bleekeri*, *R. wrightae* and *Bedotia* sp. “Nosivolo”, would be priorities in such a project. I have made contact with Mr Alex Saunders (Denver Zoo) and Mr Chris de Beer (Pretoria Zoo) to initiate discussions around this. Both have responded very positively.

8. Potential collaborative links between the Nosivolo project and SAIAB.

SAIAB is situated at the edge of Rhodes University and has access to varied facilities at SAIAB and Rhodes e.g. genetics laboratories, DNA sequencers, electro-microscopes, x-ray machines and laboratories that routinely section animal tissues such as gonads. There are also specialist aquatic entomologists / taxonomists who can help with food item identifications if necessary. Some ideas for projects that could be conducted between the Department of Biology (DBA) Antananarivo University, Conservation International (CI), Durrell Wildlife (DW), SAIAB and other organisations are as follows.

8.1. Conservation assessment of *Oxylapia polli* (Songatana).

This species has been assessed as Critically Endangered (CR: B1ab(i, iii, IUCN 2005) on the basis of it occurring in a single 'locality' and it is known to be declining. However, *Oxylapia*'s distributional range is poorly known and no assessments have been made of its population size or its genetic structure.

Surveys to assess this species' geographical range are urgently required in the Nosivolo and Mangoro Rivers and their larger tributaries. Assessments of population sizes in rapids using mark recapture and genetic methods will enable more accurate Red Data assessments. Biological studies, in particular breeding, age and growth studies, will enable the development of better conservation plans e.g. mesh size restrictions, closed fishing season time periods. Better assessments of threats are also needed such as the extent of and impacts of prawn/fish trapping within rapid areas. SAIAB and the Department of Ichthyology, Rhodes University (DIFS) are currently running very similar project for South Africa endangered species. We could take the lead in such project and collaborate with DBA, DW and CI.

8.2. Fish and aquatic invertebrate indices of eco-system health.

Developing fish and invertebrate indices for measuring ecosystem health for Madagascan waters. MSc projects with Malagasy students. Projects would involve familiarising students with assessment techniques for fish and aquatic invertebrates, learning to identify indicator taxa and the conducting field trials in Madagascar to test and modify techniques. Immediate projects would use the Nosivolo/Mangoro catchment, however, techniques would be applicable other systems in Madagascar. A South African modification of the fish index has been developed under and RSA Water Research Commission programme by the company EcoSun under the direction of Dr Johan Rall. If they are agreeable EcoSun would be good lead agents for such a project.

8.3. River rehabilitation/ alien fish removal projects.

Projects would involve the identification of reasonably small tributary systems within the Nosivolo catchment that are isolated by large waterfalls. One potential system has already been identified in the upper Sanahao River south-east of Marolambo. Others and possibly more suitable tributaries possibly exist and need to be examined.

Once a system is identified surveys for fish, aquatic invertebrates and habitat quality need to be conducted. After this we'd proposed to capture a large proportion of indigenous fishes and hold these in systems nearby and then eradicate all fishes remaining using the piscicide rotenone. After treatments are assessed to be effective indigenous fishes would be reintroduced. Local people would be encouraged and helped to improve methods of agriculture to reduce erosion and sedimentation within rivers. Recovery of the system would be monitored using invertebrate, fish and habitat indices.

Funding and collaboration for such a project could be obtained through aquarists and US Fish and Wildlife (for aid with rotenone use).

8.4 Biology projects examining feeding, breeding, age & growth.

Endangered or key indicator species should be targeted. These could be run as student projects but then enough data needs to be gathered so that theses can be completed. For example monthly samples of approximately 20-30 fish need to be collected for one year. If these collections seem too much for certain critically endangered species then perhaps lower numbers may be collected in critical periods in order to answer very specific questions. These may not result in enough data for student projects but may be enough to answer conservation questions and enable improved management plans to be developed. SAIAB is conducting similar projects in RSA and can help DBA and DW in developing specific projects.

8.5. Population genetics studies.

Population genetics would be interesting for species likely to exhibit genetic structuring within the Nosivolo basin e.g. Bedotidae, *Ancharius.* Species that are more widespread and reasonably common would be better candidates for study.

8.6. Captive breeding projects

It would be interesting to develop a project involving the breeding of fishes in controlled aquarium facilities (USA, RSA or Tana) and facilities in Marolambo. Aims:

- to investigate aspects of selected species breeding biology e.g. breeding cues, preferred spawning habitats, breeding behaviour; and
- to determine if large enough numbers of fishes can be breed, reared and held for long periods in order to supply potential rehabilitation projects.

8.7. Multidsciplinary taxonomic surveys to assess aquatic bidodiersity.

Multi-taxon surveys would be a good way to get further information about biodiversity and its distribution valuable for planning conservation strategy in the Mangoro system. Aquatic taxa that are being used in southern Africa for Red Data assessments are fishes, amphibians, decapod crustaceans, Odonata (Dragon- and damselflies), molluscs and macrophytes. An effective way to do this would be through a Conservation International AquaRap programme. The geographical scope of a survey could include the entire Mangoro system from the estuary to headwaters and the systems north and south of the Mangoro.

9. Malagasy capacity building

I was not able to visit either the University of Antananarivo or the Natural history museum. However, from general discussions with the DW/DBA team my impression is that there is relatively poor capacity within Madagascar to conduct baseline taxonomic and fisheries surveys. It also appears that basic resources needed to conduct icthyological research are poor. Given the amount of ichthyological research conducted in Madagascar over the last 20 years this is both surprising and disappointing.

I recommend that Madagascan authorities permitting ichthyological research ensure that all future projects incorporate Madagascan capacity building. This should be relative to the scope of individual projects, goals should be measurable and their success reviewed before additional research is permitted. Examples of capacity building are as follows.

- Training of counterparts could range from field training of technical officers in methods used in specific projects through to taking on students for higher degrees.
- Donations of relevant scientific papers, books and equipment.
- All data on fish records should be left with fisheries/university authorities. These should be held in a database and accessible to bonafide researchers and conservators.
- Projects that involve fish collecting should leave behind voucher collections of all species collected. If fishes need to be worked on first at research institutions then fish voucher collections should be returned to Madagascar as soon as possible.
- Voucher collections should be properly bottled, preserved and labelled when handed over to Madagascan holding authorities. The costs of bottles, preservatives etc should be borne by projects.
- Museum collections. I recommend that Madagascar does not establish museum/research collections. These are expensive and hard to justify when there is little funding available for academic, non-applied

biological research. Consequently, I recommend that voucher fish collections be deposited in Madagascan institutions and the remaining samples go to foreign research museums.

10. Additional ideas

10.1. Safety.

- Work in the Nosivolo River requires frequent passage over the river in dug-out canoes. These can capsize and DW staff should ideally be able to swim but in any case should wear life jackets.
- According to the local doctor in Marolambo the region has a high level of bilharzia (*Schistosomiasis*). DW staff should be routinely treated (twice per year) as they cannot avoid getting wet during the course of their work.
- I am not aware of the risk of Malaria but prophylaxis for staff should also be considered

10.2. Communications and outreach.

The Nosivolo Conservation project should consider producing a newsletter, distributing it mainly within the Nosivolo catchment. Future visits to Marolambo could do power point presentations to schools and public to explain the project and report back on visits.

10.3. Outreach about water quality.

Natural water quality in these east coast mountain systems should be very high. With increasing human populations water quality has clearly deteriorated due to poor farming techniques and washing activities. Some sense of caring for water needs to be instilled into local communities so that they and communities downstream from them can enjoy better water and thus health. A broad ranging water health project is suggested and could do some of the following.

- Educate people about water conservation and pollution.
- Help improving water delivery to selected communities (piped water) which would result in less washing in rivers.
- An anti-bilharzia project involving treatment and education.
- Schools projects to monitor river health.

10.4. Hydro Electric Power (HEP).

HEP on a small scale (supplying individual villages) has great potential. HEP developments could be used in bargaining with communities for setting aside wetlands and riparian zones for conservation. Where waterfalls don’t exist

weirs could be constructed to aid HEP generation and these could also be used as fish barriers in river rehabilitation projects.

10.5. Fish farming.

None of the indigenous fishes of the Nosivolo are good aquaculture candidates. Freshwater prawns (*Macrobranchium* sp.) are a major component of local peoples diets already and the technology for prawn farming is well established. This could be organised at the local or export market levels. Care with water quality of any returning waters should be an important factor and only local prawn species should be cultured.

10.6. Tourism.

There is great potential for tourism within the Nosivolo catchment e.g. walking, white-water rafting in inflatable boats, canoeing and kayaking and kloofing. All these could generate good revenues from accommodation, restaurants and guiding. It could be year round or targeted at the fishing closed season and could thus use fishermen as guides. Such activities would require pristine areas so again local people would need to put aside ‘conservation/tourist’ areas for these activities. It would also require training in certain aspects such as water safety, boat handling, guiding etc.

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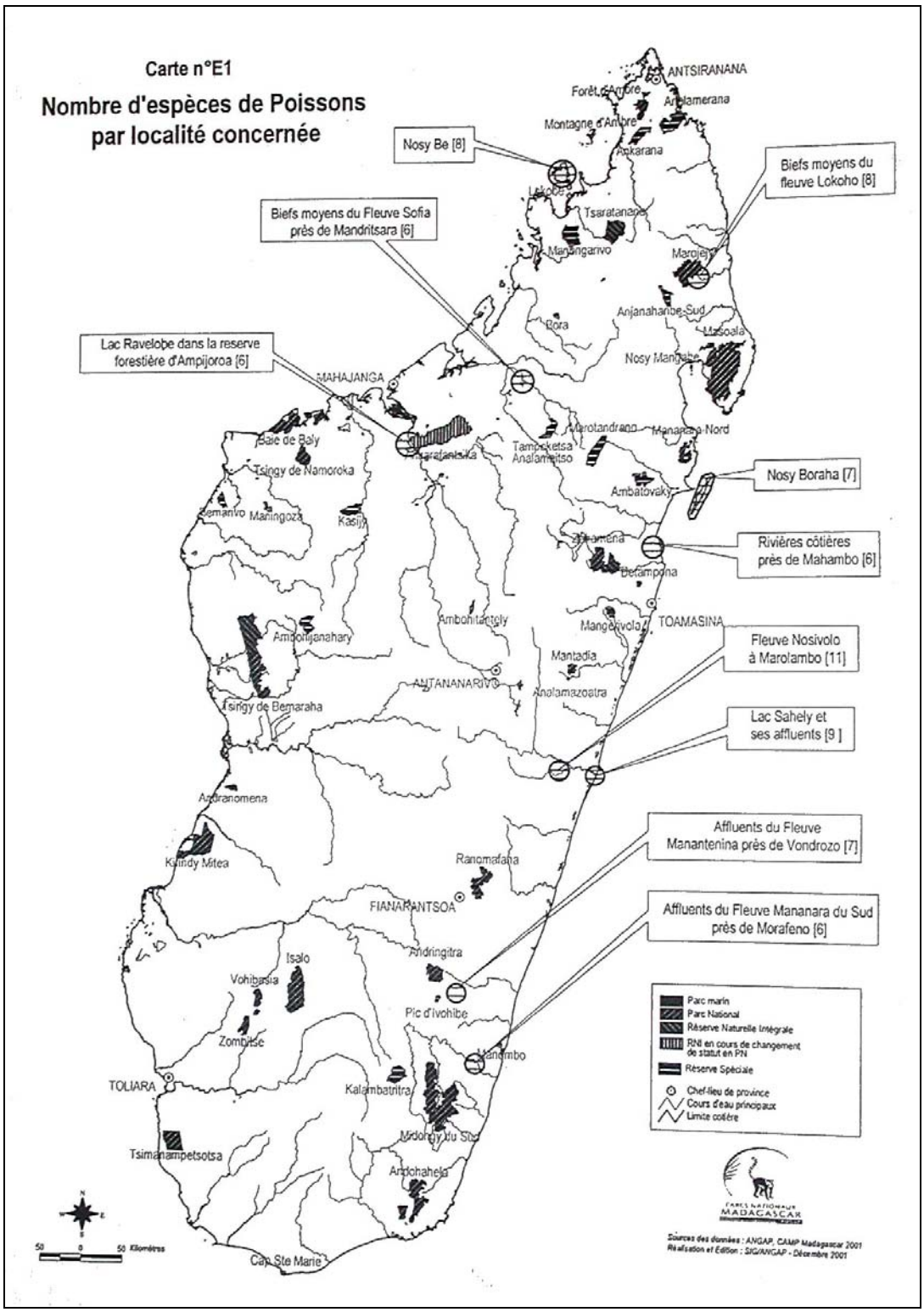
Appendix 1. Roger Bills' itinerary in Madagascar, November 2005.

Fri 4th	Travelling Grahamstown - Johannesburg
Satur 5th	Travelling Johannesburg - Antananarivo
Sun 6th	Antananarivo - discussions with Durrell Wildlife
Mon 7th	Travelled to Maralambo, introductions to local leaders
Tues 8-17th	Maralambo - fish research
Thurs 17th	AM -Travelling Maralambo – Antananarivo
	PM - Report writing
Fri 18th	Antananarivo - presentations and discussions at Conservation International offices
Satur 19th	Antananarivo - report writing
Sun 20th	Return Antananarivo - Grahamstown

Appendix 2. A map showing the numbers of endemic fishes per catchment from the of Camp 2000 workshop.



Appendix 3. Endemic fish species of the Nosivolo River. Threat categories updated October 2005.

Family	**Species**	**Vernacular name**	**English name**	**IUCN Status** W. Darwell and K.Smith 2004, IUCN SSC Freshwater biodiversity programme	**IUCN Status 2004 Red List**
Anchariidae	*Ancharius brevibarbus*	Vaona	Short barbeled Malagasy catfish	EN	DD
	Ancharius fuscus	Vahonaomby		EN	DD
Bedotiidae	*Bedotia* sp1*. Nosivolo*	Vily, Zono	Steel blue bedotia	EN	VU
	Bedotia sp2 new				
	Rheocles lateralis	Vily, Zono, Zonoala		CR	DD
	Rheocles sikorae	Vily, Zono	Spotted zono	CR	DD
Cichlidae	*Oxylapia polli*	Songatana		CR	CR
	Paratilapia sp*. Fony*	Soafony	Small spot paratilapia	VU	VU
	Paretroplus polyactis	Masovoatoka	Red eyed damba	VU	VU
	Ptychochromoides katria	Trondro, Katria		CR	VU
Clupeidae	*Sauvagella madagascariensis*		Madagascar round herring	LR	
Eleotridae	*Eleotridae* 'Soadiboka'	Soboeta, Soadiboka, Atohobolitika		LR	
	Chonophorus macrorhynchus	Atoho	Widemouth sifter goby	NT	
Gobiidae	*Sicyopterus franouxi*		Bare-naped hillstream goby	LR	
	Sicyopterus lagocephalus	Filelabato, Viliolitra		LR	
	Gobiidae 'Atohobaka'	Antohobaka			
Mugilidae	*Agonostomus telfairi*	Tsindrano	Malagasy mountain mullet	VU	LR/LC
Serranidae	*Kuhlia sauvagei*	Fihena			
Teraponidae	*Mesopristes elongatus*	Vovo	Malagasy grunter	VU	VU
Summary				**4 CR, 3 EN, 4 VU**	**1 CR, 5 VU**

CR : CRITICALLY ENDANGERED, EN : ENDANGERED,VU : VULNERABLE, LR: LOWER RISK, NT : NEAR THREATENED, DD: DATA DEFICIENT

Appendix 4. Sites visited during the November 2005 trip.

Sites in the main Nosivolo River plus several tributaries of varying sizes were sampled in an attempt to sample in varied habitats.

Figure . Sample sites during the November field trip to the Nosivolo River.

Table 1. Collection sites around Marolambo during November 2005.

Site #	River / stream	Coordinates		Date
		South	East	
M1	Nosivolo River	20º 03’ 43”	48º 06’ 53”	8/11/05
M2	Nosivolo River	20º 03’ 59”	48º 06’ 58”	8/11/05
M3	Nosivolo River	20º 03’ 27”	48º 07’ 19”	8/11/05
M4	Nosivolo River	20º 02’ 45”	48º 09’ 44”	9/11/05
M5	Nosivolo River	20º 02’ 52”	48º 08’ 39”	9/11/05
M6	Sahampotaka Stream	20º 03’ 14”	48º 08’ 12”	10/11/05
M7	Sahanao River	20º 04’ 03”	48º 09’ 13”	11/11/05
M8	Sahanao tributary	20º 03’ 45”	48º 09’ 11”	11/11/05
M9	Sahafahitra Stream	20º 05’ 15”	48º 08’ 15”	12/11/05
M10	Sahanao River near Lavajiro	20º 05’ 20”	48º 08’ 57”	12/11/05
M11	Sandranamby River	20º 02’ 59”	48º 07’ 40”	13/11/05
M12	Sandranamby River	20º 03’ 01”	48º 05’ 35”	14/11/05
M13	Sandranamby River	20º 03’ 05”	48º 06’ 49”	14/11/05
M14	Sahafahitra Stream	20º 05’ 09”	48º 07’ 54”	15/11/05
M15	Sahampotaka Stream	20º 03’ 46”	48º 07’ 53”	15/11/05

Appendix 5. Fishes of the Nosivolo River.

- **Updated list of fish species in the Nosivolo River.**

There are several fish species names used in the previous reports (Raminosoa et al. 2003, 2004, Appendix 3), which appear to be non-valid names, misidentifications or new species that have been recently described. The fishes collected in the Nosivolo River by the DW /DBA /SAIAB team in November 2005 are as follows.

Anguilla mossambica Peters 1852
Anguilla sp. (mottled, unidentified, awaiting samples to confirm ID)
Gogo ornatus Ng & Sparks 2005
Oreochromis mossambicus (Peters 1852)
Oxylapia polli Kiener & Mauge 1966
Paratilapia bleekeri Sauvage 1891
Ptychochromoides katria Rheinthal & Stiassny 1997
Tilapia rendalli (Boulenger 1896)
Bedotia sp. 'Nosivolo' (undescribed)
Rheocles wrightae Stiassny 1990
Ratsirakia legendrei (Pellegrin 1919)
Awaous aeneofuscus Peters 1852
Sicyopterus franouxi (Pellegrin 1935)
Gambusia affinis (Baird & Girard 1853) (exotic)
Xiphophorus maculates (Günther 1866) exotic)

- **Amendments to the Nosivolo fish list.**

Gogo ornatus Ng & Sparks 2005. Anchariid catfishes (common name = Vaona) have recently undergone a revision with several new species and one new genus being described by Ng and Sparks (2005). *Ancharius brevibarbus* Boulenger 1911 was previously recorded from the catchment although it was described from Ambohimango in a catchment to the north of the Mangoro system. The mottled species known from the Nosivolo is now *Gogo ornatus*. Fishermen and local scientists mentioned the possibility of a second anchariid species present in the Mangoro but this requires confirmation. The six specimens collected by us during November exhibited considerable colour and pattern variation but in all other respects appeared to be the same.

Figure 3. *Gogo ornatus* collected by gill netting in the Nosivolo River at Marolambo.

Bedotia sp. 'Nosivolo' (common name = Vily, Zono) (IUCN status: VU: B1ab(i,ii,iii)+2ab(i,ii,iii)). An undescribed species widely distributed in waters around Marolambo in both the mainstream Nosivolo through to very small streams. Sexual dichromatism with male fins becoming more red and with a red to the lower jaw, females more yellow colouration in the bases of the fins. Usually found in quiet waters at the edges of rapids and falls, appear to move up streams during the spring possibly to spawn. According to work by Stiassny and Sparks most of the bedotids feed on drift material originating from the terrestrial environment. As such they may be less affected by sedimentation than species reliant on foraging in the substrate such as catfishes, eleotrids and gobies.

Figure 4. A male (upper) and female (lower) *Bedotia* sp. 'Nosivolo' from the Sandranamby River just upstream of Betampona village near Marolambo, collected with a hand net, mask and snorkel

Rheocles wrightae Stiassny 1990 (common name = Vily, Zono) (IUCN status: EN B1ab(i,iii)). Specimens of *Rheocles* collected in the Nosivolo main-stream and tributaries around Marolambo all key out to *R. wrightae* (Stiassny 1990,

Pers. com. Dr Melanie Stiassny). These were usually collected together with *Bedotia* sp. 'Nosivolo' although were usually less numerous than *Bedotia*. Two size classes were usually present – a large adult class (approximately 100-120mm TL), which was rare and juveniles of 20-30mm TL, which were presumably last year's recruits. This species was described from the Sandrangato River, south of Moramanga. If this is a correct identification then these Nosivolo records will probably result in a down-grading of its IUCN status due to a considerable increase in its known geographical range and population size.

Figure 5. A male (upper) and female (lower) *Rheocles wrightae* from the upper Sahanao stream near Lavajiro Village, collected with at throw net.

Rheocles sikorae Sauvage 1891 (common name = Vily, Zono) has been the large bedotiid identified in previous surveys of the Nosivolo River. Without being able to examine our November collections in the laboratory or to compare these with previous collections I cannot determine if more than one species is present in the Nosivolo/Mangoro or if specimens have been identified differently.

Paratilapia bleekeri Sauvage 1891 (common name = Fony). A single juvenile specimen of *Paratilapia* was collected at site M5 in a pool just down stream from Marolambo. It may be *P. bleekeri* (pers. com. Dr Melanie Stiassny) and aquarists holding stocks of this species in USA refer them to *P. bleekeri* (pers. com. Mr Aleksei Saunders). It was collected using rotenone and only surfaced an hour after rotenone treatment. No specimens were seen during snorkelling and so it appears to be extremely rare, at least around Marolambo.

Figure 6. A juvenile *Paratilapia bleekeri* from an isolated pool (M5) on the Nosivolo River near Marolambo, collected with rotenone.

Eleotris pellegrini Mauge 1984 (common name = Soboeta, Soadiboka, Atohobolitika) was reported in previous reports on the Nosivolo River. Our November collections did not produce any specimens but we did collect another eleotrid *Ratsirakia legendrei*. At this stage I am unsure if this is simply a case of misidentification or if both species are present within the system. From my own experience of other *Eleotris* species within southern Africa *Eleotris* usually occurs lower down in systems so I would not predict its occurrence in the Nosivolo or upper Mangoro catchments.

Ratsirakia legendrei (Pellegrin 1919) (common name = Soboeta, Soadiboka, Atohobolitika) was collected in several Nosivolo and tributary sites. It was observed amongst rocks and sand in faster flowing areas of both large rivers and small streams. The eleotrids rest on and forage in the susbstrate and avoid the fast flows by being in the 'dead-water zone' close to the substrate. This record appears to be a southerly extension of the species' known distribution and so comparisons with material from other populations should be made to accurately determine the specific status of Nosivolo *Ratsirakia* specimens.

Figure 7. *Ratsirakia legendrei* collected with a hand net and mask and snorkel in the Nosivolo River at Marolambo.

Sicyopterus lagocephalus Pallas 1770 (common name = Filelabato) was considered a *nomen dubium* by Sparks & Nelson (2004).

Sicyopterus franouxi (Pellegrin 1935) (common name = Filelabato) was found in rapids at all sites within the main Nosivolo River and larger tributary (Sahanao River). It occurs in fast sections of rapids where it adheres to rocks with the pelvic sucker-disc. Large adult males were dark in colour with sometimes a broad lateral band, females were lighter in colour with indistinct vertical barring while juveniles have two horizontal bands on the body (Sparks & Nelson 2004). Fish were caught using a mask and snorkel in combination with a throw net.

Figure 8. A male *Sicyopterus franouxi* from the Nosivolo River upstream of Marolambo, collected with at throw net.

Chonophorus macrorhynchus (Bleeker 1867) (common name = Atoho) is considered a junior synonym of *Awaous aeneofuscus* Peters 1852 (pers. com. Dr Helen Larson).

Awaous aeneofuscus Peters 1852 (common name = Atoho) was collected in Nosivolo River and tributary systems in varied habitats. It appears to be widespread although not very common in fishermen's catches. A photograph of *A. aeneofuscus* from the Durrell Wildlife/Conservation International files (Hpim0089.jpg) gives a new record size for this species of 340 mm TL.

Figure 9. *Awaous aeneofuscus* from the Nosivolo River near Marolambo, collected with at throw net.

Appendix 6. Information on Madagascan fishes available through the internet.

I have started compiling a bibliography for Madagascan fishes. This is not complete but it is given above. If DW/DBA/CI wish to establish a library, which I recommend they do, SAIAB can help in photocopying and posting these to Madagascar. Information about collections and the taxonomy of Madagascan fishes is accessible through the Internet through several sites. Not all of it is easy to get to but much is available. The following notes give some of these web-sites and some information about accessing data.

http://www.redlist.org/

The IUCN red list gives information about species listed as threatened around the world. To access information on Madagascan fishes single click on 'search', fill in fields: 'text search' fish, 'what biome' freshwater, 'country' Madagascar then single click on 'search. This should give a list of 88 species (see below). Each record can be interrogated by single clicking (see below for *Bedotia* sp. nov. 'Nosivolo'. Links on this page allow access to other databases for the species under query. If it is not described as is the case with *Bedotia* sp. nov. 'Nosivolo' you'll not get any further information. A query for a described species will link to 'Fishbase' and give the species summary e.g. *Ancharius brevibarbus* (see below) and this too will have further links.

http://www.calacademy.org/research/ichthyology/catalog/fishcatsearch.html

Bill Eschmeyer's 'Catalog of Fishes' gives information on taxonomy of fishes - original scientific descriptions, details of type specimens, museum holdings and scientific work on the systematics and taxonomy of the species.

Type a genus or species name e.g. *Rheocles* into the search box and single click 'search'. This will give a list of seven species, all considered valid. One example, *Rheocles wrightae* is shown below and references can be extracted by single clicking of the reference numbers.

wrightae*, *Rheocles Stiassny 1990:22, Figs. 18a, 2b, 3 [Am. Mus. Novit. No. 2979; ref. 16658]. Sandrangato R., south of Moramanga, Madagascar. Holotype: MNHN 1942-77. Paratypes: AMNH 58908 (1); MNHN 1989-1614 (10, 1 c&s). •Valid as *Rheocles wrightae* Stiassny 1990 -- (Stiassny & Reinthal 1992:1 [ref. 13485], Stiassny & Rodriguez 2001:99 [ref. 25354], Stiassny et al. 2002:72 [ref. 26051]). *Rheocles wrightae* Stiassny 1990. Bedotiidae. Distribution: Madagascar. Habitat: freshwater.

Stiassny, M.L.J. 1990 [Ref ID: 16658]
Notes on the anatomy and relationships of the bedotiid fishes of Madagascar, with a taxonomic revision of the genus *Rheocles*. (Atherinomorpha, Bedotiidae). Am. Mus. Novit. No. 2979: 1-33.

Stiassny, M. L. J. and P. N. Reinthal 1992 (24 Feb.) [Ref ID: 13485]
Description of a new species of *Rheocles* (Atherinomorpha, Bedotiidae) from the Nosivolo tributary, Mangoro River, eastern Malagasy Republic. Am. Mus. Novit. No. 3031: 1-8.

www.fishbase.org

A rather complex form but you don't need to fill in all information. All I did was enter Madagascar in the "Information by Country / Island' box and then just below this under 'Biodiversity' I ticked Freshwater. It went straight into a three-page list of Madagascan fishes (see below). Single clicking on any species name will give the species summary and further links to species information.

www.gbif.org (Global Biodiversity Information Facility)

Click on the rather insignificant 'search' at the top left of the home page and in the 'search for name' window type the genus or species name you are interested in. For non-endemic taxa you may also want to highlight Madagascar in the country window but for endemics this is not necessary. Scroll down to the bottom of the page under 'Specimen /Observations' - here are all the records of the species split into institutions e.g. *Rheocles wrightae* give six records, four from the American Museum of Natural History (New York) and two from the Natural History Museum (Paris). Clicking on the green plus sign in the 'total' column will give access to all the records. Unfortunately, these records don't all have coordinates associated with them and they aren't easily exported to an excel spreadsheet format. However, the GBIF site does have most of the major fish collections' data in some form in its system.

Museums collections databases

http://141.211.243.52/ummz/

http://nmnhgoph.si.edu/cgi-bin/wdb/fish/catalog/form

http://www.nhm.ac.uk/research-curation/projects/fish/

Two web-sites on the fishes of Madagascar which are easy to follow are:

http://www.belowwater.com/resources/redisland/index.html

http://www.madagascarfish.org/

Appendix 7 Bibliography of Madagascan fishes.

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