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Biological characteristics of the Schlegel's goby, *Porogobius schlegelii,* in the mangrove – nipa ecosystem southeast of Niger delta, Nigeria

Mfon T. Udo[1]

Summary

A study of some aspects of the biological characteristics of Porogobius schlegelii [Gobiidae], in two different estuarine swamp creeks within Qua Iboe River estuary, Nigeria, was carried out between January and December 2004, to determine impact of replacement of mangrove by nipa palms. A total of 729 specimens of the fish were examined; out of which 50.2 % were mangrove sample [size 3.6–11.8 cm TL] and 49.8% nipa collections [size 3.7–11.4 cm TL]. In this study it was found that Schlegel's goby fish, Porogobius schlegelii from the mangrove creek area of Nigeria did not ingest the phytoplankton species Biddulphia spp., the crustacean and mollusc Tympanotonus fuscatus, whereas the algae Gyrosigma spp. and Navicula spp., dipteran larvae and insect remains were absent from dietaries eaten by the nipa creek counterparts. Despite the similarity in the rank-order of the food objects [$p < 0.002$], there was dissimilarity in the proportions of the food objects. Feeding intensity was higher in nipa vis-à-vis the mangrove creek area. Bi-sexuality existed in sex ratio between the creeks but with females' dominance in each creek. Males and females from the mangrove creek increased in body weight over those of the nipa. The mangrove creek specimens were higher in the reproductive (gonadosomatic and condition indices) investment. Mean fecundity of 8,466 and 10,164 eggs from the mangrove and nipa creeks respectively, were not statistically different. The mangrove Schlegels' were higher in power of the length-weight relationship. In brief, this study highlights the depressive influences from potent succession of the native and 'deterministic' mangrove ecosystem cum biota by the 'stochastic' alien nipa palm [Nypa] in the Qua Iboe River estuary, Nigeria.

Introduction

Vast mangrove forest dominates the coastal estuarine swamps of Qua Iboe River. As one of Nigeria's forest reserves, the estuarine mangrove ecosystems of Qua Iboe River, Cross River, Imo River and Niger Delta along with their creeks and tributaries represent a rich source of wood supply for various domestic and industrial purposes [Ekundayo, 1985]. The fertilizing effects from the decay of the mangrove macrophytes have been reported (Moses, 1985). In the same estuarine swamp creeks of Nigeria lives the Schlegel's goby fish, *Porogobius schlegelii* [Gobiidae]. At present, the aforementioned estuaries are now covered by nipa palms in large expanse of the adjoining inter-tidal swamps and only isolated residual patches of the original mangrove vegetation remains [King and Udo, 1997, Udo, 2002a,b; Udo *et al*., 2008]. The nipa has only recently been introduced from Singapore originally as an ornamental plant into the Nigerian towns of Calabar [1904] and Oron [1912].

To understand the changes in some aspects of the biology of the species, some aspects of the ecology of the fish populations in two spatially and ecologically separated creeks [mangrove and nipa palms] were studied in the Qua Iboe River estuary, Nigeria; the characteristics included in the study were, *inter alia,* diet and feeding behaviour, sexual

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dimorphism, sex ratio, reproductive investment/breeding, fecundity and length-weight relationship.

Materials and methods and results

The study was conducted in the estuarine swamps of Qua Iboe River around Ibeno Local Government Area, Akwa Ibom State, Nigeria. The Qua Iboe River system (7^0 $30'$ - 8^0 $20'$ W; 4^0 $30'$ - 5^0 $30'$ N) is one of the major hydrographic features of Akwa Ibom State.

Monthly samples of the Schlegel's goby were obtained from subsistence catches of some fisherfolks for a period of 12 months (January – December, 2004). To investigate the impact of replacement of the mangrove by the introduced nipa palms on the ecology of *P schlegelii*, fish samples were obtained separately from swamp that is predominantly covered by the original mangrove vegetation at Iwuochang (referred to as mangrove creek); and swamp that is composed mainly of introduced nipa palms at Upenekang (referred to as nipa creek). The samples were preserved in 10% formalin. The fish specimens were sexed (Udo, 2002a), measured, weighed and dissected. Quantitative dietary importance of different food objects based on Udo (2002b), were evaluated using the following indices: 1. Gut repletion index (GRI %) and 2. Mean of gut fullness (MGF) (Hyslop, 1980). The following parameters were computed according to the equations: 1. Modify food object number: MFON = $m_x + t_x$ 100/(A U B); 2. Relative gonad length: RGL = GL.100/SL; 3. Somatic weight: SW = TW – GW; 4. Gonadosomatic index: GSI = GW.100/SW; 5. Condition index: K= GW.100/TL^3; 6. Hepatosomatic index: HSI = LW.100/TW – LW; 7. Fecundity estimates: F = $_a$ $_i^b$

Dynamics of diet

Of the 729 specimens of *P. schlegelii* examined for food and feeding intensity, 366 (50.2%) were sampled from the mangrove ecosystem (size range 3.6 – 11.8 cm TL) and 363 (49. 8%) from the nipa ecosystem (range; 3.7 – 11.4 cm TL). The vegetation-dependent change in the food dietaries of *P. schlegelii* is presented in Table 1. The phytoplankton species *Biddulphia* spp., the crustacean and the mollusc *Tympanotonus fuscatus,* were not found to have been ingested by the fish in the mangrove creek; whereas the algae *Gyrosigma* spp. and *Navicula* spp., and dipteran larvae and insect remains were not present in the dietaries eaten by the fish in nipa creek. As can be seen in Table 1, despite the similarity in the rank-order of the food objects ($p < 0.002$), proportions of different foods ingested in the two ecosystems were dissimilar.

Dynamics of feeding intensity

There was a significant increase in GRI% of *P. schlegelii* from the area dominated by nipa palms ($p < 0.001$) as compared to the mangrove creek, whereas there was no creek-dependent variation in MGF ($p > 0.05$). The result is indicative of higher feeding intensity in nipa creek individuals of *P. schlegelii* than in those in the mangrove creek.

Table 1. Spatial-based variability in trophic spectrum of P. schlegelii in Qua Iboe River estuary, Nigeria

	Modify food object number [MFON %]	
Food item	Mangrove creek	Nipa palm creek
Algae		
Baccillariophyceae		
Biddulphia	-	0.09
Coscinodiscus	0.31	0.14
Gyrosigma	0.04	-
Navicula	0.20	-
Chlorophyceae		
Spirogyra	1.12	1.25
Crustacea		
Decapoda [crabs]		
Sesarma alberti	4.24	2.72
Sesarma remains	17.36	22.01
Decapoda [shrimps]		
Penaeus notialis	15.41	14.10
Penaeus remains	17.50	21.40
Detritus		
Coarse detritus	1.38	1.13
Fine detritus	1.05	1.13
Fish [prey]		
Gobioides ansorgii	0.94	0.43
Pellonulla sp	4.82	1.30
Porogobius schlegelii	17.33	9.42
Fish remains	10.54	19.20
Unid fish	2.88	1.02
Insecta		
Dipteran larvae	0.22	-
Insect remains	0.60	-
Macrophyte matter	2.25	0.52
Mollusca		
Neritina glabrata	0.09	0.14
Tympanotonus fuscatus	-	0.17
Nematoda	0.16	0.35
Sand grain	1.56	1.35
Overall total =	**100.00**	**100.0**

Sexual dimorphism

There was no significant intersexual change in the length size of fish ($p > 0.05$) between the mangrove and nipa creeks. However, there were increases in weight of the males and females ($p< 0.05$) in the mangrove creek as compared with their counterparts in the nipa creek.

Sex ratio

Generally, the sex ratio depicted female preponderance in both areas studied.

Changes in reproductive investment

Females from the mangrove creek were higher in GSI ($p<0.001$) and K ($p< 0.001$) than the nipa creek females. However, there were no significant increases in ovary length and HSI ($p> 0.05$ in each case) between the two creeks. The results suggest that reproductive investment was higher in the mangrove than the nipa creek. From the analyses, the

mangrove creek males were higher only in k ($p< 0.001$) than the nipa creek male-samples while no differences occurred in GSI, gonad length, and HSI ($p> 0.05$ in all the cases) between the creeks.

Fecundity

Mean absolute egg production of 18 specimens of the Schlegel's goby from the mangrove creek (size range 5.3 – 9.9 cm TL) was 8,466 ± 4,060 eggs (range 3,000 – 19,000 eggs). Average absolute fecundity of 16 specimens of the Schlegel's goby from the nipa creek (range 5.7 – 10.1 cm TL) was 10,164 ± 5,924 eggs (range 5,300 – 27,400 eggs). In both areas fecundity increased with fish size (length and weight), with functional equations of the forms - Mangrove: $F = 36.8723\ TL^{2.6983}$, $F = 2491.7244\ TW^{0.9109}$; Nipa: $F = 25.0001\ TL^{0.4944}$ and $F = 2577.145\ TW^{0.8835}$. However, despite the observed high number of eggs in the nipa creek area, there was no significant statistical difference ($p > 0.05$) in fecundity estimates between the two study areas.

Allometric relations

The length-weight regressions of *P. schlegelii* in the vegetation types were: mangrove: $BW= 0.011197^{2.869}$ TL ($r = 0.969$); and $BW=0.011017TL^{2.812}$ ($r = 0.967$) nipa. The length exponent in each of the creeks was not different from the expected cube law. However, there was increase of the power of the exponent by the mangrove specimens ($t = 6.706$, 727 df, $P<0.001$) over their nipa creek individuals.

Discussion

The ranking in relative importance of each food objects ingested by *P. schlegelii* were the same in the two creeks. However, individuals from the nipa creek were higher in feeding intensity than individuals in the mangrove creek. The reason for the observed higher feeding in the nipa creek area is not clear, but the observation agrees with the 'optimal foraging theory'. The theory (Schoener, 1971; Angermeier, 1982) states that, the breadth of the diet will become enlarged during periods of shortage of supply and abundance. The observation in nipa creek presents the depressive influences and ecological implication(s) of vegetation change to coastal estuarine fisheries. The exotic nipa palm does not have the advantageous fertilizing effect usually provided by decay of the mangrove vegetation and also does not provide as good a substrate for attachment of food organisms as the original mangrove vegetation (Moses, 1985; King and Udo, 1997; Udo, 2002b). This is probably due to the fact that the nipa creek is relatively a homogenous ecosystem with limited variety of microhabitats to support different food resources (cf. King and Udo, 1997). Thus, the fish in the nipa creek area must therefore eat what is available in order to grow and survive. This observation indicates further that the fish in the nipa creek will have to feed intensively to compensate for the shortage and/or irregularity in available food supply. The feeding habits of such fishes will involve an ecological switch from a specialist to a generalist diet as the nipa palm ecosystems are structurally less complex than the mangrove swamp ecosystems and thus lack the enormous differences in microhabitats that these latter ones have and which support a greater variety of food resources (Udo, 2002b).

Sexual dimorphism demonstrated larger and heavier females over the males in both swamps. This is in line with Darwin's 'fecundity advantage' model (Darwin, 1874 p.332;

see also p.275 for a similarly worded argument) which states that, in most species of animals, females attain larger body sizes than males.

The spatial cum temporal changes in breeding intensity of *P. schlegelii* highlights that there is an increase in its intensity in the mangrove specimens as compared to the fish from nipa creek, including in the seasonality in breeding. The observations made on the breeding patterns probably indicate that the living conditions in the mangrove swamp ecosystem are more suitable for the fish than those in the nipa; they also suggest that there is an ecological difference between the native, unperturbed (mangrove) and the perturbed (nipa) biotopes consisting of introduced species.

In brief, the importance of the native mangrove swamp ecosystem to fish and fisheries and richness of other resources, as compared to the introduced nipa palm ecosystem, cannot be over-emphasized. Reports also abound (Moses, 1985; Udo, 2002a, b) that, where the mangrove macrophytes have been removed and/or destroyed, fin and shellfish output has declined considerably. Thus, the mangrove swamp creek is a biotope typified by better living conditions for biota. Efforts and supporting policies are needed to maintain and protect the original ecosystems in the Niger delta area (Udo *et al*., 2008).

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Mangroves v1.0: a new taxonomic tool to characterize mangroves
The case of South East Indian and Sri Lankan mangroves and potential application to African mangroves

Juliana Prosperi[1] *, Pierre Grard*[2] *and Denis Depommier*[3]

Summary
In this paper we present an innovative tool for plant identification conceived to reinforce the national capacity building in taxonomy. We introduce ***Mangroves v1.0****, built up on a species identification system called IDAO (Identification Assistée par Ordinateur). This software allows the identification of 50 mangroves species of South East India and Sri Lanka, with the perspective to adjust and extend to other of the world. This software provides and facilitates dissemination of scientific and traditional knowledge. Corollary, it appears as a good support to training, research and development actions and its applications, from awareness to practical management of trees and the ecosystem, could benefit African mangroves and contribute to their renewed interest.*

Introduction

Ecological and socio-economic importance of mangrove trees and forests has been largely acknowledged in various coastal areas of the tropical zone, especially in Asia and Africa where mangroves are the most extensive (21 and 39 %, respectively of the world mangrove area, FAO, 2007) and rich in plant and animal species.
In these areas, they notably contribute in the protection of the marine and terrestrial environment and are a major source of food, fuel, timber, fodder, medicine, etc, for the local communities -especially fishermen who are among the poorest people (Dahdouh-Guebas *et al*., 2006). Mangroves in the Tropics are also characterized by a high human pressure and their poor management: overexploitation, of the trees notably, conversion of mangroves to other land use systems (prawn ponds, rice and salt fields…), pollution, etc.

Adequate legislation – or effective application of it - to protect, conserve and manage the mangrove in a sustainable manner are still missing in many African countries. On the other hand, although important studies have been carried out during these last decades to better know about the unique and fragile ecosystems these mangroves constitute, a lot remains to be done regarding their functioning and dynamics, in relationship with their exploitation and the possible impact of climatic changes. Therefore, scientific knowledge is needed to guide and rationalize the management of mangroves, their exploitation and reforestation, and adequately preserve their biodiversity.

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Finally, available information is not sufficiently disseminated, and the existence of several local languages makes the task more difficult (Taylor *et al.*, 2003). In this framework, lack of species identification capabilities is a major handicap for implementing the measures recommended by the Convention on Biological Diversity (CBD) in many parts of the world. The drastic reduction in the number of taxonomists throughout the world and the irremediable loss of their knowledge has made the task more difficult for ecologists and non specialists. This 'taxonomic impediment' is a serious issue hindering the full implementation of the CBD.

In mangrove ecosystems, one of the most urgent needs, despite major contributions from great diversity of disciplines (ecology, eco physiology, hydrology, soil science …), remains the identification and education on species biology. Without knowledge base containing information on this particular flora, one cannot assess its biodiversity and define priorities in terms of species conservation and, as a whole, sustainable management of mangrove.

To answer this challenge, at least partly, we conceived ***Mangroves v1.0*** that was built up on a species identification system called IDAO (*Identification Assistée par Ordinateur*, Grard, 1996). It was applied to the mangrove of South East India and Sri Lanka - with the perspective to adjust it and extend it to other mangroves of the world.

Mangroves v1.0 (Prosperi *et al.* 2005*)* was developed by the French Agricultural Research Centre for International Development (CIRAD) in co-operation with the French Institute of Pondicherry and the University of Andhra, India, and the University of Ruhuna in Sri Lanka, partners in the European funded project "Assessment of mangrove degradation and resilience in the Indian subcontinent: the cases of Godavari Estuary and South-West Sri Lanka".

Materials and methods

Classical keys for plant identification are difficult to use for non specialists. Their systems are mainly based on flower characters (not always easy to obtain when collecting samples), use technical terms and they impose the choice as well as the order of questions to obtain the identification.

IDAO is different from other computer-based species identification systems because

- It uses only drawings instead of technical jargon and provides users the freedom to choose the character that needs to be described.

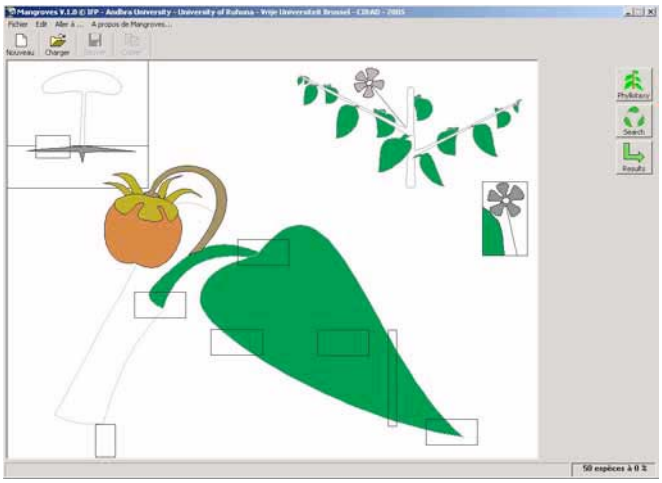

Figure 1: Mangroves v1.0 user interface

- Missing information or data are permitted, thus allowing for the identification of incomplete samples.
- A certain level of observational error is also tolerated and, at each step of the identification process, a probability of resemblance is calculated for each species. Thus, species are sorted by decreasing order of similarity.
- The users can access the photos, the description and the botanical illustrations of the species at any moment. In case users encounter doubt in the choice of characters (for description), they could ask the program for the most pertinent one. If the probability of a species identified is less than 100 per cent, the program indicates the characters that contain observation errors by the user.
- The descriptions of the species can be available through the Internet website with any type of browser.

Results

The identikit

In this article we will concentrate only on the characteristic of the "identikit" that is quintessential to the software. It comprises all the characters and all the states of these characters and helps the end-user to cross-match any character to any others, making all kinds of combinations possible. The realization of the "identikit" requires a fine expertise of the botanical characters between listed species in order to select the most pertinent vegetative and sexual ones. It uses a graphic interface based on a system of layers, which reconstitutes the plants using vectorized drawings. For *Mangroves v1.0* we have analyzed and drawn 108 botanical characters states belonging to 15 characters, representing the different layers (Table 1), and 5400 drawings necessary to identify 50 species of mangroves. These species belong to 34 genera and 26 families; they cover proper and associates mangroves species.

Table 1: Identikit characters of Mangroves v1.0

1- Habit	9 - Stipule types
2 - Roots	10 - Leaf or leaflet apex
3 - Pneumatophores	11 - Leaf or leaflet base
4 - Leaves arrangement	12 - Leaf or leaflet margin
5 - Leaves types	13 – Leaf or leaflet section
6 - Inflorescences	14 - Venation
7 - Flower colour	15 - Exudation - Sap
8 - Fruit types	

The identikit is organised around three zones represented by three main drawings of the interface: the habit, the stem with leaves and a closer view of the leaf and fruit. These drawings are simple, generic and theoretical in order to be easily comprehensible by the users, and help them in the process of plant identification. We have privileged the vegetative characters (80% of all characters, mainly linked with leaves and stems) because they are always present and more accessible than sexual ones.

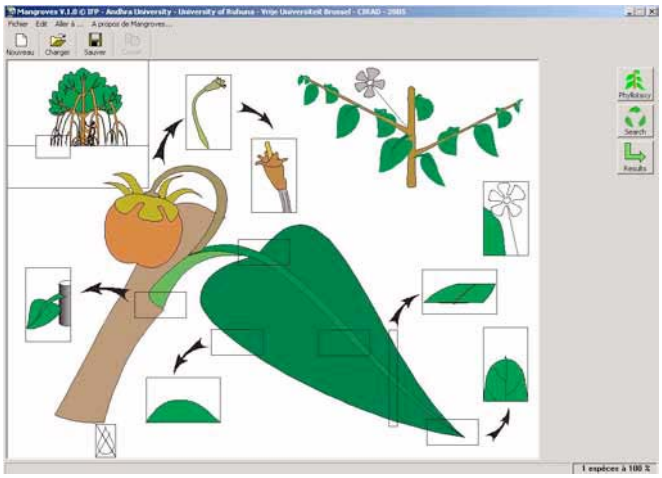

Figure 2: Mangroves identikit for the identification of one species of Rhizophora

This system allows the user to access of these characters by three ways of "point and click":

- the rectangles represented on different organs of the plants
- the colours covering bigger surface in the identikit
- the buttons placed at the right side of the identikit

During the process of identification, the user clicks on the identification screen drawings to select one character corresponding to the plant he/she wants to identify. The software

based on the calculation of similarity coefficients, provides a probability of similarity calculated for each species.

The users can access the photos, the description and the botanical illustrations of the species at any moment during the process of identification. Among 50 species, the users can learn more about botanical aspects checking with more than 500 pictures and 21 botanical plates. The description file of each species includes information about: diagnostic characters, botany & morphology, regeneration, reproductive biology, ecology, distribution and uses (see http://umramap.cirad.fr/amap2/logiciels_amap/Mangrove_web/Mangrove_list.html). All the technical terms used in the description file are highlighted and, at a click, a hypertext illustrated definition is accessible.

Mangroves v1.0 is available on CD-ROMs for personal computer platforms, through the net and we are working towards developing an open source web-based application in a Scalable Vector Graphics (SVG) format (see http://www.ifpindia.org/Identification-des-plantes-de-mangroves.html).

Conclusion and perspectives of application to African mangroves

The many students, scientists and development agents who used the taxonomic tool ***Mangroves v1.0*** we developed for the mangroves of South-East India and Sri Lanka found it innovative, easy to operate and appreciated very much its interactive iconographic component allowing the user to quickly get a reply in an illustrative and educative manner.

The identikit – and its discriminating process to identify a species- is certainly the most original part of the software, thanks to its graphic interface. And at any moment, comprehensive information on each of the 50 mangrove species can be accessed independently from the important data base we constituted.

An interesting point related to the capacity of this software and the constituted data base is the integration of both scientific and traditional knowledge – of which the multiple uses of the species. The restitution is voluntarily given in a synthetic way (species description files), but could be developed, enriched or corrected, if needed, in next versions of ***Mangroves v1.0***.

Since Ellison (2000), and others before him, reminded us the need for mangrove information clearing houses, development of international databases and improved communication among researchers, managers, planters and residents, making use of the world wide web and related information technologies, ***Mangroves v1.0*** appears as an appropriate contribution to this challenge. It notably may help managers in planting a larger number of tree species as planting methods in mangrove restoration projects focus on only a few species – hence allowing, through improved richness, to get more products and services and better conform to the original ecosystem.

From this South Asian experience, and considering the advantages of this tool in terms of information exchange, learning and capacity building, support to research and decision making for the restoration and management of mangroves, one could favourably extend

its application to other mangroves and notably to African mangroves which are among the most degraded and are locally very much endangered where they have not vanished. Incidentally, ***Mangroves v1.0*** covers most of the mangrove species of Africa, and all the 16 East African and Middle East species identified by Spalding *et al*. (1997) and Saenger (2002).

Practical applications of this tool to African mangroves, through appropriate development of its data base and integration of specific information could include:
- awareness on environmental and socio-economic importance of mangroves tree and ecosystem;
- diffusion and popularization of tested techniques of tree plantation and mangrove rehabilitation;
- integration of scientific and traditional ecological knowledge with the view to promote best practices of management and long term values of the ecosystem;
- large dissemination, worldwide and notably African wide, of the data collected, processed and made available through networking, exchanges of information, case studies, etc;
- policy, rules and regulations regarding mangroves, along with information for decision makers.

The very structure of the Web (Internet, notably) offers new opportunities for information organization and provide universally accessible, hyperlinked, multimedia information, and offer an appropriate niche for the development of this tool and its various applications.

In the perspective of a renewed interest in African mangroves and to initiate the process, major issues such as baseline information needed for environment impact assessment and management plans, dissemination of information and education, could be discussed through workshops with the assistance of international organizations, like FAO, and concerned stake holders. In this framework, ***Mangroves v1.0*** could be presented and discussed for its possible development and applications in Africa.

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COUNTRY FOCUS: Madagascar

Hajanirina Razafindrainibe[1] talks to Nature & Faune

Madagascar (Malagasy Republic) in the Indian Ocean is the world's 4th largest island (after Greenland, New Guinea, and Borneo) covering 587,931 square kilometres. According to Aditya Maheshwari and Ricketts[2] Madagascar has a population of about 17 million people, the population growth rate is 3.03% and about 88% of the people work in the agriculture sector with 13.5 million people living on only what they produce in farms. In terms of wildlife, about 85% of the animals in Madagascar only exist in Madagascar. There are 8 species of Carnivores on the island and 40 species of flightless birds. The country has the third largest mangrove forests in Africa. Between year 2000 and 2005 the annual change in forest cover: -37,000 ha; Annual deforestation rate: -0.3%. Change in deforestation rate since '90s: -41.9%; Total forest loss since 1990: -854,000 ha and total forest loss since 1990:-6.2%[3].

To obtain better insight on the relevance of Mangrove forests to Madagascar's wildlife, water resources and fisheries, *Nature & Faune* interviewed Hajanirina Razafindrainibe, a technocrat in SAGE (Service d'Appui à la Gestion de l'Environnement) Madagascar.

Nature & Faune: What is the extent and diversity of the mangrove ecosystem in Madagascar?

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[2] *Websites: http://www.freewebs.com/madagascar-wildlife/aboutmadagascar.htm of 5th August 2009 http://www.wildmadagascar.org/wildlife/; http://www.wildmadagascar.org/; http://www.cactus-madagascar.com/madagascar-wildlife/madagascar-wildlife-flora.htm; http://animals.jrank.org/pages/3068/Mongooses-Fossa-Herpestidae-DIET.html http://www.thewildones.org/Animals/lemur.html) Travel guide- Ottawa Citizen. Books: Cultures of the world Madagascar, Jay Heale; Madagascar, Mary N. Oluonye.*

[3] *FAO. 2005b. State of the World's Forests 2005. Rome (also available at www.fao.org/docrep/007/y5574e/y5574e00). http://rainforests.mongabay.com/20madagascar.htm*

country and can be grouped into two major types: estuarine mangroves localised in bay entrances, river mouths and deltas and the second type is the coastal mangrove which develops in areas inundated by fresh groundwater.

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Nature & Faune: How do the mangrove forests impact on the fishery, water resources and wildlife sectors in Madagascar?

Hajanirina* Razafindrainibe*: Mangroves are extremely rich ecosystems and play key roles for various aquatic and terrestrial species. They serve as nurseries and or habitat for many marine and estuarine species, such as the peneid shrimp, mud crab, numerous fish species and molluscs, thus their existence and health are amongst key conditions for the regeneration of these resources. For Madagascar, shrimp fishery is the most important country-based commercial fishery and contributes significantly in to the country's foreign exchange earnings. At international level, demand for mud crab has increased considerably over the past 10 years. Even if their distribution is not restricted to mangrove forests, some endemic and or threatened birds use these ecosystems as refuge or feeding areas; examples of such birds include the ankoay (*Haliaeatus vociferoides*), the vivy (*Anas bernieri*), the heron cendré. The Nile crocodile (*Crocodylus niloticus*) is still seen in some delta mangroves, while wild boars seek shelter in mangrove edges in deforested areas. Mangroves have other critical functions in protecting coasts against marine erosion, fixing sediments from upstream erosion thus protecting coral reefs from sedimentation, regulating water flows thus protecting the landscape in times of floods.

Nature & Faune: Are there any unique characteristics displayed by Madagascar's mangrove forests as compared to those in other parts of the tropics?

Hajanirina* Razafindrainibe*: It is difficult for me to say that our mangroves have unique characteristics as I am not quite sure I know other countries' mangroves. However, I think that the extent of coastal mangroves developing in areas where fresh groundwater regularly inundated the trees is quite low. Also, I think that Madagascar has the mangrove sites at lowest latitude in the area. If mangroves dynamics can be categorized in terms of siltation and site eutrophication, I would say that in Madagascar we observed a natural recovery of a mangrove site after many years of complete degradation!

Nature & Faune: Tell us briefly about the major research carried out in the Madagascar mangrove ecosystems. What are the research needs for this ecosystem?

Hajanirina* Razafindrainibe*: Not so much research have been done in Madagascar mangroves compared to other ecosystems such as the rainforests; but we can list among major research carried out: mangrove mapping, mangroves structure and biogeography,

ornithology (birds inventories), stock assessment and biology of commercial marine resources (shrimp, mud crab); wood availability assessment, fisheries.

My view is that, research should now be extended to assessing various aspects of mangrove ecosystem namely: (i) the capacity of mangroves to regulate pollutant flow from a variety of sources (pesticides, waste waters from coastal industries etc.); (ii) the regeneration capacity in the context of charcoal production and fuel wood use; (iii) the unexpected recovery from extremely degraded condition; (iv) dynamics of mangroves in-country. In addition there should be more focused studies and inventories for ecotourism purposes. Attention should be paid to the importance of mangroves for endemic and migratory birds. Coastal communities in some areas report the presence of silk worms which were exploited "years before" for thread production for feeding the looms; their stocks should be assessed for their eventual valorisation.

Nature & Faune: What are the challenges in protecting, conserving and sustainably utilizing the mangrove forests in Madagascar?

Hajanirina* Razafindrainibe*: I think that the major challenges are containing the pressure on mangroves resulting from: the urban demand for household energy (fuel wood, charcoal), conversion into rice fields, urbanization including demand in land for building, infrastructure (roads), and sand dune progression. To some extent, coastal demand in timber wood may also become a challenge specifically as natural forests are depleted in many areas. Cattle grazing were also reported to having contributed to mangrove degradation in the South of Madagascar. Sometimes popular perception can lead to mangrove destruction such as a case in the South where the communities considered mangrove as home to mosquitoes and, thus, source of malaria, and simply cut them down. But a common challenge I would stress is the inadequate enforcement of regulation due to weak forestry administration, as access to mangrove sites are mostly difficult. And not least, it seems that the discovery and extraction of potentially high value gems (diamantoids) in close proximity to mangrove ecosystems threatens the mangrove.

Nature & Faune: What are the management objectives for the mangrove forests in Madagascar and how are they enforced? What practical steps has the administration taken (or plan) in safeguarding the country's mangrove forests? Are there any governmental regulations at the community, industry and private levels?

Hajanirina* Razafindrainibe*: Overall, management objectives for mangroves tend to focus on conservation and non extractive valorisation. Mangrove ecosystems are classified as sensitive areas in Madagascar, thus, at industry level, any investment that may impact on them is submitted to the completion of a full EIA. Efforts to establishing protected areas are intensified, some sites being classified as of critical or national importance, while some remain at a lower level. Along side with protection and whenever possible, ecotourism is developed in and around these protected areas to add an economic and social sense to this protection. Madagascar is also promoting contract and community-based management of natural renewable resources through an official transfer of management to local communities. The contract includes a simplified management

plan drawn in participatory manner by communities and approved by the Department of Forestry and or Fisheries.

The law on Secured Local Management (GELOSE) has been in operation since 1996. GELOSE is originally a French acronym for "Gestion Locale Sécurisée". The word has been widely adopted by local communities to refer to transfer of natural resources management authority from government to local resident populations or community based groups. This law concretises community empowerment, as the Government's managerial role is officially transferred to communities that apply for it. To be eligible, a community has to be legally formalised as a "local resident community group" (communauté locale de base) whose constitution must respect three principles: (i) residence/proximity to the resources (all members must be resident in the area of the resource location); (ii) voluntary and (iii) non discrimination (all community members fulfilling the two previous criteria cannot be discriminated against). The first contract runs for three years, after which an evaluation is carried out and the contract can be renewed for ten years if performance is satisfactory. The contract is usually signed between the "local resident community group", the District and the Government represented by Forestry and or Fisheries Administration. Since the introduction of the GELOSE law there has been an increase in the awareness of the importance of mangroves and the requisite skills for managing it sustainably.

Nature & Faune: How are the other stakeholders (including the indigenous inhabitants of the mangroves) responding to the challenges of protecting, conserving and sustainable use of the mangrove ecosystem in the Malagasy Republic?

Hajanirina **Razafindrainibe*:*** I think that, overall, stakeholders and people are responding positively specifically to mangrove protection, except those whose livelihood is based on charcoal production. Most of marine protected areas include the adjacent mangroves; and mangrove is the first ecosystem that coastal communities want transferred under their management. In northern Madagascar for example, all mangrove sites are managed by local communities with or without a contract of transfer of management. The reason why coastal communities apply for transfer of management of mangroves is that they believe mangroves play a key role in marine stock regeneration. And these are resources upon which their livelihoods depend on. Mangrove restoration has become common. We can assume that the extent of mangrove forests have not decreased (since the empowerment of communities despite some extractive use), as compared to other forest ecosystems. This fact demonstrates the high level of success achieved by this change in management approach.

Notwithstanding the successes achieved by the indigenous inhabitants, it is still common practice to see conversion of mangrove sites into hotel resorts or private residence in many coastal cities. Cutting of mangrove trees for fencing poles is another popular culprit for decimation of mangrove ecosystem in Madagascar.

Nature & Faune: What lessons has Madagascar learned so far with regards to management of its rich mangrove forest heritage?

Hajanirina* Razafindrainibe*: Establishing a social and economic sense for protection helps a lot to achieve a stronger commitment from local communities. Developing mangrove-based market channels strengthened this attitude. Mangrove protection and conservation should be undertaken at a "large" scale to avoid shifting of pressure. Communities and individuals should be informed about specific species that are found in these ecosystems, and the various roles this ecosystem plays in their wellbeing and livelihoods.

Nature & Faune: Thank you Haja, for discussing these pertinent issues with Nature & Faune.

Dying Mangroves on the North East Coast of Africa: the case of Sudan

Michel Laverdiere[1]

Background

Sudan is the largest country in Africa with a population currently estimated at 41 million people. Its GDP per caput is around US $ 2 000. The country's revenues are largely dependent on petroleum production and also on industries, agriculture and livestock. This country has a relatively long border with the Red Sea, which maintains a few hectares of mangroves; the main species being *Avicennia marina* (Figure 1).

Figure 1. Mangroves in Red sea area of Sudan

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The FAO Subregional Office for Eastern Africa (SFE) is based in Addis Ababa Ethiopia. It provides expertise in the main sectors of FAO: Agriculture, Livestock, Fisheries, Forestry, and Natural Resources. SFE is mandated to provide expertise and resources to 8 countries: Burundi, Djibouti, Ethiopia, Kenya, Rwanda, Somalia, Sudan and Uganda

The general marine water and fisheries situation

The marine fisheries of Sudan are less developed, although waters within the jurisdiction of Sudan on the Red Sea contain a diverse assemblage of fauna and flora. Cartilaginous fishes include 30 species of sharks and 21 species of skates and rays. The reported bony fishes amount to 250 species. Molluscs and crustaceans (shrimps) are of commercial importance. Over 90 species of coral have been recorded in the fringing reefs, barrier reefs and atolls, in addition to other resources. Current exploitation emphasis is focused on finfish, mollusks and crustaceans. Apart from finfish, no stock assessment data is available for these resources. Fishing activities are primarily confined to coastal areas in lagoons and bays, boat channels, fringing reefs and the outer barrier reef. Recent annual finfish landings amount to 5 000 tons out of an estimated potential of 10 000 tons/year. Wild mollusk production is in the area of 450 tons/year. Statistics on shrimp catches are rather discordant, suggesting an estimate that does not exceed 20 tons/year while foreign trawlers operating under license agreements harvest some 130 ton/year. Mangroves are important for the production of sea food including crabs (Bage et al, 2009)

The forestry situation

Sudan is home to a variety of forest ecosystems. The North is largely desert; a relatively small area is covered by thinly stocked savanna woodland, with some tree plantations of mostly Acacia and Eucalyptus species. The South is more forested and still has significant forest resources in dense savanna woodlands. The main problem in the North is lack of trees for construction and energy. For the latter, small cookers operating on LPG gas are used as substitute, thereby alleviating the pressure on wood extraction. However fuel wood is still necessary for the poor segment of the population and also for the production of charcoal. A major issue for the management of the forest resources is the need for an updated forest inventory. The country also needs to improve the control of the invasive Mesquite (*Prosopis chilensis*) and the management of its mangroves.

The mangroves

There are about 500 hectares of mangroves left, scattered on the Red Sea Coast over hundreds of kilometers, both North and South of Port Sudan, the capital of the Red Sea State (Forestry National Corporation of Sudan, Khartoum). In general these mangroves are small stands of trees (Avicennia sp) left in a very degraded state (Figure 2). Very little attention is being paid to these mangrove stands consequently over- grazing by camels and wood cutting for fuel wood have become the norm. Moreover there is also the practice of stoppage of the flow of fresh water to the mangroves perpetrated by salt production companies, highway construction firms and by communities that build dams to collect fresh water. The impacts of this practice need further investigation. It appears that the majority of mangroves are under threat and are likely to disappear in the coming decade.

Another cause of degradation of mangrove in Sudan is linked to fishermen fishing for Sea Cucumber who collected firewood from mangrove forests for processing the catch. At present, however, fishing for Sea Cucumber is prohibited in Sudan.

Figure 2: Mangrove forest in degraded condition in the Red Sea State of Sudan

Mangroves play crucial ecological role in coastal ecosystems by protecting against tropical rain storms, anchoring the shifting mud and thus preventing erosion of coastal land and providing shelter and habitat for fish and other marine life. Mangrove also contributes to offshore fisheries by acting as nurseries and shelter. In India it is estimated that 60 per cent of economically important fish resources breed in the mangroves and that prawn and shrimp catch at sea is seen to be directly proportional to mangrove area. In Sudan the shrimp resource is at present mainly exploited by Egyptian trawlers working under license agreements. This represents the most important source of foreign currency income in the fisheries sector. Additionally mangrove is the habitat for the Mangrove Crab, a high value species collected by hand by the fishing communities and sold to restaurants and super markets.

There had been a project on coastal management (PERSGA), funded by Saudi Arabia which tried to improve the conservation of mangroves. However it ended in 2005 without resolving the many issues causing the degradation of mangroves. There seems to be some difficulty in getting the many stakeholders (camel owners, Port Sudan Harbor Authority, Sea salt producers, fishermen) to agree on the mangrove ecosystem management and the result is the absence of a management regime and consequently a lack of sustainable use of the resource.

A vision for better management of Sudan's mangroves

Mangroves are an important transition ecosystem between the land and the sea; they play a capital role on fisheries, water purification and coastal protection, as well as source of fodder and fuel wood. Despite being scarce, in a poor state and dwindling in area, the

Food and Agriculture Organization of the United Nations (FAO) finds it important for Sudan to conserve, improve and sustainably manage its mangrove resources.

FAO is committed to providing technical support to Sudan, and to learning from previous experiences to strengthen national efforts in the development of mangroves. As a knowledge-based Organization, FAO's role will include drawing from project experiences in neighbouring Egypt to assist Sudanese authorities and other stakeholders to sustainably manage mangrove ecosystem resources along the Red sea.

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FAO Supports Management of Mangrove Ecosystem Biodiversity in Cameroon

FAO Representation in Cameroon executed a project on the participatory management and conservation of mangrove ecosystem biodiversity in Cameroon. Within the framework of this project, studies were carried out on two major mangrove sites in the country namely Ndongoré (Rio Del Rey Estuary) and Douala-Edea (Cameroon Estuary). The project was implemented from January to December 2005, at the end of which the cartography of the mangrove areas in Cameroon was produced as well as a policy and strategy document for the participatory management of mangrove ecosystems in the country. In addition, a project proposal on the sustainable management of mangrove ecosystem for the Central African sub region was prepared and is awaiting implementation upon availability of funds.

For detailed information on this project, please contact: *FAO Representation in Cameroon. P.O. Box 281, Yaoundé. Physical address: 335 Rue 1810 Bastos, Yaoundé Cameroon. Email FAO-CM@fao.org Telephone: +237 22211242; +237 7486009*