Palomares, M.L.D, B. Samb, T. Diouf, J.M. Vakily, and D. Pauly. (Editors). 2003. *Fish Biodiversity: Local Studies as Basis for Global Inferences*. ACP-EU Fisheries Research Report. 14, 283 p.

ISSN 1025-3971

ACP-EU Fisheries Research Report No. 14

ACP-EU Fisheries Research Initiative

Fish Biodiversity: Local Studies as Basis for Global Inferences

EUR20956

Brussels
December 2003

ACP – EU Fisheries Research Report NO. 14

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Fish Biodiversity:
Local Studies as Basis for Global Inferences

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ACP-EU Fisheries Research Report Series

The ACP-EU Fisheries Research Reports is a series of publications that aim to share information about the development of the ACP-EU Fisheries Research Initiative and wider findings generated in order to maximise the impact of its activities. It includes proceedings of workshops and meetings, statements on policy and research activities under the Initiative. An increasing number of these, in fact, transcend the strict framework of ACP-EU bi-regional S&T cooperation, in line with the underlying global trends and mutual learning opportunities.

A great deal of additional information on the European Union is available on the Internet. It can be addressed through the Europa server (http://europa.eu.int/). Information on the results of past research cooperation and future opportunities can be gleaned from the cordis website (http://www.cordis.lu).

Information about the science and technology for sustainable development initiative of the African, Caribbean and Pacific group of countries (ACP) is accessible through the CTA server (http://knowledge.cta.int/index.php).

PREFACE

The contributions assembled in this volume were written as part of the follow-up of the training courses on the 'Management of Fish Biodiversity' organised by staff of the ACP-EU project. These courses, held from October 1997 to August 1999, were as follows:

1) Nouméa, New Caledonia, for participants from the South Pacific;
2) Port of Spain, Trinidad and Tobago, for participants from the Caribbean and Central America;
3) Swakopmund, Namibia, for participants from Southern Africa;
4) Dakar, Sénégal, for participants from Northwest and Central Africa; and
5) Nairobi, Kenya, for participants from East Africa.

We believe that regularly producing publishable contributions about the resources or fisheries, even if short ones, should be an integral part of the routine work of fisheries officers. The present volume provides proof that we managed to convey this message to several of our English and French speaking colleagues.

The title of this volume is meant to reflect the fact that even extremely ambitious studies of global fish biodiversity depend on local input data, such as presented here. Indeed, the contributions assembled here cover areas and topics often ignored when global studies are conducted, leading to biased inferences.

On the other hand, the inclusion of the data presented therein into FishBase will make them widely available, thus enabling their authors to take part in the global dialogue that will have to be established, if our biodiversity is to be used with understanding and sustainably. A final contribution from the international S&T cooperation programme (INCO) points to ways on making available in the public domain vast amounts of data for further improving analyses and understanding.

The Editors

For bibliographic purposes this report should be cited as follows:

Palomares, M.L.D., B. Samb, T. Diouf, J.M. Vakily and D. Pauly (eds.), 2003. Fish biodiversity: Local studies as basis for global inferences. *ACP-EU Fish.Res.Rep., (14): 281 p.*

ISSN 1025-3971

FOREWORD

It is particularly fitting to publish a collection of local studies on fishes in African, Caribbean and Pacific countries, their biology and use by society at a time, when the global fisheries crisis has reached such proportions that heads of State and government at the World Summit on Sustainable Development in September 2002, Johannesburg, South Africa, set the target to restore degraded marine ecosystems by 2015.

Through this publication fisheries officers from ACP countries document some features of their country's resource base which is important for food, health, cultural practices and earning income. All too often, the significant changes that have taken place in aquatic ecosystems the world over as a result of demographic growth, changed technologies, river damming and deforestation, evolving socio-economic context and perceptions are not adequately recorded in comparison with earlier conditions. Documenting occurrences of fish in each country's waters today and what aquatic biodiversity and ecosystems prevailed 10, 20, 50 or 100 years ago and how these states connect to past resource use patterns and their social embeddedness is an appropriate antidote to widespread confusion from shifting baselines. In conjunction with the archiving of such local studies in the global knowledge repository on all fish (www.fishbase.org) not only can proper credit be given to local researchers and fisheries officials, but also wider inferences drawn from the combination of many such local studies with historical records of scientific surveys and other sources.

The project 'Strengthening fisheries and biodiversity management in ACP countries' (7.ACP.RPR.545) was supported by the 7th European Development Fund (EDF) in the context of the Lomé Convention between ACP and EU countries as one way to build up the institutional capacity of African, Caribbean and Pacific countries in relation to their aquatic resources. The project allowed to develop FishBase as a comprehensive public archive for biological information, provided some basic computer equipment to ACP fisheries institutions and trained fisheries officers and NGO representatives in methods of resource assessment and ecosystem modelling. Inspired by the outcome of the 1992 'Earth Summit' in Rio de Janeiro, emphasis was put on documenting and safeguarding biodiversity as a prerequisite of future productivity and resilience of ecosystem goods and services. In parallel, international research cooperation between European teams and their partners in ACP and other developing countries and emerging economies (INCO) as part of the successive editions of the European Research Framework Programme (FP) address some of the burning questions on placing aquatic resources in their ecosystem context, on our understanding of the structure and dynamics of pelagic ecosystems, on public policies in relation to marine protected areas and sustainable forms of aquaculture.

The ACP-EU Joint Assembly, a parliamentary body composed of Members of the European Parliament and representatives of ACP countries, recommended the launch of the ACP-EU Fisheries Research Initiative out of concern, back in 1993, to ensure sustained benefits from aquatic resources, fisheries, aquaculture and trade in their products. While the above-mentioned activities developed under the Initiative were not enough to stop the downward trend in fisheries catches and ecosystem health, they did make a significant contribution (a) in terms of helping to raise awareness about the degree of damage already done to a point, where the issues have entered the international political agenda, and (b) in terms of knowledge instruments to respond in an organised manner to the demand for reversal of the prevailing trend.

In conjunction with the renewed commitment of ACP countries in 2002 to progressively allocate a higher share of their GDP to research until they reach 1%, it is hoped that fisheries departments and universities in ACP countries will produce and publish many more studies about their aquatic resource endowment. Synergistic use of development and research cooperation instruments will continue to support their local ambitions for sustainable development as well as responding to the global agenda.

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ABSTRACT

This report includes 29 contributions on various aspects of fish biodiversity, authored by participants of successive course on the ‘management of Fish Biodiversity,’ run by the European Development Fund (EDF) Project ‘Strengthening fisheries and biodiversity management in ACP countries’ under the auspices of the ACP-EU Fisheries Research Initiative. Courses were held in Noumea, New Caledonia (October 1997) Port-of-Spain, Trinidad and Tobago (May 1998), Swakopmund, Namibia (December 1998), Dakar, Senegal (April 1999) and Nairobi, Kenya (August 1999).

The topics covered include local names and traditional knowledge, faunal lists, the impacts of environmental factors on seasonal abundances, studies of food and feeding habits and the estimation of vital statistics (length-weight relationships, growth parameters, etc.). Most of the 29 studies included here refer to African fishes and ecosystems.

The format used for presentation of these results is that also used for FishBase (see www.fishbase.org), as it is intended that these results, which fill gaps in FishBase, should be incorporated therein. The 30st contribution covering data management in the public domain is the result of an INCO project using experiences with FishBase as a template.

TABLE OF ABBREVIATIONS

ACP-EU	Development co-operation between African, Caribbean and Pacific (ACP) countries and the European Union (EU) in the framework of the Lomé conventions (later followed by the new framework of the Cotonou Agreement).
CE	Commission Européenne
CECAF	Committee on Eastern Central Atlantic Fisheries, FAO
CNROP	Centre National de Recherches Océanographiques et des Pêches, Mauritanie[1]
CNSHB	Centre National des Sciences Halieutiques de Boussoura, Guinea
COPACE	Comité des pêches pour l'Atlantique Centre Est , FAO
CRODT	Centre de Recherches Océanographiques de Dakar-Thiaroye, Sénégal
EC	European Commission, Brussels, Belgium
EEZ	Exclusive Economic Zone
EU	European Union
FAO	Food and Agriculture Organization of the United Nations, Rome, Italy
FIAS	Fisheries Information and Analysis System (French 'SIAP' – Système d'information et d'analyse des pêches)
ICLARM	International Center for Living Aquatic Resources Management, Manila, Philippines[2]
INA	Institut National d'Alphabétisation, Ouagadougou, Burkina Faso
ISSCAP	International Standard Statistical Classification of Aquatic Animals and Plants
JICA	Japan International Cooperation Agency, Tokyo, Japan
JRC	Joint Research Centre of the EC, Ispra, Italy
ORSTOM	Institut Français de Recherche Scientifique pour le Développement en Coopération, Paris, France[3]
NGO	Non-governmental organisation
TAC	Total Allowable Catch
UBC	University of British Columbia, Vancouver, Canada
UE	Union Européenne
UK	United Kingdom
UNCLOS	United Nations Conference on the Law of the Sea
ZEE	Zone économique exclusive

[1] Now Institut Mauritanien de Recherches Océanographiques et des Pêches, IMROP
[2] Now Worldfish Center, Penang, Malaysia
[3] Now Institut de Recherche pour le Développement, IRD

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BIOLOGICAL STUDIES

CONTRIBUTION A LA CONNAISSANCE DE LA BIOLOGIE DE *BRACHYDEUTERUS AURITUS* DES EAUX SENEGALAISES

ON THE BIOLOGY OF *BRACHYDEUTERUS AURITUS* FROM SÉNÉGALESE WATERS

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RESUME

L'espèce semi-pélagique *Brachydeuterus auritus* (Valenciennes, 1831) n'a, jusqu'ici, jamais été étudiée au Sénégal, bien qu'elle présente un fort potentiel d'exploitation. Elle est capturée par des engins de pêche artisanale et industrielle. Cette étude décrit sa distribution le long des côtes sénégalaises, procède à l'estimation de différents paramètres biologiques indispensables à l'étude de leur dynamique et détermine la composition alimentaire de l'espèce.

ABSTRACT

Studies on the semi-pelagic species, *Brachydeuterus auritus* (Valenciennes, 1831), have not been previously conducted in Sénégal, although this species has a strong potential for fisheries exploitation. Both artisanal and industrial fisheries exploit it, mostly as bycatch. This study describes its distribution along the Sénégalese coasts, estimates of the various biological parameters essential to the study of population dynamics and determines the food consumption of this population.

INTRODUCTION

Les côtes sénégalaises, du fait de remontées d'eaux froides profondes ou 'upwelling' riches en éléments nutritifs recèlent d'importantes ressources marines. Certaines espèces sont fortement exploitées, alors que d'autres comme le 'pelon', *Brachydeuterus auritus* (Valenciennes, 1831) constituent des captures accessoires. Elle est pêchée par des engins de pêche artisanale et industrielle et elle est rejetée par certaines pêcheries spécialisées.

Bien que faisant l'objet d'une consommation locale très modérée, cette espèce n'est pas importante d'un point de vue économique. En effet, dans les principaux centres de débarquement, elle est commercialisée à des prix supérieurs à ceux des sardinelles utilisées pour la transformation artisanale (salé-séché et fumé). Ces produits sont essentiellement destinés aux marchés des pays de la sous-région. Ailleurs, de la Côte d'Ivoire au Nigéria, le pelon est très recherché et fait l'objet d'une intense exploitation. Aussi, les seules études de cette espèce sont faites dans ces pays.

L'abondance de l'espèce dans les eaux sénégalaises, la possibilité de développement de son exploitation par les pêcheries nationale et étrangère et l'existence de marchés potentiels justifient l'intérêt de cette étude qui portera en particulier sur l'estimation des paramètres biologiques indispensables à toute gestion des ressources halieutiques.

Description

Le pelon, *Brachydeuterus auritus* (Valenciennes, 1831) est appelé, selon les pays, 'Friture à écaille' ou 'Bigeye'. Cette espèce appartient à la famille Haemulidae de l'ordre des Perciformes. Elle a une distribution tropicale et subtropicale et est rencontrée le long de la côte de l'Afrique de l'ouest, de la Mauritanie à l'Angola, dans les eaux côtières entre 10 et 100 m de profondeur.

Selon la description des fiches de la FAO, le corps est oblong et comprimé. La hauteur est égale à 2.6 à 3 fois la longueur standard. Les yeux sont grands et occupent 2.5 à 3.5 la longueur de la tête; la bouche est grande et protractile; le museau est plus court que le diamètre de l'œil. La nageoire dorsale a 12 épines de force modérée et 11 à 13 rayons mous; la troisième, et parfois la quatrième épine, est plus longue que les autres. La nageoire anale a 3 épines et 9 à 10 rayons mous. La caudale est profondément échancrée. Les écailles de la ligne latérale sont de 48 à 52; 4 ou 5 rangées d'écailles sont en dessous de la ligne latérale.

Le dos de cette espèce est de couleur olive, les côtés et le ventre sont argentés à blanc. Il existe une tâche sombre sur le bord supérieur de l'opercule et sur la base de la nageoire dorsale se trouvent parfois de petites tâches foncées.

Répartition

Brachydeuterus auritus est une espèce dont la biologie a été très peu étudiée. Les travaux les plus importants ont été menés en Côte d'Ivoire, au Ghana, au Nigeria et au Congo. Certains de ces travaux ont abordé la distribution de l'espèce (Williams, 1968). Selon des études effectuées par Salzen (1957) au Ghana, l'espèce est abondante sur les fonds de 55 à 90 m. De fortes abondances de l'espèce ont été rencontrées en Sierra Léone, au Libéria, en Côte d'Ivoire et au Ghana au cours d'une campagne effectuée par le N/O *Birkut* (Chrzan, 1961), du Maroc au Ghana.

Une campagne guinéenne portant sur la distribution des poissons demersaux de l'Afrique de l'ouest a montré que le pelon est présent du Sénégal au Congo, sur les fonds de 10 à 100 m. Longhurst (1964) décrit le pelon comme une espèce eurybenthique que l'on trouve jusqu'à 100 m de profondeur, de part et d'autre de la thermocline.

Une carte de la FAO, compilant les informations disponibles sur cette espèce dans la région, décrit le schéma de migration de *Brachydeuterus auritus*. Les adultes migrent en saison froide, de la Mauritanie vers le Sénégal. En saison chaude, c'est-à-dire à partir de mai, le schéma s'inverse avec des pontes côtières lors de la remontée. La zone d'abondance du pelon s'étend le long des côtes du Sénégal avec deux nurseries d'inégale importance de part et d'autre de la presqu'île du Cap-Vert.

Une campagne acoustique conjointe a été organisée par le COPACE, le dernier semestre de 1986 et elle a couvert la zone s'étendant du Maroc au Bénin. La distribution du pelon qui a été établie concorde avec celle décrite par Garcia (1982). En fin de saison chaude (29 août au 05 septembre), l'espèce a été rencontrée à la côte, au sud du Sénégal; sa limite d'extension vers le sud est en Guinée Bissau. Par ailleurs, son absence en Guinée et sa présence à partir de la Côte d'Ivoire suggère l'existence d'un stock sud indépendant. En début de saison froide (du 23 novembre au 07 décembre), la distribution de l'espèce s'étend de la côte sénégalaise à la Guinée-Bissau.

Des campagnes d'évaluation par chalutage ont été effectuées au Sénégal par le N/O *Louis Sauger* en novembre 1986, mai 1987, mars 1988, octobre 1988 et avril 1989 (Cavérivière *et al.*, 1988). Le maillage du cul de chalut utilisé était de 45 mm. Lors de ces campagnes, le pelon a été capturé et mesuré au sud et au nord de la presqu'île du Cap-Vert. La distribution des modes en fonction de la bathymétrie montre que les jeunes individus ne sont rencontrés qu'entre 10 et 60 m. Au delà, il n'y a que des adultes dont le mode se situe entre 17 et 21 cm; ils sont également présents à la côte, mais le mode le plus élevé ne dépasse pas 19 cm.

En conclusion, cette espèce semi-pélagique évolue en bancs souvent très denses de la Mauritanie à l'Angola sur des fonds allant de la côte jusqu'à 100 m de profondeur. Les jeunes ne se rencontrent que dans la frange côtière et les adultes ont une répartition plus large et s'approchent de la côte, probablement, au moment de la ponte.

Les campagnes scientifiques

De septembre 1987 à mars 1989, des échantillons de pelon ont été prélevés chaque mois dans les principaux centres de débarquement de pêche artisanale (Saint-Louis, Kayar, Hann, MBour et Joal) et au port de Dakar. Dans les quatre derniers centres, la série de données est incomplète. Les individus collectés ont été, pour l'essentiel, capturés par les filets tournants de la pêche artisanale et par les sardiniers dakarois. Le traitement des échantillons a permis d'obtenir des informations biologiques sur les longueurs totale et à la fourche (au demi cm inférieur), le poids total, le sexe, le stade sexuel et le poids des gonades.

Les données de fréquence de taille utilisées pour l'étude de la croissance proviennent des campagnes d'évaluation par chalutage effectuées dans les eaux sénégalaises par le N/O *Louis Sauger* en novembre 1986, mai 1987, mars 1988, octobre 1988, et avril 1989. Ces campagnes ont couvert l'ensemble du plateau continental entre 10 et 100 m. Le chalut utilisé est à grande ouverture verticale de 27 m de corde de dos et de 36 m de bourrelet. Le cul du chalut est formé par des mailles de 2.5 cm de côté, soit 45.4 mm d'ouverture de maille.

La méthodologie utilisée pour l'échantillonnage a été décrite en détail par Cavérivière *et al.* (1988). Les données ont été extrapolées à la capture. La gamme de taille varie de 3 à 22 cm et peut être considérée comme représentative de la population. Les données issues des différentes campagnes ont été regroupées en une 'année synthétique' pour le traitement des fréquences de taille.

METHODOLOGIE

Relation taille-poids, facteur de condition et relation entre la longueur à la fourche et la longueur totale

La relation taille-poids permet de convertir la taille d'un poisson en poids théorique ou l'inverse. Cette équation facilite, lors de l'échantillonnage, l'estimation du poids à partir de la longueur du poisson qui est un paramètre plus aisé à mesurer.

L'indice de condition permet de suivre les variations de la balance métabolique des individus à travers les modifications saisonnières de l'embonpoint sous l'influence des facteurs externes et internes indépendamment de la longueur.

La relation entre la longueur L et le poids W des poissons est exprimée généralement par l'équation: $\mathbf{W=a\ L^b}$. Les données taille-poids peuvent être ajustées par régression linéaire si on prend les logarithmes des deux parties de la relation soit: $\mathbf{\log_{10}W=a+b\cdot\log_{10}L}$. Le facteur de condition (fc) s'exprime par l'écart entre le poids réel d'un individu et son poids théorique, dans le temps, d'après la relation taille-poids. L'équation utilisée sera celle proposée par Le Cren (1951): $\mathbf{fc=P/a\cdot L^b}$; où P est le poids observé, $a\cdot L^b$ est le poids théorique du poisson, a et b étant déterminés par la droite de la relation taille-poids et L est la longueur du poisson.

Une relation longueur à la fourche-longueur totale a été établie à partir des mesures de longueur (en mm). Cette formule s'exprime suivant une équation de la forme: $\mathbf{LF=a+b\cdot LT}$.

Sexe-ratio

La proportion des sexes est, comme la fécondité, une caractéristique de l'espèce et dont les variations sont parfois en relation avec le milieu. Par des mécanismes divers d'ajustement en réponse aux conditions variables du milieu, ces paramètres contribuent au maintien dans une certaine limite, de la capacité reproductrice de l'espèce, voire de sa pérennité. Dans le cadre de l'étude dynamique des populations, la connaissance de la proportion des sexes d'un stock permet, en liaison avec d'autres facteurs, d'évaluer la fécondité potentielle du stock (Kartas et Guinard, 1984). Le sexe-ratio sera exprimé par le pourcentage de femelles dans les différentes classes de taille.

Taille à la première maturité sexuelle

La taille à la première maturité sexuelle est définie de plusieurs manières, selon les auteurs. Dans le cadre de cette étude, elle sera la longueur à laquelle 50 % des individus sont matures, c'est-à-dire au stade III ou au delà.

Indice de maturité sexuelle

Cet indice permet de suivre l'état de maturation sexuelle des gonades des poissons mâles ou femelles et son évolution dans le temps détermine la période de ponte. Il sera exprimé par le rapport gonado-somatique: **RGS=Pg/P**, où Pg est le poids de la gonade et P le poids de l'individu.

Croissance

L'estimation de la croissance des poissons est un paramètre indispensable de la biologie des pêches. Elle est essentielle pour la plupart des évaluations de stocks étant donné que c'est la croissance moyenne des poissons qui régit, d'année en année, les captures effectuées par les pêcheries. La croissance des poissons peut être exprimée au moyen d'une équation unique telle que l'équation de von Bertalanffy dont la version la plus simple est: $\mathbf{L_t=L_8\cdot(1-e^{-K(t-to)})}$. Dans cette expression, L_8 est la longueur moyenne que le poisson atteindrait s'il avait grandi jusqu'à un âge infini, K est un coefficient de croissance, t_o est l'âge que le poisson aurait eu à la longueur zéro s'il avait grandi selon un modèle défini par l'équation (t_o a en général une valeur négative) et L_t est la longueur à l'âge t. L'estimation des paramètres de la croissance a été effectuée en passant par deux étapes :

1. La méthode Bhattacharya du logiciel FiSAT (Gayanilo *et al.*, 1996) qui a permis de décomposer les distributions modales de chaque échantillon en plusieurs composantes normales, ceci en utilisant les différences des logarithmes des effectifs des classes;

2. Après avoir suivi une cohorte sur trois années, la méthode graphique de Gulland et Holt, qui donne des estimations de croissance, a été ensuite utilisée, i.e., $\mathbf{(L_2-L_1)/(t_2-t_1)=a-KL}$; où $\mathbf{L=(L_1+L_2)/2}$ et où L_1 et L_2 sont les longueurs successives correspondant respectivement aux temps t_1 et t_2. L'ordonnée à l'origine a et la pente b donnent des estimations de K et L_8, grâce aux relations: **K=-b** et $\mathbf{L_8=a/K}$.

Pour comparer les différentes estimations de croissance, l'équation empirique de Pauly et Munro (1984) a été utilisée, i.e., $\mathbf{ø=log_{10}K+2\cdot log_{10}L_8}$, dans laquelle K est exprimé sur une base annuelle et L_8 en cm. Par ailleurs, un index permettant de caractériser la performance relative de la croissance de l'espèce a été calculé. En effet, face à la difficulté de tester la validité d'estimation de croissance variée, une approche a été proposée par Pauly (1980a). Il a montré qu'en exprimant sur un graphe les logarithmes des coefficients de croissance K, en fonction des poids asymptotiques W_8, pour une grande variété d'espèces, on obtient une régression linéaire avec une pente très proche de la valeur théorique de 0.67. Ainsi, on peut écrire: $\mathbf{log_{10}K=a-2/3\cdot log_{10}W_8}$ ou $\mathbf{a=log_{10}K+2/3\cdot log_{10}W_8}$. Si la pente est fixée par des considérations physiologiques et reste constante, les différences dans les caractéristiques de croissance peuvent être révélées par le point d'interception sur l'axe y, soit a.

Mortalité

L'estimation de la mortalité totale est effectuée par unecourbe des captures. La valeur initiale de Z est obtenue à partir de l'équation: **ln(N/? t)=a+b·t**, où N est le nombre de poissons pleinement recrutéset donc vulnérables à l'âge t, -b=Z=mortalité totale, et ?t le temps de croissance nécessaire à l'intérieur d'une classe (Gayanilo *et al*., 1996). La mortalité naturelle (M) est estimée par l'équation de Pauly (voir Gayanilo *et al*., 1996): $\mathbf{\log_{10}(M)=-0.0066-0.279\cdot\log_{10}(L_8) +0.6543\cdot\log_{10}(K) +0.4632\cdot\log_{10}(T)}$. Il est supposé que la mortalité naturelle M reste constante pour toutes les cohortes considérées. En déduisant la mortalité naturelle M de la mortalité totale Z, on obtient la mortalité par pêche **F=Z-M**.

Nutrition

L'analyse des contenus stomacaux permet de connaître le comportement alimentaire. La nutrition de *Brachydeuterus auritus*, jusqu'à présent, n'a été étudiée qu'au Nigeria. Les travaux ont été menés successivement par Longhurst (1957), Sagua (1966) et Ikusemiju *et al.* (1979). Les estomacs ont été prélevés dans les échantillons utilisés pour étudier la biologie. L'examen des estomacs a permis d'identifier et de regrouper les espèces. Les données ont été traitées en utilisant la méthode par occurrence et la méthode numérique. La définition et les problèmes inhérents à l'utilisation de ces deux méthodes ont été discutés en détail par Hyslop (1980). La méthode par occurrence consiste à calculer le pourcentage du nombre de poissons qui ont ingéré la même quantité de nourriture par rapport au nombre total de poissons examinés. Pour la méthode numérique, les organismes présents dans tous les estomacs sont comptés et le pourcentage correspondant à chaque organisme est calculé.

RESULTATS

Relation taille-poids

La relation taille-poids a été calculée séparément pour les mâles, les femelles et les deux sexes (Figure 1). L'intervalle de taille observé et utilisé est de 10.5 à 20.6 cm pour n=1,011 femelles. Les relations trouvées sont les suivantes: $\mathbf{W_{femelles}=0.02467\cdot L^{2.908}}$, n=1,011, r=0.89; $\mathbf{W_{mâles}=0.01322\cdot L^{3.115}}$, n=1,101, r=0.92; $\mathbf{W_{tous}=0.01986\cdot L^{2.979}}$, n=1,449, r=0.90. Dans ces équations W, le poids vif, est exprimé en gramme et L, la longueur totale, en centimètre.

Facteur de condition

L'évolution mensuelle de l'indice de condition est présentée sur la Figure 2. Les variations saisonnières de l'embonpoint sont assez faibles. Toutefois, une légère baisse, apparaît en saison chaude, au cours de laquelle le milieu est pauvre. De plus, cette saison correspond à la période de ponte et cette baisse s'expliquerait, entre autres, par l'utilisation des réserves énergétiques pour la reproduction. En revanche, les indices les plus élevés ont été observés durant la saison froide, i.e., période pendant laquelle la nourriture est abondante et le rapport gonado-somatique faible.

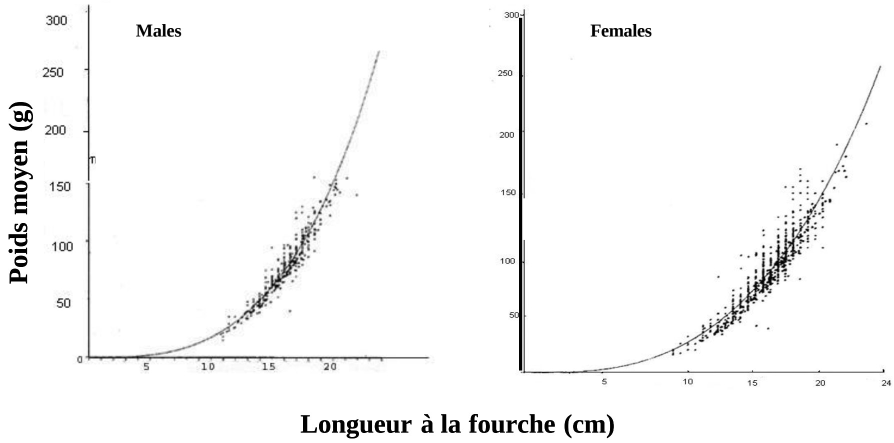

Figure 1. Relation taille-poids chez *Brachydeuterus auritus* à partir des campagnes d'évaluation par chalutage effectuées dans les eaux sénégalaises par le N/O *Louis Sauger* en novembre 1986, mai 1987, mars 1988, octobre 1988, et avril 1989.

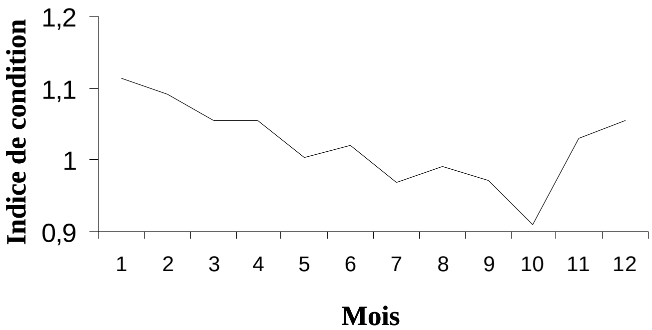

Figure 2. Évolution mensuelle de l'indice de condition chez *Brachydeuterus auritus* à partir des campagnes d'évaluation par chalutage effectuées dans les eaux sénégalaises par le N/O *Louis Sauger* en novembre 1986, mai 1987, mars 1988, octobre 1988, et avril 1989.

Relation longueur fourche-longueur totale

La formule tirée de la régression entre les mesures de longueur totale et de longueur à la fourche, toutes deux en mm, a été définie comme suit: **LF=0.9058·LT+2.151** où r=0.99 et **LT=1.091·LF-0.2147** où r=0.99. Ces résultats, illustrés sur la Figure 3, sont très proches de ceux trouvés au Congo et qui sont exprimés en cm soit, i.e., **LT=1.08·LF+0.35** (Fontana et Bouchereau, 1976). Cette relation est utile quand il s'agit de comparer les résultats de certains travaux pour lesquels les mesures de longueur ne sont pas réalisées de la même manière.

Sexe-ratio

La Figure 4 montre l'évolution des pourcentages de femelles capturées sur la côte sud en fonction de la taille, avec une nette dominance des femelles. Sur la côte nord, cette prédominance n'est observée que dans les tailles supérieures à 20 cm (il faut noter, dans ce cas, que la taille de l'échantillon était faible). Cependant, à partir des données de capture, il est difficile de savoir si cette répartition est réelle au niveau de la population, car elles pourraient résulter du fait que les femelles sont plus accessibles aux engins de pêche. Toutefois, cette prédominance des femelles qui, par ailleurs, sont les seules à être représentées au delà de 22 cm, a déjà été observée au Congo (Fontana et Bouchereau, 1976) et au Nigéria (Ikusemiju *et al.*, 1979). De même, cette caractéristique biologique est fréquente dans les régions tropicales où pour de nombreuses espèces, notamment pélagiques, les individus mâles sont peu représentés dans les grandes tailles. En revanche, les travaux de Ikusemiju *et al.* (1979) font état d'une prédominance des mâles par rapport aux femelles (100 mâles pour 46 femelles). Cette étude présente, toutefois, des limites, notamment la faiblesse de la taille de l'échantillon (460 individus) et la courte durée de l'étude (d'octobre 1975 à mars 1976). Par ailleurs, la distribution du sexe-ratio en fonction de la taille n'a pas été faite, ce qui aurait permis de savoir si la dominance des mâles est réelle pour toutes les classes de taille.

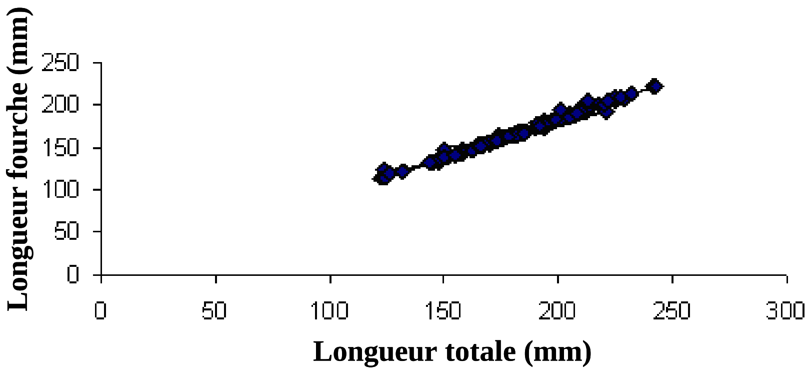

Figure 3. Relation entre les longueurs fourche et totale chez *Brachydeuterus auritus* à partir des campagnes d'évaluation par chalutage effectuées dans les eaux sénégalaises par le N/O *Louis Sauger* en novembre 1986, mai 1987, mars 1988, octobre 1988, et avril 1989.

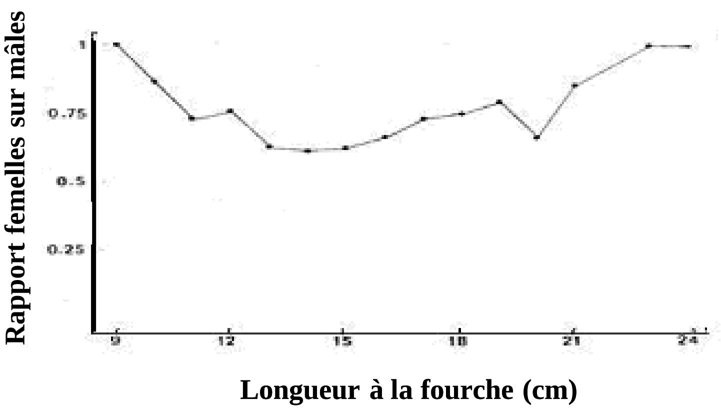

Figure 4. Évolution des pourcentages de femelles capturées sur la côte sud en fonction de la taille chez *Brachydeuterus auritus* à partir des campagnes d'évaluation par chalutage effectuées dans les eaux sénégalaise par le N/O *Louis Sauger* en novembre 1986, mai 1987, mars 1988, octobre 1988, et avril 1989.

Taille à la première maturité sexuelle

En considérant comme poisson mâture tout individu ayant atteint le stade III, les Figures 5 illustrent les tailles à la première maturité à 14.4 cm pour les mâles et à 14.8 cm pour les femelles. Cependant, ces illustrations ne reflètent pas, surtout pour les mâles, l'allure de la courbe théorique, en raison des points correspondants aux grandes tailles. Cela s'expliquerait, entre autres, par les effectifs réduits des grandes classes de taille et par le fait que certains individus peuvent avoir déjà pondu au moment de la capture.

Indice gonado-somatique

Les valeurs mensuelles du rapport gonado-somatique ont été calculées pour les mâles et les femelles (Figure 6) ayant atteint la taille à la première maturité sexuelle. La ponte est fractionnée et s'étale durant toute la saison chaude, avec des pics en juin et en septembre. Au Congo, trois pontes annuelles (mai, septembre-octobre et janvier) ont été mises en évidence, au Nigéria, deux (décembre-janvier et juillet-août) et en Côte d'Ivoire une, de janvier à août.

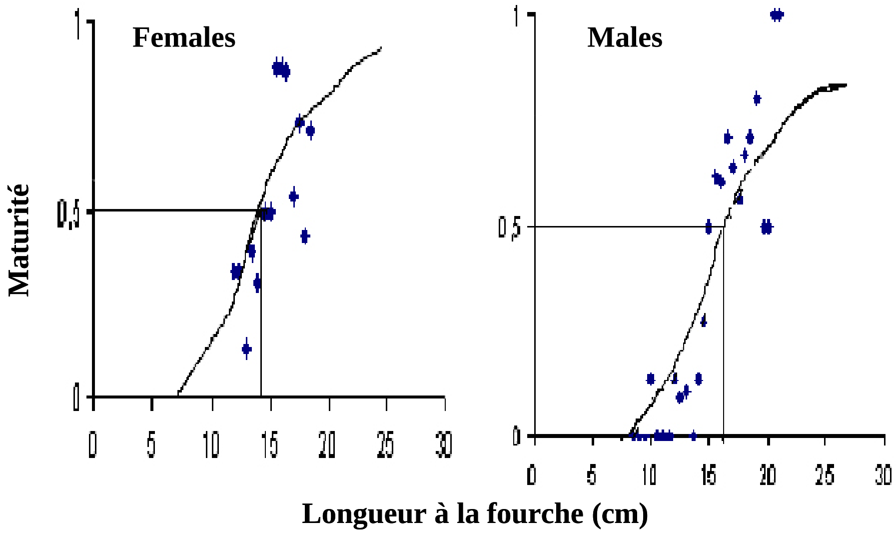

Figure 5. Tailles à la première maturité chez *Brachydeuterus auritus* à partir des campagnes d'évaluation par chalutage effectuées dans les eaux sénégalaises par le N/O *Louis Sauger* en novembre 1986, mai 1987, mars 1988, octobre 1988, et avril 1989.

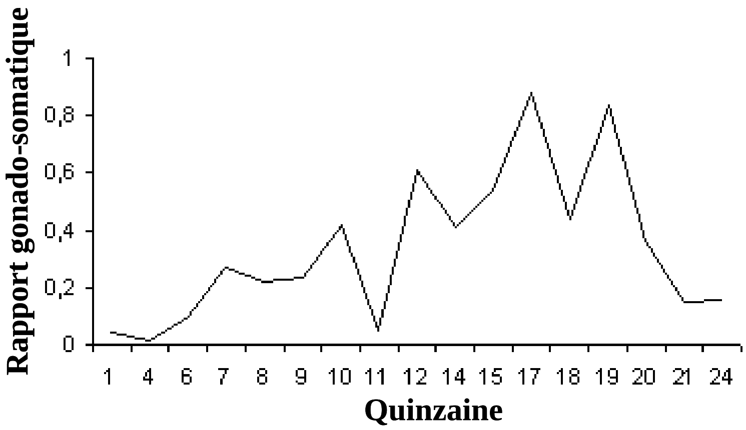

Figure 6. Rapport gonado-somatique chez *Brachydeuterus auritus* à partir des campagnes d'évaluation par chalutage effectuées dans les eaux sénégalaises par le N/O *Louis Sauger* en novembre 1986, mai 1987, mars 1988, octobre 1988, et avril 1989.

Croissance

Le Tableau 1 donne les valeurs modales (en cm) des groupes d'individus identifiés par la méthode de Bhattacharya (Gayanilo *et al.*, 1996). En suivant la cohorte de valeur modale 6.48 cm au mois de novembre de l'année t, on peut retenir l'hypothèse que ces individus atteignent 10.5 cm en avril de l'année t+1, 13.0 cm en novembre de la même année, 16.3 cm en novembre de l'année t+2 et 18.2 cm de l'année t+3.

Tableau 1. Longueurs totales modales (cm) des cohortes ou groupes de *Brachydeuterus auritus* identifiés par la méthode de Bhattacharya à partir des campagnes d'évaluation par chalutage effectuées dans les eaux sénégalaises par le N/O *Louis Sauger*.

Mars 1988	Avril 1989	Mai 1987	Octobre 1988	Novembre 1986
6.9	–	–	6.9	6.5
10.7	10.5	12.2	13.1	13.0
16.6	18.2	16.5	–	16.3

Tableau 2. Paramètres de croissance de *Brachydeuterus auritus* pour 5 pays africains et en comparaison avec ceux obtenus dans cette étude (voir Figure 8).

Pays	Auteurs	L_∞	K	Ø
Congo	Fontana et Bouchereau (1976)	23.5	0.732	2.61
Côte d'Ivoire	Barro (1979)	23.1	0.400	2.33
Togo	Beck (1974; mâle)	23.1	0.292	2.19
Togo	Beck (1974; femelle)	22.1	0.322	2.20
Nigeria	Raitt et Sagua (1972)	20.6	0.400	2.23
Sénégal	Samb (cette étude)	22.3	0.590	2.47

L'application de la méthode graphique de Gulland et Holt donne (Figure 7) les estimations suivantes: **L_8 =22.3 cm (LT)** et **K=0.59 an^{-1}**. Ces résultats sont comparables à ceux estimés par d'autres auteurs au Nigéria (Raitt et Sagua, 1972), au Togo (Fontana et Bouchereau, 1976) et enfin en Côte d'Ivoire (Barro, 1979). Le Tableau 2 et la Figure 8 présentent, respectivement, les estimations et les courbes de croissance (K) de l'espèce. La valeur trouvée au Sénégal se situe dans l'intervalle défini pour la valeur calculée au Congo. L'essentiel des différences réside dans le coefficient de croissance qui est plus élevé au Congo où les auteurs ont trouvé trois pontes par an; en Côte d'Ivoire, une seule ponte annuelle a été identifiée. Les indices calculés sont pratiquement les mêmes que ceux trouvés au Nigéria et au Togo. Ces résultats sont en concordance avec ceux de Munro (1983) qui a estimé, pour les Pomadasyidés, des valeurs de K comprises entre 1.11 et 1.79, pour une moyenne de 1.46 an^{-1}.

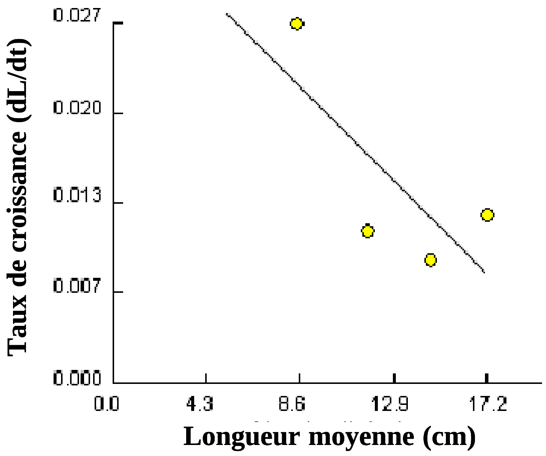

Figure 7. Estimation de croissance par la méthode de Gulland et Holt (L_8 =22.3 cm LT et K=0.59 an^{-1}) pour *Brachydeuterus auritus* à partir des campagnes d'évaluation par chalutage effectuées dans les eaux sénégalaises par le N/O *Louis Sauger* en novembre 1986, mai 1987, mars 1988, octobre 1988, et avril 1989.

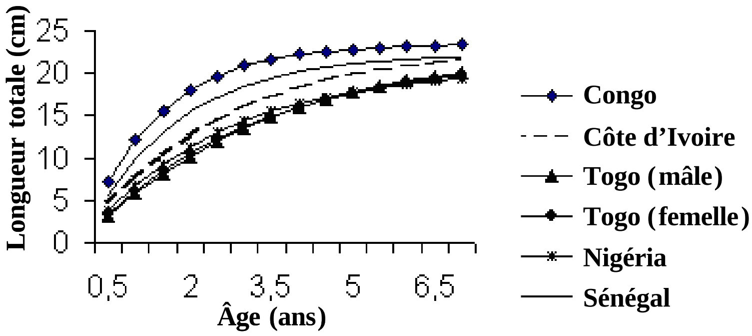

Figure 8. Courbes de croissance chez *Brachydeuterus auritus* à partir des données rassemblées dans le Tableau 2.

Mortalité

Sur la courbe de capture (Figure 9), la valeur de Z obtenue est Z=1.54 an^{-1}. L'équation empirique de Pauly (1980b), pour une température moyenne de 18°C, donne une mortalité naturelle M=1.12 an^{-1}. Ainsi, la mortalité par pêche estimée à partir de cette valeur de M est F=0.415 an^{-1} et le taux d'exploitation est E=0.27.

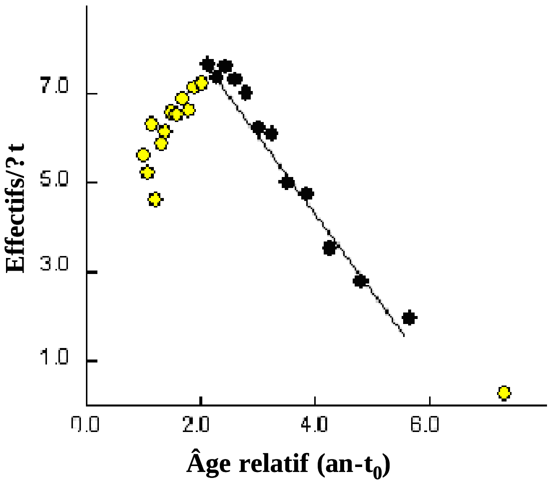

Figure 9. Courbe de capture chez *Brachydeuterus auritus* à partir des campagnes d'évaluation par chalutage effectuées dans les eaux sénégalaises par le N/O *Louis Sauger* en novembre 1986, mai 1987, mars 1988, octobre 1988, et avril 1989.

Nutrition

Le Tableau 3 donne les résultats de l'application des méthodes par occurrence et numérique. Les crustacés constituent le groupe le plus important des espèces identifiées dans les contenus stomacaux. Ils représentent 68.7 % par la méthode par occurrence et 92.8 % par la méthode numérique. Parmi les crustacés, ce sont les calanoïdes qui dominent avec un pourcentage de 13.9 % par la méthode par occurrence et de 44.5 % par la méthode numérique. Par la méthode par occurrence, les crustacés sont suivis par les amphipodes (9.3 %) et les larves de crustacés (4.6 %). En revanche, avec la méthode numérique, ce sont les oeufs de crustacés qui ont un pourcentage très élevé (39.8 %). Cependant, il faut noter que cette nourriture n'a été identifiée que dans deux échantillons et que le fort pourcentage résulte de la spécificité de la méthode qui amplifie le pourcentage.

Tableau 3. Résultats de l'analyse des contenus stomacaux de *Brachydeuterus auritus* à partir des campagnes d'évaluation par chalutage effectuées dans les eaux sénégalaises par le N/O *Louis Sauger* en 1986-1989 (voir les travaux de Cavérivière *et al*., 1988, 1989).

Groupes d'espèces	Méthode par occurrence		Méthode numérique	
	Nombre	**%**	**Nombre**	**%**
Crustacés				
Pince de crustacés	1	1.2	4	0.13
Amphipodes	8	9.3	5	0.16
Cumacés	1	1.2	2	0.06
Calanoïdes	12	13.9	1,315	44.6
Cladocères	1	1.2	1	0.03
Cyclopoïdes	1	1.2	1	0.03
Harpacticoïdes	2	2.3	2	0.06
Larves de balane	1	1.2	1	0.03
Larves de crustacés	4	4.6	13	0.44
Larves mysis	1	1.2	4	0.13
Larves de cirripèdes	3	3.5	10	0.33
Larves zoé de brachyoure	2	2.3	12	0.40
Larves cypris de *Lepas*	1	1.2	1	0.03
Mysidacés	3	3.5	22	0.74
Ostracodes	3	3.5	3	0.10
Oeufs de crustacés	2	2.3	1,175	39.8
Partie antérieure de calanoïde	5	5.8	131	4.44
Partie antérieure d'amphipode	1	1.2	1	0.03
Partie antérieure de mysidacés	1	1.2	1	0.03
Partie postérieure de calanoïde	2	2.3	32	1.08
Partie postérieure de mysidacés	2	2.3	2	0.06
Sergestidés	2	2.3	2	0.06
Sous total	59	68.7	2,740	92.8
Mollusques				
Larves de lamellibranches	5	5.8	56	1.89
Gastéropodes	1	1.2	4	0.13
Véligères de gastéropodes	1	1.2	4	0.13
Sous total	7	8.2	64	2.15
Poissons				
Oeufs de poisson	3	3.5	64	2.16
Poissons	1	1.2	1	0.03
Restes de poisson	3	3.5	3	0.10
Juvéniles de poisson	1	1.2	1	0,03
Sous total	14	16.4	69	2.32
Lophophoriens				
Chaetognathe	2	2.3	20	0.67
Annélides				
Annélides polychètes	1	1.2	4	0.13
Larves d'annélide	3	3.5	38	1.28
Morceaux de larves d'annélide	1	1.2	9	0.30
Partie antérieure d'annélide	1	1.2	1	0.03
Sous total	6	7.1	52	1.74
Fragments d'algues rouges	1	1.2	1	0.03
Echinodermes	1	1.2	4	0.13
Débris organiques	2	2.3	–	–

Par la méthode par occurrence, les poissons représentent, après les crustacés, le groupe le plus important avec 9.4 % du bol alimentaire et 2.3 % par la méthode numérique. Un clupéidé entier a été trouvé dans l'un des estomacs. Les mollusques, avec 8.2 % par la méthode par occurrence et 2.1 % par la méthode numérique, représentent le troisième groupe. Il s'agit surtout de larves de lamellibranches. Des annélides, des lophophoriens, des échinodermes, des fragments d'algues rouges et des débris organiques ont été également trouvés dans les contenus stomacaux, mais en des quantités relativement faibles.

En conclusion, aussi bien au Sénégal, qu'au Nigéria, ce sont les crustacés qui dominent dans les bols alimentaires analysés. La méthode par occurrence donne 68.7 % pour le Sénégal, contre 37.4 % pour le Nigéria (Ikusemiji *et al.*, 1979) et près de 80.0 % dans l'étude menée par Sagua (1966). Les deux autres groupes qui viennent ensuite sont les mollusques et les poissons qui sont essentiellement constitués de juvéniles de petits pélagiques côtiers.

CONCLUSION

Les espèces secondaires des captures, comme le pelon, *Brachydeuterus auritus*, font l'objet de très peu d'études, bien qu'elles constituent de fortes potentialités dans le milieu marin. Les paramètres biologiques estimés dans cette étude permettent de disposer à présent de connaissances préliminaires. Le fort potentiel de cette espèce et l'intérêt qu'elle suscite dans de nombreux pays voisins militent en faveur de l'exploitation de cette ressource. Avec le développement de la pêcherie de pelon, les données statistiques exhaustives permettront d'identifier les travaux à mener pour une meilleure connaissance de l'espèce.

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REPRODUCTION ET FECONDITE DES POISSONS DU FLEUVE KOLENTE, BASSE-GUINEE

REPRODUCTION AND FECONDITY OF FISHES OF THE KOLENTÉ RIVER, LOWER GUINEA

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RESUME

La reproduction et la fécondité de *Brycinus longipinnis* et de *Schilbe micropogon* du fleuve Kolenté dans la Basse-Guinée ont été étudiées à partir d'échantillons obtenus de septembre 1991 à septembre 1992. La longueur standard à la maturité sexuelle du *Schilbe micropogon* est environ 108 mm avec une période de reproduction de juin à août, la première maturité étant observée en avril avec une augmentation rapide atteignant un RGS de 20.5 % en juillet. La fécondité moyenne observée et de 382,510 oeufs par kilogramme de femelle et la gamme de diamètre d'ovocyte de 0.50-1.08 mm avec une distribution unimodale.

Brycinus longipinnis a deux modes de maturité, 63 millimètres et 81 millimètres; les femelles matures se produisent tout au long de l'année, mais le nombre maximum des femelles matures (29.7 % de l'échantillon) a été observé en juin avant les inondations annuelles. La fécondité moyenne est 155,863 oeufs par kilogramme de femelle. La distribution des ovocytes est unimodale avec une gamme de diamètre de 0.83-1.25 mm.

En plus de ces deux espèces principales, quelques paramètres de fécondité ont été enregistrés pour l'espèce suivante: *Petrocephalus lévêquei*, diamètre d'ovocyte de 1.16-1.91 mm et fécondité moyenne de 89,400 oeufs par kilogramme de femelles; Synodontis *waterloti*, diamètre d'ovocyte de 1.08-1.66 mm avec une fécondité moyenne de 72,399 oeufs par kilogramme de femelle; *Polypterus palmas*, diamètre d'ovocyte de 1.25-2.00 mm et fécondité moyenne de 42,809 oeufs par kilogramme de femelle.

ABSTRACT

The reproduction and fecondity of *Brycinus longipinnis* and *Schilbe micropogon* from the river at Kolenté station in the Lower Guinea were studied from samples obtained from September 1991 to September 1992. Standard length at sexual maturity of the *Schilbe micropogon* is about 108 mm with a reproduction peak from June to August, first maturity being observed in April with a rapid increase reaching an RGS of 20.5 % in July. An average fecundity of 382,510 eggs per kg of female was observed, with ovocyte diameters ranging from 0.50-1.08 mm, with a unimodal distribution.

Brycinus longipinnis has two maturity modes, 63 mm and 81 mm; mature females occur throughout the year, but the maximum number of mature females (29.7 % of the sample) was observed in June prior to the annual floods. The average fecundity is 155,863 eggs per kg of female. The distribution of ovocytes is unimodal with a diameter range of 0.83-1.25 mm.

In addition to these two main species, some fecundity parameters were recorded for the following species: *Petrocephalus levequei* – ovocyte diameter range of 1.16-1.91 mm and an average fecundity of 89,400 eggs per kg of females; *Synodontis waterloti* – ovocyte diameter range of 1.08-1.66 mm

with an average fecundity 72,399 eggs per kg of female; *Polypterus palmas* – ovocyte diameter range of 1.25-2.00 mm with an average fecundity of 42,809 eggs per kg of female.

INTRODUCTION

La reproduction des poissons des eaux continentales de l'Afrique de l'Ouest a surtout été étudiée au Mali (Paugy, 2002) et en Côte d'Ivoire (Albaret, 1982); en Guinée, les travaux sont rares. C'est pour cette raison que, dans le cadre d'une convention entre l'ORSTOM et le CNSHB (Office de Recherche Scientifique et Technique/Centre National des Sciences Halieutiques de Boussoura), une étude de la reproduction des poissons du fleuve Kolenté a été entreprise ce qui a permet un échantillonnage régulièr pendant un an à une station fixe (Figure 1). Ces analyses ont concerné les deux espèces les plus abondantes: *Brycinus longipinnis*, à large répartition et *Schilbe micropogon*, à répartition limitée dans la zone occidentale guinéenne. Par ailleurs, le diamètre des ovocytes et la fécondité moyenne de *Petrocephalus levequei*, de *Synodontis waterloti* et de *Polypterus palmas* ont été décrits.

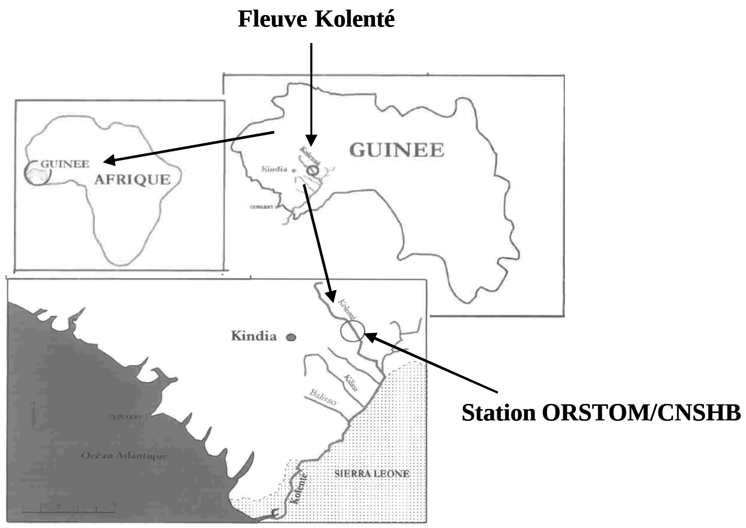

Figure 1. Carte du site d'étude indiquant la station ORSTOM/CNSHB dans le Fleuve Kolenté où les échantillons on été pris, de septembre 1991 à septembre 1992.

MATERIEL ET METHODE

La longueur standard (LS) a été mesurée en mm et le poids total en grammes relevé. La détermination du sexe est faite par un examen macroscopique des gonades et le stade de maturité sexuel, en utilisant l'échelle à sept stades de Durand et Loubens (1970). Les deux premiers et trois derniers stades ont été regroupés, ce qui a réduit l'échelle à quatre stades: stade 1 (F1): femelle immature ou au repos sexuel; stade 2 (F2): femelle en début de maturation; stade 3 (F3): femelle en maturation ; stade 4 (F4): femelle en maturation avancée, mûre ou prête à pondre.

Le rapport gonado-somatique ou RGS, rapport entre le poids des gonades et le poids somatique, est calculé pour chaque stade. Les gonades mâles sont réparties en deux groupes: les mâles (-) qui regroupent tous les individus immatures, au repos ou en début de maturation et les mâles (+) constitués par les individus en maturation.

Pour déterminer la taille à la première maturité sexuelle, la médiane de la classe de taille à laquelle 50 % des femelles sont au stade 4 a été retenue. Pour établir la fécondité moyenne, les gonades des femelles au stade 4 sont conservées dans du formol à 4 %. Le comptage et les mesures des ovocytes sont faits à la loupe binoculaire sur laquelle est fixée un micromètre oculaire. A l'objectif de grossissement 12 utilisé, une unité de micromètre oculaire est égale à 0.083 mm.

RESULTATS

La courbe de maturité sexuelle de *Brycinus longipinnis* a deux modes: l'un à 63 mm et l'autre à 81 mm de longueur standard. *Schilbe micropogon* a un mode à 108 mm. En ce qui concerne l'évolution du RGS et des stades de maturation sexuelle, chez *Brycinus longipinnis*, les femelles matures sont rencontrées toute l'année et le RGS est maximum en juin (Figure 2; gauche), c'est-à-dire, avant la période de crue. Le rapport gonado-somatique est inversement proportionnel à la taille des individus des espèces étudiées.

Chez *Schilbe micropogon*, la reproduction est saisonnière. La maturation débute en avril, elle est suivie d'un développement rapide, avec des maxima de RGS en juillet (Figure 2; droite). La période de reproduction dure de juin à août ; après cette période, bien que certaines femelles présentent encore de signes de maturation, le RGS moyen est faible.

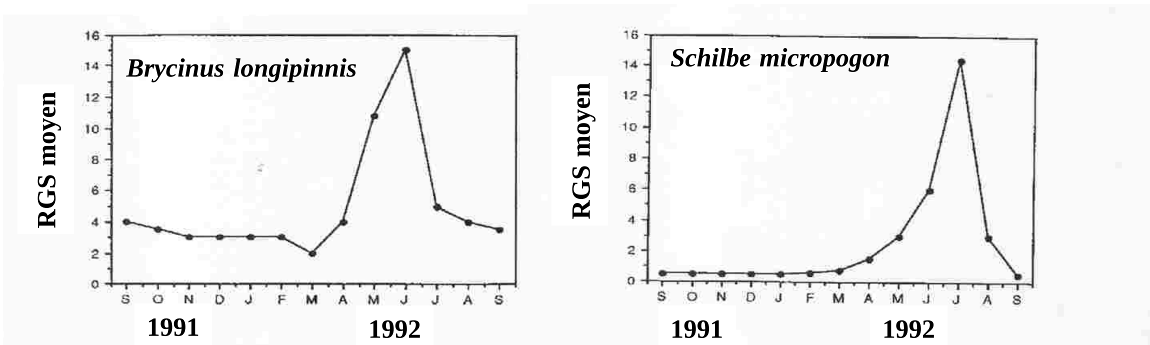

Figure 2. Rapport gonado-somatique chez *Brycinus longipinnis* et *Schilbe micropogon* échantillonnés dans le fleuve Kolenté, Basse-Guinée, de septembre 1991 à septembre 1992.

Le Tableau 1 donne les variations de taille des ovocytes et de la fécondité moyenne exprimée en nombre d'œufs et en nombre d'œufs par kilogramme de femelle pour les cinq espèces étudiées. La distribution des ovocytes des cinq espèces étudiées est représentée sur la Figure 3. Les paramètres des relations linéaires entre la fécondité, la longueur standard, le poids du corps et le poids des gonades sont résumés dans le Tableau 2. La distribution du diamètre des ovocytes des espèces étudiées indique que la ponte n'est pas fractionnée. Les principaux résultats obtenus sur la reproduction des cinq espèces sont donnés dans le Tableau 3.

Tableau 1. Taille des ovocytes et fécondité (nombre d'œufs par kg de femelle) de cinq espèces de poissons du fleuve Kolenté en Basse-Guinée échantillonées en septembre 1991 au septembre 1992.

Espèces	Taille des ovocytes (mm)	Nombre d'œufs	Fécondité
Brycinus longipinnis	0.83-1.25	2,664	155,863
Schilbe micropogon	0.50-1.08	11,238	382,510
Petrocephalus levequei	1.16-1.91	2,388	89,400
Synodontis waterloti	1.08-1.66	2,948	72,399
Polypterus palmas	1.25-2.00	6,380	42,809

Tableau 2 : Paramètres des régressions linéaires entre la fécondité, la longueur standard (mm), le poids du corps (g) et le poids des gonades (g) de cinq espèces des poissons du fleuve Kolenté en Basse-Guinée échantillonnées entre septembre 1991 et septembre 1992.

Espèce	LS *vs* fécondité	r	Poids du corps *vs* fécondité	r	Poids des gonades *vs* fécondité	r
Brycinus longipinnis	F = 170·LS - 12581	0.728	F = 153·P_c - 161.63	0.691	F = 712·P_g - 1158.4	0.734
Schilbe micropogon	F= 464·LS - 49478	0.873	F = 531·P – 4843.8	0.908	F = 3112·P_g - 987.53	0.917
Petrocephalus levequei	F = 44.9·LS - 2623	0.804	F = 68.5·P + 356.45	0.816	F = 402·P_g + 602.09	0.871
Synodontis waterloti	F = 80.3·LS - 6206	0.724	F = 72.2·P - 90.926	0.707	F = 442·P_g + 273.55	0.938
Polypterus palmas	F = 70.8·LS - 11185	0.801	F = 46.3·P - 690.52	0.870	F = 373·P_g - 767.93	0.966

Tableau 3. Résultats obtenus sur la fécondité (F) de cinq espèces de poissons du fleuve Kolenté en Basse-Guinée entre septembre 1991 et septembre 1992.

Espèces	n	LS (mm)	Poids du corps (g)	RGS moyen (%)	F moyen/ kg de femelle	F relative/ kg de femelle
Brycinus longipinnis	14	67-101	6,4-30,8	15,01	155863	156
Schilbe micropogon	16	111-151	19,4-51	14,34	382510	382
Petrocephalus lévêquei	9	94-130	14,2-43,6	15,89	89400	89
Synodontis waterloti	9	103-133	20,6-60	17,29	72399	72
Polypterus palmas	7	246-270	96,7-200	15,05	42809	43

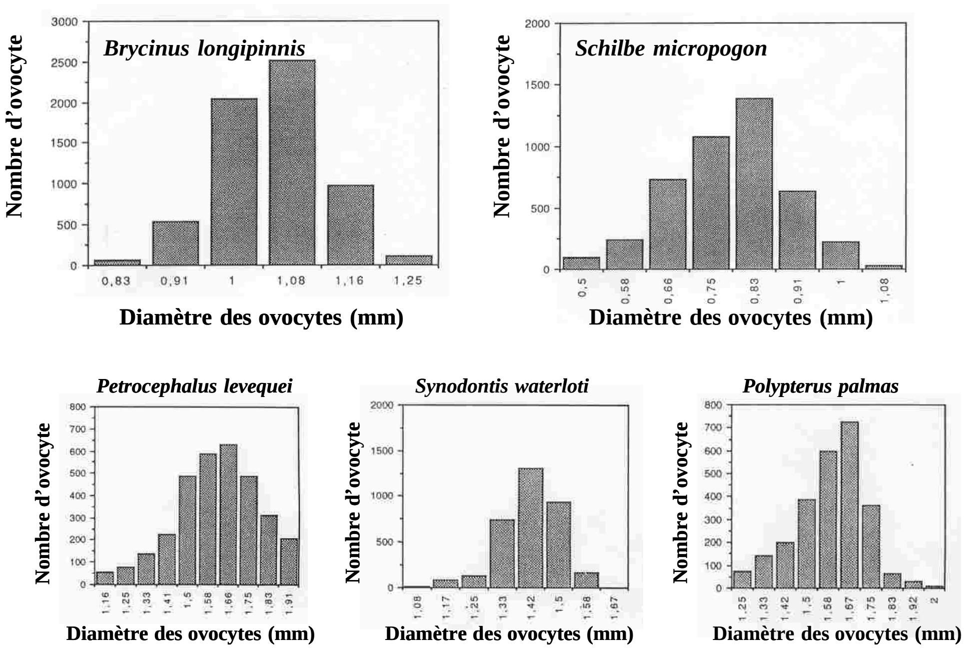

Figure 3. Histogramme des fréquence des diamètres des ovocytes chez les espèces de poisson du Fleuve Kolenté échantillonnées entre septembre 1991 et septembre 1992.

DISCUSSION

Les résultats obtenus sur la reproduction de *Brycinus longipinnis* et de *Schilbe micropogon* à Kolenté sont comparables à ceux des espèces rencontrées dans d'autres régions. En effet, selon Ganda (1987), en Sierra Léone, *Brycinus longipinnis* se reproduit de mai à août, avec un maximum de femelles matures en juillet-août. En Côte d'Ivoire, la taille à la première maturité sexuelle varie de 42 mm (à la station Kan sur la Rivière Didiévi) à 70 mm (à la station Bandama sur la Rivière N'Zi N'Da). En règle générale, plus les rivières sont grandes, plus la taille à la première maturité est élevée Paugy (2002). Cependant, les données récoltées sont insuffisantes pour déterminer de façon satisfaisante la période de ponte de *Brycinus longipinnis* qui, selon Planquette et Lemasson (1975), se situerait en fin de saison sèche. Au Togo, dans le Mono, la reproduction est continue si on considère l'ensemble de la population, alors qu'elle est annuelle au niveau de l'individu (Paugy et Benech, 1989).

Toutes les études menées en Afrique de l'ouest indiquent que la reproduction de *Brycinus longipinnis* est très étalée, probablement, sur toute l'année, avec un pic marqué en début de saison des pluies. La distribution bi-modale de la taille à la première maturité sexuelle notée en Guinée est un résultat important, car, jusqu'à ce jour, ce phénomène n'a été observé que chez les espèces sahéliennes (Benech, 1990). Dans ce pays, comme ailleurs en Afrique de l'ouest, les données sur la croissance sont insuffisantes pour déterminer si la bi-modalité observée est due à deux classes d'âges ou si elle résulte de différences dans les vitesses de croissance. Le nombre d'œufs par ponte observé en Guinée est du même ordre de grandeur que celui trouvé en Côte d'Ivoire (2,175 œufs), de même que le RGS moyen des femelles matures (13.5 %).

Les résultats obtenus sur la période de reproduction de *Schilbe micropogon* dans la Kolenté sont semblables aussi à ceux observés en Sierra Léone (Ganda, 1987) où la reproduction débute en mai avec un pic en juin, c'est-à-dire, un peu avant la crue. Ces observations sont aussi très similaires à celles faites sur l'espèce voisine, *Schilbe intermedius*, en Côte d'Ivoire (Albaret, 1982), au Tchad (Blache, 1964) et dans les fleuves Gambie (Svensson, 1933; Johnels, 1954) et Sénégal (Reizer, 1971). Quelque soit la région, cette espèce se reproduit pendant une période limitée à deux ou trois mois et toujours pendant la crue. Chez *Schilbe micropogon*, le nombre d'œufs par ponte observé en Côte d'Ivoire est supérieur (Albaret, 1982) à celui trouvé en Guinée (44,900 contre 18,140). A l'inverse, le RGS moyen des femelles matures est plus faible en Côte d'Ivoire qu'en Guinée (8.0 contre 14.3).

La taille à la première maturité sexuelle des deux espèces de *Schilbe (Schilbe intermedius*, en Côte d'Ivoire et *Schilbe micropogon en Guinée)* est du même ordre de grandeur dans les deux pays. Pour les autres espèces étudiées, seules les valeurs relatives à la fécondité et au RGS moyen sont comparables à celles obtenues dans d'autres régions. Selon Albaret (1982), qui a travaillé sur la reproduction et la fécondité des poissons d'eau douce de Côte d'Ivoire, le nombre d'œufs émis à chaque ponte est fonction de la taille des ovocytes. Plus ils sont gros, plus faible est la fécondité moyenne.

La taille à la première maturité sexuelle et le cycle de maturation des gonades a permis de déterminer la période de ponte de *Brycinus longipinnis* et de *Schilbe micropogon* dans le fleuve Kolenté. La reproduction de *Brycinus longipinnis* est plus ou moins étalée sur toute l'année et sa période de ponte va de mai à juillet, avec un pic en juin, c'est-à-dire, un peu avant la crue. Chez *Schilbe micropogon* la reproduction est saisonnière (de juin à août) et le pic est en juillet. La distribution unimodale des diamètres des ovocytes indique que la ponte n'est fractionnée chez aucune des espèces étudiées.

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RELATION TAILLE-POIDS DE 11 ESPECES DE POISSONS DU BURKINA FASO

LENGTH-WEIGHT RELATIONSHIPS OF 11 FISH SPECIES OF BURKINA FASO

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ABSTRACT

The parameters of length-weight relationships, i.e., $W=a{\cdot}L^b$, were determinated for 11 species caught in tributaries (Souru, Nakambé, Mouhoun and Bougouriba) of the Volta River, Burkina Faso. Values of b ranged from 2.71 to 3.20.

RESUME

Les paramètres de la relation taille-poids de la forme $W=a{\cdot}L^b$ ont été déterminés chez 11 espèces de poissons pêchés dans des tributaires (Souru, Nakambé, Mouhoun et la Bougouriba) de la rivière Volta, Burkina Faso. Les valeurs de b variaient de 2.71 à 3.20.

INTRODUCTION

Dans les écosystèmes lotiques sahéliens, la biologie et l'écologie de certaines espèces piscicoles d'intérêt économique sont insuffisamment étudiées. C'est le cas en particulier des paramètres de croissance, la taille et le poids. Chez les poissons, le poids (W) est relié à la taille (L) par une relation non linéaire de la forme, $\mathbf{W=a{\cdot}L^b}$. La connaissance de cette relation trouve des applications en biologie des pêches et dans l'évaluation des stocks halieutiques (Kochzius, 1997; Ruiz-Ramirez *et al.*, 1997; Le Tourneur *et al.*, 1998). Par ailleurs les paramètres a et b donnent généralement des informations sur les variations pondérales d'un individu par rapport à sa taille et peuvent à ce titre être comparés entre deux ou plusieurs populations vivant dans des conditions écologiques similaires ou différentes.

Le présent article contribue à améliorer la connaissance de ces paramètres chez les poissons dans les écosystèmes fluviaux de la zone sahélienne. Ces écosystèmes représentent plus d'un tiers de la base productrice du poisson au Burkina Faso (Breuil, 1995), et l'étude envisagée servira de point de comparaison entre la croissance des poissons dans les lacs de barrages, qui ont pris une importance considérable ces dix dernières années, et les systèmes fluviaux.

MATERIEL ET METHODES

Les données pour 9 espèces ont été extraites d'un rapport interne à l'administration des pêches et consécutive à un inventaire piscicole dans les fleuves des Hauts-Bassins de la Volta de 1980 à 1981. De plus, de juin à juillet 2000, les longueurs et les poids de 294 individus du Arowana, *Heterotis niloticus*, et d'un poisson chat du genre *Clarias* ont été collectés. Dans les deux cas, les captures ont été effectuées par des pêcheurs professionnels, utilisant des filets maillants, avec des mailles supérieures ou égales à 30 mm. Les échantillons furent prélevés parmi les spécimens présentés à la vente. Les poissons furent identifiés à partir de la description de Roman (1966). La longueur standard des poissons fut mesurée en cm de l'extrémité de la bouche à la fin du pédoncule caudal. Le poids total (non éviscéré) de chaque poisson a été mesuré en gramme. Le sexe n'a pas été différencié. Les données brutes ont été analysées en utilisant le logiciel Microsoft EXCEL. Les paramètres a et b de la relation $\mathbf{W=aL^b}$ ont été estimés à travers une transformation logarithmique linéaire de type $\mathbf{ln(W)=ln(a)+ b \cdot ln(L)}$.

RESULTATS ET DISCUSSION

Le Tableau 1 indique pour chaque espèce, le nombre de spécimens collectés, les valeurs minimales et maximales de la taille et du poids, les paramètres a et b estimés ainsi que le coefficient de corrélation (r^2) de la relation taille-poids. Les effectifs examinés par espèce sont faibles car les sujets collectés étaient de bonne valeur commerciale. Il en est de même pour les tailles des poissons qui ne représentent que celles autorisées par la réglementation forestière.

Tableau 1. Relation taille-poids de neuf espèces de poissons pêchés dans les fleuves des hauts-bassins de la Volta.

Espèces	Lieu de capture	n	Taille (cm)	Poids (g)	a	b	r^2
Clarias anguillaris	Nakambé	24	26-29	165-4000	0.0052	3.20	0.976
Clarotes laticeps	Bougouriba	24	13-56	50-1595	0.0343	2.87	0.963
Clarias sp.	Souru	187	22-72	100-4400	0.0061	3.14	0.830
Distichodus rostratus	Mouhoun	15	16-52	90-3000	0.0184	3.05	0.981
Heterotis niloticus	Nakambé	20	20-76	172-7000	0.0422	2.71	0.977
Heterotis niloticus	Souru	294	22-67	200-3300	0.0230	2.80	0.962
Labeo coubie	Mouhoun	16	14-52	80-2550	0.0576	2.74	0.994
Lates niloticus	Mouhoun	38	12-128	40-53000	0.0239	3.00	0.996
Mormyrus rume	Bougouriba	14	20-70	80-3000	0.0157	2.86	0.977
Oreochromis niloticus	Mouhoun	14	17-29	260-920	0.0993	2.72	0.926
Tilapia zillii	Bougouriba	17	10-27	52-890	0.0751	2.81	0.986

Si l'on ignore *Clarias* sp., qui est mal défini au niveau taxonomique, les valeurs de r^2 varient de 0.926 pour *Oreochromis niloticus* à 0.996 pour *Lates niloticus*, traduisant ainsi une régression hautement significative ($p=0.01$). Les valeurs estimées de b sont autour de 3 pour *Clarias anguillaris, Distichodus rostratus, Lates niloticus*, indiquant pour ce groupe que la forme du corps ne change pas au cours de la croissance. Notons que les valeurs de b pour les deux populations de *Heterotis niloticus* sont faibles comparées aux valeurs des populations dans le Sud (Sudan: 3.03; Hickley et Bailley, 1986). Pour le reste des poissons examinés, la valeur de b varie de 2.7 à 2.8, ce qui signifie en terme de croissance, que le développement du corps (croissance pondérale) est moins rapide que celui de la taille. Pour toutes ces espèces examinées dans le système fluvial des Hauts-Bassins de la Volta, la valeur de b est concordante avec celle habituellement rapportée et admise par la littérature et qui situe cette valeur entre 2.5 et 3.5 (Pauly, 1997). Dans ces écosystèmes fluviaux, les conditions d'une croissance isométrique peuvent être appliquées aux espèces examinées.

Les données relatives à la croissance des poissons dans les écosystèmes fluviaux sahéliens sont très peu abondantes dans la littérature. Ces milieux représentent un important support à la production piscicole et des études devraient s'intéresser à ces écosystèmes afin de permettre une comparaison de croissance avec les espèces des lacs de barrage, dont l'importance s'accroît d'année en année dans les pays sahéliens.

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BIOLOGY OF *POLYPTERUS SENEGALUS* (PISCES, POLYPTERIDAE) IN THE PRU RIVER, GHANA

BIOLOGIE DE *POLYPTERUS SENEGALUS* (PISCES, POLYTERIDAE) DE LA RIVIERE PRU AU GHANA

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ABSTRACT

The biology of lungfish *Polypterus senegalus* (Pisces, Polypteridae), was studied, based on samples from the Pru River, in Ghana, where it is abundant in backwaters and coves. The length-weight relationship is expressed by the equation $\mathbf{W=0.0963 \cdot L^{3.1}}$ (live weight in g, standard length in cm; n=110). The corresponding mean condition factor ($\mathbf{K=W \cdot 100/L^3}$) was 0.68. Fecundity (F) was related to both standard length (cm) and weight (g) as summarised by the equations $\mathbf{F=227+0.0125 \cdot L}$ and $\mathbf{F=59.3+0.016 \cdot W}$, respectively. Relative fecundity was estimated to be 25.7 eggs per g body weight. Analyses of stomach contents revealed preys consisting mainly of insects.

RESUME

La biologie de *Polypterus senegalus* (Pisces, Polypteridae) a été étudiée à partir de spécimens de la Rivière Pru au Ghana, où cette espèce est abondante dans les bras morts et les anses. Le rapport taille-poids est exprimé par $\mathbf{W=0.0963 \cdot L^{3.1}}$ (poids vif du corps en gramme, longueur standard en cm et n=110). Le facteur de condition correspondant est exprimé par $\mathbf{K=W \cdot 100/L^3}$=0.68. Le rapport de la fécondité (F) avec la longueur standard et le poids est exprimé respectivement par $\mathbf{F=227+0.0125 \cdot LS}$ et $\mathbf{F=59.3+0.016 \cdot W}$. La fécondité relative est estimée à 25.7 œufs par gramme du corps. Des analyses des contenus stomacaux montrent que cette espèce se nourrit principalement d' insectes.

INTRODUCTION

Polypterus senegalus (Cuvier, 1829) is widely distributed in freshwater bodies of West Africa, and is known in Ghana as 'alideka' in Ewe (Titiati, 1970). The fish is a living representative of a group that can be traced to the Devonian period. Its primitive features include "a cylindrical body structure, armour-like scales, a dorsal fin made up of a series of finlets, and fan-like pectoral fins, representing early forms in the evolution of vertebrate limbs" (Holden and Reed, 1972). In addition, the young fish possess external gills, while the adults use lungs to aid in respiration (Holden and Reed, 1972). In Ghana, *P. senegalus* occurs in Volta Lake (Evans and Vanderpuye, 1970), and in most of the Volta basin, including the Pru River, where it is particularly abundant (Abban, 1982). However, its biology has been little studied in Ghana, and hence this contribution.

MATERIALS AND METHODS

Samples were obtained with gillnets and castnets in different parts of the Pru River, and the standard length (to the nearest mm) and weight (to the nearest gram) of fish samples were recorded. The sex and stage of gonad development were determined, based on the scale in Laevastu (1965). The stomach and gonads of each specimen were removed and preserved in 10 % formalin for subsequent food and fecundity analyses. Fecundity was determined by gonad sub-sampling (by weight), as described in Ricker (1968), then plotted against body length, and against weight. Stomach contents were recorded studied using the 'points method' of Hynes (1950), which combines relative volumes and frequencies of occurrence. The parameters a and b of a length-weight relationship of the form $\mathbf{W=a \cdot L^b}$ were estimated by linear regression, after logarithmic transformations.

RESULTS AND DISCUSSION

A total of 110 fish were sampled, ranging in length from 13.8 to 35.1 cm (SL). The linearised version of the length-weight relationship (not shown) gave an extremely good fit, and led to the equation $\mathbf{W=0.0963 \cdot L^{3.1031}}$ with length expressed as standard length (cm) and live weight in gram. Fish with mature ova also had immature ones, suggesting that spawning occurs in multiple batches. Mean relative fecundity was estimated to be 25.7 eggs per g of body weight. The relationship between body length and fecundity was $\mathbf{F=227 + 0.0125 \cdot L}$ (r=0.64; n=16), while that between fecundity and weight was $\mathbf{F=59.3+0.0160 \cdot W}$ (r=0.66; n=16).

As might be noted in Table 1, insects formed 51 % of the diet (in % volume) and occurred in all stomachs sampled; this corresponds with earlier observations of the author (unpublished data), based on samples from the Afram arm of Volta Lake. However, the presence of crabs and of remnant from a large vertebrate (a bird) indicates a high versatility in capturing preys, perhaps one of the reason why this and related lungfish species were able to maintain themselves for so long without marked morphological changes.

Table 1. Diet composition of *Polypterus senegalus* in the Pru River, Ghana (n=40).

Food Items	Volume (%)	Occurrence (%)
Crabs	28	40.0
Birds (1 leg only)	15	2.5
Odonata nymphs	19	100.0
Orthoptera larvae	11	100.0
Tricoptera	10	100.0
Hemiptera	6	100.0
Diptera larvae	5	20.0
Unidentified materials	6	100.0

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MORPHOMETRIC RELATIONSHIPS OF COMMERCIALLY IMPORTANT FISH SPECIES FROM BENIN

LES RELATIONS MORPHOMETRIQUES DES ESPECES DE POISSONS COMMERCIAUX DU BENIN

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ABSTRACT

The Beninese part of the Atlantic Ocean's continental slope is not well known, and this include the aquatic living resources, i.e., the ichthyofauna, which is subjected to high exploitation rates. In order to ensure the sustainable management of these commercially important resources, two research institutions associated with the fisheries services of the Government of Benin performed a study to understand their aquatic resources. The objective of this study was to establish length-weight relationships as well as total length to standard length conversion ratios for the major fish species caught. This was achieved for 22 species.

RESUME

La partie béninoise de la pente continentale de l'Océan Atlantique n'est pas très connue, y compris ses ressources vivantes aquatiques comme par exemple, l'ichtyofaune, soumise à des taux d'exploitation élevés. Afin d'assurer la gestion durable de ces ressources commercialement importantes, deux établissements de recherches associés aux services de pêche du gouvernement du Bénin ont réalisé une étude destinée à mieux connaître leurs ressources aquatiques. Les objectifs de cette étude sont d'établir les rapports de tailles longueur-poids et des longueurs totale-standard pour les espèces les plus importantes. Les résultats présentés ici couvrent 22 espèces.

INTRODUCTION

The fisheries off the coast of Benin play an important role in the national economy. However the past has seen a rather uncontrolled development of this highly diversified sector, which has raised concern about the sustainable management of its resources. In view of this, the University of Benin, the National Oceanographic Centre, and the Department of Fisheries of Benin jointly organised a three-year research programme, devoted to a better understanding of the biology and ecology of the fish fauna off Benin and identification of those shelf areas that might prove suitable for trawl fisheries.

The present report summarises the results of morphometric studies carried out on the major commercial fish species of Benin.

MATERIALS AND METHODS

The data used for this study were obtained during regular trawl surveys that were part of the ongoing research program described above. Each haul was sorted by species and subsamples consisting of 20 individuals for each species of interest were taken. Each fish was weighed, i.e., total wet weight, in grams and standard and total lengths in cm were measured. Length–weight relationships were established according to the function $\mathbf{W=a \cdot L^b}$, where W represents total weight in gram and L represents total length in cm. Total length (TL, cm) to standard length (SL, cm) conversion ratios were then expressed using the linear equation $\mathbf{TL=a+b \cdot SL}$. The parameters (a) and (b) in both of these functions were computed by means of the least squares regression routine of Microsoft Excel for Windows.

RESULTS AND DISCUSSIONS

The parameters of the length-weight relationships estimated for 22 species are summarised in Table 1 together with their respective standard deviation and correlation coefficients. Also presented in this table are values from other studies of the same species. The parameter (b) in the present study ranges from 2.85 (*Epinephelus aeneus*) to 3.65 (*Fistularia petimba*), which is within the typical range of values of (b) usually found in fish. Moreover, the values (2.85 in *E. aeneus* to 3.4 in *B. auritus*) observed in this study for the parameter b of the equation describing the weight-length relationships are very close for all species to values reported in previous study. Indeed, in Nigeria and Brazil for example, Nomura (1962) observed the value 2.91 in *Chloroscombrus chrysiurus*, in Ghana, Rivajec (1973) obtained 2.88 in *Dentex canariensis*. Similarly, the values 3.23 in Sénégal (Magnusson and Showers, 1993), 2.95 in Ghana (Lim, 1987) and 3.29 in South Africa (Van der Elst, 1981) were reported for *E. aeneus*, *Pagrus coeruleostictus* and *Trichiurus lepturus* respectively. The values obtained in those previous studies for the parameter a are generally very low (see Table 1), similar to the one estimated in our study (0.0002-0.0222).

The relationship between standard length and total length for the species investigated in this study are summarised in Table 2. The high correlation coefficients for all of these relationships show that these models are appropriate. Fish size varied from 18.6 cm in *Brachydeuterus auritus* to 73.5 cm in *Trichiurus lepturus*. This shows that species diversity also implies the diversity in size. Size comparisons with results of previous studies indicate that size vary by country, e.g., the maximum size (24 cm; see Beck, 1974) reported for *B. auritus* in Togo is higher than that (18.6 cm) observed in the present study.

ACKNOWLEDGEMENTS

We thank the Japan International Cooperation Agency (JICA) for supporting this research programme by allowing us to use their fishing vessels. The International Center for Living Aquatic Resources Management (ICLARM) and the European Commission (EC) provided scientific and technical assistance through the EC funded project on 'Strengthening Fisheries and Biodiversity Management in ACP countries'. Finally, we thank the Director of the Direction des Pêches in Cotonou and his staff for their help in organising the research work.

Table 1. Length-weight relationships of commercially important species off Benin; total lengths in cm and wet weight in grams.

Species	Mina Common names	TL_{min}	TL_{max}	n	a	sd	b	sd	r^2	Country	Source
Brachydeuterus auritus	Noutoui	7.5	18.6	98	0.0051	0.076	3.36	0.069	0.961	Benin	This study
		–	24.0	–	–	–	–	–	–	Togo	Beck (1974)
		–	30.0	–	–	–	–	–	–	–	Bauchot (1992)
Chloroscombrus chrysurus	Zozroevi	7.8	25.5	71	0.0111	0.059	2.86	0.053	0.977	Benin	This study
		1.0	35.0	–	0.0160	–	2.91	–	–	Brazil	Nomura (1962)
		10.0	24.5	–	0.0699	–	2.52	–	–	Colombia	Garcia *et al*. (1998)
		5.0	28.0	–	0.0140	–	2.78	–	–	Nigeria	King (1996)
Cynoglossus cynoglossus	Afokpakpa	14.5	47.2	30	0.0022	0.068	3.21	0.021	0.985	Benin	This study
		–	–	139	0.0040	–	3.15	–	–	India	Edwards *et al*. (1971)
Dentex canariensis	Cica cica	4.2	34.5	81	0.0154	0.036	2.98	0.029	0.993	Benin	This study
		8.5	40.4	128	0.0169	–	3.04	–	0.989	Gulf of Guinea	Showers (1993)
		16.4	40.4	40	0.0156	–	3.06	–	–	Ghana	Showers (1993)
		–	–	–	0.0223	–	3.00	–	–	Morocco	Mennes (1985)
		–	–	–	0.0189	–	2.88	–	–	–	Rivajec (1973)
Drepane africana	Gbagba	8.2	23.5	103	0.0128	0.028	3.28	0.085	0.991	Benin	This study
		–	45.0	–	–	–	–	–	–	Sénégal	Thiam (1988)
Elops lacerta	Agban	27.0	33.8	5	0.0059	0.033	3.00	0.051	0.944	Benin	This study
Epinephelus aeneus	Toboko	18.6	68.0	9	0.0207	0.099	2.85	0.062	0.997	Benin	This study
		39.0	56.0	14	0.0017	–	3.58	–	–	Cap Verde	Magnusson and Magnusson (1987)
		–	–	–	0.0053	–	3.23	–	–	Sénégal	Cury and Worms (1982)
Fistularia petimba	Dan	46.3	98.0	9	0.0000	0.076	3.65	0.008	0.983	Benin	This study
		19.0	44.0	43	0.0003	–	3.16	–	0.993	New Caledonia	Le Tourneur *et al*. (1998)
Galeoides decadactylus	Shikoue	10.5	34.5	100	0.0102	0.049	3.02	0.037	0.984	Benin	This study
		16.0	32.0	312	0.0119	–	3.14	–	–	Cap Verde	Magnusson and Magnusson (1987)
Ilisha Africana	Kanflanvi	9.0	25.0	178	0.0057	0.050	3.06	0.043	0.967	Benin	This study
		3.5	11.5	114	0.0219	–	2.54	–	–	Nigeria	King (1996)
		11.3	21.1	142	0.0078	–	2.99	–	–	Nigeria	King (1996)
		–	–	–	0.0038	–	3.35	–	–	Sierra Leone	Anyangwa (1991)
Lagocephalus laevigatus	Ako	7.5	47.5	18	0.0187	0.023	2.89	0.052	0.996	Benin	This study
Pagellus bellottii	Cica-cica	13.5	24.1	34	0.0172	0.037	2.92	0.060	0.983	Benin	This study
		10.5	19.5	144	0.0136	–	3.15	–	0.932	Côte d'Ivoire	Showers (1993)

Species	Mina Common names	TL_{min}	TL_{max}	n	a	sd	b	sd	r^2	Country	Source
		10.5	19.8	33	0.0346	–	2.82	–	0.963	Liberia	Showers (1993)
Pagrus coeruleostictus	Cica-cica	7.2	39.6	83	0.0222	0.041	2.88	0.031	0.991	Benin	This study
		12.6	38.3	41	0.0252	–	2.95	–	–	Ghana	Showers (1993)
		19.0	54.0	328	0.0287	–	2.95	–	–	Sénégal	Dah *et al*. (1991)
		–	–	–	0.0025	–	2.95	–	–	Eastern Central Atlantic	Lim (1987)
Pentanemus quinquarius	Shicoue guinfio	11.2	22.8	61	0.0006	0.070	3.43	0.046	0.963	Benin	This study
		10.2	24.0	32	0.0003	0.146	4.07	0.119	0.975	Benin	This study
		–	35.0	–	–	–	–	–	–	–	Daget and Njock (1986)
Pomadasys jubelini	Cocouin	13.2	36.0	20	0.0182	0.071	2.90	0.055	0.994	Benin	This study
		11.8	15.1	17	0.0018	–	2.81	–	–	Nigeria	King (1996)
Pseudotolithus elongatus	Kan	9.0	62.5	250	0.0032	0.046	3.27	0.033	0.975	Benin	This study
		5.5	12.5	88	0.0911	–	3.64	–	–	Nigeria	King (1996)
Pteroscion peli	Finvi	6.5	19.7	147	0.0112	0.004	3.03	0.041	0.974	Benin	This study
		–	32.0	–	–	–	–	–	–	–	Chao and Trewavas (1990)
Raja miraletus	Tatra, Zoun (Fon)	17.5	46.8	10	0.0037	0.004	3.07	0.047	0.994.	Benin	This study
		16.6	41.0	28	0.0003	–	3.25	–	0.998	Spain	Manella *et al*. (1997)
Selene dorsalis	N'gogba	6.5	23.5	69	0.0087	0.018	3.09	0.050	0.953	Benin	This study
		18.0	38.0	85	0.0428	–	2.73	–	–	Cap Verde	Magnusson and Magnusson (1987)
Sphyraena sphyraena	Lizi	8.5	44.8	44	0.0049	0.006	3.01	0.027	0.998	Benin	This study
		33.5	49.8	22	0.031	–	2.32	–	–	Greece	Petrakis and Stergiou (1995)
Trichiurus lepturus	Adokin	23.9	73.5	109	0.0002	0.112	3.33	0.069	0.956	Benin	This study
		59.3	112.0	20	0.0002	–	3.25	–	–	Colombia	Garcia *et al*. (1998)
		28.0	105.0	393	0.0008	–	3.48	–	–	Cuba	Claro and Garcia-Arteaga (1994)
		–	–	–	0.0002	–	3.29	–	–	South Africa	Van der Elst (1981)

Table 2. Relationships between standard length (SL) and total length (TL) of commercially important species off Benin (length in cm).

Species	Mina common names	a	b	r^2
Brachydeuterus auritus	Noutoui	0.732	1.200	0.965
Chloroscombrus chrysurus	Zozroevi	0.134	1.310	0.991
Cynoglossus cynoglossus	Afokpakpa	0.193	1.076	0.999
Dentex canariensis	Cica-cica	0.021	1.300	0.999
Drepana africana	Gbagba	0.758	1.240	0.981
Elops lacerta	Agban	1.646	1.231	0.983
Epinephelus aeneus	Toboko	0.863	1.200	0.994
Fistularia petimba	Dan	9.274	1.242	0.986
Galeoides decadactylus	Shikoue	0.439	1.390	0.982
Ilisha africana	Kanflanvi	0.075	1.240	0.963
Lagocephallus laevigatus	Ako	0.212	1.265	0.927
Pagrus coeruleostictus	Cica-cica	0.219	1.310	0.992
Pentanemus quinquarius	Cica-cica	1.650	1.316	0.973
Pentanemus quinquarius	Shikoue guinfio	0.981	1.300	0.983
Pomadasys jubelini	Cocouin	0.502	1.200	0.997
Pseudotolithus elongatus	Kan	1.474	1.200	0.991
Pteroscion peli	Finvi	0.478	1.290	0.980
Raja miraletus	Tatra, Zoun (Fon)	0.211	1.242	0.986
Selene dorsalis	N’gogba	0.261	1.280	0.991
Sphyraena sphyraena	Lizi	0.161	1.180	0.996

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POPULATION PARAMETERS FOR THE SIX COMMERCIAL SPECIES IN LAKE KAINJI, NIGERIA USING LENGTH FREQUENCY DATA SAMPLED FROM ARTISANAL FISH CATCHES

PARAMETRES DE POPULATION DE SIX ESPECES COMMERCIALES DE POISSONS DU LAC KAINJI, NIGERIA, BASES SUR DES DONNEES DE FREQUENCE DE TAILLES DE LA PECHE ARTISANALE

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ABSTRACT

Estimates of growth parameters are widely used for detailed assessment and modelling of fish species and fisheries. The length-weight relationship, age at length zero (t_o), growth coefficient (K), asymptotic length (L_∞) and rates of natural (M) and total mortality (Z) were estimated for the six main commercial species from the artisanal fishery of Lake Kainji, Nigeria. Length-weight relationships were calculated from individual fish length and weight records collected from sampling using fleets of multi-meshed gill nets. Large numbers of fish lengths for length frequency analysis were obtained by sampling direct from the fishers' catches. Large sized fish were under-represented in the sample since fishers mainly fished with gears that targeted small fish. The number of fish sampled was raised to the total yield of each species and gear type. Data were analysed using the FiSAT software. For four of the commercial species, the estimate of K was around 0.5 year^{-1}, whilst L_∞ was approximately 50 cm. *Lates niloticus* had the lowest value of K (0.25 year^{-1}) and the largest L_∞ (159 cm). *Oreochromis niloticus* had a K=0.25 year^{-1} and L_∞=53 cm. Natural mortality was the lowest for *L. niloticus* (M=0.49 year^{-1}) and fishing mortality was highest for *Chrysichthys niloticus* (F=4.3 year^{-1}). Length-weight, growth parameter and mortality estimates generally agreed with previously published figures from Lake Kainji and elsewhere. The majority of fish caught of the main commercial species in the Lake Kainji fishery were from the 0+ cohort, at a size far below the optimal length at capture. This suggests growth overfishing of the six sampled species. The situation was most apparent for *Citharinus citharus*.

RESUME

Les estimations des paramètres de croissance sont largement utilisées pour des analyses de la biologie et pour la modélisation détaillées de la pêche. Les paramètres du rapport longueur-poids, l'age à la taille zéro (t_o), le coefficient de croissance (K), la longueur asymptotique (L_∞) et les taux de mortalité totale (Z) et naturelle (M) ont été estimés pour les six espèces commerciales principales de la pêche artisanale du lac Kainji, Nigeria. Les rapports longueur-poids ont été calculés à partir des données de longueur et de poids de poissons rassemblés en utilisant des flottes de filets maillants multi-engrenés. Un grand nombre de longueurs de poissons pour l'analyse de fréquence de tailles ont été obtenues par l'échantillonnage direct de la capture des pêcheurs. Des poissons de grande taille ont été sous représentés dans l'échantillon parce que les pêcheurs ont principalement ciblé les petites tailles de poissons. Le nombre de poissons prélevés a été élevé à la production totale de chaque espèce et engin de pêche. Ces données ont été analysées en utilisant le logiciel FiSAT. Pour quatre espèces commerciales, K a été estimé à des valeurs proches de 0,5 an^{-1}, avec L_∞ à près de 50 cm de longueur totale. *Lates niloticus* a eu la valeur la plus basse de K (0,25 an^{-1}) et la plus grande L_∞ (159 cm; LT).

Oreochromis niloticus a eu un K de 0.25 an^{-1} et L_∞ de 53 cm ; LT. La mortalité naturelle la plus basse est celle de *Oreochromis niloticus* (M=0.49 an^{-1}) et la plus haute est celle de *Chrysichthys niloticus* (M=4.3 an^{-1}). Les paramètres du rapport longueur-poids, de croissance et les calculs de mortalité sont généralement conformes aux chiffres précédemment édités pour le Lac Kainji et ailleurs. La majorité des poissons d'espèces commerciales exploitées dans le Lac Kainji vient de la cohorte 0+, à une taille bien au-dessous de la longueur optimale de capture. Ceci suggère une surexploitation de croissance des six espèces prélevées. La situation était la plus évidente pour *Citharinus citharus*.

INTRODUCTION

The World Bank (1992) stated that most fish stocks, globally, are fully or over-exploited. This led them to recommend that fisheries research should be directed towards increasing the understanding to enable accurate management decisions. The recommendation is particularly valid for many tropical reservoir fisheries. An important aspect of such 'management-orientated' research is the estimation of the maximum size and age of fish, length-weight relationships and population parameters of the commercial fish species. These are essential, not only to gain an understanding of the fish species, but also for use in analytical fisheries models; particularly yield per recruit, dynamic pool models, and more recently, for trophic modelling of ecosystems (Ecopath with Ecosim; see Pauly *et al*., 2000). The accuracy of the estimates of population parameters can therefore affect the validity of management decisions.

Within temperate fisheries, otoliths, scales and vertebrae display seasonal markings for both summer and winter. These form daily and/or annual rings, which can be used to indicate the age of the fish (Bagenal, 1974). The lack of defined seasons in tropical fisheries means that often only daily growth rings can be identified and high-powered microscopes are required to count these (Pauly, 1987). It is therefore often difficult and time consuming to age fish species from tropical fisheries using hard parts (Gulland and Rosenberg, 1992).

In the present study the ageing by hard parts was further hampered by the lack of expertise of staff and the fact that fishers were unwilling to allow the cutting and removal of hard parts from their fish. These are likely to be common problems within tropical fisheries of developing countries. A method more suited to tropical fish species has been the conversion of age-based models into length-based models (Sparre *et al*., 1989). This involves the collection of fish lengths from each fish species. The resulting 'length-frequency data' have the advantage that they are relatively quick and inexpensive to collect and that they can be used to give an overview of fishing patterns (du Feu, 2003a). Analysis of length frequency data was made easier through the FiSAT software (Gayanilo and Pauly, 1997[4]).

Despite the voluminous research undertaken since the creation of Lake Kainji, little recent work is directed at estimating the growth parameters of its fish species. Banks *et al*. (1965) presented length at age data for *Oreochromis niloticus* in pre-impounded river fishery, while Lelek (1972) presented those for the early lake fishery. Mean length at age estimates in the lake fishery were made by ageing hard parts for Bagridae (using spines and vertebrae; Ajayi, 1972), Mochokidae (vertebrae; Willoughby, 1974) and *Lates niloticus* (scales; Balogun, 1988).

This paper presents recent estimates of population parameters for the six main commercial species using length frequency data. The parameters estimated for each species include the asymptotic fish length (L_∞), growth coefficient (K), age at length zero (t_o) and the instantaneous rates of natural (M) and fishing (F) mortalities. It is hoped that these estimates will add to those available for tropical fisheries and so assist managers working elsewhere.

[4] Fish Stock Assessment Tools initiated by Daniel Pauly from the ELEFAN software at ICLARM and developed further by F. Gayanilo through a collaborative effort with FAO

MATERIALS AND METHODS

Measurements of length frequency were collected for the six main commercial species of Lake Kainji (Table 1). The species were identified from the yield estimates derived by the 1995 to 1997 catch assessment survey (du Feu 2003b). *L. niloticus* was included due to its high market price and large contribution to the total catch value of the fishery.

Table 1. The six main commercial fish species sampled for length frequency from Sept. 1997 to Dec. 1998 in the Lake Kainji fishery, Nigeria. English common names obtained from FishBase (Froese and Pauly, 2003 and see www.fishbase.org). Hausa common names from Anon. (1997).

Species	Author	English name	Hausa name
Citharinus citharus citharus	(Geoffroy St. Hilaire, 1808-1809)	Moonfish	Falia
Sarotherodon galilaeus galilaeus	(Linnaeus, 1758)	Mango tilapia	Garagaza, Gargaza
Oreochromis niloticus niloticus	(Linnaeus, 1758)	Nile tilapia	Bugu, Falga, Garagaza, Gargaza, Karfasa
Hemisynodontis membranaceus	(Geoffroy St. Hilaire, 1808-1809)	Catfish	Bulundi, Folashe, Karfasa
Chrysichthys nigrodigitatus	(Lacepède, 1803)	Bagrid catfish	Durukulli, Marushe, Tandu, Warushe
Lates niloticus	(Linnaeus, 1758)	Nile perch	Giwan ruwa, Giwan rowan

Two stage cluster sampling and pooling of data was used (Lohr 1999). Sampling stations were Anfani and the Dam site (in the southern basin), Warra and Foge Island (central basin) and Jijima, Zamare and Rofia (northern basin; see Figure 1). Individual fish lengths were sampled from fishers' catch landed at the seven sampling sites during the middle 10 days of every month from September 1997 to December 1998. September represented the time of spawning and the beginning of the first year cohort for many of the sampled species (Omorinkoba and du Feu, 1994). Individual fish lengths were recorded from each fishing gear type and separated into 10 mm length classes (Table 2).

The total number of fish caught during each month for each species, gear type and length class was estimated. This was done by raising the number of fish sampled during the length frequency sampling to the total yield from each gear type using the monthly yield estimates from the catch assessment survey. The length-weight relationships were used to convert fish lengths into weights. The resulting length frequency distribution was assessed to determine whether it represented all sizes of fish occurring within the natural population. To do this, *C. citharus* was used as an example. The distribution from the length frequency sampling was compared with that obtained from gill net trial sampling. Gill net trials involved sampling between February and April with multi-meshed gill nets (mesh sizes 25 to 178 mm) throughout the lake, the catch was assumed to be more representative of the size structure of the fish populations. Numbers of fish lengths were pooled for the three months. To obtain distributions of fish that were comparable, the small number of lengths obtained from the gill net trial (*n*=227) were raised to the total number recorded by sampling fishers' catches.

Estimates of length-weight relationships for the six fish species were obtained from records of individual fish length (L; cm) and weight (W; g) from sampling with different meshed gill nets (gill net trials) undertaken between 1970 and 1996. Both sexes were combined and the relationship expressed as: $\mathbf{W=\log_{10}a+b\cdot\log_{10}L}$. Conversions between length types (total, fork and standard lengths) by species were calculated to enable comparison/conversions with data from other sources (Table 3).

The winter point (WP) was expressed as the fraction of a year at which the species' growth rate was minimal. The amplitude (C), represented by a value between zero and one, describes the magnitude of the annual (seasonal) fluctuation of growth rate. Approximate values of WP and C were estimated considering the limnology and productivity of the lake and the biology of the species.

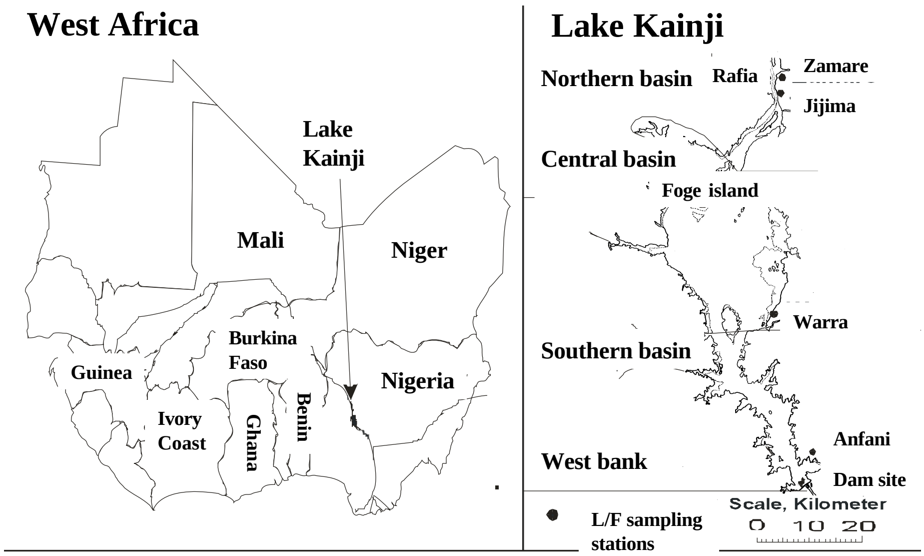

Figure 1. West Africa, showing the location of Lake Kainji and the sampling stations used for the collection of length frequency data.

Table 2. Total number of individual fish lengths sampled in Lake Kainji, Nigeria (Sept. 1997 to Dec. 1998) for each of the six commercial species and fishing gear types. The numbers, rounded to the nearest 100, are given prior to raising to the estimated monthly yield using data from the catch assessment survey. FL: fork; TL: total; and SL: standard length.

	Citharinus citharus	***Sarotherodon galilaeus***	***Oreochromis niloticus***	***Hemisynodontis membranaceus***	***Chrysichthys nigrodigitatus***	***Lates niloticus***	**Total**
L. type	SL	TL	TL	FL	FL	TL	–
Gill net	53100	27000	16100	2500	22000	8000	128700
Drift net	10300	7100	7100	6700	6000	100	37300
Beachseine	15300	3500	2000	6200	1600	600	29200
Cast net	8700	8300	2000	700	0	100	19800
Longline	0	0	100	0	100	1200	1400
Trap	100	5800	10000	200	12000	600	28700
Total	87500	51700	37300	16300	41700	10600	245100

The maximum fish length (L_{max}; cm) was obtained from the gill net trial data and converted to the asymptotic fish length (L_∞; cm), using: $\mathbf{L_\infty=10^\wedge(0.044+0.9841 \cdot \log_{10} L_{max}}$ (Froese and Binohlan, 2000). To facilitate the identification of growth curves, a three-month running mean was applied to the length frequency data for *C. citharus* and *S. galilaeus*. Square root transformation was applied to *O. niloticus* and *C. nigrodigitatus*.

The value of L_∞ was used as an initial input for the estimation of growth parameters by ELEFAN and Shepherd's method (see Gayanilo and Pauly 1997). For those species where the modal length groups for differing cohorts were distinct (*C. citharus* and *L. niloticus*), the growth parameter estimates were verified using Bhattacharya's modal progression analysis. Values were then further refined using Hasselblad's NORMSEP method (Hasselblad, 1966).

The growth rate (K; year^{-1}), the refined estimates of L_∞ and the theoretical age at which the fish has zero length (t_0; years) were calculated using Gulland and Holt and von Bertalanffy plots. Estimates of t_0 were obtained mainly from an empirical model in Froese and Pauly (2003). Length growth performance indices, phi prime (?', for length), were estimated as **?'=log$_{10}$K+2·log10L$_\infty$** (Pauly and Munro, 1984). For each species the mean value of ?' and L_∞ from the ELEFAN and Shepherd's method, Gulland and Holt and von Bertalanffy plots were used to calculate the mean value of K.

Table 3. Length-length conversions of five species from the Lake Kainji fishery, Nigeria calculated from fish lengths (in mm) collected during the gill net trial fishing from 1970 to 1996. TL= total length, FL= fork length, SL= standard length. L_{min}=minimum fish length sampled, L_{max}=maximum fish length sampled, r= coefficient of correlation.

Species	Formula	L_{min}	L_{max}	r	Sample size
Citharinus citharus citharus	TL=1.200FL - 2.90; FL=0.819TL + 5.55	130 FL	528	0.99	261
Sarotherodon galilaeus galilaeus	TL=1.291SL + 2.25; SL=0.772TL - 1.22	43 SL	318	0.99	100
Oreochromis niloticus niloticus	TL=1.251FL + 4.41; FL=0.737TL + 11.14	120 FL	280	0.96	337
Hemisynodontis membranaceus	TL=1.364FL - 14.36; FL=0.705TL + 17.70	76 FL	354	0.98	224
Chrysichthys nigrodigitatus	TL=1.256SL - 6.74; SL=0.791TL + 6.09	16 SL	524	0.99	982

Natural mortality (M; year^{-1}), the mortality caused by all other factors except fishing, was estimated using: $\mathbf{log_{10}M=-0.065-0.287 \cdot log_{10}L_\infty+0.604 \cdot log_{10}K+0.513 \cdot logT}$ (Pauly, 1980). Here, L_∞ is the total length (cm) and T is the mean annual water temperature of 27.85ºC (Mbagwu and Adeniji 1994). Total mortality (**Z=M+F**; year^{-1}) was estimated using Jones' length-cumulation method, i.e., **ln(C$_i$/? t$_i$)=a+b·t$_{il}$**, where ? t_i is the time difference for fish to grow or **1/K·ln(L$_\infty$-L$_{i+1}$)** and **b·t$_{il}$=1/K·ln(1-(L$_i$/L$_\infty$)·(L$_\infty$-L$_i$))**, C_i=terminal catch, L_i=mid point of the length class. The exploitation rate, the fraction of all deaths caused by fishing, was estimated as **E=F/Z**.

RESULTS

Assessment of methodology

The comparison of the distribution of the length frequencies sampled (from fishers' catches) with those obtained from the gill net trial data for *C. citharus* is shown in Figure 2. The data were combined for the three months during which gill net trial samples were collected. The sample number for the gill net trial data was small (n=227) and had to be raised to the higher number of length-frequency data. Results are therefore tentative. Figure 2 also shows that sampling from fishers' catches provided higher proportion of numbers of fish at small size than gill net trial data (fishery independent data) for sizes below 17 cm. For fish lengths greater than 20 cm, the sampling from gill net trial data provided the larger proportion of samples, particularly for sizes greater than 23 cm. The overall distributions are, however, similar.

Estimates of the length-weight relationships

C. citharus and *L. niloticus* exhibited approximate isometric growth, i.e., their growth proceeds in the same dimension as the cube of length (L^3). The four remaining species, the catfishes and tilapia show allometric growth, i.e., growth proceeding in a different dimension than L^3 (see Table 4).

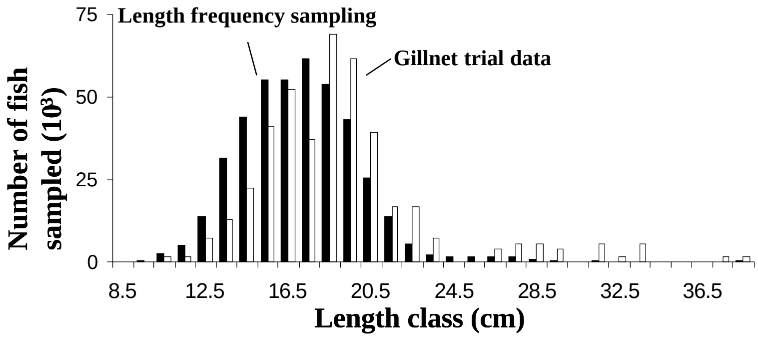

Figure 2. Comparison of the distribution of fish lengths sampled during length-frequency sampling and gill net trial fishing between February and April 1996 for *Citharinus citharus* in Lake Kainji, Nigeria. Total number of fish sampled during the gill net trial fishing was raised to the total number sampled during the collection of length-frequency data. Length classes are 1 cm wide.

Table 4. Length-weight relationships for six major commercial species in the Lake Kainji fishery, Nigeria calculated from fish lengths (in cm) and weights sampled during gill net trial fishing, 1970 to 1996. TL= total length, FL= fork length, SL= standard length. L_{min}=minimum length sampled, L_{max}=maximum length sampled, r^2=Pearson's correlation coefficient, CV=coefficient of variation.

Species	Length type	Sample size	L_{min} (cm)	L_{min} (cm)	r^2*	a	CV Std. Err.	b	CV Std. Err.
Citharinus citharus	FL	185	11.0	28.9	0.94	0.020	0.162	3.04	0.052
							0.003		0.017
Sarotherodon galilaeus	TL	59	12.4	35.7	0.98	0.014	0.004	3.14	0.106
							0.154		0.053
Oreochromis niloticus	TL	15	8.3	19.5	0.96	0.017	0.602	3.13	0.067
							0.010		0.210
Hemisynodontis	FL	381	15.4	28.0	0.67	0.015	0.007	3.12	0.222
membranaceus							0.332		0.113
Chrysichthys nigrodigitatus	FL	191	16.0	30.0	0.83	0.028	0.012	2.79	0.186
							0.279		0.092
Lates niloticus	TL	833	13.0	52.0	0.94	0.015	0.002	2.94	0.049
							0.078		0.025

Estimation of the growth parameters

Citharinus citharus citharus

The first year cohort was well represented in the length frequency sample and showed a prominent progression of distinct modes. The strong representation of the first year cohort was due to the targeting of the species by small meshed nets and the high bycatch of beach seine. Length classes for *C. citharus* older than the first year cohort were less well-defined (Figure 3). Fishing of the upper length classes within first year cohort some five months after spawning (February onwards) caused the modes to have a positive skew. The number of fish sampled declined seven months after spawning (April onwards) due to juveniles leaving the shallow nursery areas and migrating to deeper water. Thereafter, they could not be sampled by the majority of inshore fishing gears. The reduced number was also due to the fishing out of the upper length classes by the fishing methods that targeted small-sized fish.

The initial estimate of L_∞ using gill net trial data was 43.6 cm. The value of K from the scan the K values using ELEFAN was 0.54 $year^{-1}$. The value of R_n (goodness of fit index) was 0.12. Optimising for these two parameters, ELEFAN produced a similar value for L_∞ and a slight increase in K. Response surface analysis gave a slightly higher value for L_∞ and a lower K. Shepherd's scan of K values decreased K to 0.47 $year^{-1}$. Gulland and Holt and von Bertalanffy plots gave lower estimates of K and higher estimates of L_∞. The mean ?' from all these methods was used to calculate the final estimation of L_∞=56.6 cm and K=0.47 $year^{-1}$ (Table 5).

Sarotherodon galilaeus galilaeus

The number of small-sized fish in the length frequency sample of *S. galilaeus* increased from August 1998. This was assumed to represent the time of the main spawning and was used as the starting point for plotting growth curves. Baijot and Moreau (1997) report the main spawning season in small reservoirs in Burkina Faso to be June to August. The value of L_∞, obtained from the gill net trial data, was refined using ELEFAN response surface analysis. Resulting values were L_∞=43.0 cm, K=0.41 $year^{-1}$. The scan of K values gave a higher estimate of K. The ELEFAN optimising routine gave an estimate of L_∞=45.7 cm and K=0.47 $year^{-1}$. Plotting the results from Shepherd's scan of K values back onto the length-frequency curve did not produce a better fit than the results from ELEFAN. The results from the ELEFAN response surface analysis were therefore used as the final estimates.

Oreochromis niloticus niloticus

Using estimates obtained from the gill net trial data as initial inputs for ELEFAN produced high values of L_∞ and K for *O. niloticus*. ELEFAN's scan of K values agreed with these estimates but displayed a second optimum for R_n with a lower K value. Shepherd's scan of K values also gave a lower estimate for K. Final estimates were L_∞=53.2 cm and K=0.29 $year^{-1}$.

Hemisynodontis membranaceus

The length frequency distribution gave a clear depiction of the first, second and third year cohorts. September was used as the starting point for the growth curve. Like many of the lake species, this month corresponds to the peak spawning of the species due to the occurrence of the main flood at this time. ELEFAN scan of K values gave an estimate of K=0.55 $year^{-1}$. The estimate of R_n was improved by using increasing values for L_∞; higher values of L_∞ caused the value of K to decline. An optimum value for R_n=0.16 was achieved, where L_∞=52 cm and K=0.53 $year^{-1}$. The mean of the estimates were used to scan K values. The resulting curve was bimodal and was not used. Response surface analysis also produced a wide spread of values and made the identification of an optimum value of R_n difficult. The identification of peaks in the Bhattacharya's and NORMSEP methods was straightforward. The subsequent linking of means was, however, more problematic. The initial results from ELEFAN were therefore used as estimates of L_∞ and K.

Chrysichthys nigrodigitatus

There was a large variation in the number of *C. nigrodigitatus* sampled every month. This was caused by the seasonality of the trap fishery that was responsible for catching most *C. nigrodigitatus*. Large numbers were sampled in March when fencing of drawdown areas of the lake using traps was prominent. L_∞ was derived from gill net trial data and used for ELEFAN optimising parameter routine. This gave an estimate of L_∞=49 cm and K=0.54 $year^{-1}$. ELEFAN's scan of K values increased the estimate of K to 0.59 $year^{-1}$ (R_n=0.15). Shepherd's scan of K values gave unrealistic estimates of L_∞. Results from ELEFAN were therefore taken as the final estimates.

Lates niloticus

The distribution of length frequencies for *L. niloticus* was dominated by samples from the first year cohort. Older cohorts were represented as smaller modes. The extended breeding period from November to April was evident from the high number of juveniles sampled during this time. ELEFAN's response surface analysis gave estimates of L_∞=155 cm and K=0.27 year^{-1}. ELEFAN's scan of K values produced similar estimates. The values obtained from Shepherd's scan of K values missed several observed peaks when plotted and were not used. Gulland and Holt and von Bertalanffy methods gave estimates that were similar to those from ELEFAN. The K value, calculated from the mean ?' was taken as being representative of the population.

Table 5. Estimates of winter point (WP), amplitude (C) and growth parameters (L_∞, K and ?') of six major commercial species in the Lake Kainji fishery, Nigeria using data collected during the sampling of length frequencies between September 1997 to December 1998. L_∞=asymptotic fish length, K=growth coefficient, ?'=length-based index of growth performance, mean annual water temperature=27.85°C.

Species	WP	C	L_∞ (cm)	K	?'	Method used
Citharinus citharus	0.75	0.2	56.6	0.47	3.17	Mean ?' of ELEFAN, Shepards, Gulland and Holt, von Bertalanffy plots
Sarotherodon galilaeus	0.66	0.2	45.7	0.47	3.00	ELEFAN
Oreochromis niloticus	0.66	0.2	53.2	0.29	2.92	Mean ?' of ELEFAN and Shepards
Hemisynodontis membranaceus	0.25	0.2	52.0	0.53	3.14	ELEFAN
Chrysichthys nigrodigitatus	0.25	0.2	49.0	0.53	3.10	ELEFAN
Lates niloticus	0.17	0.2	158.7	0.25	3.80	Mean ?' of ELEFAN, Gulland and Holt and von Bertalanffy

Mortality rates

Values for total mortality (Z, see Table 6) ranged from 1.39 year^{-1} (*O. niloticus*) to 5.29 year^{-1} (*C. nigrodigitatus*). In all cases, with the exception of *O. niloticus*, the largest proportion of mortality was caused by fishing mortality (F). For *L. niloticus*, *C. nigrodigitatus and S. galilaeus*, F accounted for about 80% of total mortality (Z). Estimates of fishing mortality varied more than natural mortality, from *O. niloticus* (0.62 year^{-1}) to *C. nigrodigitatus* (4.31 year^{-1}). Four of the six sample species had values of F>3.0 year^{-1}. Natural mortality (M) for most of the sampled species was high, as is commonly the case with tropical species. The value of M is a mean for all the cohorts of a species and is therefore usually expected to be highest during the juvenile stages when the number of predators is large. This was the case for *L. niloticus*, whose adults have few predators and has a low overall value of M. The exploitation rate (E) was lowest for *C. citharus* and *O. niloticus* and high for the remaining four species.

DISCUSSION

The objective when sampling length frequencies of fish populations is to ensure that the sampled frequency distribution of fish lengths mirrors that of the actual population (Hoenig *et al*., 1987). To achieve this, the methods of sampling of catch and effort and length-frequencies need to be carefully implemented (Gulland and Rosenberg, 1992). Gulland (1987) pointed out that one way to help ensure that the sample represents the natural population is to collect as many length frequency samples as possible.

Direct sampling of the landed fish catches helped ensure that a large number of fish was measured (*n* ~ 250,000) at minimal expense for the six major commercial species in Lake Kainji. The lowest number was collected for *L. niloticus.* Pauly (1987) recommended that larger sized fish, such as *L. niloticus*, require more samples due to the increased number of age classes in the samples. The average of 700 *L. niloticus* sampled every month is still considered adequate by Hoenig *et al*. (1987). Numbers of fish measured of the remaining five species were in excess of 1,500 fish per month.

Table 6. Total (Z; year^{-1}), natural (M; year^{-1}) and fishing (F; year^{-1}) mortalities, rate of exploitation (E) and length at t_0 (year) for six major species of the Lake Kainji fishery, Nigeria using data collected during the sampling of length frequencies between September 1997 to December 1998 and a mean annual water temperature=27.85°C.

Species	Z	r (Z)	CI (Z) lower	CI (Z) upper	M	M/K	F	E	t_0
Citharinus citharus	2.07	-0.946	1.81	2.33	0.90	1.91	1.17	0.56	-0.04
Sarotherodon galilaeus	4.86	-0.993	4.53	5.19	1.00	2.14	3.86	0.79	-0.30
Oreochromis niloticus	1.39	-0.885	1.15	1.64	0.72	2.48	0.67	0.48	-0.50
Hemisynodontis membranaceus	4.17	-0.947	3.32	5.01	0.97	1.87	3.20	0.76	-0.30
Chrysichthys nigrodigitatus	5.29	-0.990	4.96	5.62	0.98	1.85	4.31	0.81	-0.30
Lates niloticus	3.61	-0.861	2.75	4.47	0.49	1.96	3.12	0.86	0.24

A further advantage of sampling from fish catches was that samples could be raised to the total catch of each gear type. This helped ensure that fish from easily sampled gears did not dominate the final sample. Separation by gear type also enabled later assessment of fishing patterns by gear (du Feu, 2003a).

A problem noted when sampling direct from catches was the possible bias caused by measuring fish only from fishers willing to co-operate with the investigators. This was also noted around Lake Victoria by Garrod (1963). In the case of Lake Kainji, the bias is likely to be small since the main reason that caused fishers not to cooperate was the length of time taken to sample large catches. Large catches were characterised by small fish, which however, were already well represented in the final sample due to the large sample sizes recorded within these length ranges.

The large diversity of fishing methods (and mesh sizes) used in the Lake Kainji fishery meant that a cross section of fish sizes were caught and sampled. The distribution of fish sizes sampled was compared with that obtained from sampling using experimental fishing with graded fleets of gill nets. The comparison is limited due to the small samples obtained from the gill nets and the short three-month sampling period. The method did provide an approximate crosscheck of representation of the sample. The two distributions appeared similar, with the majority of fish being of small size. There was some indication that the larger sized fish in the population were not adequately sampled using lengths recorded from fishers' catches. This was due to the fishers mainly using gears that targeted small sized fish within shallow waters and not fishing in deeper waters where the larger fished lived.

Final growth curves of all the species sampled were therefore mainly based on small sized fish, which implies that ut was difficult to estimate the value of L_∞. It was therefore necessary to verify values of L_∞ from the length frequency sampling with the maximum fish sizes sampled during the historical gill net trial fishing. The lack of large sized fish will also cause mortality to be overestimated. This is because large fish, if not present in the sample, are assumed to have died (Hoenig *et al*., 1987).

This problem is likely to be common. A way to overcome it may be to undertake a more thorough sampling program using a range of experimental gear. However, it is thought unlikely that research or project programs will be able to afford such high intensity sampling. A further consideration is that inland fisheries are increasingly becoming overexploited and therefore a large amount of effort will be required to obtain the sample number recommended by Hoenig *et al.* (1987). An alternative method may be to sample from the fishers, but to raise the final sample numbers by the proportion obtained from experimental gill net trials (or gill nets handed over for the fishers).

The analysis of length frequency data using FiSAT (Gayanilo and Pauly, 1997) did not produce 'clear and unambiguous' sets of values for L_∞ and K. Gulland and Rosenberg (1992) stated that this is a general finding when analysing length frequency data. It was therefore necessary to use a variety of differing analytical routines contained in FiSAT when estimating the growth parameters for Lake Kainji. The mean ?' from the various von Bertalanffy parameter estimates and the mean L_∞ was used to calculate the final estimate of K. The availability of 15 months' worth of data, allowing length curves to overlap, further helped verify results.

The growth curves for Lake Kainji were easier to identify for species that had well defined spawning times and high fingerling growth rates (such as *C. citharus*). Length modes for species with more than one spawning per year (such as the Cichlidae) were less easy to identify. Lelek (1972) who sampled length frequencies just after the impoundment of Lake Kainji reported similar findings.

It is important to compare the growth estimates for Lake Kainji with estimates from other water bodies. Gulland and Rosenberg (1992) suggested that estimates can vary from one water body to another, since environmental factors such as lake productivity, food availability and predation may vary. Such fluctuations will be particularly evident following the initial flooding of reservoirs before the ecosystems have stabilised (du Feu, 2003c). The comparison of estimates from individual reservoirs will therefore also present problems.

The length-weight relationships derived for three species in Lake Kainji were found to agree with previous estimates from the reservoir. These were *L. niloticus* (Balogun, 1988), *H. membranaceus* (Willoughby, 1974) and *C. nigrodigitatus* (Ajayi, 1972).

The mean size of the first year cohort of *C. citharus* was 20.5 cm in the pre-impounded river fishery and was 25.0 cm in the early Lake Kainji fishery (Imevbore and Okpo, 1975). In the present study, the mean size declined to around 15.0 cm. The reduction might possibly have been caused by food not being as abundant as it was during the initial lake flooding. It may also have been due to the decreasing size of gear (such as mesh size) that targeted the upper length classes of these cohorts. This was evident from the lower number of fish sampled within these classes (Figure 3).

FishBase (Froese and Pauly, 2003) was used to compare the growth parameters and mortality estimates with records from other water bodies (Tables 7 and 8). The computed growth coefficient (K) for *C. citharus* in Lake Kainji was slightly less than values reported from Lake Chad in West Africa while estimates of L_∞ were similar (Table 7). Estimates of natural mortality for Lake Chad were similar. However, fishing mortality of the species in the Lake Kainji fishery was slightly lower (Table 8).

S. galilaeus appears to grow slightly larger in Lake Kainji, whilst the growth rate is within the wide range of values reported elsewhere in Africa. Estimates of total mortality were more than double the other values cited for reservoirs in West Africa.

Estimates of L_∞ and K for *O. niloticus* in Lake Kainji agreed with estimates from Lakes Victoria and Nasser and a small reservoir in Nigeria. Comparison of mortality estimates was not possible due to the small number of published estimates. However it appears to be low for Lake Kainji.

Table 7. Comparison of estimates of growth parameters L_∞ (cm); K (year^{-1}), and ?' for major commercial fish species from Lake Kainji, Nigeria using data collected during the sampling of length frequencies between September 1997 to December 1998 with estimates obtained from other water bodies; TL=total length, FL=fork length, SL=standard length. Data arranged by ascending values of L_∞. Records marked with * were recalculated growth parameters using length at age data from cited authors and von Bertalanffy plots.

Species	Locality	Country	Length type	L_∞ (cm)	K (year^{-1})	?'	Reference
Citharinus citharus	Lake Kainji	Nigeria	FL	56.6	0.47	3.17	Present study
	Lake Chad	Chad	TL	49.3	0.54	3.12	Moreau *et al*. (1995)
	Lake Chad	Chad	SL	63.9	0.59	3.38	Benech (1974)
Sarotherodon galilaeus	Lake Kainji	Nigeria	TL	45.7	0.47	3.00	Present study
	Lake Chad	Chad	SL	26.6	0.60	2.63	Moreau *et al*. (1986)
	Petit Bale Reservoir	Burkino Faso	TL	36.2	0.22	2.46	Baijot and Moreau (1997)
	Lake Nasser	Egypt	SL	41.0	0.29	2.68	Moreau *et al*. (1986)
	Lake Kainji	Nigeria	TL	49.7	0.46	5.05	Lelek (1972)*
Oreochromis niloticus	Lake Kainji	Nigeria	TL	53.2	0.29	2.92	Present study
	Lake Nasser	Egypt	SL	52.1	0.26	2.77	Moreau *et al*. (1986)
	Opa Reservoir	Nigeria	TL	56.7	0.26	2.93	King (1997)
	Lake Victoria	Kenya	TL	61.3	0.39	3.12	Dache (1994)
Hemisynodontis membranaceus	Lake Kainji	Nigeria	FL	52.0	0.53	3.14	Present study
	Lake Volta	Ghana	SL	44.5	0.62	3.09	Ofori-Danson *et al*. (2001)
	Lake Kainji	Nigeria	FL	49.0	–	–	Willoughby (1974)
Chrysichthys nigrodigitatus	Lake Kainji	Nigeria	FL	49.0	0.53	3.10	Present study
	Lake Volta	Ghana	SL	44.5	0.65	3.11	Ofori-Danson *et al*. (2002)
	Lake Kainji	Nigeria	FL	45.0	–	–	Ajayi (1972)
Lates niloticus	Lake Kainji	Nigeria	TL	158.7	0.25	3.80	Present study
	Lake Kainji	Nigeria	TL	160.0	0.24	5.76	Balogun (1988)*
	Lake Kainji	Nigeria	TL	174.0	0.26	–	Balogun (1988)
	Speke Gulf, Lake Victoria	Tanzania	TL	185.0	0.17	3.76	Witte and de Winter (1995)
	Nyanza Gulf, Lake Victoria	Kenya	TL	205.0	0.19	3.90	Asila and Ogari (1988)

Table 8. Comparison of the estimates of natural (M; year^{-1}), fishing (F; year^{-1}) and total mortality (Z; year^{-1}) for major commercial fish species from Lake Kainji, Nigeria using data collected during the sampling of length frequencies between September 1997 to December 1998 with estimates obtained from other water bodies. Data sorted by ascending values of Z.

Species	Locality	Country	M	F	Z	Reference
Citharinus citharus	Lake Kainji	Nigeria	0.90	1.17	2.07	Present study
	Lake Kainji	Nigeria	0.75	1.23	1.98	Moreau *et al*. (1995)
	Lake Chad	Chad	1.04	1.56	2.56	Moreau *et al*. (1995)
Sarotherodon galilaeus	Lake Kainji	Nigeria	1.00	3.86	4.86	Present study
	Fleuve Sénégal	Sénégal	1.13	0.99	2.12	Moreau *et al*. (1995)
	Lac Ramitinga	Burkina Faso	1.51		2.28	Moreau *et al*. (1995)
Oreochromis niloticus	Lake Kainji	Nigeria	0.720	0.67	1.39	Present study
	Nyanza Gulf Lake Victoria	Kenya	–	–	3.02	Getabu (1992)
Hemisynodontis membranaceus	Lake Kainji	Nigeria	0.97	3.20	4.17	Present study
	Lake Volta	Ghana	1.28	3.20	4.48	Ofori-Danson *et al*. (2001)
Lates niloticus	Lake Kainji	Nigeria	0.49	3.12	3.61	Present study
	Nyanza Gulf Lake Victoria	Kenya	0.34	1.60	1.94	Asila and Ogari (1988)

The value of L_∞ for *H. membranaceus* agreed with the earlier estimate of the species for Lake Kainji, but was higher than that cited for Lake Volta. Values for K, fishing and total mortality (Z), however, were in agreement.

The estimate of L_∞ for *C. nigrodigitatus* agreed with a previous estimate for Lake Kainji by Ajayi (1972) and with estimates from Lake Volta. Growth rates of *C. nigrodigitatus* for Lake Kainji were slightly lower than those estimated for the species from Lake Volta.

Values of L_∞ and K for *L. niloticus* in Lake Kainji were in agreement with earlier estimates from the reservoir using ageing by scales, and length-frequency analyses by Balogun (1988). Fishing and total mortality were higher than reported in Lake Victoria.

Length frequency studies of *L. niloticus* have mainly been performed in East Africa (Froese and Pauly, 2003). *L. niloticus* in Nigeria do not appear to grow as large as the species in East Africa. The calculated L_∞ and the estimate by King (1997) for the River Niger were lower than values cited for Lake Victoria by Asila and Ogari (1988). The calculated growth rates for Lake Kainji, however, appeared higher than that recorded for Lake Victoria.

Mortality estimates for all sampled species are high. The high rates of exploitation indicate that this is due to high levels of fishing mortality. This agrees with the numbers and sizes of fish caught calculated for the lake fishery. More detailed analysis will be possible when the population parameter estimates are used in fisheries models. The initial indication is that there is a high mortality of the early year groups. The majority of the fish caught were below the optimal length at capture. This suggests growth overfishing. Higher economic return may therefore be possible if the size at capture were increased. The need for management intervention in the Lake Kainji fishery is thus strongly indicated.

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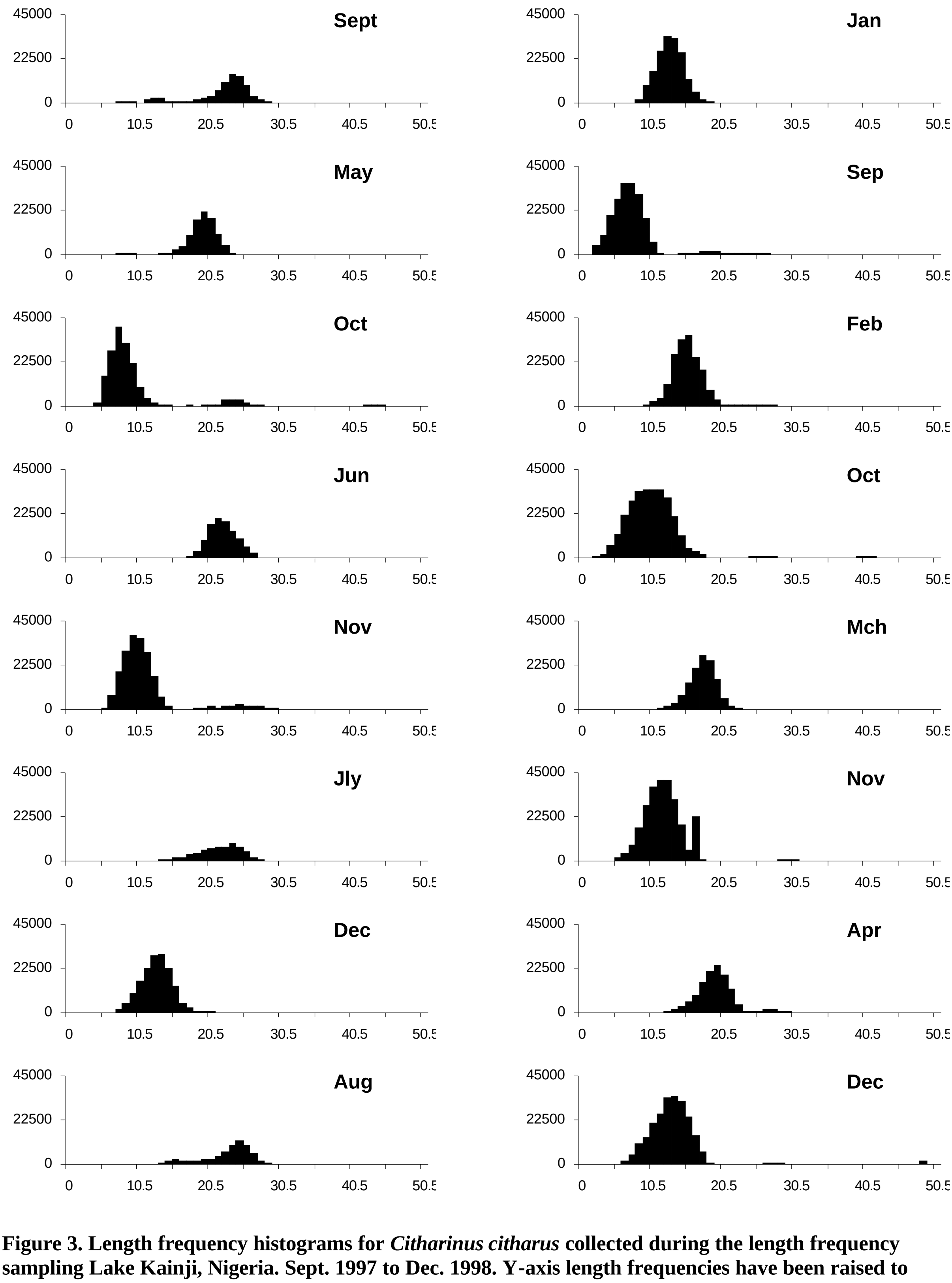

Figure 3. Length frequency histograms for *Citharinus citharus* collected during the length frequency sampling Lake Kainji, Nigeria. Sept. 1997 to Dec. 1998. Y-axis length frequencies have been raised to total catch data from the catch assessment survey. X-axis length classes are 10 mm wide.

GROWTH, FEEDING AND REPRODUCTION OF THE WEST AFRICAN ILISHA, *ILISHA AFRICANA* OFF SIERRA LEONE

CROISSANCE, ALIMENTATION ET REPRODUCTION DU LATI, *ILISHA AFRICANA*, AU LARGE DE LA SIERRA LEONE

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ABSTRACT

Samples of *Ilisha africana* (Bloch, 1795) were collected from the artisanal beach seine fishery in Sierra Leone, West Africa, from July 1993 to March 1994, and used to estimate growth and diet-related parameters. The relationship between weight (in gram) and total length (cm) for *I. africana* (male and females combined) was found to be $W=0.008 \cdot L^{2.94}$. Length at first maturity was 12.6 cm for males and 14.6 cm for females. Fecundity ranged from 6,384 to 17,219 eggs per individual, while the relationship between fecundity (F) and body size (total length) was best described by the model $F=27.6\ L^{2.088}$. Growth parameters of the VBGF were estimated as asymptotic length=28.2 cm and K=1 $year^{-1}$. Natural and apparent total mortality were 1.8 and 5.5 $year^{-1}$, respectively, the latter being an overestimate due to the migration of older specimens from the sampling area.

The diet composition showed a gradual transition from a predominance of crustaceans and detritus in smaller fish, towards a substantial portion of the diet being fish in larger specimens. January was identified as a month with high spawning activity for *I. africana*, with the data suggesting the existence of another spawning period in August/September.

Implications for management suggest that there is a high risk of both recruitment and growth overfishing for this species, if it is to be found that it also makes up a large proportion of the usually discarded catch of the shrimp fishery operating in deeper waters.

RESUME

Des échantillons d'*Ilisha africana* (Bloch, 1795) ont été rassemblés à partir de la pêche artisanale par seine de plage en Sierra Leone, Afrique occidentale, de juillet 1993 à mars 1994, et ont été employés pour estimer les paramètres de croissance et le régime alimentaire. Le rapport entre le poids (en gramme) et la longueur totale (en centimètre) pour *Ilisha africana* (mâle et femelles combinés) a été calculé à $W=0.008 \cdot L^{2.94}$. La longueur à la première maturité sexuelle était de 12,6 cm pour les mâles et de 14,6 cm pour les femelles. La fécondité est de 6.384 à 17.219 oeufs par individu ; le rapport entre la fécondité (F) et la taille du corps (longueur totale) est décrit par l'équation $F=27.6\ L^{2.088}$. Les paramètres de croissance, suivant l'hypothèse de von Bertalanffy, ont été estimés en tant que longueur asymptotique de 28,2 cm et K de 1 an^{-1}. La mortalité naturelle et la mortalité totale apparentes étaient

1,8 et 5,5 an^{-1}, respectivement, cette derniere valeur étant une surestimation due à la migration des spécimens âgés de la zone échantillonée.

L'étude du régime alimentaire a montré une transition progressive des crustacés et du détritus chez les plus petits poissons vers le poisson aux plus grands spécimens. Janvier a été identifié comme le mois d'activité reproductive élevé; les données ont suggéré l'existence d'une période de ponte additionelle en août et septembre.

Les implications pour la gestion suggèrent un un gros risque de surexploitation pour cette espèce, notamment si elle contribue également une grande proportion de la capture habituellement rejetée par la pêche dans les eaux plus profondes

INTRODUCTION

Ilisha africana (Bloch, 1795) (Figure 1, inset) occurs along the West African coast from northern Sénégal to Angola. It is a typical representative of a group of small predatory clupeids with a laterally flattened body, relatively small tail and a large up-turned mouth. This bentho-pelagic species occurs in warm inshore waters, along sandy beaches and further offshore, often down to about 25 m water depth, where it forms a common constituent of tropical trawl catches (Longhurst and Pauly, 1987). It is also found in brackish waters, lagoons and estuaries, penetrating into near freshwater (Fischer *et al*., 1981; Marcus and Kusemiju, 1984; Whitehead, 1985; Yankson and Azumah, 1993).

In Sierra Leone, *I. africana* is an important component throughout the year in artisanal landings at most coastal beaches and estuaries along the coast (Okera, 1978), where it is fished with beach seines from the shore. It is also caught in the Sierra Leone River estuary in accord with its tolerance for estuarine conditions. In the early 1990, total annual catch in Sierra Leone was reported to be around 3,000 t (FAO, 1999), which might be an underestimate, given the inaccessibility to fisheries officers of many of the fishing villages along the Sierra Leone coast.

The present study is an attempt to estimate a number of biological and ecological parameters pertaining to *I. africana*, as required for managing the fishery and constructing ecosystem models of the near-shore waters as was done, e.g., for Mozambique (Paula e Silva *et al*., 1993), Brunei Darussalam (Silvestre *et al*., 1993) or the northeastern Venezuela shelf (Mendoza, 1993).

MATERIALS AND METHODS

Sampling

Fish samples were obtained twice monthly from July 1993 to March 1994, except for November and December during which *I. africana* was absent from the catches. Until February 1994, samples were collected from beach seine catches landed at Goderich village and caught at adjacent beaches (see Figure 1). In March 1994, the samples came from Hamilton village because of the absence of *I. africana* in the catches landed at Goderich.

At each sampling event, large samples of *I. africana* were taken at random from the catches and used for length measurements yielding 4,456 fish measured during the period of investigation. Measured fish were arranged by length and then sub-samples were taken for further studies at the rate of at most 15 specimens per one-centimeter length group.

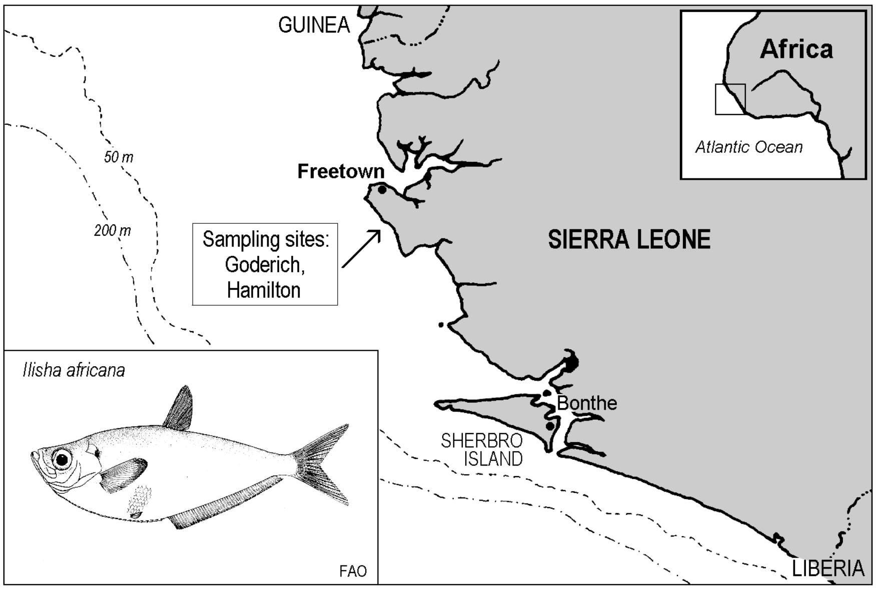

Figure 1. Map showing the coastline of Sierra Leone and the location of the sampling sites; inset: *Ilisha africana* reproduced from Whitehead (1985).

Length and weight measurements

Length measurements taken included total length (TL) and standard length (SL), the latter measured from the tip of the mouth to the end of the hypural bone, with both lengths measured to the lower centimetre. Weight (W) is expressed as fresh weight, measured to the nearest gram.

The length-weight relationship is expressed by the equation: $\mathbf{W=a\cdot L^b}$, where W is the body weight of fish (in g); L, the body length (cm; TL); a, the multiplicative factor; and b, the exponent of the length-weight relationship. To estimate the regression coefficients a and b, the length-weight data pairs were analysed by ordinary least square regression, using a linearised form of the above equation, viz.: $\mathbf{\log_{10}W=\log_{10}a+b\cdot\log_{10}L}$. The goodness of fit of the regression analysis is estimated by r^2.

Length frequency analyses

All analysis of length frequency data was done with the FiSAT software of Gayanilo *et al.* (1996), which includes the ELEFAN routine for estimating growth parameters.

Growth

The growth in length of *I. africana* is assumed to be best described by the von Bertalanffy Growth Formula (VBGF), *viz*.: $\mathbf{L_t=L_8\cdot(1-e^{-K\cdot(t-to)})}$; where, L_t is the mean total length (in cm) of the fish at age t; L_∞ is the mean asymptotic total length (cm); K is a growth constant ($year^{-1}$); t is the age of the fish; and t_0 is the theoretical "age" of the fish at zero length. For the purpose of this analysis the "age at zero length" (t_0) was set to zero. Thus, all time dimensions in the analysis are expressed in relative terms. This, however, has no influence on the results presented here. With the growth parameters L_∞ and K thus obtained, the growth performance index ?' (Pauly and Munro, 1984) was computed from: $\mathbf{?'=\log_{10}K+2\cdot\log_{10}L_8}$, with the parameters K and L_∞ as defined above.

Mortality

Total mortality (Z) can often be estimated from a length converted catch curve under the assumption that the collected length frequency data represent a steady-state population. If other factors, such as the migration of older (= larger) specimens to areas beyond the reach of the sampling gear influence the shape of the length frequency histograms, the computed total mortality is overestimated (hence “apparent” total mortality).

The routine provided in FiSAT to compute total mortality is basically a plot of number of fish occurring in a certain length class divided by the time (Δt) it takes a fish to grow through a length class, vs. the mean (relative) age of the fish in that length class. Z is estimated by means of linear regression of the form: $\mathbf{ln\cdot(N_i/?\,t_i)=a+bt_i}$, where, N_i is the number of fish in length class i; Δt_i is the time needed for the fish to grow through length class i; t_i is the (relative) age of the fish in length class i; a, b the coefficients of the regression analysis; where b (with signed changed) is an estimate of total mortality Z.

Natural mortality (M) was computed using an approach suggested by Pauly (1980), which relates natural mortality to the growth parameters L_∞ and K of the VBGF and to mean annual water temperature (T, in °Celsius).

Diet composition

Stomach fullness

For each specimen in the sub-sample, for which weight and length were measured, an analysis of stomach content was carried out. To this end, the stomachs were dissected and the degree of stomach fullness was estimated visually for each fish using a ‘point’ method, wherein a zero point was allotted to a completely empty stomach, 10 for a fully distended stomach, and intermediate values ranging from 1 to 9 to stomachs with increasing degrees of fullness.

Relative food abundance

The stomachs were fixed in 5% formalin before proceeding with the identification of food items. Food items were sorted into five major groups, *viz.*: ‘Fish’, ‘Crustaceans’, ‘Phytoplankton’, ‘Detritus/Sand’, and ‘Miscellaneous’. The food items usually contained in these groups are listed in Table 1. In addition to these five groups, the occurrence of nematodes in the stomachs was noted, though nematodes are not food, but parasites. Where necessary, identification of the various items was done with the help of a low power microscope. No attempt was made to identify items to the species level. Occurrence of each of the predefined food groups in a stomach was expressed on a relative scale ranging from zero (food group not present in stomach) to ten (food group is the only one present in the stomach) (Kikuchi and Yamashita, 1992).

Table 1. Food items making up the five food groups defined for *Ilisha africana* sampled from catch landings in Goderich, Sierra Leone from July 1993 to March 1994.

Food Group	Food Items
Fish:	Fish, fish larvae, scales, eggs, fish bones;
Crustaceans:	Pink and white shrimps, crabs (appendices), stomatopods, copepods, amphipods;
Detritus/Sand:	—
Phytoplankton:	Noctiluca, Trichodesmium, Bacillaria, diatoms;
Miscellaneous:	Molluscs, insects, coelenterates and unidentified debris.

Reproduction

Maturity stages

Specimens from the sub-sample with weight and length measurements were used to determine maturity stages. The gonads were dissected, weighed (accuracy=0.01 g), and the sex and maturity stages determined by direct observation using (for the latter) the scale of gonad maturity stages given by Marcus and Kusemiju (1984).

Fecundity

Fecundity was determined by estimating the average number of eggs contained in the ovaries. Samples of *I. africana* for fecundity estimates were obtained in different months of the study period. Only gonads at maturity stages III, IV and V were selected, yielding sixteen such gonads during the period of this study. The gonads were dissected, weighed and preserved in Gilson's fluid for about three months to break down the ovarian tissues and separate the eggs from each other. Then the eggs were fixed in 5 % formalin to be hardened until ready for counting. Before counting, the formalin was decanted and replaced with water to clean the eggs, and remove the ovarian tissues; any remaining tissues were removed manually.

Egg counts weres done using the wet gravimetric sub-sampling method. The eggs of a single gonad were filtered and total weight (W_t) determined. The sample was then split into sub-samples and the weight measured (W_s). A number of these sub-samples were spread over a grid of 1 cm x 1 cm squares, and the eggs in randomly selected squares counted. The average number of eggs per square raised to the total number of squares containing eggs gave an estimate of the total number of eggs in a sub-sample (N_s). The sum of these counts, raised by the relationship between total sample weight and accumulated weight of sub-samples used for egg counts then gave the estimated total number of eggs (N_t) in an ovary, or: $\mathbf{N_t=[S(N_{s1},. N_{s2},\ldots N_{sn})/S(W_{s1}, W_{s2},\ldots W_{sn})]\cdot W_t}$. This gravimetric method is reported to sometimes generate an underestimate (Bridger, 1961). However, Wolfert (1969) reported that the method produced less variable results than the one based on volumetric measurements.

RESULTS AND DISCUSSION

Length-weight relationships

Table 2 summarises the length-weight parameters and their corresponding statistics. A comparison of the coefficient b of the length-weight relationship suggests that females have a higher value of b than males in *I. africana*. While this might be true to some extent the present data set also shows that such results are easily generated by the inability to sex smaller individuals (hence the large number of unsexed fish in the sample). The parameter b for unsexed fish is much lower (2.87) than the one for males (3.06) or females (3.26), as is the average length in this group compared to those of males and females (9.1 cm *vs* 12.4/13.2 cm). As a consequence it is felt that the result of b for all specimens combined (2.94) represents best the length-weight relationship in *I. africana* over the whole length range. Only if dealing specifically with larger specimen of *I. africana* might it be worthwhile to consider using the sex-specific values of b listed in Table 2.

Length conversions

A total of 622 pairs of values for total length (TL) and standard length (SL) were available to compute the relationship between TL and SL. Using linear regression analysis and forcing the regression line through the origin of the coordinates, two relationships were obtained: one predicting SL from TL and the other to predict TL from SL. The resulting formulas are **SL=0.814·TL** and **TL=1.227·SL**.

Table 2. Length-weight relationships of *Ilisha africana* sampled from catch landings in Goderich, Sierra Leone from July 1993 to March 1994. Summary of the parameters obtained through regression analysis, separately by sex, and all specimens combined

Parameters	Male	Female	Unsexed	Combined
Constant (a)	0.006	0.004	0.010	0.008
Coefficient (b)	3.063	3.255	2.873	2.944
Regression coefficient (r2)	0.940	0.946	0.941	0.958
No. of observations (n)	216	246	159	621
Std. Error of constant (Sa)	0.058	0.056	0.054	0.026
Std. Error of coefficient (Sb)	0.053	0.050	0.057	0.025
Std. Error of Y-estimate (S(y))	0.060	0.060	0.106	0.077
F statistics	3368	4273	2506	14186
Min. length	6.5	7.3	3.8	3.8
Max. length	19.1	21.2	22.6	22.6
Average length	12.4	13.2	9.1	11.9

Length at first maturity

Length at first maturity (L_{m50}) is the length at which 50 % of the fish have reached maturity. Figure 2 presents a cumulative plot of number of mature specimens versus total length for both sexes in *I. africana*. Using a weighted average of the values in the two length classes adjacent to the 50 % maturity level, the corresponding values for L_{m50} are as follows: Male, 12.6 cm (n=216); Female, 14.6 cm (n=246). This suggests that male *I. africana* attain maturity at a smaller size than females, the difference being almost 15 % of their total body length at that stage. The smallest male found in the sample to have reached maturity measured 10.1 cm, while the corresponding size for females was 12.6 cm.

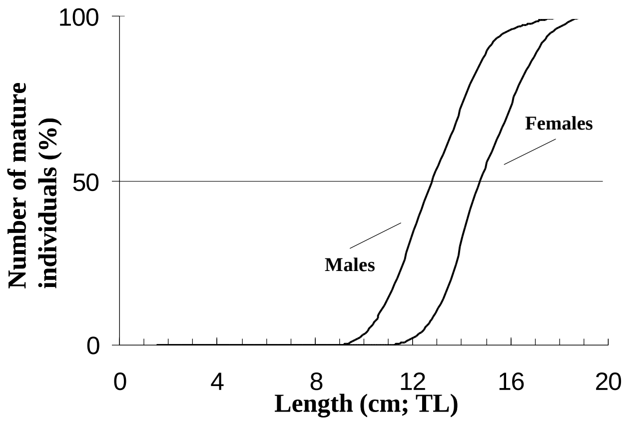

Figure 2. Cumulative plot of length at first maturity for *Ilisha africana* sampled from catch landings in Goderich, Sierra Leone from July 1993 to March 1994; shown separately for males and females.

Growth

The analysis of the length frequency data with ELEFAN (see Figure 3) yielded growth parameters, summarised in Table 3 which also includes results for the same parameters from other growth studies for *I. africana*. The results are comparable to those obtained for this species in a predominantly marine environment in Nigeria. *I. africana* from the Niger Delta seems not to reach such large sizes as in Sierra Leone. But on the other hand, it approaches its asymptotic length much faster as manifested by a higher value of K. As different as the growth parameters in Table 3 might look, the underlying growth performance is very similar, as is shown by the relatively narrow range of ?' values (2.85-3.05).

Table 3. Growth parameters of the von Bertalanffy Growth Formula (L_∞ and K) and growth performance index ?' for *Ilisha africana* (unsexed, total length in cm) sampled from catch landings in Goderich, Sierra Leone from July 1993 to March 1994.

Country	L_∞ (LT, cm)	K (year^{-1})	φ'	Source
Nigeria (east of Niger delta)	22.0	2.33	3.05	Stockholm and Isebor (1993)
Nigeria (marine)	29.6	0.80	2.85	King (1997)
Sierra Leone (south of Freetown)	28.2	1.00	2.90	this study

Figure 3 presents the length frequencies of *I. africana* with the growth curve as identified by ELEFAN superimposed as a solid line. Fish represented by this growth curve have been hatched early May and will take about two years to come within 80 % of their asymptotic length. As *I. africana* can be expected to have two spawning periods per year, as do many other tropical fishes (Longhurst and Pauly, 1987), a second growth curve with the same parameters was drawn over the length frequencies to trace the growth of a second batch of recruits. Jointly, the two growth curves explain well the peaks in the frequency histogram. The origin of the second curve suggests the birth-date of these recruits to be in January, which coincides with a high level of maturity stages in *I. africana* at that time (see below).

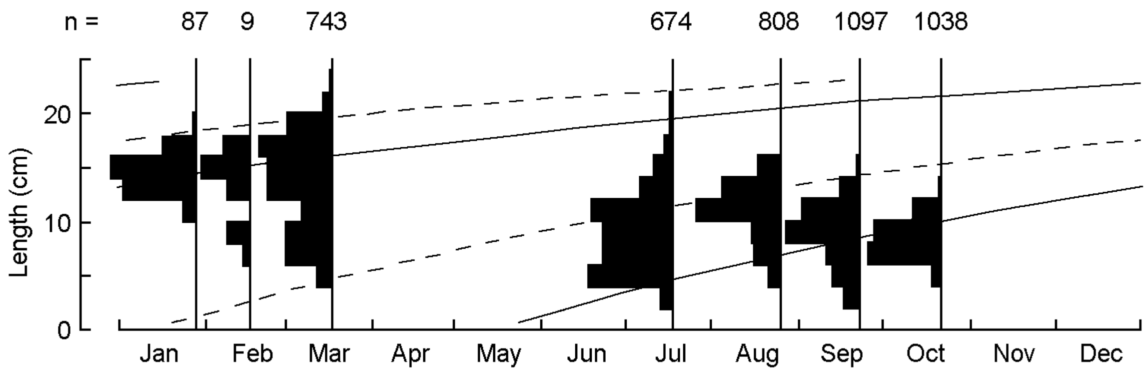

Figure 3. Length frequencies of *Ilisha africana* sampled from catch landings in Goderich, Sierra Leone from July 1993 to March 1994, with superimposed VBGF. Both curves are based on the same set of growth parameters, i.e., L_∞=28.2 cm TL and K=1.0 year^{-1} (R_n=0.366). Note that for a better presentation of the growth curves, samples from 1993 have been plotted as samples taken at the same time in 1994. This has no effect on the results but facilitates the visual interpretation of the data.

Mortality

Using the approach of length converted catch curves in FiSAT, apparent total mortality (Z) was estimated to be 5.5 year^{-1} (r=0.983). The confidence interval for this estimate ranges from 4.32 to 6.67 year^{-1}. However, the absence of larger specimens from the samples (Figure 3) and the seasonal disappearance of *I. africana* from the sampling area indicate a regular migration pattern of older fish towards deeper waters. This violates the assumption of the samples representing the entire population. Thus, the above estimates are most likely an overestimate of the true value of the total mortality. Natural mortality (M) calculated from Pauly's (1980) equation, the VBGF growth parameters and a mean annual water temperature (T) of 27.8°Celsius resulted in an estimate of M=1.81 year^{-1}.

Diet composition

A total of 621 specimens were analysed for the months of July, August, September, October and January. Out of these, 117 (18.8 %) had empty stomachs. The total lengths of the specimen examined ranged between 3.8 cm and 22.6 cm. Occurrence of food items was assessed using a point system based on visual examination of the stomachs. Though not as accurate as a weight-based assessment method, it allows for the rapid examination of a large number of samples, and thus was given preference in this study. Table 4 summarises the diet composition in each sampling month, while Table 1 provides the list of items contained in each group. Figure 4 presents the overall diet composition for *I. africana* (sum of monthly totals, weighted by sample size).

Table 4. Monthly variation in the distribution of various components of the diet of *Ilisha africana* sampled from catch landings in Goderich, Sierra Leone from July 1993 to March 1994; food points, expressed in percent of total food points accumulated in each month.

Sample Month	Sample Size (n)	Fish	Crustaceans	Detritus	Phyto-plankton	Misc.
Jul-93	97	37.3	18.5	22.0	5.2	17.0
Aug-93	224	43.3	26.3	13.1	3.6	13.7
Sep-93	100	22.0	49.5	11.3	6.9	10.3
Oct-93	150	33.8	9.0	32.2	8.0	16.9
Jan-94	50	34.7	38.0	12.2	1.8	13.4

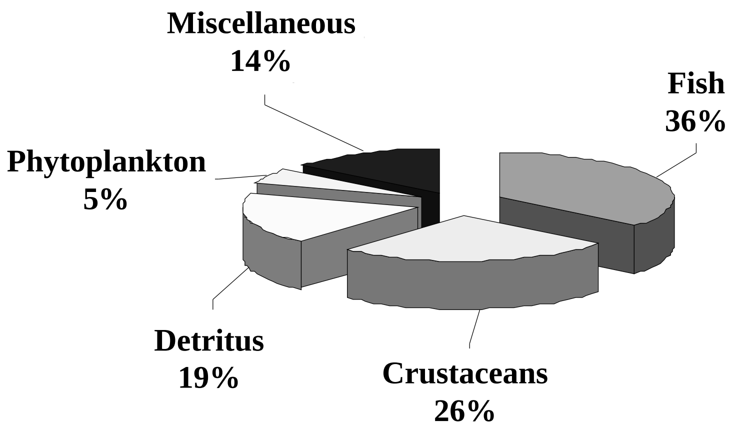

Figure 4. Diet composition of *Ilisha africana* for the period July 1993 to January 1994 from catch landings in Goderich, Sierra Leone; total occurrence in percent, weighted by monthly sample size and summarised over all months.

The relative distribution of the various food item groups in Figure 4 clearly shows the overall importance of fish as food for *I. africana* (35 %) followed by the group ‘crustaceans’ (25 %) and ‘detritus/sand’ (18 %). The rest consisted mainly of molluscs, insects, and unidentified items (‘miscellaneous’); ‘phytoplankton’ comprised only a very small portion in the diet of *I. africana* (5 %). The general pattern of this diet composition remained the same throughout the period of investigation, except for the month of September, where there was a dominance of crustaceans in the diet. September is the height of the rainy season in Sierra Leone. Thus, this result might reflect the decreased availability of fish as food to *I. africana*, due either to changes in salinity (and hence changes in distribution pattern of their prey) or increased turbidity of the coastal waters, making the catching of their regular prey more difficult.

Figure 5 summarises the occurrence of the various diet components observed in *I. africana* in relation to body size. Data were aggregated by 2 cm length classes (TL) over the whole period of observation. It clearly shows the gradual change from a predominantly crustacean/detritus diet in the younger stages of *I. africana* to a diet in the older individuals, where fish plays the most important role. The 'miscellaneous' component, which comprises molluscs, insects and unidentified matter, occupies a fairly constant proportion of the diet throughout the life span of *I. africana*, whereas phytoplankton and detritus tend to disappear from the diet of older individuals. The nematodes found in the stomachs of *I. africana* were considered parasitic and, thus, not part of their diet. Infestation with parasites (here expressed as the occurrence of nematodes in the stomach) seems generally low, reaching a maximum of 3 % in larger individuals.

Fecundity

Egg counts were carried out on 16 preserved females, with lengths ranging from 14.0-22.6 cm LT and weights from 20.0-70.8 g. Fecundity started at 6,384 eggs and reached 17,219 eggs in larger individuals. Using the geometric mean of this range, the average fecundity of *I. africana* is about 10,484 eggs per female, which is slightly higher than the 8,716 eggs per individual reported from a Nigerian estuary (King, 1991). Relative fecundity varied between 221 and 369 eggs per gram body weight (mean=295).

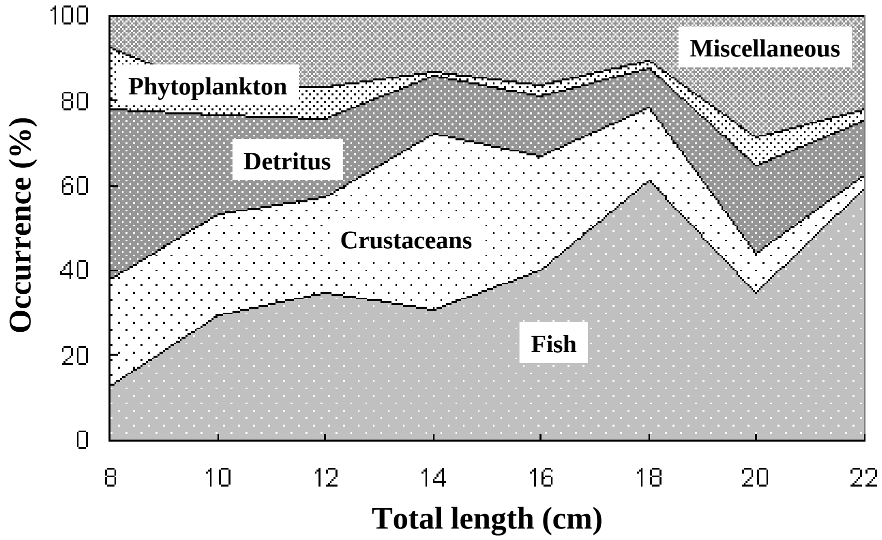

Figure 5. Length-dependent variation in diet composition of *Ilisha africana* for the period July 1993 to January 1994, sampled from catch landings in Goderich, Sierra Leone.

The relationship between fecundity on one hand and fish length, body weight, respective gonad weight on the other were investigated by means of least square regression technique with fecundity being set as the dependent variable. These relationships can be described by the following models (r^2, i.e., fit of the log-linear regression analysis): a) total length (TL, cm), $\mathbf{F=27.6 \cdot L^{2.088}}$, ($r^2$=0.923); b) body weight (W, gram), $\mathbf{F=993.1 \cdot W^{0.662}}$, ($r^2$=0.937); c) gonad Weight (G, gram), $\mathbf{F=11967.4 \cdot G^{0.672}}$, ($r^2$=0.797). While the correlation between fecundity and length, respective body weight, is quite strong, this is less obvious in the relationship between fecundity and gonad weight, an observation also reported elsewhere (Marcus and Kusemiju 1984; King *et al*. 1991).

Spawning periodicity

The classification of the gonad stages was used to identify months with a high percentage of individuals in spawning condition (stages III and higher). Table 5 presents the results of the monthly variation in the percentage of mature individuals in the samples.

Table 5. Monthly distribution of percentage of mature males and females of *Ilisha africana* (gonad stage III and higher) for the period July 1993 to January 1994, sampled from catch landings in Goderich, Sierra Leone.

	Females			Males		
Month	Number immature	Number mature	% mature	Number immature	Number mature	% mature
July	23	12	34.3	26	10	27.8
August	68	15	18.1	20	59	74.7
September	38	0	0.0	10	25	71.4
October	60	3	4.8	24	20	45.5
January	8	19	70.4	0	22	100.0

Both females and males of *I. africana* show a very clear peak of spawning activity in January, where 70 % of the females and 100 % of the males are in spawning condition. For the other sampling months, the situation is less clear. Practically no females in ripe conditions were observed in September, while in the same time males seem to be in another period of high spawning activity. Such an asynchronous pattern in a spawning cycle, however, seems very unlikely to occur naturally and the results, therefore, should be treated with some scepticism. It might very well be that larger sample sizes are needed to obtain a clearer picture of this possible second spawning period. It was also noted that while maturing individuals were frequently found in the samples, occurrence of spawning and/or spent individuals was rather the exception.

Implications for management

It has been previously mentioned that larger specimens of *I. africana* are generally missing from the catches of the beach seines at the sampling site. This selectivity towards smaller and younger individuals of the population is most likely due to the size-dependent distribution of the species, the larger ones usually being found in deeper waters and thus out of reach for beach seines.

In order to assess in a more general context the possible effects of the beach seine fishery on the *I. africana resource* off Sierra Leone, the available length frequencies (weighted by sample size) were used to generate a single frequency distribution representative of the average length composition of the species in the catches over a year (see Figure 6). This distribution peaks at a total length of 9 cm. As suggested by Froese and Binohlan (2000), index lines were added to the graph, which place the frequency distribution into a framework of biological parameters against which fishing practices can be assessed.

These index lines comprise the length at first maturity (L_m) for males (12.6 cm TL) and females (14.6 cm TL), as well as the asymptotic length (L_∞, 28.2 cm TL) of the VBGF. Clearly, the bulk of the catches comprise specimens of a length considerably below the line where 50 % of the fish attain maturity and practically no fish is caught in the upper third of the length range.

The implications of this will largely depend on the question whether the length distribution shown here is characteristic of a heavily exploited fishery or whether the catches represent only a small fraction removed from the stocks. If the latter applies, there is little reason for concern, as the remaining stock is probably not much affected. In case exploitation is high, it is very likely that recruitment overfishing occurs, i.e., the stock's capacity to reproduce may be affected. The fact that larger fish are absent from the catches could have a positive impact on recruitment, though, as in fish the old, large females are known to have a comparatively much higher fecundity than smaller ones. However, a large trawler fleet usually operates in the deeper waters off the coast of Sierra Leone (Vakily, 1992), which is very likely to add more fishing pressure on the stocks of primarily larger specimens of *I. africana*. Before a conclusion can be drawn, information from the Sierra Leone industrial fishery is needed on catch, effort, and size distribution in respect to *I. africana*.

Beside recruitment overfishing, another factor to consider is whether a fishery makes good use of the available growth potential of a species. The optimum length (L_{opt}) at capture for a given stock is defined as the length where the product of individual times their average weight reaches a maximum, as determined by means of yield per recruit analysis. Applying this concept to a large data set consisting of estimates of asymptotic length and a corresponding value of L_{opt}, Froese and Binohlan (2000) have shown that L_{opt} can be estimated from asymptotic length (L_∞) using the empirical relationship: $\mathbf{\log_{10}L_{opt}=-0.2161+1.0\cdot\log_{10}L_8}$ (see Froese and Binohlan, 2000, for the estimation of confidence intervals).

The shaded area in Figure 6 denotes the length range at which *I. africana* is assumed to produce an optimum yield for an L_∞ of 28.2 cm TL. This range lies between 16 and 18 cm. Most of the catch, though, consists of smaller fish. It thus can be assumed that the beach seine fishery investigated in this study does not make full use of the growth potential offered by *I. africana*. This would have to be considered when making a comprehensive assessment of the catches and the species composition of this fishing gear. If *I. africana* turns out to be the main target species, it might be worthwhile to develop a fisheries management plan for these beach seines that will ultimately increase the average size of this species in the catches.

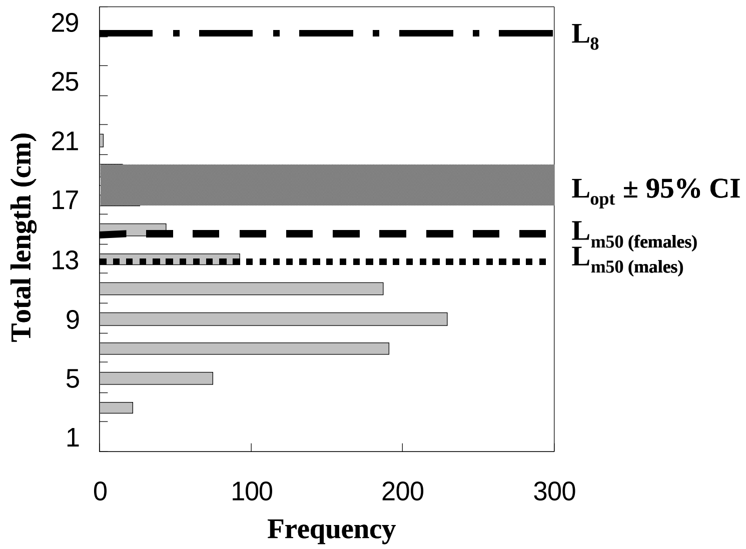

Figure 6. Average size distribution of *Ilisha africana* in beach seine catches with superimposed lines identifying the length at first maturity (L_{m50}) for males and females, as well as the asymptotic length (L_∞) given by the von Bertalanffy growth function. The grey shaded area denotes the mean length (L_{opt}) and its 95 % confidence interval (CI), at which the species would generate the maximum possible yield according to a yield-per recruit analysis.

ACKNOWLEDGMENT

We thank Daniel Pauly, M.L. Deng Palomares, and Rainer Froese for useful comments and K.A. Koranteng for a critical review of the manuscript. This research was conducted by of one of us (A. Cham) in the context of a thesis project at the Department of Zoology, Fourah Bay College, University of Sierra Leone.

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BIOLOGICAL PARAMETERS OF SOME EXPLOITED FISH SPECIES IN THE COASTAL WATERS OF CAMEROON

PARAMETRES BIOLOGIQUES DE QUELQUES ESPECES DE POISSON EXPLOITEES DANS LES EAUX COTIERES DU CAMEROUN

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ABSTRACT

Investigations of biological parameters of exploited fish species has been carried out at the Fisheries and Oceanographic Research Station in Limbé Cameroon, since 1984. Knowledge of biological parameters of exploited fish species is an essential tool in fish stock assessment and proper understanding of the dynamic of the exploited fisheries resources. These parameters are summarised herein, for use and/or comparisons with other countries with similar ecosystems and/or fish fauna. Comparing the values of these population parameters (especially L_m) with the existing lengths observed in fish landings, one can conclude that the sciaenids are being over-fished whereas the clupeids mostly exploited by the artisanal fishery are in a comparatively better shape.

RESUME

Les paramètres biologiques des poissons exploités ont fait l'objet d'études à la Station de Recherche Halieutique et Océanographique de Limbé, Cameroun depuis 1984. La connaissance des paramètres biologiques des poissons exploités est essentielle pour l'évaluation des stocks et la maîtrise de la dynamique des ressources. Ces paramètres sont résumés dans cet article pour être utilisés et/ou comparés à ceux d'autres pays ayant des écosystèmes ou faunes de poissons similaires. En comparant les valeurs de ces paramètres (spécialement Lm) avec les longueurs observées au niveau des captures actuelles, il ressort que les « Bars » sont surexploités, tandis que les stocks de sardinelles surtout exploitées par la pêche artisanale sont encore en bon état.

INTRODUCTION

Biological parameters required to assess the state of the fisheries resources in Cameroon are scanty, e.g., an early attempt by Djama and Pitcher (1989). However, due to the importance of the fishery sector in Cameroon, especially with regard to its contribution to high value protein food supply (46% of animal protein consumed in Cameroon), employment generation (5% of the active population) and earnings from export of *Penaeus notialis* to Europe (Djama, 1992), regular updating of the state of the stock are necessary for proper management of the resources.

This paper summarises population parameters of some exploited fish species in Cameroon waters to be used for improved assessment and understanding of the dynamics of these important resources. Other countries with similar ecosystems and fish fauna may also make good use of these biological parameters, be it only for comparisons.

MATERIALS AND METHODS

The Fisheries and Oceanographic Research Station in Limbé, Cameroon, began investigations of biological parameters of exploited fish species in 1984. Fish length frequency data and individual fish weight (in g) were used in these analyses. Very often, length frequency measurements (total length in cm) were taken from representative fish samples once or twice a month, for a minimum period of one year. For the length-weight relationship studies, a minimum number of 300 fish were weighed within 0.1 g using a Mettler balance.

The methods used to estimate population parameters include: Bhattacharya's (1967) method of decomposing a population distribution into Guaussian components; Macdonald and Pitcher's (1979) mixture analysis; the estimation of growth parameters using ELEFAN 1 (Pauly and David, 1981); the estimation of the von Bertalanffy growth coefficient (K) from a fixed value of L_8 using a representative population sample (see Wetherall *et al.*, 1987); and Shepherd's (1987) length composition analysis. Sometimes, it was necessary to combine one or two methods to yield the necessary biological parameters (Djama and Pitcher, 1989).

RESULTS

Target fish species

Both the demersal and small pelagic resources are exploited by the artisanal and commercial fisheries of Cameroon. The artisanal fishery mostly exploits small pelagic species, mainly clupeids, while the commercial fishery is specialised in the exploitation of demersal resources, especially croakers (Table 1).

Table 1. Some target fish species of the commercial and artisanal fisheries of Cameroon.

Type of fishery	Family	Species
Commercial fishery	Sciaenidae	*Pseudotolithus typus*
		P. elongatus
		P. Sénégalensis
	Cynoglossidae	*Cynoglossus canariensis*
	Polynemidae	*Pentanemus quinquarius*
		Galeoides decadactylus
	Ariidae	*Arius heudolotii*
Artisanal fishery	Sciaenidae	*Pseudotolithus typus*
		P. elongatus
		P. Sénégalensis
	Clupeidae	*Sardinella maderensis*
		Ethmalosa fimbriata
		Ilisha africana

Biological parameters

Biological parameters presented in this paper were obtained either from available literature (including theses submitted by researchers of the Station). As previously mentioned, croakers and clupeids constitute the two essential components of the fisheries landings in Cameroon. Croakers are demersal coastal resources living on soft bottoms (sand or sandy mud); they belong to and in fact define the sciaenid community (Longhurst, 1963). Clupeids are small coastal pelagic fishes exploited by the artisanal fishery. *Sardinella maderensis*, one of the most commonly caught species, feeds on plankton, e.g., diatoms, dinoflagellates and crustacean larvae (Hilton-Taylor 2000). Table 2 presents population parameters of these species.

Table 2. Summary table of population parameters of some target fish species of the fisheries of Cameroon; L_c=length at first capture; L_m=length at first maturity.

Family	Species	L_∞ (cm)	K ($year^{-1}$)	L-W relationship	L_c (cm)	L_m (cm)	Source
Sciaenidae	*Pseudotolithus typus*	82.7	0.25	$W=0.00368L^{3.164}$	–	–	Djama (1988)
		81.5	0.22	–	11	–	Djama and Pitcher (1989)
		80.0	0.23	–	–	–	Djama and Pitcher (1989)
		81.0	0.20	–	–	–	Djama (1992)
		63.3	0.13	$W=0.00636L^{3.030}$	–	–	Njock (1990)
		61.9	0.26	–	–	–	Njock (1990)
	Pseudotolithus elongatus	51.0	0.28	$W=0.00598L^{3.097}$	–	19.5	Njock (1990)
		61.4	0.20	–	–	–	Njock (1990)
	Pseudotolithus Sénégalensis	61.0	0.32	$W=0.00389L^{3.224}$	11	–	Djama and Pitcher (1989)
		67.0	0.23	–	–	23.0	Djama (1992)
		52.3	0.24	$W=0.00416L^{3.206}$	–	–	Njock (1990)
		51.0	0.21	–	–	26.5	Njock (1990)
Cynoglossidae	*Cynoglossus canariensis*	63.0	0.40	$W=0.00221L^{3.223}$	–	–	Njock (1990)
Ariidae	*Arius heudelotii*	68.5	0.15	–	15	–	Njock (1990)
	Arius parkii	55.0	0.29	–	12	–	Njock (1990)
Polynemidae	*Pentanemus quinquarius*	30.0	0.39	$W=0.00402L^{3.182}$	11	–	Njock (1990)
	Galeoides decadactylus	41.2	0.20	$W=0.00132L^{2.921}$	12	–	Njock (1990)
Clupeidae	*Sardinella maderensis*	27.2	0.48	–	9	–	Gabche and Hockey (1995)
	Sardinella maderensis	32.5	0.59	–	11	–	Djama (1989a)
	Sardinella maderensis	–	–	–	–	16.5	Youmbi and Djama (1990)
	Sardinella maderensis	27.7	0.82	$W=0.00132L^{2.921}$	9	–	Djama (1989b)

DISCUSSION

According to results in Table 2, the average length at first maturity for the three croaker species is approximately 23 cm. Landing data from Djama (1992) indicate an average value of 20 cm for croakers suggesting that sciaenids are exposed to growth overfishing in Cameroon. Similarly for clupeids, the main target of artisanal fisheries, growth overfishing is suggested by the fact that most species, including *Sardinella maderensis* (length at first maturity of 16.5 cm; see Youmbi and Djama, 1990), are captured at 12-14 cm (recent observations).

Further studies would need to done on the feeding habits of these species as well as on the trophic interactions of the species groups in order to establish a good understanding of the impact of the various fisheries on this ecosystem.

ACKNOWLEDGEMENTS

I am pleased to acknowledge the assistance of ACP-EU Initiative Project ‘Strengthening fisheries and biodiversity management in ACP countries’, through the provision of computer and electronic communication facilities. Without this assistance, this work could certainly remain in the manuscript files of the Research Station.

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COMMERCIAL STATUS OF TWIN SPOT SNAPPER (*LUTJANUS BOHAR*) AND GOLD BAND JOB FISH (*PRISTIPOMOIDES FILAMENTOSUS*) IN FISHERIES OF ERITREA

STATUT COMMERCIAL DU VIVANEAU CHIEN ROUGE (*LUTJANUS BOHAR*) ET DU COLAS FIL (*PRISTIPOMOIDES FILAMENTOSUS*) DANS LA PECHE ERITREENNE

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ABSTRACT

The fisheries of Erithrea are underdeveloped and artisanal in nature. They employ mainly gill nets and hook and line targeting coral reef fishes (groupers, snappers, emperors etc.) and pelagic species (mackerels, barracuda, jacks, etc). Two of the 140 species that are caught, *Lutjanus bohar* and *Pristipomoides filamentosus* contribute 16 % and 7 % of the total artisanal catch, respectively. The status of these two species were evaluated using length-frequency analysis; results indicated that only 3.2 % and 4.3 % of these species' catches, respectively, consist of fishes with size less than their length at first maturity, indicating a low risk of overfishing.

RESUME

La pêche dans les eaux de l'Erythrée est sous-développée et souvent artisanale. Les engins de pêche traditionnelle sont principalement des filets maillants et des hameçons et lignes spécialisés pour la pêche de certains poissons associés aux récifs coralliens, par exemple, des mérous, des lutjans, et des empereurs, ainsi que des espèces pélagiques comme les maquereaux, les barracudas, et les carangidés. Deux des 140 espèces, *Lutjanus bohar* et *Pristipomoides filamentosus* contribuent respectivement à 16 % et 7 % des captures artisanales. Les statuts de ces deux espèces ont été évalués sur base de l'analyse des fréquences de taille ; les résultats indiquent que respectivement 3.2 % et 4.3 %des captures de ces deux espèces sont des poissons avec des longueurs inférieures aux longueurs à l'âge de maturité sexuelle, ce qui indique un risque bas de surpêche.

INTRODUCTION

Erithrea is located at the southern part of the western Red Sea and has an extended continental shelf area of 56,000 km^{-2}. Major features are the Dahlak Archipelago and other islands; overall, there are more than 350 islands in the area. Both coastal and offshore islands, the majority being surrounded by fringing reefs, support a large and diverse reef fishes community with an estimated maximum sustainable yield (MSY) of 3,000 to 8,500 t.

Eritrea's fisheries fall under the category 'lightly fished' and the fish stocks in these waters are likely to be underexploited. Due to a limited infrastructure and to a particular political history, the fisheries of the country were mostly underdeveloped and artisanal. The most commonly used gears were gillnets and hooks and lines deployed from traditional boats; catches were mainly composed of reef and pelagic fishes. The artisanal fisheries land about 140 species, including groupers, snappers, emperors, jobfishes, mackerels, barracudas and jacks. However the contributions of these different groups to the total catch is very disparate. Two spot snapper, *Lutjanus bohar*, and Gold-band jobfish, *Pristipomoides filamentosus*, are two of the most abundantly represented species in the 1996–2000 artisanal catch average of 16 % and 7 %, respectively.

The high spatial variability of Eritrean fishing effort deployment and the limited biological data on the various target species, has so far prevented the estimation of CPUE trends that would have helped in evaluating the status of its fishery. Length-frequency data for these two species were available, however, and it was possible to do some analyses of these data, the results of which are presented in this paper.

METHODOLOGY

To evaluate the status of the two commercially important species, Twin spot snapper (*Lutjanus bohar*) and Gold band jobfish (*Pristopomoides filamentosus*), a representative sample from artisanal catches of length-frequency data was taken for each species. Samples were collected from major landing areas in Massawa where fish are landed for domestic consumption and exportation and the two fish landing harbours at Ghibi and Erifish, representing 80 % of the total artisanal catch.

Samples were obtained from fishers using 'sambuks', 'houri' and longliners, all of which targeted the two species being studied here. Okidegbe (2001) describes two types of sambuks, i.e., 6-8 m long wood or fiberglass boat powered by a 6-15 hp outboard engine with 3-4 crew members; and 13-15 m long boats with an inboard diesel engine and 6-12 crew members. The houri is a 3 m long dugout canoe operated by one or two men sailing or paddling or fitted with a 6 hp outboard engine (Okidegbe, 2001). The sampling scheme followed here was random with respect to boat types. To mininise potential bias, length measurements preceeded size sortings of the catch. Total length (TL) of the fishes were measured with measuring boards. Standardised data-sheets were used to record sample parameters, then logged into Excel spreadsheets.

Data parameters not measured during the survey were taken from the FishBase database (see www.fishbase.org and Froese and Pauly, 2000). These include $\mathbf{L_{opt}}$ (optimum length), $\mathbf{L_m}$ (length at maturity), and also the length-weight relationship parameters **a** and **b**. The status of the fisheries targeting these two species were evaluated using input data adapted from FishBase and the length-frequency analysis tool proposed by Froese *et al*. (2000).

Table1. Catch weight (in kg) of *Lutjanus bohar* and *Pristipomoides filamentosus* estimated from the length-frequency tool of Froese *et al*. (2000) and length-frequency distributions from survey data collected in Massawa, Ghibi and Erifish, Eritrea.

Twinspot snapper (*Lutjanus bohar*)				Goldband jobfish (*Pristipomoides filamentosus*)			
Class (cm; TL)	**Midlength**	**Freq.**	**Weight (kg)**	**Class (cm; TL)**	**Midlength**	**Freq.**	**Weight (kg)**
20-25	22.5	3	1	20-25	22.5	0	0
26-30	27.5	22	8	26-30	27.5	5	3
31-35	32.5	44	28	31-35	32.5	23	19
36-40	37.5	85	84	36-40	37.5	19	23
41-45	42.5	76	111	41-45	42.5	24	42
46-50	47.5	59	122	46-50	47.5	30	71
51-55	52.5	59	166	51-55	52.5	42	131
56-60	57.5	58	217	56-60	57.5	63	252
61-65	62.5	39	189	61-65	62.5	56	283
66-70	67.5	25	154	66-70	67.5	31	194
71-75	72.5	10	77	71-75	72.5	16	122
76-80	77.5	1	9	76-80	77.5	15	138
				81-85	82.5	12	131
				86-90	87.5	8	103
				91-95	92.5	18	270
				96-100	97.5	12	209

RESULTS

Over the entire sampling period, 481 and 374 specimens of *Lutjanus bohar* and *Pristipomoides filamentosus* were sampled, respectively. The catch distribution by length classes indicated that 48.9 % of the yield of *Pristipomoides filamentosus* was contributed by lengths above 57.5 cm, while 20.7% of *Lutjanus bohar* catches were contributed by lengths above 62.5 cm (see Table 1).

Note that no records are available on growth parameters of these two species from the Red Sea. Thus, values of L_{opt} and L_m resulting from the length-frequency analysis tool proposed by Froese *et al*. (2000) were estimated from von Bertalanffy growth parameters adapted from results of studies performed on the same species in nearby waters (see Table 2).

The fishes caught with size ranges between L_m and L_{opt} for *Lutjanus bohar* and *Pristipomoides filamentous* represented 35 % in the former and 24 % in the latter. Catch biomasses caught before maturity represented 30 % and 14.4 % for these two species, respectively.

Table 2. Estimates of L_{opt} (optimal length), L_m (length at maturity), L_8 (length at infinity) and length-weight constants for *Lutjanus bohar* and *Pristipomoides filamentosus* estimated from the length-frequency tool of Froese *et al*. (2000) and length-frequency distributions from survey data collected in Massawa, Ghibi and Erifish, Eritrea.

Parameter	*Lutjanus bohar*	Reference	*Pristipomoides filamentosus*	Reference	Remarks
L_{max} (cm; TL)	90	Frimodt (1995)	100	Anderson (1983)	
L_8 (cm; TL)	66	Munro (1983)	87.4	Hardman-Mountford *et al.* (1998)	Median record of estimates available in FishBase
K (year)	0.33	*idem*	0.36	*idem*	*idem*
T'	3.16		3.44		from L_8, K using Pauly and Munro (1984)
M (year^{-1})	0.63		0.62		from L_8, K and annual mean temperature of 27ºC using Pauly (1980)
L_{opt} (cm; TL)	59.7		66.5		from L_{max} using Beverton (1992)
L_m (cm; TL)	48.8		53.5		from L_8 using Froese and Binohlan (2000)
a	0.0121	Ralston (1988)	0.0514	Mees (1993)	Median record of estimates available in FishBase
b	3.12	*idem*	2.78	*idem*	*idem*

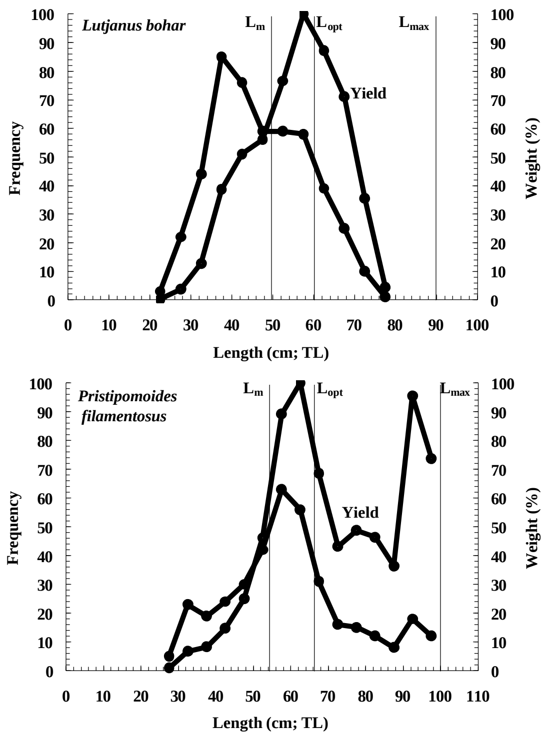

Figure 1. Results of the length-frequency analyses (Froese *et al*., 2000) on length-frequency distributions of *Lutjanus bohar* and *Pristipomoides filamentous* from survey data collected in Massawa, Ghibi and Erifish, Eritrea.

DISCUSSION AND CONCLUSION

The part of the catch biomass of the populations of *Lutjanus bohar* and *Pristipomoides filamentous* at L_{opt} represented 79.3 % and 51.1 % of the catch biomass. Figure 1 show the catch biomass peak situated between L_m and L_{opt}. This indicates that the catch is largely based on sexually mature fishes and that the fisheries are not at risk of recruitment and/or growth overfishing. Eritrean fisheries statistical reports record total annual catches of snappers and jobfishes ranging between 300 and 500 t. This is small compared to the estimated 8,500 t of potential yield of snappers, groupers, emperors and jacks in Guidicelli (1984).

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GROWTH, MORTALITY, MATURITY AND LENGTH-WEIGHT PARAMETERS OF SELECTED FISHES OF THE OKAVANGO DELTA, BOTSWANA

CROISSANCE, MORTALITE, MATURITE ET RELATIONS TAILLE-POIDS DES POISSONS D U DELTA DE L'OKAVANGO, BOTSWANA

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ABSTRACT

This preliminary compilation presents growth and natural mortality parameters for 28 species of freshwater fish from the Okavango Delta, Botswana. The majority of the population parameters are derived from unpublished data collected by staff of the Fisheries Section (Botswana) while data from 8 species are adapted from the first author's MS thesis. The maturity parameters were derived from historical data collected by the JLB Smith Institute of Ichthyology (South Africa).

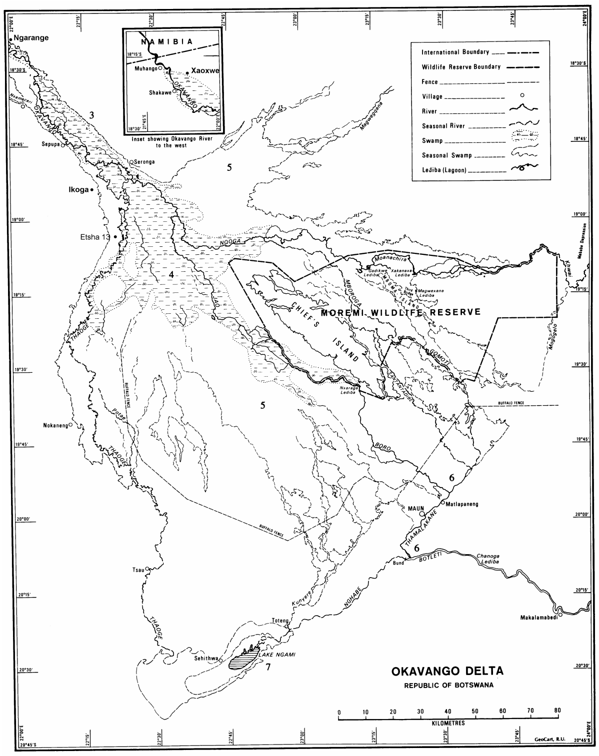
RESUME

Cette compilation préliminaire présente des paramètres de croissance et de mortalité naturelle de 28 espèces des poissons d'eau douce du Delta de l'Okavango, Botswana. La majorité de ces paramètres sont obtenus à partir des données brutes non publiées rassemblées par les chercheurs de la Fisheries Section (Botswana). Certaines données sur 8 espèces ont été obtenues grâce à la thèse de Maîtrise du premier auteur. Les paramètres de maturité sexuelle sont tirés de l'analyse des données rassemblées par le JLB Smith Institute of Ichthyology (Afrique de Sud).

INTRODUCTION

Embedded in the otherwise arid and parched Kalahari Desert is the delta of the Okavango River which, with an area of 16 835 sq. km, is the largest inland delta in the world (Allanson *et al*., 1990). The Okavango River is created by the confluence of the Cubango and Cuito rivers in Angola just west of the Caprivi Strip, where the river enters the Botswana border at Mohembo (McCarthy, 1992; Giske, 1996). Annual inflow is about 11,000 million m^3, which is augmented by 5,000 million m^3 of rainfall. Of this, 15,400 million m^3 is lost annually to the atmosphere through evapo-transpiration (McCarthy, 1992; Giske, 1996) while approximately 2 % of the input appears as output at the distal end of the Delta (Wilson and Dincer, 1976). As a green oasis in the arid Botswana, the Okavango is aptly named "The Jewel of the Kalahari" (Ross, 1989) and is the most important water body therein. The Okavango delta supports the largest capture fishery in Botswana, which yields approximately 340 tons annually (Mosepele, 2001; see Figure 1). Several studies have been done on the biology (Merron *et al*., 1990; Holden and Bruton, 1994; Booth *et al*., 1995), ecology (Merron and Bruton, 1988, 1995), taxonomy (Skelton *et al*., 1985) and assessment (Bills, 1996) of the fishes of the Okavango Delta. However, no estimates of the von Bertalanffy growth parameters, mortality parameters, size at maturity and length weight coefficients of the fishes of the Delta have been published. Therefore, this contribution is a first attempt to compile a preliminary array of the important parameters of fishes from the Okavango delta.

Approximately 80 species of freshwater fish occur in the Okavango (Kolding, 1996; AQUARAP, 2000). Twenty-eight of the most common and important species are presented. The cichlid species are the most important commercially and recreationally exploited species in the Okavango delta. Most of the momyrids and cyprinids are important prey species for the top predators, *Hydrocynus vittatus*



(Tigerfish) and *Hepsetus odoe* (African pike); the former also is an important recreational species.

Fig. 1: The Okavango Delta, Botswana; major biomes of the delta: 3-Okavango riverine floodplain; 4-Permanent swamp; 5-Seasonal swamp; 6-Drainage rivers; 7-Lake Ngami.

MATERIALS AND METHODS

Swedish Lundgren Nets (SLN) were used to collect data for analysis of vital population parameters of selected fish species. The mesh sizes in these experimental nets were increased with the underlying assumption that they are non-selective over a wide range of the different size classes present in a fish population. This “non-selectivity” feature is important for the assumption that the sample is representative of the population. Two fleets of experimental monofilament Swedish Lundgren Nets (SLN), consisting of 12, 3-m long panels were set at each station for approximately 12 hours. Two fleets of multi-filament nets consisting of 5, 5-m long and 2-m deep panels were also used at each sampling station. The data used for maturity studies data existed in old computer printouts at the JLB Smith Institute of Ichthyology in Grahamstown, South Africa. It is the only time series of gill net data from the Delta (1983-1991). A description of the data collection process is provided in Merron and Bruton (1988).

Data collected by the JLB Smith Institute of Ichthyology between 1983 and 1991 and the data collected from this study were analysed separately for length-weight relationships. A regression was done in PASGEAR (Kolding, 2000) on the length-weight relationship, $\mathbf{W=a \cdot L^b}$ (Ricker, 1975) to estimate the coefficients. All the species data were corrected for gear selectivity before further analysis for growth parameters in FiSAT (Gayanilo and Pauly, 1997). Millar and Holst (1997) normal location shift curve was used to correct for selectivity in species whose maximum retention length changed with mesh size, while the log normal selection curve was used for species such as the tigerfish and catfishes which exhibited skewed distributions due to entanglement by spines, teeth, etc. For all species the ELEFAN I module implemented in FiSAT was used to calculate parameters for the von Bertalanffy growth function (VBGF) (Pauly, 1982). In ELEFAN I, the parameter t_0 of the VBGF is replaced by a starting sample (SS) number and a starting length (SL), with both coordinates defining a size at which some non-zero frequencies are observed (Gayanilo and Pauly, 1997). These points are used to fix the curve onto a time scale. ϕ' is a growth performance index which can be used to compare the growth performance of fish in length (Gayanilo and Pauly, 1997). The length at maturity (L_m) was estimated by fitting the data to a logistic model implemented in PASGEAR (Kolding, 2000).

Total mortality (Z) was calculated from a linearised length-converted catch-curve analysis (Gayanilo and Pauly, 1997). Sparre and Venema (1998) suggest that, in many cases, direct estimates of natural mortality (M) are impossible to obtain. Hence, methods for measuring M provide at best, rough estimates. “Pauly’s empirical formula” (Pauly, 1980) was used to obtain such estimates.

RESULTS AND DISCUSSION

Vital population parameters for 28 selected species from the Okavango Delta are listed in Table 1. The VBGF has been discussed and used extensively to model fish growth from length frequency data (Pauly, 1982, 1983, 1987; Sparre and Venema, 1998; Galucci *et al*., 1996; Lai *et al*., 1996). The present study used the VBGF implemented in ELEFAN I in FiSAT (Gayanilo and Pauly, 1997). Galucci *et al*. (1996) indicate that the ELEFAN method does not have an underlying statistical model, which means that the accuracy of the estimated growth parameters cannot be determined using parametric methods. Hence no confidence interval was estimated for these parameters. Concerns about the robustness and validity of this method have been raised in favour of age-based methods from hard body parts (see Ebert, 1987; Wetherall *et al*., 1987; Matsuishi, 1998; Pauly 1982; Thiam 1988).

Pauly’s empirical formula has been used extensively in tropical and temperate fisheries to estimate M (Kraljevic *et al*., 1996; Gabche and Hockey, 1995; Sparre and Venema, 1998). This model assumes that (1) small fish have high natural mortalities; (2) fast growing species have high natural mortalities; and (3) warmer ambient temperature results in higher natural mortalities. Stergiou and Papaconstatinou (1993) advise that different methods for the estimation of M be used due to several reasons: (1) all methods suffer from certain limitations and are subject to various assumptions; (2) a variety of methods provides a conservative range of M values; and (3) errors arising from method-specific assumptions and/ or limitations may cancel each other. In their review, they found that length-based methods tended to produce low estimates for M, and conversely for age-based methods. Empirical regressions, on the other hand, tended to produce estimates close to the mean estimates of all the direct methods. No other methods for M estimates were done in this study, thereby placing reliance on “Pauly’s empirical formula”, which made it difficult to assess the reliability of the estimated M values. However, consistency between the estimated M values and the estimated VBGF parameters were tested by applying the M on an arbitrary un-fished cohort to determine if it died out at the time where the estimated size had reached close to L_∞. In this regard, it can be asserted that the estimates of K, M and L_∞ are reliable.

Total mortality (Z) was estimated from length-converted catch curves modified from age-structured catch curves (Beverton and Holt, 1957; Gulland, 1969; Ricker, 1975; Pauly, 1982, 1983, 1987; Lablache and Carrara, 1988). The length converted catch curve estimates Z by assuming that mortality is uniform with age and that the sample is representative of the age groups considered. If these assumptions are satisfied, the right limb of the catch curve can be assumed to represent survivorship (Ricker, 1975).

Table 1. Growth, maturity and mortality related parameters of 28 species of freshwater fish from the Okavango Delta, Botswana. Taxonomic names after Skelton (1993). The maturity parameters are expressed in standard length instead of total length because Merron and Bruton (1988) used standard instead of Total lengths. $^{T}L_{\infty}$ =asymptotic length estimated from total length; a^{T} and b^{T} = length/ weight coefficients calculated from total length in cm. Data marked with * were adapted from the first author's thesis.

Family	Species	$^{T}L_{\infty}$	a^{T}	b^{T}	K	$L_{50\%}$ (?)	$L_{50\%}$ (?)	M	Z	?’
Cichlidae	*Oreochromis andersonni*	53.0*	0.004*	3.424*	1.00*	24.30	28.12	1.39*	3.99*	3.45*
	O. macrochir	40.0*	0.014*	3.106*	1.00*	14.66	20.16	1.50*	2.71*	3.20*
	Tilapia rendalli	47.0*	0.026*	2.911*	0.78*	24.78	19.52	1.22*	3.30*	3.24*
	Serranochromis angusticeps	44.0*	0.003*	3.449*	1.00*	26.30	28.02	1.46*	1.95*	3.29*
	S. robustus	56.5*	0.008*	3.229*	0.83*	–	23.62	1.21*	2.24*	3.42*
	S. macrocephalus	42.0	0.012	3.072	0.77	–	17.93	1.25	2.91	3.13
	Sargochromis carlottae	35.0	0.017	3.02	0.96	15.50	14.31	1.52	2.33	3.07
	S. codringtonni	42.0	0.011	3.15	0.77	17.69	15.50	1.25	1.45	3.13
	S. giardi	45.0	0.005	3.363	0.66	20.90	19.61	1.11	2.37	3.13
Clariidae	*Clarias gariepinus*	90.5*	0.021*	2.738*	0.26*	27.28	36.18	0.50*	1.00*	3.33*
	C. ngamensis	80.0	0.009	2.960	0.35	26.94	37.05	0.62	1.39	3.35
Characidae	*Hydrocynus vittatus*	68.0*	0.002*	3.355*	0.55*	39.17	28.72	0.88*	0.99*	3.41*
	Brycinus lateralis	17.0	0.004	3.325	2.80	–	–	3.74	16.46	2.91
Schilbeidae	*Schilbe intermedius*	45.5*	0.005*	3.190*	0.40*	20.23	18.92	0.80*	1.42*	2.92*
Mormyridae	*Mormyrus lacerda*	47.0	0.017	2.810	0.80	29.36	30.65	1.24	1.12	3.25
	Marcusenius macrolepidotus	29.0	0.005	3.202	0.70	12.83	13.58	1.30	5.72	2.77
	Petrocephalus catastoma	20.0	0.007	3.169	0.78	7.60	7.55	1.55	4.05	2.49
Mochokidae	*Synodontis nigromaculatus*	30.9	0.016	2.80	0.80	14.28	16.10	1.40	3.57	2.88
	S. woosnami	–	0.179	2.026	–	13.56	14.49	–	–	–
	S. macrostigma	–	0.029	2.633	–	–	–	–	–	–
	S. macrostoma	–	0.018	2.810	–	–	–	–	–	–
	S. leopardinus	–	0.263	1.877	–	13.27	13.12	–	–	–
	S. thamalakanensis	–	0.157	2.056	–	–	–	–	–	–
	S. vanderwaali	–	0.032	2.613	–	–	–	–	–	–
Claroteidae	*Parauchenoglanis ngamensis*	–	0.022	2.750	–	–	–	–	–	–
Hepsetidae	*Hepsetus odoe*	49.0	0.001	3.653	0.59	24.68	24.29	1.01	2.04	3.15
Cyprinidae	*Labeo lunatus*	48.0	0.012	2.930	0.60	–	–	1.02	2.53	3.14
	Barbus poechii	–	0.004	3.488	–	7.68	6.02	–	–	–

Lack of data made it difficult to estimate the growth and mortality parameters for *Synodontis* sp. (Paul Skelton and Roger Bills, pers. comm.). Several biases might have affected the validity of the results obtained from this study. Govender (1994) discusses that length frequencies from young fish are best to determine growth rates because of better separation of modes. In addition, growth of younger fish is fastest which makes the identification of moving modes over time easier. Lastly, the determination of K in relation to L_{∞} is more robust when the length frequencies contain younger fish. There were few cichlid juveniles in the data, which suggests that the samples were unrepresentative of the younger size classes. This may have introduced bias in growth parameter estimations.

It is also possible that the sampling stations in this study could have been major habitat for few size classes of the species in the study. Predators like tigerfish are known for cannibalism (Merron and Bruton, 1988) which results in strict segregation of size classes by habitat. Skelton (1993) states that juvenile tilapia (*Oreochromis andersonii*, *O. macrochir*, *Tilapia rendalli*, etc.) prefer littoral areas while the adults prefer deeper waters. A rigorous sampling design should take these spatio-temporal variations into consideration, which was not done in this study. These factors might have also introduced error into the growth parameters estimated here.

Growth parameters were assumed to represent the general population, irrespective of sex differences in growth, which may also introduce bias into the results. Skelton (1993) reports that female *Hydrocynus vittatus* exceed 70 cm (fork length) while males grow to only about 50 cm. He also mentions that growth rate in female *Clarias gariepinus* decreases after about three years, whereas males continue to grow. Dudley (1972) and Kapetsky (1974) estimated growth parameters by sex for *O. andersonnii*, *O. macrochir* and *Tilapia rendalli*, which indicated growth differences between the sexes. Salvanes and Ulltang (1992) avoided this source of error in their growth estimates of cod; there were no significant differences between males and females before pooling data from the two sexes. Such two-step analysis was not done here, due to limited data, which might have also compromised the growth estimates.

The growth of tropical floodplain fish tends to be fast and seasonal (MRAG 1994). Merron and Bruton (1988) made similar observations for the Okavango fishes. Therefore, the seasonalised version of the VBGF has been used in lieu of the generalised VBGF to account for these seasonal differences in growth in other studies (Pauly, 1982; Thiam, 1988). However, Sparre (1990) shows that growth seasonality is important only in the case of short-lived species with one or at most two spawning periods during their life (e.g., penaeid shrimp). He also thought that the seasonalised VBGF makes it difficult to estimate Z from length converted catch curves though this problem is solved in FiSAT (see Gayanilo and Pauly, 1997, p. 118-122). The generalised VBGF was therefore used instead of the seasonalised model assuming that it reflected average growth of Okavango fishes. However, it might still be necessary to estimate growth parameters using both methods for the sake of comparison and validation. Moreover, Mosepele (2000) discusses the possibility of separate populations of similar species in the Okavango, based on the differences observed between his estimated growth parameters for *O. andersonni* and *O. macrochir* and those obtained by Booth *et al*. (1995, 1996). Similar species experience different growth rates in different habitats (Lowe-McConnel, 1982; Merron and Bruton, 1988). The complex nature of the Okavango then suggests that it may be prudent to separate data from different locations in the delta, which was not done in this study. These species specific differences based on different habitats might have caused bias in the parameters estimates, when the data from the different sampling stations was pooled for analysis.

ACKNOWLEDGEMENTS

We would like to express our gratitude to the fisheries research sampling team, for their tireless effort to provide us with valuable data, despite spending time away from their loved ones. Special thanks to Loago Mokunki (Special), Kesego Kutoro (Kays), Aaron Samoxa (Le-Arrow) and Ontekotse Mach (Matebe). Our many thanks go to Prof. Paul Skelton, the Director of the JLB Smith Institute of Ichthyology for giving us access to their data, and to the priceless assistance that Roger Bills, the curator of their natural history museum, gave in deciphering the data. Thanks to Jeppe Kolding and Trevor Mmopelwa on their encouragement to write this paper.

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RAINFALL DETERMINES DIET COMPOSITION FOR *SCHILBE INTERMEDIUS* AND *OREOCHROMIS MOSSAMBICUS* IN GABORONE RESERVOIR, GABORONE, BOTSWANA[5]

NIVEAU DE PRECIPITATION DETERMINANT LA COMPOSITION DE NOURRITURE CHEZ *SCHILBE INTERMEDIUS* ET *OREOCHROMIS MOSSAMBICUS* DANS LE RESERVOIR DE GABORONE, GABORONE, BOTSWANA.

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ABSTRACT

Oreochromis mossambicus and *Schilbe intermedius* were caught using monofilament gill nets in Gaborone reservoir, Gaborone, Botswana. The stomach contents were studied to see if there were differences in diet composition during the wet and dry seasons. In the wet season, the dominant food ingested by *S. intermedius* and *O. mossambicus* were insects (83 % dry weight) and algae (66 % dry weight), respectively; whereas in the dry season the predominant components of the diet were fish (68 % dry weight) and detritus (83 % dry weight), respectively. The increase in rainfall also improved the quality of the diet for *O. mossambicus* as the level of protein, energy and organic matter in the diet increased in quantity. However, for *S. intermedius* the effect of rainfall resulted in shifting the diet from fish that requires effort to capture, to insects that tend to be easily accessible. Thus, seasonal patterns of rainfall can affect food resources and quality of fish diets.

RESUME

Oreochromis mossambicus et *Schilbe intermedius* ont été échantillonés à l'aide de filets maillants en monofilaments dans le réservoir de Gaborone, Gaborone, Botswana. Les contenus stomacaux ont été étudiés pour déterminer les différences de composition du régime alimentaire pendant les saisons sèches et humides. Pendant la saison des pluies, la nourriture dominante ingérée par *Oreochromis mossambicus* et *Schilbe intermedius* étaitdes insectes (83 % du poids sec) et des algues (66 % du poids sec), respectivement; considérant que pendant la saison sèche les composantes prédominantes du régime alimentaire étaient des poissons (68 % du poids sec) et dudétritus (83 % du poids sec), respectivement. L'augmentation des précipitations a également amélioré la qualité de la nourriture ingérée par *Oreochromis mossambicus* avec une augmentation en quantité du niveau de protéine, d'énergie et de matière organique. Cependant, l'augmentation des précipitations a décalé le régime alimentaire du *Schilbe intermedius* qui se nourrit normalement du poisson, une proie qui exige un effort pour la capturer, aux insectes qui sont devenus plus facilement accessibles. Ainsi, les modèles saisonniers des précipitations peuvent également affecter les sources de nourriture et la qualité du régime alimentaire des poissons dans ce barrage.

[5] Submitted to *Botswana Notes and Records*, Nov/Dec 2003. Vol. 35.

FOOD AND FEEDING HABITS OF TIGERFISH, *HYDROCYNUS VITTATUS*, IN LAKE KARIBA, ZIMBABWE

L'ALIMENTATION DU POISSON-CHIEN, *HYDROCYNUS VITTATUS*, AU LAC KARIBA, ZIMBABWE

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ABSTRACT

Lake Kariba is a man-made dam that was created in the late 1950s, in which the Tigerfish, *Hydrocynus vittatus* (Castelnau, 1861), an indigenous piscivorous fish, was able to adapt to the newly created lacustrine ecosystem while the Kapenta, *Limnothrissa miodon* **(**Boulenger, 1906), was introduced to fill the vacant pelagic niche that had been created. Prior to the introduction of *L. miodon*, fishes of the family Characidae and Cichlidae were the dominant prey items. After the introduction of *L. miodon*, Kapenta became the dominant food item in the Tigerfish diet (more than 45 %). Thus, the introduction of the exotic *L. miodon* resulted in a major dietary shift for the indigenous *H. vittatus*.

RESUME

Le lac Kariba est un barrage construit à la fin des années 1950s, où le characidé *Hydrocynus vittatus* (Castelnau, 1861), une espèce locale piscivore, a pu s'adapter et où le clupéidé *Limnothrissa miodon* **(**Boulenger, 1906) a été introduit pour remplir la niche pélagique crée par le lac. Avant l'introduction de *L. miodon* dans le lac, le régime alimentaire de *H. vittatus* était surtout composé d'espèces de Characidé et Cichlidé. L'introduction de *L. miodon*, espèce exotique, dans le lac pendant les années 1970 a déclanché une modification importante du régime alimentaire de *H. vittatus*.

INTRODUCTION

Lake Kariba is a man-made lake on the border between Zambia and Zimbabwe between longitudes $26^0$40' to $29^0$03' East and latitudes $16^0$28' to $18^0$06' South. Construction of the dam began in 1955 and it was completed in 1959 (Coche, 1974). The lake has a catchment area of 663,820 km^2 and a total surface area at full supply level of 5,500 km^2. The lake's volume at the normal operating level (485 m above sea level) is 156.5 km^3 (see Coche, 1974 for details on the morphometry of the lake).

The Tigerfish, *Hydrocynus vittatus* (Castelnau, 1861), is an important species in Lake Kariba, particularly for the 'Inshore gillnet fishery'. In 1995, it constituted 24 % of its annual catch of 1,175 t, and 20 % of the annual catch of 1,310 t in 1999. In the 'Kapenta fishery', Tigerfish is the most important species by weight in the by-catch with a total of 8 t landed in 1995 (Karenge and Kolding, 1995). Tigerfish is also one of the popular angling species in the lake and is usually featured in the annual International Tigerfish Tournament which attracts national and regional anglers from as well as anglers from Europe and North America. In the 1996 tournament, a total of 4 t of Tigerfish were caught in this three-day event (Lake Kariba Fisheries Research Institute, unpublished data).

Kapenta, *Limnothrissa miodon* (Boulenger, 1906), was introduced into Lake Kariba from Lake Tanganyika in 1967 and 1968 (Bell-Cross and Bell-Cross, 1971). This introduction was aimed at filling the vacant pelagic ecological niche created by the construction of Kariba dam. A few years after the introduction, Kapenta had established itself and it became an important food item for some of the indigenous species including Tigerfish (Kenmuir, 1973). The biology of Kapenta has since been closely associated with that of the Tigerfish, since part of the natural mortality of Kapenta is due to Tigerfish predation. Prior to the introduction of Kapenta, cichlids were the main prey item of Tigerfish.

A number of Tigerfish studies were conducted in the mid 1960s and early 1970s (e.g., Matthes, 1968; Kenmuir, 1973). However, over the last twenty years, no major studies have been carried out to assess whether there have been any further changes in the feeding pattern of this species. The objectives of the study is thus: (a) to assess the food composition of *H. vittatus* in the mid 1990s; (b) to determine the importance of *L. miodon* as a prey item in the diet of Tigerfish; and (c) to determine whether there are dietary overlaps among different length classes.

MATERIALS AND METHODS

The study was carried out in the Eastern Basin of Lake Kariba, on the Zimbabwean side from March 1994 to January 1997 at three stations (Figure 1), i.e., Fothergill, Lakeside and Crossroads. At Lakeside station, a fleet of bottom set multifilament gillnets was used with stretched mesh sizes of 38, 51, 63, 76, 89, 102, 114, 127, 140, 152, 165 and 178 mm. At Fothergill and Crossroads, both top-set and bottom-set gillnets were used with the same stretched mesh sizes. Nets were set between 16H00 and 18H00 and retrieved the following morning between 06H30 and 08H30.

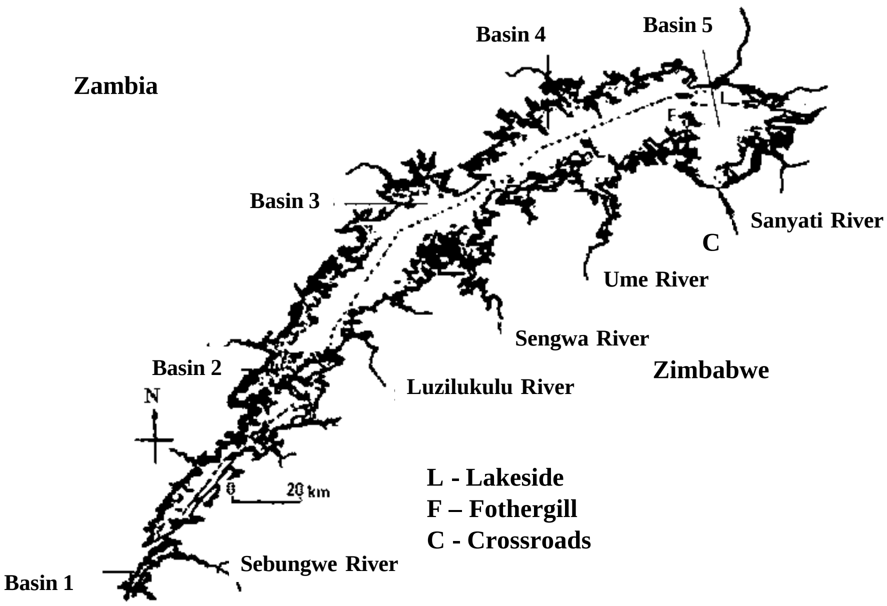

Figure 1. Map of Lake Kariba showing stations sampled between March 1994 to January 1997.

Total and standard lengths (TL, SL; cm) and weight (g) data were obtained. Stomach contents were examined and indentified to the species level where possible, otherwise to Family or Order level. The frequency of occurrence method was used to determine the important food items (Hyslop, 1980). In order to determine whether there was a change in food composition among the different size groups, the fish were separated into seven length classes. The overlap coefficient of Colwell and Futuyma

(1971) was used, i.e., $\mathbf{C_{ih}=1-0.5^{(Pij-Phj)}}$, where C_{ih}=overlap coefficient of length groups i and j; P_{ij}=proportional occurrence of prey type j in length group i; and P_{hj}=proportional occurrence of prey type j in length group h.

RESULTS AND DISCUSSION

The regression between total length (TL) and standard length (SL) resulted in the relationship: TL=1.207·SL+1.483 (n=2,335; r^2=0.9739). Out of 3,195 stomachs examined, only 34 % were filled. Table 1 summarises the food items resulting from the stomach contents analyses for *Hydrocynus vittatus* sampled at the three stations. Adult *H. vittatus* are predominantly piscivorous on the families Clupeidae, Cichlidae, and Characidae and sometimes on Clariidae, while invertebrates constituted a very small percentage of the diet (Figure 2). The distribution of prey items by length class of *H. vittatus* (Figure 3) shows that *Limnothrissa miodon* and cichlids were the major prey items across length classes, with the exception of fish in the 17.0-22.9 cm class and those >43 cm; which feed predominantly on cichlids.

Table 1. Food items occurring in the stomachs of *Hydrocynus vittatus* sampled at three stations in Lake Kariba from March 1994 to January 1997.

Common name	Scientific name
Kapenta	*Limnothrissa miodon*
Imberi	*Brycinus imberi*
Silver Robber	*Brycinus lateralis*
Silver Catfish	*Schilbe intermedius*
Sharptooth Catfish	*Clarias gariepinus*
Zambezi Happy	*Pharyngochromis acuticeps*
Southern Moothbrooder	*Pseudocrenilabrus philander*
Pink Happy	*Sargochromis codringtonii*
Kariba Bream	*Oreochromis mortimeri*
Freshwater Shrimp	*Caridina nilotica*
Chironomids	–
Grasshoppers	Order: *Othoprena*: Suborder: Coelifera
Termites	Order: Isoptera

The frequency of *L. miodon*, a shoaling small-sized fish, in the food bolus might be due to its suitability as compared to cichlids, which are relatively large-sized prey. As mentioned above, *L. miodon* was not always the preferred prey of *H. vittatus*. The trend in *H. vittatus* diet has changed since the early 1960s, i.e., Matthes (1968) reported a predominance of characids and cichlids in its diet which was later confirmed by Kenmuir (1973). Increased consumption of *L. miodon* by *H. vittatus* was observed by Kenmuir (1973) in the early 1970s after its introduction to Lake Kariba, and this is confirmed in this study.

Note that this shift in the diet of *H. vittatus* may not be a simple effect of the abundance of *L. miodon* in the lake. Consider *Synodontis zambezensis*, an abundant species in the littoral zone of the lake (Sanyanga, 1996) which has not been observed in the stomachs of *H. vittatus*. Matthes (1968) and Kenmuir (1973) noted that *S. zambezensis* occurred infrequently in the diet of *H. vittatus* even though it seems to be a highly suitable prey item.

The analyses of stomach contents by length class indicated a high degree of dietary overlap over all length classes. Note that, since no *H. vittatus* juveniles were sampled, the dietary overlap presented in Table 2 refers only to adults. Kenmuir (1973) reported that *H. vittatus* fry were cannibalistic, however, no evidence of cannibalism was obtained in this study: fry were absent in the catch survey due to the selective nature of the sampling gear.

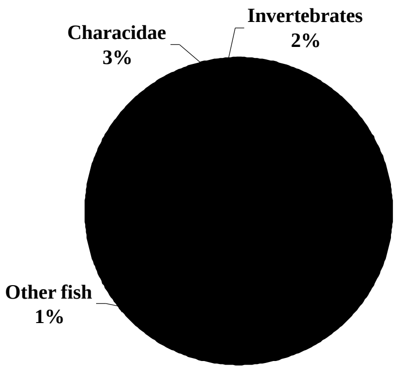

Figure 2. Frequency occurrence of prey items in 3,195 stomachs of *Hydrocynus vittatus* sampled at three stations in Lake Kariba from March 1994 to January 1997.

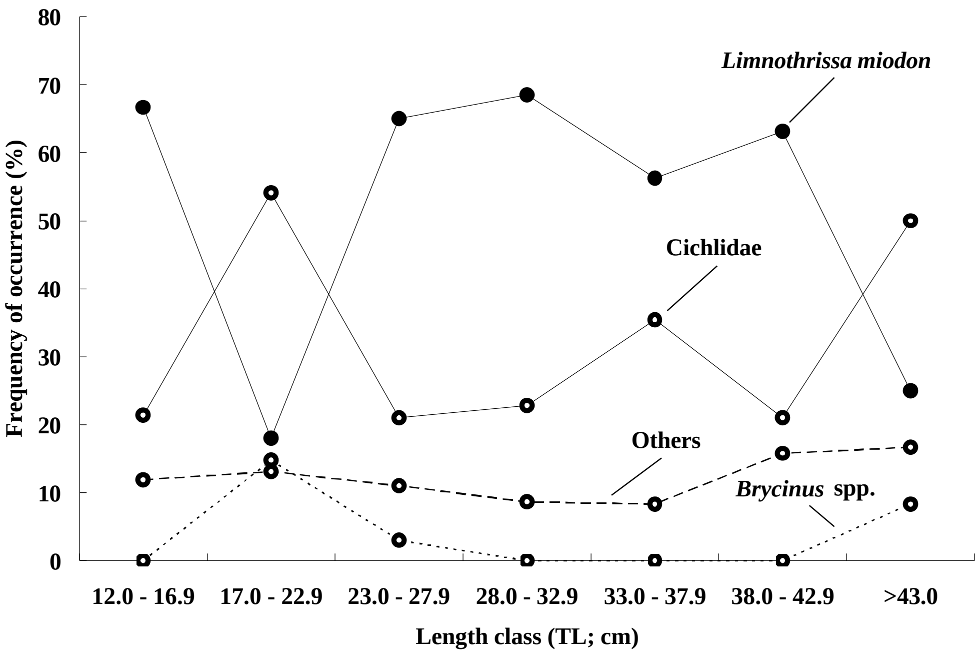

Figure 3. Frequency of occurrence of different prey items by length class in 3,195 stomachs of *Hydrocynus vittatus* sampled at three stations in Lake Kariba from March 1994 to January 1997.

Table 2. Size related dietary shift among the different length groups of *Hydrocynus vittatus* sampled at three stations in Lake Kariba from March 1994 to January 1997.

Length groups	17.0 - 22.9	23.0 - 27.9	28.0 - 32.9	33.0 - 37.9	38.0 - 42.9	> 43
12.0 – 16.9	0.51	1.0	0.995	0.995	1.0	1.0
17.0 – 22.9		1.0	0.995	0.995	1.0	1.0
23.0 – 27.9			0.995	0.995	1.0	1.0
28.0 – 32.9				0.99	0.995	0.995
33.0 – 37.9					0.995	0.995
38.0 – 42.9						0.64

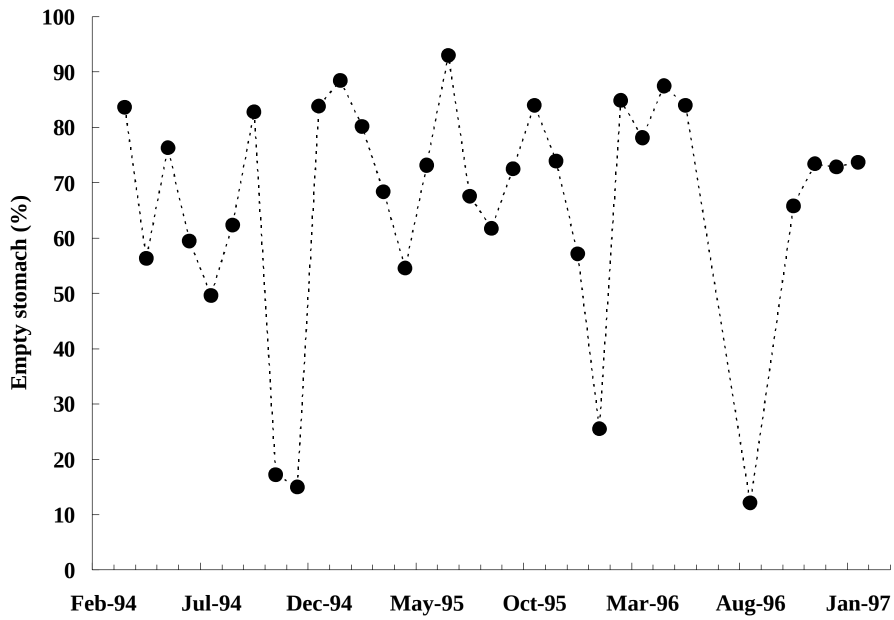

Figure 4. Incidence of empty stomachs in 3,195 individuals of *Hydrocynus vittatus* sampled at three stations in Lake Kariba from March 1994 to January 1997 varied from 49 to 93 %. Note that post capture digestion might have contributed to the high incidence of empty stomachs in the samples.

The stomach analyses also indicated a high incidence of empty stomachs, i.e., a mean monthly value of >40 % of empty stomachs was recorded (Figure 4) with lows records during October and November 1994 and January 1996. In a study of *H. vittatus* from Lake Kariba, Matthes (1968) noted that the percentage of empty stomachs varied from 60% to 90% and 20% of the empty stomachs were attributed to post-capture digestion. Matthes (1968) also showed that stomach eversion was low in this species. Since very few of the stomachs which contained food were completely full, a quantitative assessment of stomach fullness was not possible.

The results of this study show that L. *miodon* is currently the major prey item in the diet of *H. vittatus*. This predation on *L. miodon* has a significant impact on this population's natural mortality. Since natural mortality is an important parameter in ecosystem models, e.g. ECOPATH (Christensen and Pauly, 1995; Moreau *et al*., 1997) as well as in stock assessment models (Sparre and Venema, 1998), a follow-up study investigating such parameters as well as the interactions between the different prey and predator groups is recommended to better understand the long-term effects of introducing exotic species into a closed ecosystem such as Lake Kariba.

ACKNOWLEDGEMENTS

I would like to thank R. Nyandoro, I. Mushaike, L. Chitenga, A. Moyo, M. Masireta and K. Chavhuta who provided support and assistance during the long hours of field work performed for this study.

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SOME POPULATION PARAMETERS OF THE GOATFISH, *MULLOIDICHTHYS VANICOLENSIS* FROM THE LAGOON OF MAURITIUS

QUELQUE PARAMÈTRES DE LA POPULATION DU ROUGET, *MULLOIDICHTHYS VANICOLENSIS* DU LAGON DE L'ILE MAURICE

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ABSTRACT

The length-weight relationship, growth and mortality parameters of a population of goatfish, *Mulliodichthys vanicolensis* (Valenciennes, 1831) from the Mauritius Lagoon were estimated from samples collected during 1988. The growth parameters L_∞=42.0 cm TL and K=0.68 year^{-1} were estimated from length frequency data. The following estimates of mortality parameters were calculated: total mortality, Z=2.64 year^{-1}; natural mortality, M=1.17 year^{-1}; fishing mortality, F=1.47 year^{-1}. Exploitation rate was estimated at E=0.56 and length at which 50 % of the fish will be vulnerable to fishing gear (L_{50}) was calculated at 19.8 cm TL. Annual recruitment was found to occur in one seasonal pulse only.

RESUME

Les paramètres du rapport longueur-poids, de la croissance et de la mortalité de la population du rouget, *Mulliodichthys vanicolensis* (Valenciennes, 1831) du lagon de l'île Maurice ont été estimés à partir d'échantillons obtenus en 1988. Les paramètres de croissance L_∞=42,0 cm de longueur totale et K=0,68 an^{-1} ont été estimés à partir des données de fréquence de taille. Les valeurs suivantes des paramètres de mortalité ont été calculées: mortalité totale, Z=2,64 an^{-1}; mortalité naturelle, M=1,17 an^{-1}; mortalité par pêche, F=1,47 an^{-1}. Le taux d'exploitation a été estimé à E=0.56 et la longueur à laquelle 50 % des poissons sont vulnérable aux engins de pêche (L_{50}) a été calculée à 19,8 cm de longueur totale. Le recrutement annuel se fait durant une seule période de l'année.

INTRODUCTION

Goatfishes (Family Mullidae) are commercially important fishes contributing about 12 % of the total annual catch of 1,200 to 1,500 t by the artisanal multi-gear and multi-species fishery of the lagoon and off-lagoon of Mauritius (Anon., 1997). This group is represented by several species including *Upeneus vittatus* ('Rouget canal' or 'Rouget queue grise' in French), *Parupeneus cyclostomus* ('Rouget deux frères'), *P. bifasciatus* ('Rouget gros la bouche'), *P. heptacanthus* ('Rouget grande barbe'), *P. macronema* ('Rouget taché'), *P. barberinus* ('Rouget chinois'), *Mulloidichthys flavolineatus* and *M. vanicolensis* (Baissac, 1976). The last two species known locally as 'Yellow tailed goatfish' ('Rouget queue jaune') are relatively more abundant than the others, but are often confused with one another except by the presence of a dark spot on the lateral line of the former (see FishBase, www.fishbase.org). *Mulloidichthys vanicolensis* is more predominant in the south east of Mauritius, where all the fish samples were obtained.

MATERIALS AND METHODS

Materials for this study were obtained from 1,800 individuals ranging in size from 8 to 36 cm by-catches of a 1988 seine fishing collection of live penaeid shrimp spawners from the lagoon of Mauritius for a pilot hatchery (Anon., 1986). A beach seine, 75 m long and with mesh size of 0.5 cm, was operated in selected areas of the lagoon on a monthly basis. The seinings also extended into two fishing reserves (see Figure 1). Fish total lengths were measured to the nearest mm and weighed to the nearest gram. The sexes were determined on sub-samples by dissection. Gonads were weighed to the nearest milligram and the gonado-somatic indexes of both sexes separately were determined as **GSI=GW·100/BW,** where GW=gonad weight and BW=body weight. The constants of the length-weight relationship of the form, $\mathbf{W=aL^b}$, were determined separately by non-linear least squares fit to the equation for both sexes as well as for the mixed population using the Abee software (Pauly and Gayanilo, 1987).

The FISAT software (Gayalino *et al.*, 1996) was used with the length-frequency distributions to estimate von Bertalanffy growth parameters, **K** (growth coefficient) and $\mathbf{L_\infty}$ (asymptotic length). The growth performance index (?') described in Pauly and Munro (1984) was calculated using the relationship, i.e., $\mathbf{?'=logK+2\cdot log_{10}L_\infty}$.

Total mortality (**Z**) was estimated from length converted catch curves and natural mortality (**M**) from the empirical relationship of Pauly (1980), using a mean annual environmental temperature of 24 ^{o}C. The estimate of **F** was obtained by substracting **M** from **Z** and exploitation ratio was obtained as **E=F/Z**. The parameter $\mathbf{L_{50}}$ was determined by extrapolating the catch curve backward and calculating the numbers of fish that would have been caught, had it not been for selection effects and incomplete recruitment (assuming knife-edge selection). The relative yield-per-recruit and relative biomass-per-recruit were derived from the estimated values of **K,** $\mathbf{L_\infty}$**,** $\mathbf{L_{50}}$ and **M** (Pauly and Soriano, 1986). A recruitment pattern was obtained by the projection on the length axis of the available set of length frequency data.

RESULTS AND DISCUSSION

Length- weight relationship

The results of the length-weight regression analyses are summarised in Table 1, where the maximum and minimum sizes of the fish sampled are also given. Values of the exponent (**a**) for male and female and unsexed fish are very close to 3, i.e., reflecting isometry, with highly significant values of the coefficient of determination ($\mathbf{r^2}$).

Growth parameters

The original length frequency distribution was restructured (3 cm interval) and the best fitting growth curve was obtained iteractively by the method of joining peaks using the ELEFAN I routines incorporated in the FISAT package (Figure 2). The best value of the ratio of the number of peaks through which the curve passes relative to the total number of peaks (Rn) obtained was 0.499.

It may be assumed that the bias in growth parameter estimation as pointed out by Guanco-May (1991) has been eliminated in this study by the use of the non-selective gear (mesh size=0.5 cm) where fish of small sizes have been adequately sampled. The life span of *M. vanicolensis* as recalculated using the 'life history tool' in FishBase 99 with input values of L_∞=42 cm and K= 0.68 year^{-1} and t_o=-0.2 is 4.2 years. These results suggest that the fish has a relatively short life cycle with a fast growth rate.

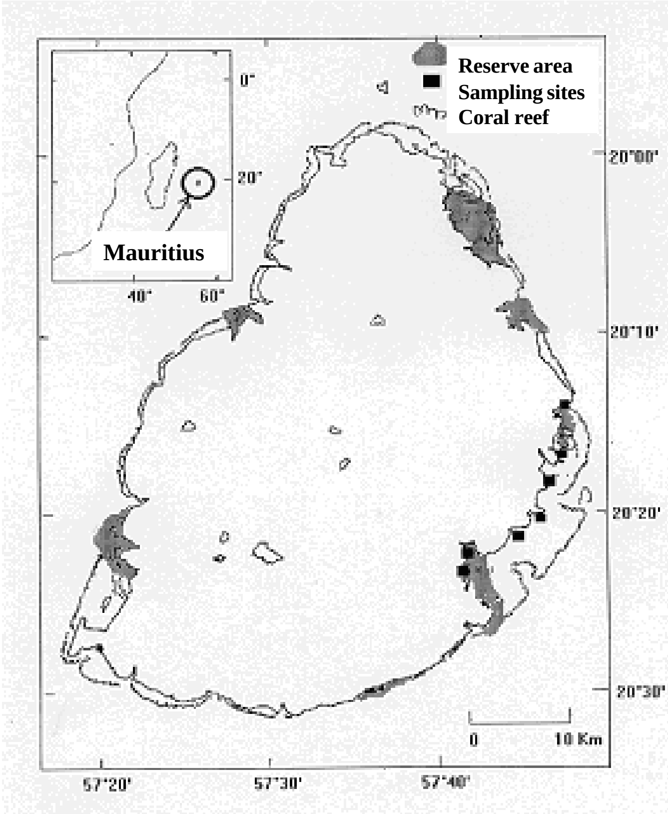

Figure 1. Sampling stations during the 1988 seine collections in the Mauritius Lagoon.

Table 1. Length-weight relationships of *Mulloidicthys vanicolensis* sampled from prawn seine survey in the Mauritius lagoon in 1988.

No of individuals	Sex	Range (cm, TL)	a	b	r^2
108	female	14 - 39	0.0145	2.905	0.985
124	male	10 - 33	0.0099	3.015	0.960
200	unsexed	10 - 39	0.0133	2.923	0.9227

Values of growth performance indices (?') for *M. vanicolensis* adapted from FishBase 99 are presented in Table 2. The concept of growth performance requires that values of (?') are normally distributed within a given species with different populations, each of which has different but mutually compatible values of L_{∞} and K. The value of (?') obtained in this study (3.08) is close to both the average values of the population of the male and female (2.70) and that of the female alone (3.11) from the Gulf of Aqaba region. More growth data on this species from other regions would be required for a more valid comparison of its growth performance.

Table 2. Growth parameter estimates and indices of growth performance of *Mulloidicthys vanicolensis* sampled from prawn seine survey in the Mauritius lagoon in 1988 in comparison with a Red Sea population.

Location	Sex	TL_{∞}	K	?'	References
Red Sea, Jordan	female	36.3	0.970	3.107	Wahbeh, M.I. 1992
Red Sea, Jordan	male	32.8	0.199	2.331	Wahbeh, M.I. 1992
Mauritius	unsexed	42.0	0.680	3.079	This study

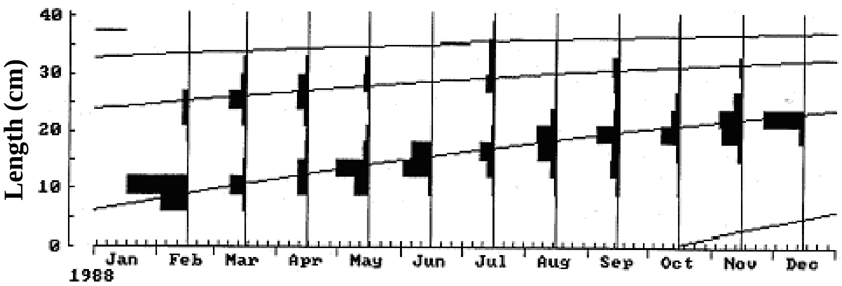

Figure 2. Growth curves fitted by ELEFAN I to length-frequency of *Mulloidicthys vanicolensis* in Mauritius Lagoon in 1988 (K=0.68 year^{-1}; L_∞=42 cm TL).

Mortality

Figure 3 represents the catch curve utilised in the estimate of total mortality (Z). The open oval dots represent fish not fully recruited and hence discarded from the calculation. A value of 2.64 year^{-1} (r=0.982) was obtained from the descending arm of the curve using the fully recruited points (shown as black oval dots). The estimates of natural mortality (M), fishing mortality (F) and exploitation rate (E=F/Z) were 1.17 year^{-1}, 1.47 year^{-1} and 0.556, respectively.

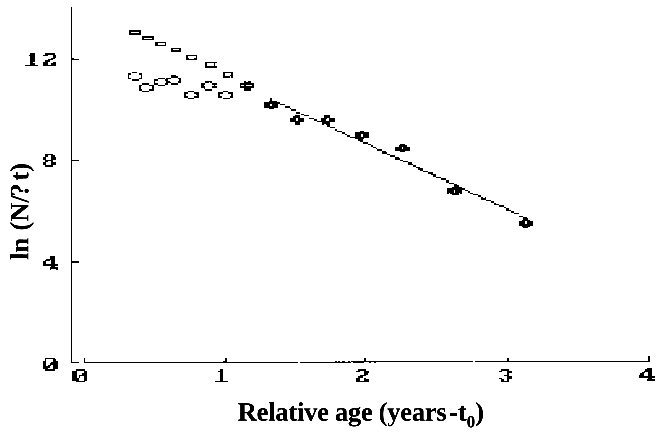

Figure 3. Length-converted catch curve for *Mulloidicthys vanicolensis* s in Mauritius Lagoon in 1988.

Selection pattern/probability of capture

Figure 3 also shows the extrapolated catch curve (shown in rectangular open dots) from which Figure 4 was derived. This provided an estimate of L_{50}=19.8 cm (which is also equivalent to L_C, the mean length at first capture) and is close to the minimum legal size, 20 cm TL, prescribed in the 5th Schedule of the Fisheries Regulation 18 of 1983 for goatfish (Anon., 1983).

The minimum lengths at maturity for male and female of this species have been observed to be 19 cm TL and 21 cm respectively (Jehangeer, unpublished data). The value of mean length at which 50 % of the population reach first maturity (L_m) is about 24 cm TL. Thus, it would appear that L_C or L_{50} calculated from this study is lower than L_m, implying that individual fish of this stock are vulnerable to fishing before reaching sexual maturity. However the implementation of management measures such as fishing reserves in the Lagoon, close of fishing season for large nets between October and February, limitation on the number of nets (gillnets and large nets) and minimum mesh sizes (Anon., 1998) may contribute to mitigate the effect of fishing mortality on the mature fish population (Mauree, 1988). However, in order to consolidate the management measures already in place, it may be necessary to increase the minimum legal size for *M. vanicolensis*.

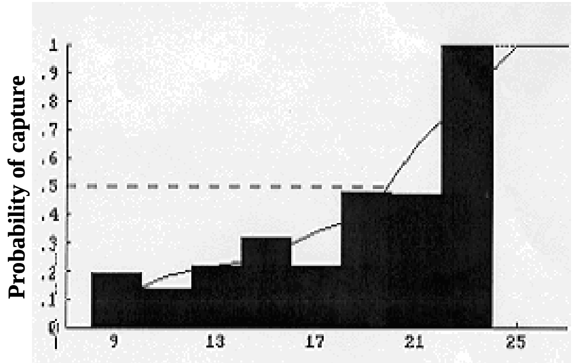

Figure 4. Selection pattern for *Mulloidicthys vanicolensis* (L_{50}=19.8 cm TL) in Mauritius Lagoon in 1988.

Recruitment pattern

The recruitment pattern shown in Figure 5 suggests one seasonal pulse per year. This corresponds with trends in gonado-somatic index (GSI) calculated for monthly samples of the same species as presented in Figure 6, showing one spawning season with one peak towards October and November. The origin of the growth curve (also in October) in Figure 2 is thus supported. These results also provide some validation to the close of season (October to February) mentioned earlier, which is aimed at a broad spectrum of summer reproducing fish.

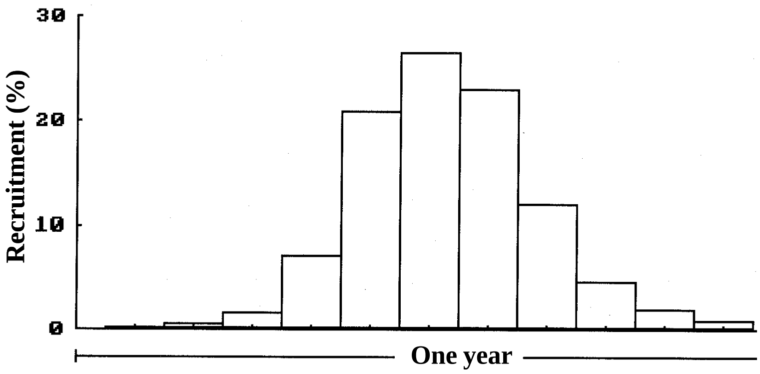

Figure 5. Seasonality of recruitment pattern for *Mulloidicthys vanicolensis* in Mauritius Lagoon in 1988.

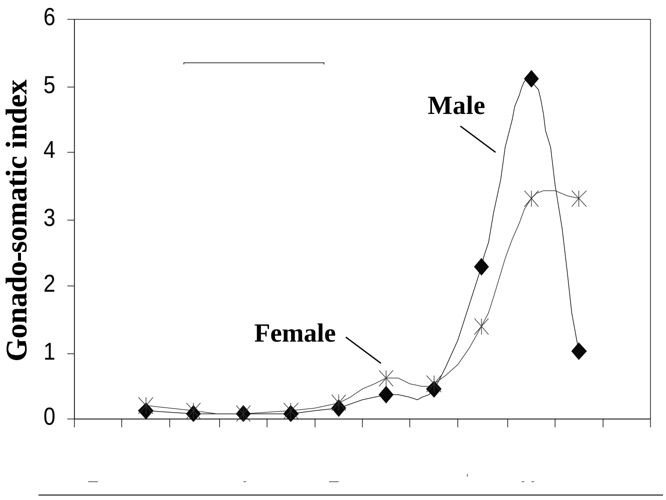

Figure 6. Seasonal changes in gonado-somatic index for *Mulloidicthys vanicolensis* in Mauritius Lagoon in 1988.

Relative yield-per-recruit and biomass-per-recruit

Y'/R and B'/R were determined as functions of L_{50}/L_∞ and M/K respectively. Figure 7 shows that the exploitation rate (E=0.56) is lower than either that which generate optimum yield per recruit ($E_{0.1}$=0.66) or maximum yield-per-recruit (E_{max}=0.71). This indicates that yield-per-recruit could be increased slightly by increasing E. However, maximisation of yields would lead to relatively low stock biomass, i.e., to low catch per effort.

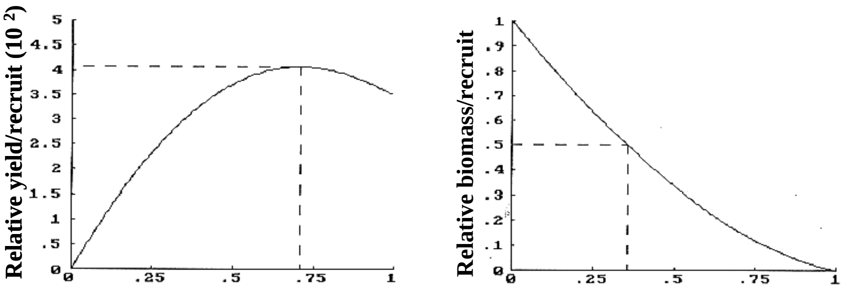

Figure 7. Relative yield per recruit and relative biomass per recruit for *Mulloidicthys vanicolensis* (L_c/L_∞ =0.472; M/K=1.72) in Mauritius Lagoon in 1988.

The relatively low value of E could possibly be attributed to the fact that the fish samples were collected both from the lagoon and the adjoining fishing reserve (see Figure 1) where fishing with large nets and gillnets is prohibited (Anon., 1998), except for authorised scientific purposes such as the shrimp collection programme mentioned earlier. The closing season for a period of four months and the other management measures mentioned previously may also have contributed to the low E value. This also partly explains why in spite of the actual intensive fishing over the years, the yields from the lagoon have remained more or less stable as the same management measures affect all the fish stocks of the lagoon.

Thus, this preliminary study can be considered indicative of the overall state of the stock of *Mulloidicthys vanicolensis* of the lagoon. However, more detailed analyses on catches from the lagoon artisanal fishery may have to be carried out to verify conclusions reached therein.

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FISH COMMUNITY STUDIES

ÉTUDE DE LA DIVERSITE BIOLOGIQUE DES POISSONS JUVENILES DE LA BAIE DU LEVRIER, MAURITANIE

A STUDY ON THE BIOLOGICAL DIVERSITY OF JUVENILE FISHES OF LÉVRIER BAY, MAURITANIA

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RESUME

Une étude des poissons juvéniles a été réalisée dans la Baie du Lévrier à Nouadhibou (Mauritanie) dans quatre stations, d'avril 1993 à novembre 1994. Quarante cinq espèces appartenant à 29 familles et à 13 ordres ont été rencontrées. La biodiversité est liée à la nature du biotope et aux conditions hydroclimatiques, en particulier à l'existence de saisons de transition.

ABSTRACT

A study of juvenile fishes was carried out in Baie du Lévrier (Nouadhibou, Mauritania) at four stations from April 1993 to November 1994. Forty five species belonging to 29 families and 13 orders were recorded. Biodiversity is related to the biotope type of stations, hydroclimatic conditions, notably, the transition between seasons.

INTRODUCTION

Sur le plan écologique, les zones marines et côtières mauritaniennes sont d'un très grand intérêt, tant au niveau faunistique que floristique. En effet, c'est un lieu de contact entre les espèces à affinité tempérée et tropicale, caractérisé par la présence, au Cap Blanc, d'une zone de remontée d'eaux froides profondes ou upwelling, alors que la zone des hauts fonds du Banc d'Arguin emprisonne des eaux chaudes. Ce régime hydrologique, très particulier, favorise une diversité de biotopes rares sur la côte ouest africaine (Maigret, 1974; Gaudechoux et Richer de Forges, 1983; Séverin Reyssac, 1983; Chlibanov *et al*., 1982). La Baie du Lévrier et le Banc d'Arguin constituent des nurseries pour plusieurs espèces.

Jusqu'à une date récente, les études des espèces marines en Mauritanie étaient focalisées sur les adultes. Suite à des travaux menés au Banc d'Arguin, Francour (1987) a accrédité l'hypothèse de l'existence de nurseries et de frayères. Jager (1990, 1993) confirme la présence des premiers stades de développement de plusieurs espèces dans les zones les plus côtières du Banc d'Arguin.

La Baie du Lévrier est indissociable de l'écosystème du Banc d'Arguin du fait de la dynamique des masses d'eau. L'hypothèse la plus récente fait aboutir la dérive littorale de la baie dans la cuvette nord-est, ce qui contribue vraisemblablement à l'apport de particules organiques. L'étude de la diversité biologique est donc nécessaire pour identifier les espèces et connaître leur saisonnalité et poursuivre les travaux entamés au Banc d'Arguin vers la fin des années 1980. Et ceci, d'autant plus que les zones d'occurrence de la diversité biologique sont considérées comme des zones de concentration de géniteurs pour la ponte.

MATERIEL ET METHODE

D'avril 1993 à novembre 1994, chaque mois (sauf en juin 1993 et en septembre 1994), des poissons juvéniles ont été capturés à la senne de plage expérimentale dans la Baie du Lévrier dans quatre stations. La senne de plage utilisée a une longueur de 60 m, une chute de 4 m et une maille de 10 mm. A chaque extrémité, un bois d'un mètre est placé entre les cordages. Après des essais préliminaires dans différents sites, 4 stations proches les unes des autres ont été retenues. Plusieurs critères ont guidé le choix de celles-ci, compte tenu de la diversité des objectifs visés. En effet, les stations ont été choisies afin de connaître l'influence de facteurs tels que l'habitat, la pollution, l'exposition aux vents dominants, la proximité d'un abattoir et d'ateliers de traitement et de transformation du poisson, sur la composition spécifique et la diversité biologique.

Les stations choisies étaient, par ailleurs, facilement accessibles par voie terrestre et maritime (Figure 1), sauf pendant les grandes marées. La station1 (station A) est située près de la pointe aux crabes, à l'entrée sud de la Baie du Repos, qui est proche de l'abattoir de Nouadhibou et des ateliers de traitement et de transformation du poisson. La station2 (B) est proche de la première; elle est assez exposée aux vents dominants. La station3 (C) est située dans une petite baie à plus de 600 m de la Pointe du Rey, au sud de laquelle les profondeurs de 3 à 4 m (Anon., 1988) sont proches du rivage. La station4 (D), à environ 1.5 km au nord de la Pointe du Rey, est en dehors de la baie de Cansado, en face au Banc de l'Ardent. Un herbier de phanérogames existe dans cette zone.

Pour obtenir des échantillons, un seul coup de senne est donné. La pêche a lieu le plus souvent entre 10H00 et 10H30. La senne de plage est déployée à l'aide d'une pirogue à moteur qui décrit un arc de cercle à partir de la plage. La durée de cette opération est au maximum de 5 minutes. Si la pêche est bonne, un échantillon dont le poids est inférieur à 25 kg est prélevé et la proportion de l'échantillon par rapport à la prise totale est notée. Si la capture est inférieure à 25 kg, la totalité de l'échantillon est conservée. Cela a servi, par la suite, à faire les conversions nécessaires pour calculer des prises par unité d'effort (PUE) à des fins de comparaisons intra- et inter-stations. Les individus de plus de 100 g sont triés et mis de côté. Dans le cas où les captures sont inférieures à 10 individus ou composées exclusivement d'individus de grande taille, un second coup de senne est donné, généralement, 10 minutes après le premier, pour permettre la reconstitution éventuelle des bancs. Le premier coup de trait n'est pas alors pris en compte.

La composition spécifique est déterminée au laboratoire après le retour de pêche. Lorsqu'il y a un problème de détermination, les individus sont congelés pour être soumis à différents ichtyologistes. Le poids de chaque espèce est noté, ainsi que les fréquences de taille des principales espèces. Pour comparer les peuplements entre les stations et connaître l'évolution temporelle de ceux-ci à l'intérieur d'une même station, différents indices ont été utilisés, en particulier celui de Shannon : **$(H'=-\sum P_i \cdot \log_{10}(2 \cdot P_i)$; $P_i=n_i/N$** (abondance relative de l'espèce i dans l'échantillon), n' étant la somme des effectifs des espèces (S) constituant l'échantillon considéré et n_i l'effectif de la population de l'espèce i. Des peuplements à physionomie très différente peuvent avoir une même diversité (Barbault, 1992). Il est donc indispensable de calculer l'équitabilité, c'est-à-dire. **$E=H'/\log_{10}S$,** qui est le rapport entre la diversité observée et la diversité théorique maximale (équi-répartition des effectifs entre les espèces présentes).

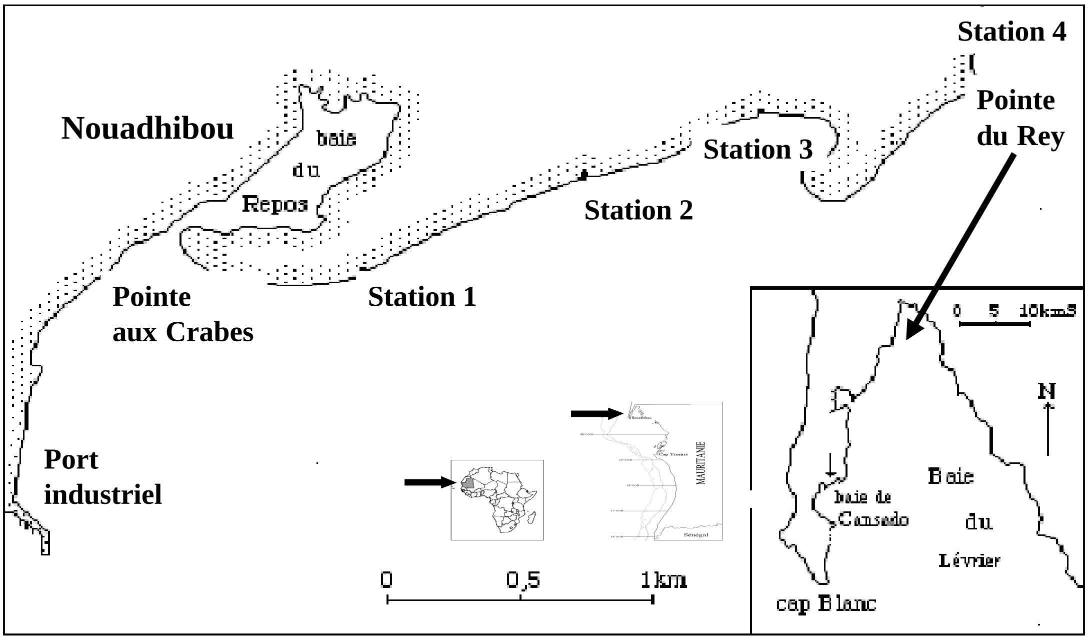

Figure 1. Les 4 stations étudiées entre le Port industriel et la Pointe du Rey dans la Baie du Lévrier en Mauritanie.

L'analyse a été effectuée avec le logiciel SPAD, un logiciel pour l'analyse des données (voir http://www.cisia.com/Spad/). Les données des quatre stations ont été mises les unes à la suite des autres. Pour faire une distribution de fréquence de la PUE (prise par unité d'effort), les données ont d'abord été homogénéisées, car elles étaient très hétérogènes (par exemple, le nombre de *Sardinella maderensis* varie de 0 à 10,175 d'une station à une autre). Différentes transformations ont été testées avant de retenir les transformations logarithmiques qui, bien qu'elles écrasent les fortes valeurs, ont le mérite de « normaliser » les distributions. Les données sont en nombre d'individus. Cette analyse a pour objet de rechercher un éventuel effet station et saison. L'analyse factorielle des correspondances (AFC), indiquée dans ce cas, permet de traiter des tableaux de contingences. Dans la présente étude, il s'agit d'un tableau croisant le trait de senne, par mois et par station avec les espèces. De plus, l'AFC est peu sensible aux zéros et elle permet de comparer des éléments de poids ayant une très forte variabilité. A la suite de l'AFC, une classification ascendante hiérarchique des traits dans l'espace des facteurs de l'AFC a été réalisée afin de définir des classes de station en terme de composition spécifique.

RESULTATS

Quarante cinq espèces appartenant à 29 familles ont été répertoriées entre 1993 et 1994 dans la Baie du Lévrier dont 25 rencontrées dans la station A, 21 dans la station B, 28 dans la station C et 27 dans la station D. La liste des espèces rencontrées dans la zone d'étude par Ordre et par Famille est présentée dans le Tableau 1 ainsi que les fréquences de présence par station. Vingt espèces sont rares ou très rares; ce sont les espèces qui ne sont présentes que dans une seule station. Sept espèces ne sont représentées que par un seul individu, 6 sont rencontrées dans deux stations à la fois, 8 dans 3 et 12 dans toutes les stations. Pour ce dernier cas, il s'agit des espèces les plus importantes: *Sardinella maderensis, Diplodus bellottii* et *Dicentrarchus punctatus.* L'appartenance spécifique de plusieurs individus n'a pas pu être déterminée (cas des Gobiidae).

Les indices de diversité trouvés sont faibles et très variables. Les valeurs moyennes sont données dans le Tableau 1. L'équitabilité varie de 0 à 1. Elle tend vers 0 quand la quasi-totalité des effectifs est concentrée sur une espèce, elle est de 1 lorsque toutes les espèces ont la même abondance.

Plusieurs espèces, parmi les 45 rencontrées, ont un poids très faible et donc une influence réduite sur les résultats; elles ont donc été utilisées comme variables supplémentaires.

Analyse Factorielle des Correspondances

Les résultats de l'analyse factorielle des correspondances (AFC) fondée sur l'abondance relative des espèces rencontrées sont présentés sur la Figure 2. Sur cette représentation, les trois premiers axes concourent avec 41 % de l'inertie totale, le quatrième et le cinquième axe contribuent respectivement pour 9.5 et 7 %. Le premier axe oppose les espèces démersales (*Synaptura lusitanica*, *Symphodus bailloni*, *Halobatrachus didactylus*, Gobiidae etc.) à des espèces pélagiques ou semi-pélagique (*Sardinella madersensis*, *Caranx ronchus* et *Liza aurata)* La présence de *Lithognatus mormyrus* s'explique par son comportement pélagique plus prononcé à l'état juvénile. Dans le groupe démersal apparaît *Mugil capurii* qui est une espèce semi-pélagique, mais sa contribution à cet axe est de toute façon faible. Le second axe oppose *Lithognathus mormyrus* (espèce démersale) à *Caranx rhonchus* (pélagique). Le troisième axe est construit par les Mugilidae, *Liza aurata* d'un côté et *Mugil cephalus* de l'autre.

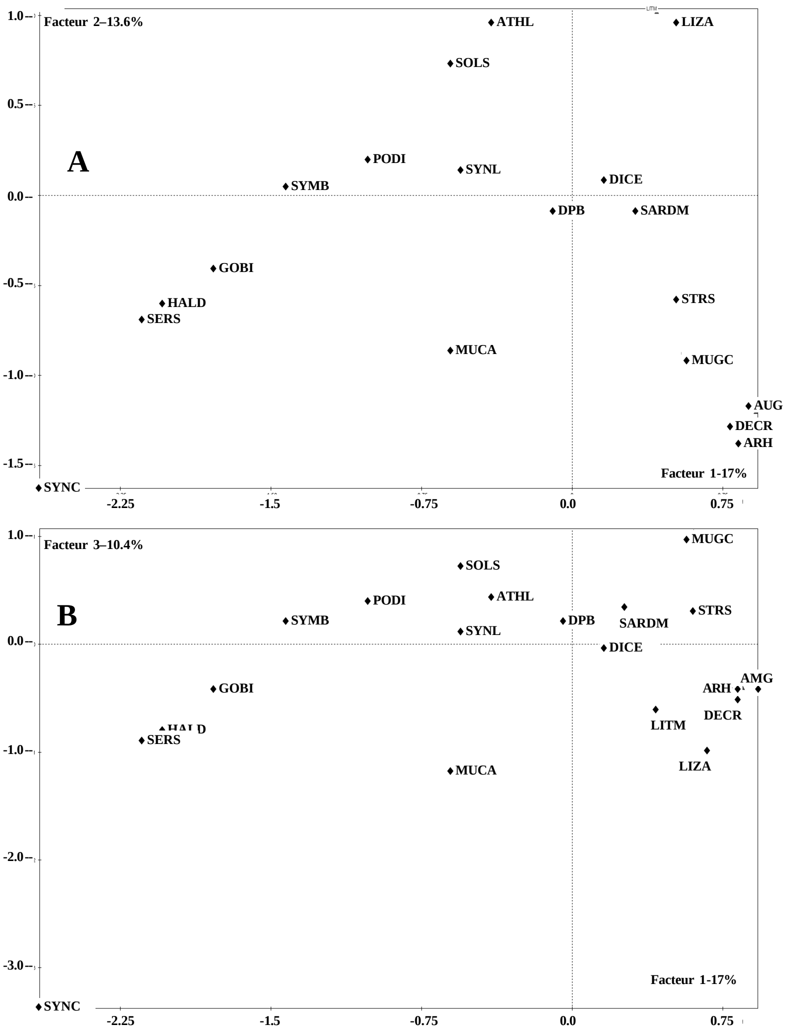

Figure 2. Résultats de l'analyse factorielle pour les 3 premiers axes: A) facteur 1 et 2 ; B) facteur 1 et 3.

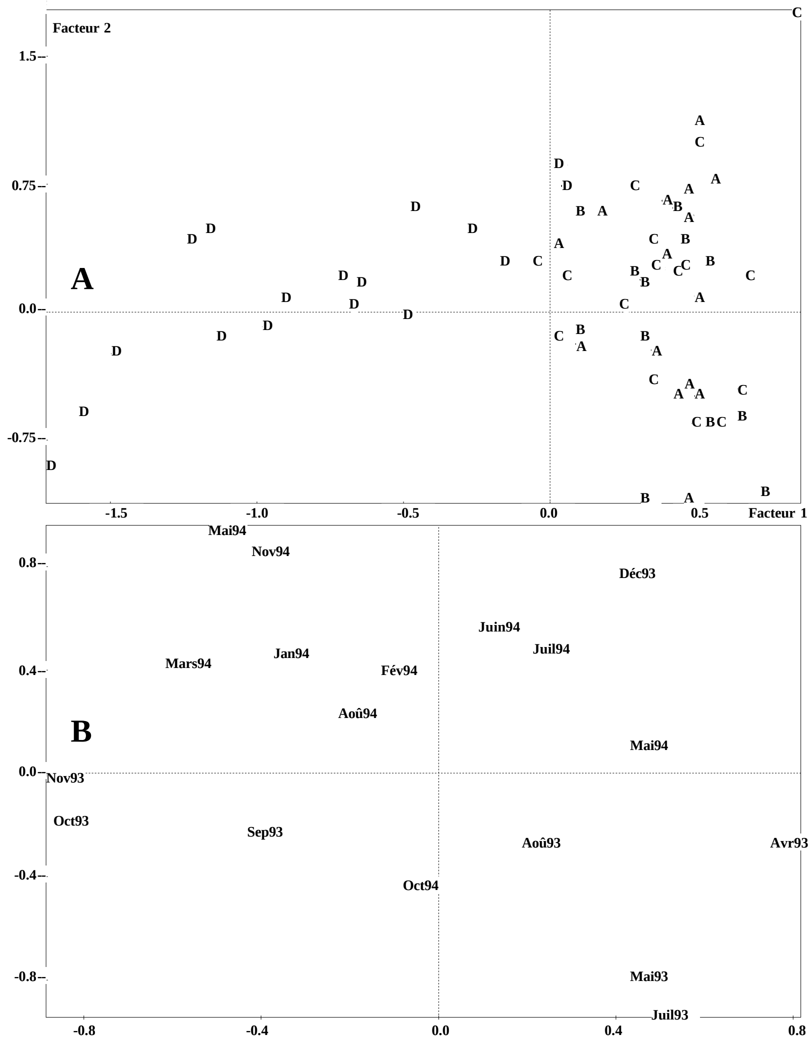

Figure 3. Résultats de l'analyse factorielle pour les traits de sennes par station (A) et par mois (B).

La représentation des traits de senne par station et par mois fait ressortir (Figure 3) que la station D s'individualise surtout pendant les mois de novembre mais aussi en septembre, octobre, février et mars. Le mois de novembre correspond à la période de transition chaude-froide. L'axe 2 est structuré par la station B (coordonnées négatives) et par une autre partie de la station D (coordonnées positives) également lors des périodes de transition. Ce phénomène est aussi observé pour la station A pendant les mois d'avril, de mai et d'août. Il y a un effet saison de transition qui apparaît de façon pas toujours nette dans trois des quatre stations. La contribution de la station C aux deux premiers axes est faible. Cela s'explique par une grande diversité des espèces lors des périodes de transition qui correspondent à la présence simultanée d'espèces à affinités chaude et froide.

Classification ascendante

Une classification ascendante réalisée sur le tableau des données de l'AFC permet de constituer 6 classes de station (Figure 4). La station D (herbier), la plus individualisée, est répartie en deux classes, dont une est composée d'un seul élément. Les autres classes sont plutôt hétérogènes et sont constituées d'éléments appartenant aux différentes stations.

Tableau 1: Liste des espèces rencontrées dans les 4 stations étudiées (sA-sD) dans la Baie du Lévrier capturées à la senne de plage expérimentale entre avril 1993 et novembre 1994. Les fréquences de présence par station des espèces et leur occurrence totale(n) ainsi que l'indice de diversité moyens par station sont aussi indiqués.

Ordre	Famille	Espèces	Code	SA	Sb	sC	sD	n
1	2	3	4	5	6	7	8	9
Atheriniformes	Atherinidae	*Atherina lopeziana*	ATHL	0	2	2	5	9
Batrachoidiformes	Batrachoididae	*Halobatrachus didactylus*	HALD	0	0	0	2	2
Beloniformes	Belonidae	*Strongylura senegalensis*	STRS	6	3	7	0	16
Clupéiformes	Clupeidae	*Sardinella maderensis*	SARDM	13	16	14	11	54
		Sardinella aurita	SARA	0	0	2	0	2
		Ethmalosa fimbriata	ETHM	1	1	3	2	7
	Engraulidae	*Engraulis encrasicolus*	ENGE	1	0	2	0	3
Perciformes	Mugilidae	*Liza aurata*	LIZA	11	7	8	2	28
		Mugil capurrii	MUCA	4	9	6	5	24
		Mugil cephalus	MUGC	3	1	2	0	6
	Sparidae	*Diplodus sargus*	DIPS	1	8	2	10	21
		Diplodus bellottii	DIPB	13	14	15	14	56
		Dentex canariensis	DENC					0
		Lithognathus mormyrus	LITM	5	6	6	4	21
	Carangidae	*Orcynopsis unicolor*	ORCU	0	2	1	0	3
		Caranx rhonchus	DECR	3	2	3	0	8
		Campogramma glaycos	AMG	1	2	2	0	5
		Seriola dumerili	SERD	1	0	1	0	2
		Lichia amia	HYPA	0	0	0	1	1
	Pomatomidae	*Pomatomus saltatrix*	POMS	1	3	2	4	10
	Polynemidae	*Galeoides decadactylus*	GALD	4	8	4	6	22
	Mullidae	*Pseudupeneus prayensis*	PSEP	2	0	1	0	3
	Haemulidae	*Pomadasys incisus*	PODI	0	1	1	8	10
		Pomadasys jubelini	POMJ	1	0	0	0	1
	Scianidae	*Umbrina canariensis*	UMBC	0	0	0	3	3
	Labridae	*Symphodus bailloni*	SYMB	0	0	9	1	10
	Stromateidae	*Stromateus fiatola*	STRF	0	0	1	0	1
	Gobiidea	Pas identifié	GOBI					0
	Serranidae	*Serranus cabrilla*	SERC					0
		Serranus scriba	SERS	0	0	0	1	1
		Serranus sp.	SERP	0	0	0	5	5
	Moronidae	*Dicentrarchus punctatus*	DICE	13	14	15	14	56
	Trachinidae	*Trachinus draco*	TRAD	1	0	0	0	1
Pleuronectiformes	Soleidae	*Solea senegalensis*	SOLS	2	3	1	7	13
		Synaptura lusitanica	SYNL	3	3	3	5	14
		Synaptura cadenati	SYNC	0	0	0	1	1
		Dicologlossa cuneata	DICC	0	0	0	1	1
	Bothidae	*Arnoglossus* sp.	ARNS	1	0	0	0	1

Tableau 1 cont.

Ordre	Famille	Espèces	Code	SA	Sb	sC	sD	n
Rajiformes	Gymnuridae	*Gymnura* sp.	GYMS	0	0	0	1	1
	Rhinobatidae	*Rhinobatos rhinobatos*	RHIR	0	0	0	1	1
Siluriformes	Ariidae	*Arius heudelotii*	ARIH	1	5	0	0	6
Syngnathiformes	Syngnathidae	*Syngnathus* sp.	SYNG	0	0	0	3	3
Tetraodontiformes	Tetraodontidae	*Ephippion guttifer*	EPHG	0	0	1	0	1
Torpediniformes	Torpedinidae	*Torpedo* sp.	TORS	0	0	1	0	1
Decapoda	Peneidae	*Melicertus kerathurus*	PANK	1	0	0	1	2
Sepiida	Sepiidae	*Sepia officinalis*	SEPO	4	7	4	10	25
Nombre total	–	–	–	25	21	28	27	461
Indice de Shannon (Bits)	–	–	–	1.20	1.37	1.52	1.71	–
Equitabilité	–	–	–	0.20	0.19	0.23	0.24	–

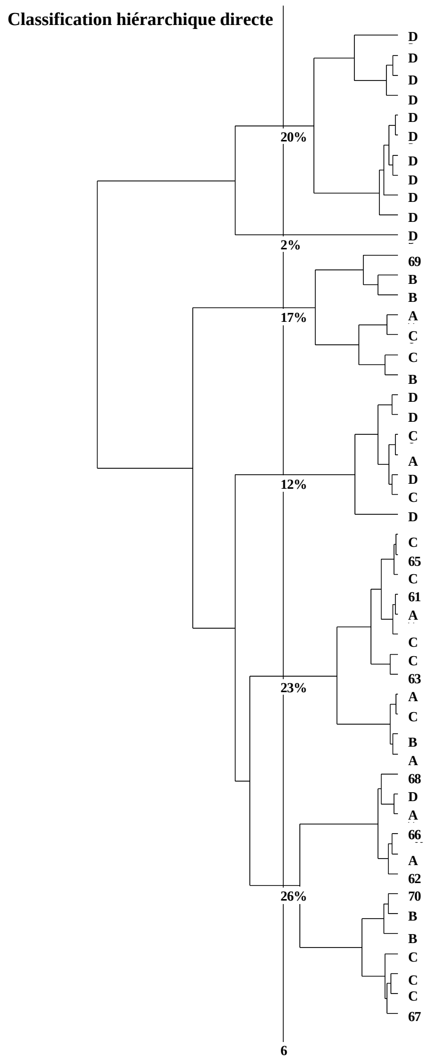

Figure 4. Classification ascendante réalisée sur le tableau des données de l'AFC permet de constituer 6 classes de stations (voir texte pour plus de détails).

DISCUSSION ET CONCLUSION

Quarante-cinq espèces appartenant à 29 familles et à 13 ordres ont été capturées dans les quatre stations étudiées dans la Baie du Lévrier. Gaudechoux et Richer de Forges (1983) donnent le chiffre de 483 espèces et de 143 familles dans la ZEE mauritanienne. L'étendue limitée de la zone étudiée par rapport à l'ensemble de la ZEE mauritanienne explique l'écart entre les deux résultats.

Le nombre d'espèces capturées dans la Baie du Lévrier est le même que celui rapporté pour le Banc d'Arguin (Jager, 1993), avec, cependant, une dizaine d'espèces différentes. Ceci peut s'expliquer par l'utilisation d'un engin de pêche différent (chalut à perche), par des différences de salinité et de température, et par la grande diversité des habitats au niveau du Banc d'Arguin. Il faut cependant noter que l'étude portant sur cette dernière zone n'a été menée qu'en septembre 1988, alors que les travaux présentés ici ont duré 18 mois. Pour une comparaison fine, le nombre d'espèces répertoriées en septembre dans la Baie du Lévrier est de 14 espèces. Tout cela tend à confirmer la grande diversité ichtyologique du Banc d'Arguin.

La couverture spatio-temporelle de la zone d'étude étant correcte, on peut supposer que le nombre d'espèces rencontrées traduit de manière quasi exhaustive la richesse spécifique de la zone. Par ailleurs, les longueurs totales de plusieurs espèces (13 cm pour *Sardinella maderensis* et 15 cm pour *Diplodus bellottii*, par exemple) rencontrées dans la Baie du Lévrier (données non publiées) correspondent à celles de juvéniles, ce qui confirme l'hypothèse que cette zone est effectivement une zone de nurseries et de nourriceries pour plusieurs espèces.

Par ailleurs, l'indice de diversité augmente de l'intérieur vers l'extérieur de la Baie. La station D, qui est un herbier, a l'indice le plus élevé, ce qui traduit une plus grande diversité spécifique. Les indices de diversité dépendent de la richesse spécifique S et de la répartition des effectifs entre les différentes espèces (Barbault, 1992). L'équitabilité est plus faible à l'intérieur de la Baie qu'à l'extérieur (0.24) dans la zone de l'herbier, ce qui indique, dans le premier cas, la prédominance d'une espèce et, dans le second cas, l'équilibre entre les espèces.

Plusieurs auteurs, Barbault (1992) en particulier, ont souligné que la diversité mesurée n'est qu'une estimation grossière et arbitraire de la zone étudiée; le nombre d'individus d'une espèce ne constitue pas forcément une bonne représentation de sa place dans l'organisation d'un peuplement. De plus, les différentes espèces n'ont pas obligatoirement le même comportement vis à vis de l'engin de pêche utilisé (par exemple la majeure partie des mulets sautent par dessus le filet pendant la pêche).

Un effet saison de transition est à l'origine de la forte contribution des stations A, B, et D aux axes 1 et 2; cela s'explique par la présence de plusieurs espèces ayant des préférences thermiques « douces ». La station D est la plus diversifiée, avec essentiellement des espèces démersales. La prédominance de ces dernières est due à l'exposition aux vents dominants et au fait que l'herbier (sur une zone peu profonde) occupe tout le volume d'eau, ce qui empêche les pélagiques d'évoluer.

Enfin, en l'absence d'études antérieures de la zone, il est impossible de se prononcer sur l'évolution de sa diversité biologique, diversité qui est de plus en plus soumise à une industrialisation et à une intensification des activités de transformation du poisson.

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LA MARE AUX HIPPOPOTAMES (BURKINA FASO): ASPECTS HYDROBIOLOGIQUES ET HALIEUTIQUES.

THE HIPPOPOTAMUS POND (BURKINA FASO): HYDROBIOLOGY AND FISHERIES

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RESUME

Cette étude apporte de nouvelles données sur l'écosystème aquatique de La Mare aux Hippopotames, Burkina Faso. Son peuplement piscicole est inventorié en saison sèche et comparé aux données pré-existantes. Les relations taille-poids sont calculées pour les espèces principales, les prises et l'activité halieutique sont analysées et des recommandations sont formulées pour une meilleure gestion du milieu exploité.

ABSTRACT

This study brings new data on the aquatic ecosystem of the Mare aux Hippopotames (Hippopotamus Pond), Burkina Faso. Its fish community is described for the dry season and compared with preexistent data. Length-weight relations are calculated for the principal species; production, i.e., catches and fisheries activities are analysed and some recommendations are formulated for a better management of the pond.

INTRODUCTION

La Mare aux Hippopotames est située au sein de la forêt classée du même nom (réserve MAB/UNESCO depuis 1986), à 65 km au nord de Bobo-Dioulasso, dans la province du Houet (Figure 1). On y accède en prenant la route Bobo - Dédougou, puis en empruntant la piste pour Bala et Bossora. Au moment de la présente étude, la seule publication concernant l'hydrobiologie de la Mare était celle de Blanc et Daget (1957).

LE MILIEU NATUREL

Climatologie et hydrologie

Le climat est de type Sud-Soudanien avec une pluviométrie de l'ordre de 1000 mm par an et une température annuelle moyenne de 28°C. La « Mare aux Hippos » se trouve dans la plaine d'inondation du Muhun, à une altitude d'environ 300 m. Elle correspond à une dépression située sur la rive droite de ce cours d'eau. Cette plaine d'inondation du Muhun est la seule du pays et s'étend approximativement de la confluence du Kou à celle du Sourou, au Nord de Dédougou. Le Muhun ou Volta Noire est la branche principale du fleuve Volta; il prend sa source sur le plateau gréseux au Nord de la falaise de Banfora, et se jette dans le lac Volta au Ghana. Son régime hydrologique est de type tropical pur (Rodier 1964).

La Mare est alimentée en permanence par le Tinamou, ruisseau qui trouve son origine au niveau de résurgences phréatiques diffuses, à 4 km environ au Sud. L'écoulement est continu sur l'année et assure une alimentation pérenne de la Mare. On retrouve le Tinamou en aval jusqu'à sa confluence avec la Leyessa, affluent rive droite du Muhun; ce tronçon représentant environ 2 km. Ce réseau hydrologique s'inscrit en saison des pluies dans le complexe de plaine d'inondation du Muhun; il y a alors mélange des eaux. Les eaux du Tinamou d'origine souterraine sont limpides et vont se charger, pendant leur temps de séjour dans la Mare, en matière organique (phytoplancton); ce qui leur donne à la sortie leur couleur verte. Les eaux du Muhun sont, à l'opposé, chargées en sédiments limono-argileux qui leur donnent une coloration marron foncé. Cette différence de teinte des eaux est particulièrement observable au niveau de la confluence Leyessa-Muhun, car les eaux ne se mélangent pas immédiatement.

L'alternance saison sèche et saison des pluies entraîne des fluctuations importantes du niveau des eaux de la Mare et le marnage peut atteindre 3 à 4 m. La surface, quant à elle, varie de 80 à 350 ha environ (évaluation d'après imagerie Spot). La profondeur moyenne ne semble pas excéder 1 mètre au mois de février.

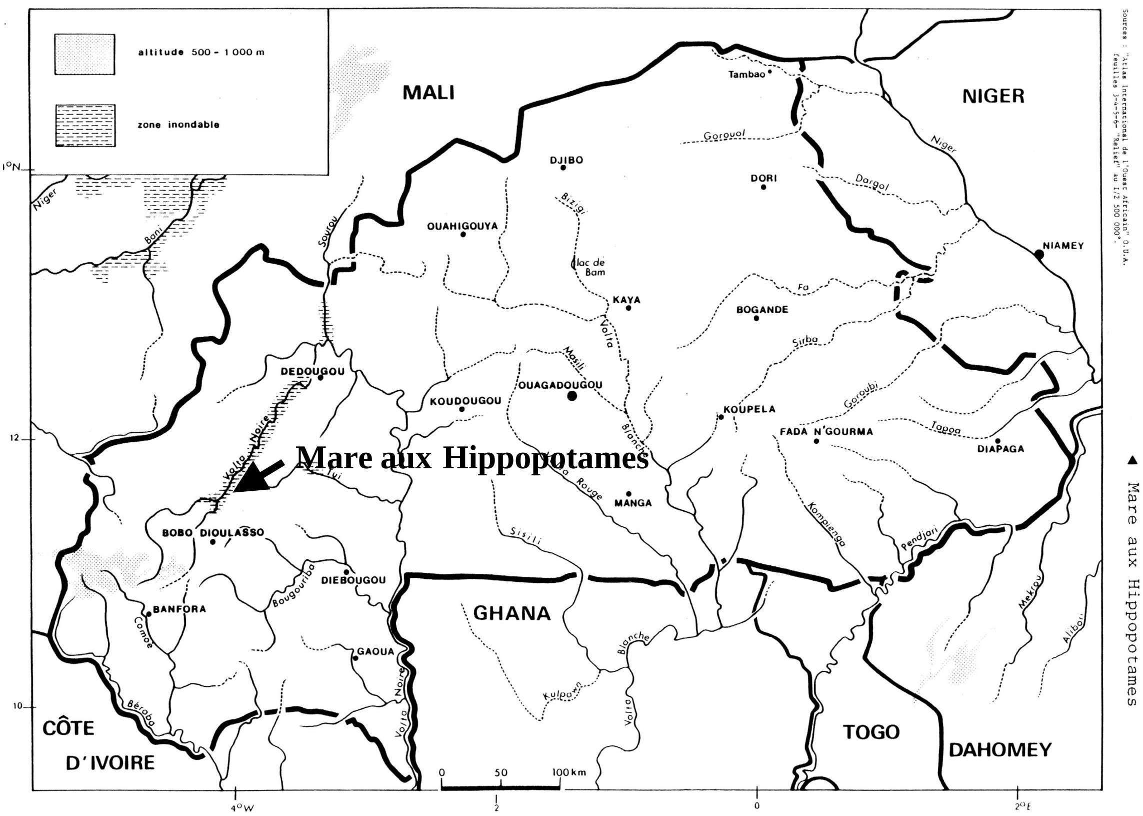

Figure 1. La Mare aux Hippopotames se trouve au nord de Bobo-Dioulasso dans la plaine d'inondation de Muhun (carte adaptée de l'Atlas International de l'Ouest Africain. O.U.A. feuilles 3-4-5-6 relief au 1/2,500,000).

Physico-chimie des eaux

Les mesures effectuées, pour partie sur le terrain, pour partie au laboratoire d'Hydrobiologie de Toulouse (UPS), ne valent bien sûr que pour la saison sèche, époque de basses eaux à laquelle ont été faits nos prélèvements. Les résultats figurent dans le tableau 1 où ils ont été mis en correspondance avec ceux obtenus par Blanc et Daget (1957), 33 ans plus tôt mais à la même époque de l'année.

Les eaux s'écoulent sur un substrat constitué par des grés du Cambrien à 'yeux de quartz' et passées schisteuses, à caractère acide et siliceux. Elles sont globalement de bonne qualité mais peu riches. Faiblement acides, elles ont une conductivité et une quantité de matières en suspension modérée. Les ions (Na^+, K^+, Mg^{++}) sont présents en moyenne quantité et la salinité est normale. L'alcalinité (TAC) est très faible. L'oxygénation est satisfaisante et même bonne pour un tel plan d'eau. Les eaux sont pauvres en nitrates et phosphates et ne montrent pas de signe d'eutrophisation (Tableau 1).

Flore et faune

Les eaux de la Mare sont riches en phytoplancton et possèdent une flore aquatique assez importante. En partant du centre vers la périphérie, on rencontre :

- la végétation aquatique proprement dite, avec pour principales espèces: *Azolla* sp.; *Eichornia natans; Ipomea* sp.; *Mimosa pigra*; *Neptunia* sp.*;* et *Pistia stratiotes;*
- la végétation semi-aquatique, avec essentiellement, *Ficus congensis;* et
- la végétation des zones inondables, avec comme espèces caractéristiques, p.ex. *Crataeva religiosa*, *Mitragyna inermis* et *Vetiveria nigritana*.

Tableau 1. Physico-chimie des eaux de la Mare aux Hippopotames, Burkina Faso. Noter que les valeurs sont concordantes, sauf pour ce qui est de la silice; la valeur de 251 est probablement une erreur dans la publication, la concentration saturante étant de 140 $mg{\cdot}l^{-1}$ à 25°C. Peut-être s'agit-il de 25,1 $mg{\cdot}l^{-1}$? Valeur déjà élevée mais qui pourrait s'expliquer du fait du substrat siliceux. En revanche, la conductivité que nous mesurons est très proche de celle mesurée sur le terrain par Corsi and Coenen (1988): 154 $\mu S{\cdot}cm^{-1}$.

Paramètre	février 1956 (Blanc et Daget, 1957)	février 1989 (cette étude)
pH	6,5	6,8
THT (°f)	5,0	11,6
TAC (mg $CaCO_3{\cdot}l^{-1}$)	51,5	70,0
Na^+ ($mg{\cdot}l^{-1}$)	0,83	2,5
K^+ ($mg{\cdot}l^{-1}$)	6,24	10,9
Mg^{++} ($mg{\cdot}l^{-1}$)	12,4	8,0
SiO_2 ($mg{\cdot}l^{-1}$)	251	4,7
NaCl ($mg{\cdot}l^{-1}$)	32,4	33,0
$N\text{-}NO_2^-$ ($\mu g{\cdot}l^{-1}$)	–	Traces
$N\text{-}NO_3^-$ ($\mu g{\cdot}l^{-1}$)	–	40,0
$P\text{-}PO_4^{3-}$ ($\mu g{\cdot}l^{-1}$)	–	11,0
O_2 (mg/l)	–	6,6
% de saturation		80,0
Conductivité (à 20°C en µS/cm)	–	148,0
MES ($mg{\cdot}l^{-1}$)	–	34,0
Température (°C)	–	25,0

Mis à part les poissons, qui font l'objet d'un paragraphe séparé, divers animaux font partie du paysage de la Mare et contribuent au fonctionnement de l'écosystème. Notre étude n'avait pas pour but de réaliser un inventaire exhaustif de la faune inféodée au plan d'eau et nous nous contenterons de citer les espèces rencontrées au cours de nos investigations sur l'ichtyofaune et sa pêche. Tout d'abord et de façon un peu anecdotique, signalons la présence d'un invertébré régulièrement piégé dans les nasses des pêcheurs: il s'agit d'un coléoptère dytiscidé, dont la larve, comme l'adulte, s'attaquent aux alevins: *Cybister vicinus*. En ce qui concerne les vertébrés, nous avons rencontré:

- un serpent qui s'était pris dans un filet; il s'agit d'un colubridé aquatique de l'espèce *Grayia smithii*. Comme autres reptiles, les pêcheurs mentionnent la présence de crocodiles de petite taille, signalés aussi par Blanc et Daget (1957): il pourrait s'agir soit de jeunes crocodiles du Nil (*Crocodylus niloticus*), soit de crocodiles cuirassés (*Osteolaemus tetraspis*);

- de nombreux oiseaux d'eau. Leur liste est détaillée dans le rapport ENGREF sur la Réserve Biosphère de la Mare aux Hippopotames et nous n'en parlerons pas ici; et

- les hippopotames bien sûr (*Hippopotamus amphibius*). Un groupe d'une douzaine d'individus se trouvait en permanence à proximité du campement de pêcheurs. Un autre groupe était souvent présent dans le Nord de la Mare, riche de 27 individus. En saison sèche, l'effectif en « hippos » se monte donc à une quarantaine d'individus.

LES POISSONS ET LA PECHE

L'ichtyofaune

L'inventaire des espèces présentes dans la Mare a été réalisé à partir des débarquements des pêcheurs et à partir de pêches à la ligne ou à l'épervier, effectuées en louant les services d'un pêcheur du campement. Ceci, afin de prospecter les zones d'herbiers peu profondes et de pouvoir utiliser un filet à petites mailles pour capturer les juvéniles et les petites espèces. L'identification des poissons s'est faite à l'aide de l'ouvrage de Lévêque et Paugy (1984). La liste des espèces rencontrées apparaît dans le Tableau 2, où elle est mise en parallèle avec celle établie par Daget (Blanc et Daget, 1957) à partir de ses observations en 1956. Ce dernier cite 42 espèces alors que nous n'en citons que 30, parmi lesquelles 23 sont communes aux deux listes.

Nous pouvons remarquer que 4 familles complètes nous manquent: les poeciliidés, les aplocheilidés, les citharinidés et les distichodontidés. Pour les deux premières, sachant que les représentants des espèces concernées dépassent rarement 30 mm de longueur, on comprend qu'ils aient pu nous échapper. Pour les 2 autres, il s'agit au contraire d'espèces de tailles assez importantes (jusqu'à 600-700 mm de longueur totale) et, surtout, caractérisées par un corps haut et comprimé. Leur morphologie les rend donc particulièrement sensibles à la pêche aux filets. L'effort de pêche étant très probablement plus élevé actuellement qu'en 1956, il se peut que ces espèces, bien que n'ayant pas disparu, soient rapidement victimes des pêcheurs en début de saison sèche; leur stock ne se renouvelant qu'à la crue suivante du Muhun.

En revanche, nous avons rencontré 2 familles non signalées par Daget: les protoptéridés et les malaptéruridés. Les deux espèces rencontrées sont faciles à identifier et il ne peut y avoir confusion. La présence du protoptère n'est cependant pas surprenante, elle était largement soupçonnée par Daget. Le malaptérure, quant à lui, était signalé dans la rivière Bougouriba et il n'est donc pas non plus étonnant qu'on le retrouve dans la Mare. D'un point de vue biogéographique, le peuplement piscicole de la Mare aux Hippos est logiquement composé de formes typiquement soudaniennes (Durand et Lévêque, 1981).

Les pêcheurs

Les permanents sont au nombre de 10 et installés dans le campement dit de Djegada, à l'extrémité sud-est de la Mare. Ce groupe est pluriethnique et, à côté d'une majorité de Bobos, on trouve des Dioulas, des Bafings, un Bozo et un Koroboro. Leur seule activité est la pêche. Avec 13 autres membres, qui pratiquent aussi la pêche mais sont pluri-actifs et ont des cultures, ils forment l'actuel Groupement des pêcheurs. A ces 23 membres permanents s'ajoutent les pêcheurs occasionnels qui, lorsqu'ils viennent pratiquer sur la Mare, louent le matériel aux résidents. Au total le nombre de pêcheurs qui fréquentent la Mare se monte donc à environ une cinquantaine. Signalons qu'aucune femme ne séjourne au campement de la Mare.

Tableau 2. Faune piscicole de la Mare aux Hippopotames. Note: *Marcusenius senegalensis* est aussi signalé présent dans la Mare par Roman (1966), au même titre que *Hyperopisus bebe occidentalis*, *Mormyrus hasselquistii*, *Mormyrus rume*, *Petrocephalus bovei* et *Lates niloticus* (octobre-novembre 1964).

Famille	Espèces signalées par Daget en 1957	Espèces rencontrées en 1989
Protopteridae		*Protopterus annectens*
Polypteridae	*Polypterus bichir lapradei*	
	Polypterus endlicheri	*Polypterus endlicheri*
	Polypterus senegalus senegalus	*Polypterus senegalus senegalus*
Osteoglossidae	*Heterotis niloticus*	*Heterotis niloticus*
Mormyridae	*Hyperopisus bebe occidentalis*	
		Marcusenius senegalensis
	Mormyrus hasselquistii	
	Mormyrus rume	*Mormyrus rume*
	Petrocephalus bovei	
Gymnarchidae	*Gymnarchus niloticus*	*Gymnarchus niloticus*
Characidae	*Alestes baremoze*	
	Brycinus macrolepidotus	*Brycinus macrolepidotus*
	Brycinus nurse	*Brycinus nurse*
	Hydrocynus brevis	
Distichodontidae	*Distichodus brevipinnis*	
	Distichodus rostratus	
Citharinidae	*Citharinus citharus*	
	Citharinus latus	
Cyprinidae	*Barbus leonensis*	
		Barbus macrops
	Labeo coubie	
	Labeo senegalensis	*Labeo senegalensis*
Bagridae	*Bagrus bayad*	
Clarotidae	*Auchenoglanis occidentalis*	*Auchenoglanis occidentalis*
		Chrysichthys auratus
	Clarotes laticeps	
Schilbeidae	*Schilbe intermedius*	*Schilbe intermedius*
Clariidae	*Heterobranchus bidorsalis*	
		Heterobranchus sp.
	Clarias anguillaris	*Clarias anguillaris*
		Clarias gariepinus
Malapteruridae		*Malapterurus electricus*
Mochokidae	*Hemisynodontis membranaceus*	*Hemisynodontis membranaceus*
	Synodontis clarias	*Synodontis clarias*
	Synodontis nigrita	
	Synodontis schall	*Synodontis schall*
Poeciliidae	*Micropanchax pfaffi*	
	Poropanchax normani	
Aplocheilidae	*Epiplatys bifasciatus*	
	Epiplatys spilargyreus	
Channidae	*Parachanna obscura*	*Parachanna obscura*
Centropomidae	*Lates niloticus*	*Lates niloticus*
Cichlidae	*Hemichromis bimaculatus*	*Hemichromis bimaculatus*
		Hemichromis fasciatus
	Oreochromis niloticus	*Oreochromis niloticus*
	Sarotherodon galilaeus	*Sarotherodon galilaeus*
	Tilapia zillii	*Tilapia zillii*
Anabantidae	*Ctenopoma kingsleyae*	*Ctenopoma kingsleyae*
Tetraodontidae	*Tetraodon lineatus*	*Tetraodon lineatus*

Les engins de pêche

Le plus utilisé en saison sèche est l'épervier, idéal pour la pêche en eaux peu profondes. La maille du filet est de 30 mm. On trouve aussi des filets maillants (de maille toujours au moins égale à 30 mm), des nasses (de très petite maille) et des palangres de 500 à 3000 hameçons (numéro 10 ou 11), utilisées sans être appâtées. Les embarcations sont des barques en planches clouées, avec membrures, de 4,50 à 5 m de long pour 0,80 à 1 m de large, que les pêcheurs construisent eux-mêmes à partir de planches de bois rouge ou de bois blanc. Leur durée de vie est de 8 ans pour celles en bois rouge, de seulement la moitié pour celles en bois blanc. Les réparations se font par colmatage avec du coton imbibé d'huile de vidange ou, mieux, de beurre de karité.

La production

D'après la formule d'Henderson & Welcomme (1974), il est possible d'estimer le potentiel halieutique d'un plan d'eau à partir de sa profondeur moyenne et de la conductivité de ses eaux. Le chiffre obtenu pour la Mare, à titre indicatif pour la saison sèche, est de 150 $kg{\cdot}ha^{-1}{\cdot}an^{-1}$. Soit pour une surface de 80 à 100 ha en saison sèche, 12 à 15 $t{\cdot}an^{-1}$. En fait, les différents paramètres (conductivité, profondeur moyenne, surface) varient au cours de l'année et il est difficile d'arrêter un chiffre. Pour cela nous préférons donner une fourchette de 10 à 30 $t{\cdot}an^{-1}$. La production, calculée par les Eaux et Forêts d'après les pesées de ces dernières années, se montait à 46 t en 1986, 27 t en 1987 et 23 t en 1988 (Tableau 3).

Sachant que ces chiffres sont probablement sous-estimés car il est difficile de contrôler tous les débarquements, on se rend compte qu'ils sont élevés si on se réfère au potentiel calculé. On voit par ailleurs que la production est en baisse sur les 3 années (1986-88) et l'on peut soupçonner un effort de pêche trop important.

Nos observations lors des débarquements montrent qu'une paire de pêcheurs ramène en moyenne par sortie 11,5 kg de poissons, soit 5,8 kg par pêcheur. Le rendement moyen étant de 1,3 $kg{\cdot}hour^{-1}$ de pêche/pêcheur.

D'après les Eaux et Forêts, le nombre de sorties mensuelles moyen serait de 15, tous types de pêcheurs confondus, et le nombre moyen de pêcheurs par jour de 30. La production pour le mois de février pourrait donc s'évaluer autour de 2,610 kg (5,8x30x15). Or, d'après les données du tableau 3, on voit que les mois les plus productifs sont janvier, février et novembre. En février, selon ces chiffres, s'effectuerait 11,5 % de la pêche annuelle, ce qui nous permet d'extrapoler le chiffre précédent (2,610 kg) et d'estimer la production annuelle à 23 t (22,696 kg). Cette valeur, bien que basée sur des approximations, reste tout à fait cohérente.

Répartition spécifique des prises

Toujours dans le Tableau 3, on peut observer que les tilapias constituent le gros des prises; 51 % en moyenne sur les 3 dernières années. Le Tableau 4 donne le résultat de nos observations : les tilapias représentent 74 %. Ce chiffre, bien que différent des moyennes annuelles, est à rapprocher de la valeur de février 1988, 79 % (contre 36 % en février 1986 et 1987). Il s'agit donc soit de fluctuations normales, soit d'une prédominance croissante des tilapias, soit de l'emploi de techniques ou matériel plus sélectifs, en vue de capturer préférentiellement ces tilapias qui se vendent bien. Sur les 3 dernières années, l'ensemble « tilapias-*Heterotis*-clariidés » représente 88 %. Signalons que le tilapia le plus fréquent dans nos observations est, de loin, le *Sarotherodon galilaeus* (83 % des tilapias) et il n'y a pas de raison de penser que cette proportion varie beaucoup sur l'année.

Tableau 3. Répartition des prises mensuelles de poisson sur la Mare aux Hippopotames. Captures exprimées en kg (Source: Eaux et Forêts).

Mois	Tilapias	*Heterotis niloticus*	Clariidés	*Gymnarchus niloticus*	Divers	Total	%
1986							
janvier	3098	1206	3573	598	–	8475	18
février	2104	1088	2028	678	–	5898	13
mars	3899	1678	1198	867	–	7642	16
avril	3472	1786	1203	789	–	7250	16
mai	1086	612	676	235	264	2873	6
juin	1022	778	572	159	112	2643	6
juillet	787	524	472	109	108	2000	4
août	83	27	118	63	–	291	1
septembre	51	153	82	73	130	489	1
octobre	148	234	98	183	170	833	2
novembre	2016	875	907	426	678	4902	10
décembre	1739	475	624	83	156	3077	7
Total	19505	9436	11551	4263	1618	46373	
%	42	20	25	9	4		
1987							
janvier	1646	472	643	89	314	3164	12
février	876	527	472	44	517	2436	9
mars	1797	–	264	–	–	2061	8
avril	897	349	146	–	970	2362	9
mai	945	273	173	43	61	1495	5
juin	1896	–	972	–	179	3047	11
juillet	734	35	1073	6	1035	2883	10
août	567	22	934	4	89	1616	6
septembre	895	17	479	8	148	1547	6
octobre	937	–	–	–	180	1117	4
novembre	2545	11	92	10	263	2921	11
décembre	2132	8	147	–	135	2422	9
Total	15867	1714	5395	204	3891	27071	
%	59	6	20	1	14		
1988							
janvier	2083	2	333	–	63	2481	11
février	2211	–	516	–	78	2805	12
mars	1132	–	249	–	47	1428	6
avril	348	–	107	–	34	489	2
mai	230	–	85	–	24	339	1
juin	377	–	485	48	148	1058	5
juillet	224	–	984	22	187	1417	6
août	359	–	903	56	473	1791	8
septembre	1017	–	512	42	330	1901	8
octobre	2034	578	239	37	214	3102	13
novembre	2366	2123	169	27	55	4740	21
décembre	1154	36	459	–	–	1649	7
Total	13535	2739	5041	232	1653	23200	
%	58	12	22	1	7		

Tableau 4. Importance relative des principales espèces dans les pêches sur la Mare aux Hippopotames en février 1989. Divers = genres *Hemichromis*, *Brycinus*, *Synodontis*, *Auchenoglanis*, *Clarias*, *Mormyrus*, *Gymnarchus* et *Schilbe*.

Espèce	Nombre	%	Poids (g)	%	Poids moyen (g)
Sarotherodon galilaeus	733	69	49658	61	68
Tilapia zillii	90	8	4694	6	52
Oreochromis niloticus	96	9	5652	7	59
Total 'tilapias'	919	86	60004	74	65
Heterotis niloticus	98	9	17251	21	176
Divers	50	5	4302	5	86

Taille des prises

Trois paramètres ont été mesurés sur les poissons capturés: les longueurs standard et totale, au mm près; le poids, à 1 g près jusqu'à 200 g; à 10 g près au-delà. D'après ce que nous pouvons voir dans le Tableau 5, la taille moyenne des poissons capturés est faible et, de plus, il y a une absence totale de spécimens de grande taille. Les valeurs moyennes et extrêmes figurent dans le Tableau 5 ci-dessous.

Tableau 5. Longueurs et poids des principales espèces capturées sur la Mare aux Hippopotames : valeurs extrêmes et moyennes.

Espèce	LS_{min} (cm)	LS_{moy} (cm)	LS_{max} (cm)	LT_{min} (cm)	LT_{moy} (cm)	LT_{max} (cm)	P_{min} (g)	P_{moy} (g)	P_{max} (g)
Sarotherodon galilaeus	7,6	11,1	15,5	10,0	14,3	19,6	23	67,7	161
Tilapia zillii	7,4	10,3	15,1	9,9	13,0	19,2	20	52,2	159
Oreochromis niloticus	7,9	10,7	18,7	9,7	13,6	22,1	20	58,9	222
Heterotis niloticus	17,2	23,7	32,7	19,0	25,9	35,5	76	176,0	490

Les seuls poissons dépassant le poids d'un kilogramme que nous avons pu observer durant notre séjour sont au nombre de 4: 1 *Gymnarchus niloticus* de 1410 g; 1 *Protopterus annectens* de 1850 g; 1 *Heterotis niloticus* de 2210 g; 1 *Clarias anguillaris* de 2920 g. Cette absence de gros individus et ces tailles moyennes très faibles sont en faveur d'un diagnostic de surexploitation de la Mare en période sèche. Les relations taille-poids des principales espèces, pour l'époque considérée et pour les gammes de taille observées, sont présentées dans le Tableau 6 et les courbes correspondantes apparaissent dans les graphiques de la Figure 2.

Tableau 6. Relations taille-poids, i.e., $P\ (g)=a \cdot LT\ (cm)^b$, des principales espèces pêchées sur la Mare aux Hippopotames en période sèche.

Espèce	a	b	n	r
Sarotherodon galilaeus	0,028393	2,902	733	0,984
Tilapia zillii	0,044137	2,743	90	0,970
Oreochromis niloticus	0,037705	2,800	96	0,986
Heterotis niloticus	0,016239	2,842	98	0,956

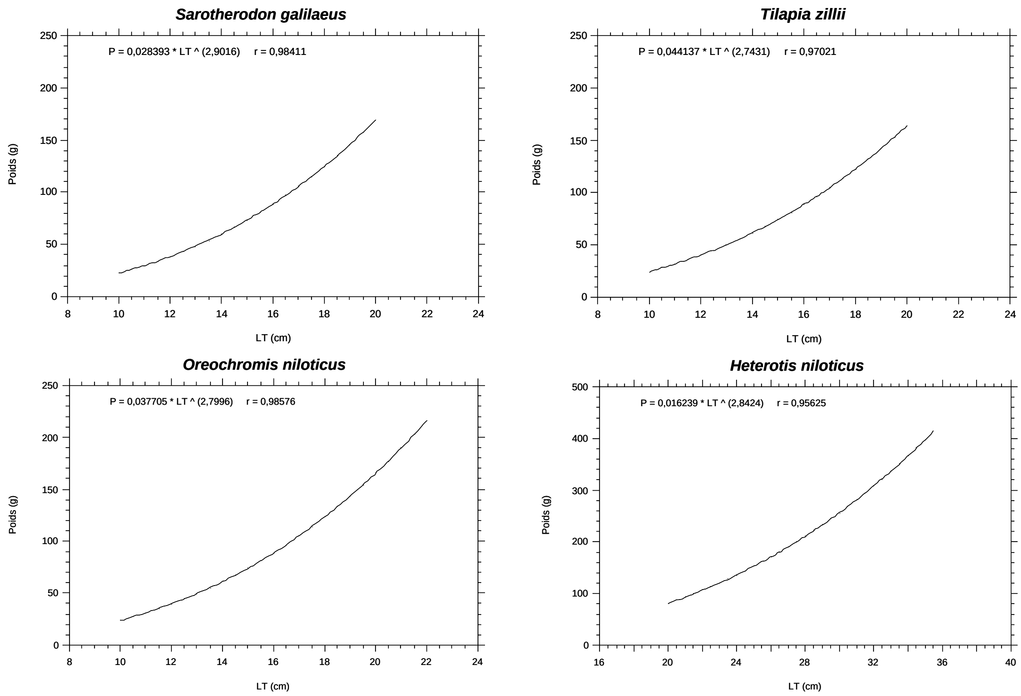

Figure 2. Courbes poids-longueur pour les principales espèces de la Mare aux Hippopotames.

CONCLUSION

La Mare aux Hippopotames s'inscrit, du point de vue hydrologique, dans l'unique plaine d'inondation du pays. Ce type de milieu est particulièrement riche (cf. delta central du Niger au Mali) et favorable à la reproduction d'un bon nombre d'espèces piscicoles, qui viennent se reproduire et pondre parmi la végétation submergée en période de hautes eaux.

La faible étendue et la bonne accessibilité de la Mare rendent celle-ci vulnérable. En effet, une trop forte activité halieutique en période de basses eaux peut compromettre son rôle important de frayère et de production d'alevins et de juvéniles de poissons. D'autre part, bien que le comportement des gros individus géniteurs les pousse à regagner le lit mineur dès le commencement de la baisse des eaux, il semble que leur absence dans les pêches au mois de février soit aussi due à leur vulnérabilité et liée à la pêche intensive sur la Mare. Enfin, les tilapias, qui ne présentent pas ce type de comportement migrateur et se reproduisent tout au long de l'année, sont tous de faible taille dans les captures observées. Il se pourrait que la pression de pêche entraîne un nanisme de leurs populations, avec abaissement de la taille de première maturité; mais ceci demanderait à être vérifié par des études de biologie de la reproduction. Une taille de première capture devrait être déterminée, de façon à proposer à la communauté de pêcheurs de la Mare un maillage pertinent, afin d'optimiser les rendements. Pour les tilapias, cette taille minimale devrait se situer autour de 12 cm de longueur totale.

La connaissance de la Mare aux Hippopotames reste partielle, un inventaire plus précis et étalé sur les diverses périodes de l'année devrait être réalisé afin de connaître exactement les espèces présentes, leurs déplacements et leur biologie, et ainsi pouvoir être à même d'édicter des consignes d'aménagement de la pêche sur la Mare.

Sachant que l'activité de pêche constitue un appoint non négligeable pour le maintien économique des pêcheurs occasionnels et, surtout, est à la base de la subsistance d'un groupe de pêcheurs permanents, qui entretiennent le campement de pêche et ont la possibilité d'en contrôler l'accès, tout aménagement futur devrait prendre en compte ce groupement et s'appuyer sur lui pour la mise en place et le respect d'éventuelles nouvelles règles de gestion halieutique de la Mare aux Hippopotames.

REMERCIEMENTS

Cette étude est le résultat d'une mission organisée par l'École Nationale du Génie Rural, des Eaux et des Forêts, Centre de Montpellier, effectuée du 30 janvier au 17 février 1989, avec la collaboration de Mamadou Lo (Sénégal) et Ibrahim Maman (Niger).

Nos remerciements vont aux pêcheurs riverains de la Mare pour leur accueil et leur patience lors de la prise de nos diverses mesures sur leurs poissons. Nous tenons aussi à remercier les différentes personnes qui ont permis et facilité notre travail et notre séjour, tout particulièrement Jean Bedel de l'ENGREF, Mamadou Lo, Ibrahim Maman, Jean-Noël Poda de l'IRBET et Georges Kaboré, agent des Eaux et Forêts du département de Satiri. Enfin, c'est grâce à l'aimable suggestion de Deng Palomares que cette étude est finalement publiée.

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GAINING A QUICK OVERVIEW OF THE LAKE KAINJI FISHERY, NIGERIA: THE USE OF LENGTH FREQUENCY DATA

UNE VUE D'ENSEMBLE DE LA PECHE AU LAC KAINJI, NIGERIA: L'UTILISATION DES DONNEES DE FREQUENCE DE TAILLE

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ABSTRACT

The assessment of tropical fisheries using surplus yield or dynamic pool models usually requires detailed and long-term data. Length distribution histograms of fish maybe used as an alternative method as they offer a quick and easily understood portrayal of the distribution of fish size caught. The length distributions can be compared with fish lengths at optimal capture, first maturity and with asymptotic length. This comparative method was used to investigate length frequency data of the three main commercial fish species of the man-made reservoir in Lake Kainji, Nigeria, and collected some 30 years after its creation. Length-frequency histograms are presented for total catch for the 12 month sampling period and for catch by month. Results indicate that the catch of all three fish species mainly comprised of the first year cohort. Almost all fish were caught below their optimal size at capture, and below length at first maturity. The beach seine fishery was responsible for the highest mortality of juvenile fish, particularly of the Characoid, *Citharinus citharus*. Small meshed cast nets also caught many undersized fish, as did the widely used 25 mm mesh nylon twined gill nets. The situation is considered to be potentially damaging to a sustained fishery. Given the high growth rates of juveniles, it is proposed that the fishery would provide a higher economic return if the mean size at capture were raised.

RESUME

L'évaluation de la pêche tropicale basée sur des modèles de production excédentaire ou de dynamique d´aggrégation exigent habituellement des données détaillées et à long terme. Une comparaison des histogrammes de distribution de taille des poissons peut-servir de méthode alternative vu qu'elles offrent une représentation rapide et facilement comprise de la distribution de la taille de poissons capturés. Les fréquences de tailles peuvent être comparées aux longueurs de la capture optimale, à la première maturité. Cette méthode comparative a été employée pour étudier les données de fréquence de taille des trois principales espèces commerciales de poissons du réservoir dans le lac Kainji, Nigéria rassemblées 30 ans après sa création. Des histogrammes de fréquence de longueur sont présentés pour la prise totale pour la période de prélèvement de 12 mois et pour les prises mensuelles par engin de pêche. Les résultats indiquent que la prise de chacune de ces trois espèces de poissons consiste principalement en juvéniles. Presque tous les poissons ont été pêchés au-dessous de leur taille optimale à la capture et de longueur à la première maturité. Les seines de plage étaient responsables de la mortalité la plus élevée, en particulier de *Citharus citharinus*. Les filets de font à petites mailles ont également capturé beaucoup de poissons immatures, de même que les filets maillants en nylon tortillés de maille de 25 millimètres. La situation est considérée comme potentiellement préjudiciable à une pêche soutenue. Etant donné les taux de croissance élevés de juvéniles, on propose que la pêche produirait une retombée économique plus élevée si les tailles moyennes des captures étaient augmentées.

INTRODUCTION

National authorities and administrators of development projects tend to underestimate the time needed to undertake proper fisheries assessment. It is often assumed that fisheries managers can quickly identify fisheries management problems and their required solutions. However, this is frequently not the case. Managers rarely have sufficient quality data on which to base their decisions (Cowx, 1991; Verheust, 1998). Time must therefore be devoted to data collection activities.

The data sought usually includes regular counts of the total number of existing gears, as well as, routine measurements of catch and effort. Such data is often expensive to collect from highly diversified fisheries and inaccessible villages. A further problem is that a long-time series of data is needed to determine trends. Government institutions are often unable to afford or justify expensive and long-term data collection.

The reservoir fishery of Lake Kainji is a typical example. A joint co-operation project, the 'Nigerian-German Kainji Lake Fisheries Promotion Project,' commenced in 1993. The project objective was to design and implement a management plan for the fishery in Kainji Reservoir. The problem, however, was that no fisheries data had been collected for fifteen years. Monitoring of the fishery was therefore started as early as possible. Training of data recorders and information dissemination among the fishers meant that obtaining reliable data took time. Time was also needed to assemble the time series of data required by fisheries models.

A further problem, unique to reservoir fisheries, is that the aquatic environment and the fishery change as the reservoir gets older and stabilises. It is therefore often difficult to identify reliable trends in the fishery. Sparre and Venema (1992) noted that such changes cause problems when using fisheries assessment tools, such as surplus yield or dynamic yield models, which require that the fishery is stable. Fisheries managers can therefore often be confronted with the dilemma of having to design or implement management plans without fully understanding the fishery. There is thus a need to identify other fishery assessment methods by which a quicker and perhaps less costly understanding of the fishery can be gained.

Using fish lengths to depict the total catch is one such method. This represents an alternative use of length frequency data which are usually collected in order to estimate population parameters of fish species. This contribution presents a method using quick and easily understandable pictorial representation of the composition of fish catch using fish length measurements as a first indicator of overfishing. In the same manner, length frequency measurements by gear type are used to indicate the number and size of fish caught as well as the months and the fishing methods responsible for catches of undersized fish. These are compared with independent estimates of size at maturity, optimal lengths of capture and asymptotic fish lengths. Yield per recruit analysis is used to show the relationship between optimal and actual levels of fishing effort. This methodology was explained during a training course on strengthening of fisheries and biodiversity management in Africa, Caribbean and Pacific (ACP) countries held in Kenya in 23 August to 3 September 1999 and organised by ICLARM as part of the ACP-EU Fisheries Research Initiative (see Froese and Binohlan, 2000).

This method, which uses easily understandable graphs depicting the patterns of fishing, was useful for the Lake Kainji fishery. It gave an early indicator of fishing patterns prior to the results of the catch assessment survey becoming available. It is hoped that this contribution will be useful to managers of other water bodies where quick overviews of the fishery are required.

MATERIALS AND METHODS

The total weight and numbers of fish caught and mean size at capture by species as well as the gear measurements for the Lake Kainji fishery between 1995 and 2000 were obtained from monthly sampling of catch and effort, i.e., catch assessment surveys (du Feu, 2003a). The size composition of the catch of the three main commercial species was determined by measuring individual fish lengths. Fish were sampled from fishers' catches at seven landing stations from all six fishing gear types used in the lake fishery. The sampling period was the middle 10 days of each month from Sept. 1997 to Dec. 1998. The sampled species were *Citharinus citharus* (Geoffroy St. Hilaire, 1808-09), *Sarotherodon galilaeus* (Linnaeus, 1758) and *Lates niloticus* (Linnaeus, 1758). About 150,000 fish were measured to the nearest 10 mm (Table 1).

Table 1. Individual fish lengths sampled for three commercial species by gear type during length frequency sampling in Lake Kainji, Nigeria (Sept. 1997 to Dec. 1998). The numbers are given before they were raised to the estimated monthly yield calculated from the monthly catch assessment survey. Data is presented by decreasing number of samples, rounded to the nearest 100, per gear type.

Gear type	Gear code	*Citharinus citharus*	*Sarotherodon galilaeus*	*Lates niloticus*	Total number sampled
Length type measured		FL	TL	TL	
Gill net	GN	53,100	27,000	8,000	88,100
Beach seine	BS	15,300	3,500	600	19,400
Drift net	DN	10,300	7,100	100	17,500
Cast net	CN	8,700	8,300	100	17,100
Trap	TR	100	5,800	600	6,500
Longline	LL	–	–	1,200	1,200
Total	–	87,500	51,700	10,600	149,800

Length-weight relationships were derived from individual length and weight measurements sampled by fleets of multi-meshed gill nets between 1970 and 1996 (gill net trail sampling) (du Feu, 2003b). The total number of fish caught was calculated by raising the weight (from the length-weight relationship) of the sample to the total monthly catch of the species per gear type. The total weight of fish was then converted back to lengths to give the total number of fish in each length class caught every month by each gear type. The distributions of the total number of fish lengths caught are presented as histograms. The length at maturity (L_m), optimum length at capture (L_{opt}) and asymptotic length (L_∞) were superimposed onto the plots to give a pictorial view of the level of overfishing for each species. The maximum length (L_{max}) at capture was obtained from the gill net trial sampling and converted to L_∞, i.e., $\mathbf{L_\infty=10^{(0.044+0.9841 \cdot \log_{10} L_{max})}}$ (Froese and Binohlan, 2000). This L_∞ estimate was used as an initial input for the estimation of growth parameters by ELEFAN and Shepherd's method (du Feu, 2003b). Estimates of the length at first maturity (L_m) were derived from Pauly's revised equation, i.e., $\mathbf{L_m=10^{(0.898 \cdot \log_{10} L_\infty - 0.0781)}}$ (Froese and Binohlan, 2000). The yield per recruit model of Beverton and Holt (1957) was used to identify L_{opt} and assess the effect of increasing the size at capture on yield.

RESULTS

Overview of the number and size of fish caught for each fish taxa in the Lake Kainji fishery

Table 2 shows that the total fish yield between 1995 and 1998 was comprised of a large number of fish families and species. Of the 20 fish taxa sampled by the catch assessment survey, 15 contributed less than 5 % to the total yield. The mean size at capture for all species was small. Large numbers of Cichlidae, *Chrysichthys nigrodigitatus*, *Citharinus citharus* and *Hemisynodontis* sp. were caught.

The present mix of fish species caught reflects the diversity of fishing gears and gear configurations used (principally differing mesh sizes), which were able to target most species throughout their life history. In 1998, gill nets had an average mesh size of 74 mm (s=32; range 25 to 240 mm). Cast nets, which also caught many juveniles, had a mean mesh size of 59 mm (s=19; range 25 to 125 mm). A further example of the diversification of fishing gears is the beach seine that targeted the small pelagic Clupeidae, i.e., *Sierrathrissa leonensis* Thys van den Audenaerde, 1969 and *Pellonula leonensis*

Boulenger, 1916. The beach seine fishery also had juvenile species bycatch of most major commercial species. At the peak in 1998, the bycatch was 20% of the weight of the total beach seine catch (Figure 1).

Table 2. Fish yield (tons) from Lake Kainji, Nigeria. Catch composed of the bulk of lake species occurring in the lake, with similar yields and caught at extremely small sizes. Estimates were calculated from the monthly catch assessment survey between Jan. 1995 and Dec. 1998. The fish taxa are arranged in decreasing order of total yield. Total yield figures have been rounded to the nearest 100 t.

Family	Species	Total yield (t)	Proportion of total yield (%)	Total number caught (millions)	Mean weight (g)
Clupeidae	–	41,700	32.5	–	–
Citharinidae	*Citharinus citharus*	12,700	9.9	172	74
Cichlidae	–	12,200	9.5	203	60
Mochokidae	*Synodontis membranaceus*	8,700	6.8	47	184
Bagridae	*Chrysichthys* sp.	8,200	6.4	229	36
Cyprinidae	*Labeo* sp.	5,800	4.5	82	70
Mochokidae	*Hemisynodontis* sp.	5,400	4.2	121	45
Bagridae	*Bagrus* sp.	5,100	4.0	14	357
Mormyridae, Gymnarchidae, Osteoglossidae and Ophicephalidae	–	4,500	3.5	30	150
Centropomidae	*Lates niloticus*	4,100	3.2	10	394
Alestiidae	*Alestes* sp. and *Brycinus* sp.	3,600	2.8	83	43
Bagridae	*Auchenoglanis* sp.	3,500	2.7	28	124
Citharinidae	*Distichodus* sp.	3,300	2.6	31	107
Clariidae	*Clarias* sp.	3,000	2.4	27	113
Alestiidae	*Hydrocynus* sp.	2,500	2.0	11	224
Clariidae	*Heterobranchus* sp.	1,400	1.1	2	788
Schilbeidae	–	1,000	0.8	23	44
Other catfish (e.g., Malapteruridae)	–	900	0.7	5	191
Cyprinidae	*Barbus* sp.	400	0.3	5	75
Other Cichlidae	*Hemichromis* sp.	400	0.3	5	67
Total	–	128,400	100.0	1,128	114

Citharinus citharus

The charocoid, *Citharinus citharus* accounted for 15 % of the annual total lake yield (for all species excluding Clupeidae) between 1995 and 2000. The annual percentage contribution varied between 12 % and 18 %, with higher percentages recorded for years following large floods that caused a high spawning of *C. citharus.* Apart from 1996, *C. citharus was* the highest yielding species between 1995 and 1998 (again excluding clupeids).

Length frequencies sampled during 1998 indicated that almost all *C. citharus* were caught below the length of maturity and far below the optimal length at capture (see Figure 2). The highest fishing mortality for *C. citharus* occurred for fish between 10 and 12 cm in length. This was less than 1/3 the size of L_{opt}. Figures 2 and 4 show that small sized *C. citharus* from the first year cohort were targeted just two months after they had spawned. The first year fingerlings have rapid growth (K=0.47 $year^{-1}$) (du Feu, 2003b). The early fishing mortality suggests severe growth overfishing of the species.

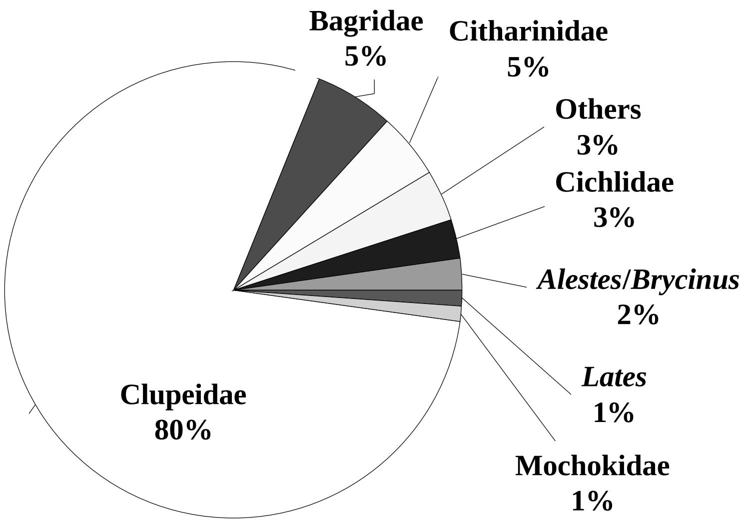

Figure 1. Catch composition of the beach seine fishery targeting small pelagic Clupeidae in Lake Kainji, Nigeria. Note that this fishery's bycatch accounted for 20% of the total catch. The annual yield of the beach seine fishery was 9,000 t (7,200 t clupeids with 1,800 t bycatch). Estimates were calculated from the catch assessment survey in 1998.

Of all the fishing methods, the beach seine accounted for the largest fishing mortality of *C. citharus* (46 % of the total number caught) at an extremely small mean weight of 30 g (Figure 3). All *C. citharus* less than 5.5 cm in length were caught by beach seines. The gear was also responsible for the majority of individuals caught measuring less than 10 cm. Fishing pressure was highest for *C. citharus* from September (immediately after spawning) to December, after which it declined (Figure 4). Large numbers and small sized *C. citharus* were also caught by cast nets (24 % of all *C. citharus* caught at a mean weight of 82 g), particularly from October to February. Cast nets caught 33 % of all *C. citharus* below the optimum size at capture. The nets did not catch *C. citharus* less than 6 cm in length or larger than 30 cm, but caused the highest fishing mortality of fish between 10.5 and 16.5 cm. *C. citharus* greater than 16.5 cm in length were mainly caught by gill nets and, to a lesser extent, by cast nets.

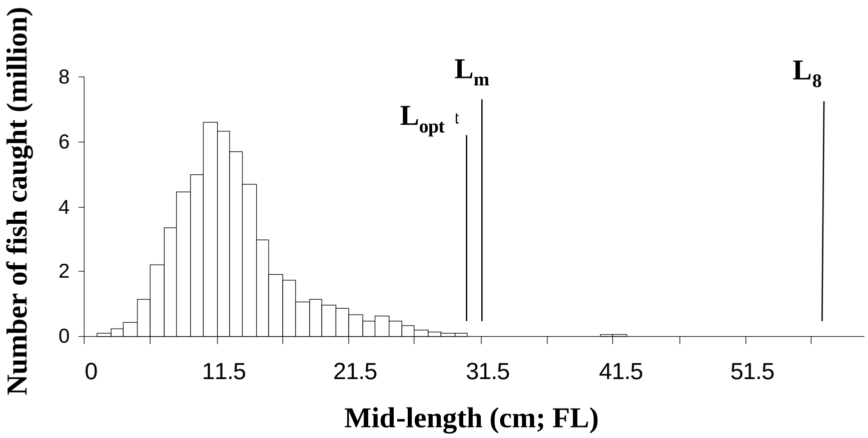

Figure 2. Showing that the modal length of *Citharinus citharus* (10.5 cm) caught in the Lake Kainji fishery was approximately 1/3 the size of optimal length at capture (L_{opt}=29.9 cm; derived from yield-per-recruit analysis) and below the length at first maturity (L_m=31.3 cm; du Feu, 2003b). The length frequency distribution is taken from fish sampled from commercial catches between Sept. 1997 to Dec. 1998. (L_∞=56.6 cm; asymptotic length at capture; du Feu, 2003b).

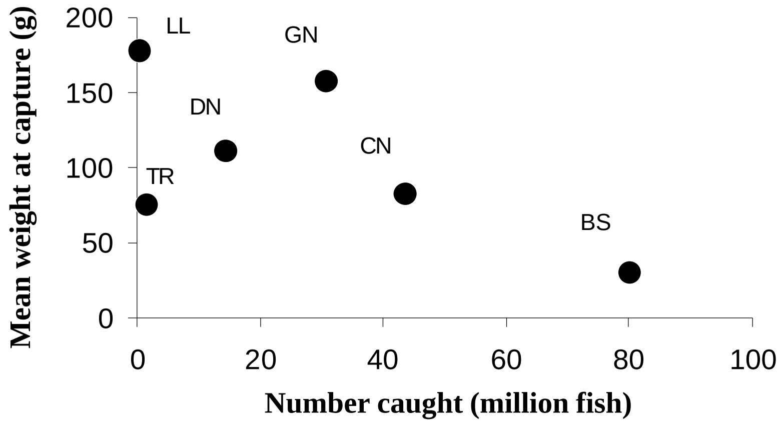

Figure 3. Beach seines accounted for the largest fishing mortality of *Citharinus citharus* at the smallest mean size. Total numbers and mean size of fish caught were calculated from the gear based catch assessment survey of Lake Kainji between Jan. 1995 to Dec. 1998.

Drift nets were mainly responsible for the high mortality of *C. citharus* during October and November. The nets targeted the newly spawned juveniles as they migrated into the main lake from the spawning grounds in the northern basin. The modal length of *C. citharus* caught by drift nets at this time was just 8.5 cm (1997) and 10.5 cm (1998). The high mortality of *C. citharus* from September to December is cause for concern since the fish caught measured between 2.5 to 17.5 cm and almost 95 % of the *C. citharus* caught were from the first year cohort spawned two months before.

The yield per recruit curve of *C. citharus* suggests that increasing the size at first capture will lead to a higher yield maximised at high fishing efforts (Figure 5) and a decrease in yield for larger sizes of fish can be expected if the fishing effort is too low. At the current level of fishing effort (F=1.17 $year^{-1}$) the yield from *C. citharus* can be increased by 43 % if the species are caught at L_{opt}, i.e., even if most fishing gears targeted this species, controlling the early mortality by beach seines and increasing the cast and gill net mesh size will raise the size at capture and increase yields.

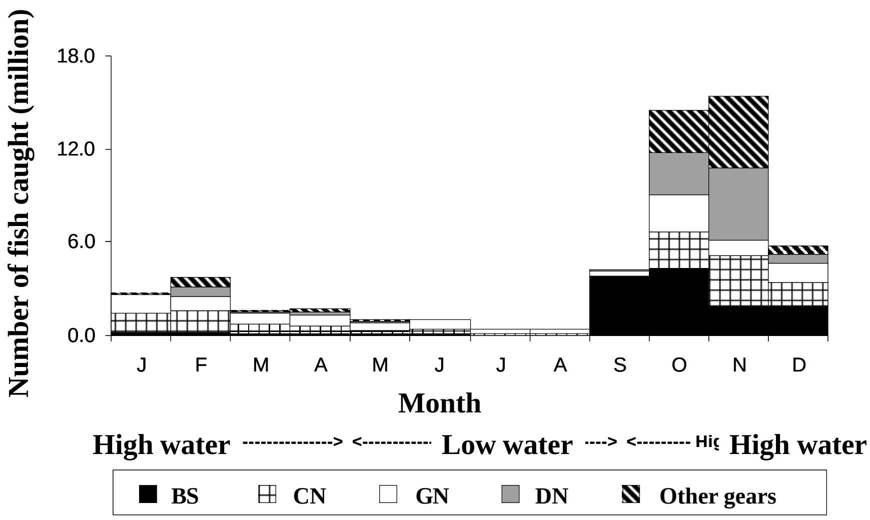

Figure 4. Most fishing mortality of *Citharinus citharus* occurred between October and November just after annual spawning and was caused by all gear types. The length-frequency distribution is taken from the monthly fish lengths sampled from all commercial gear types during 1998.

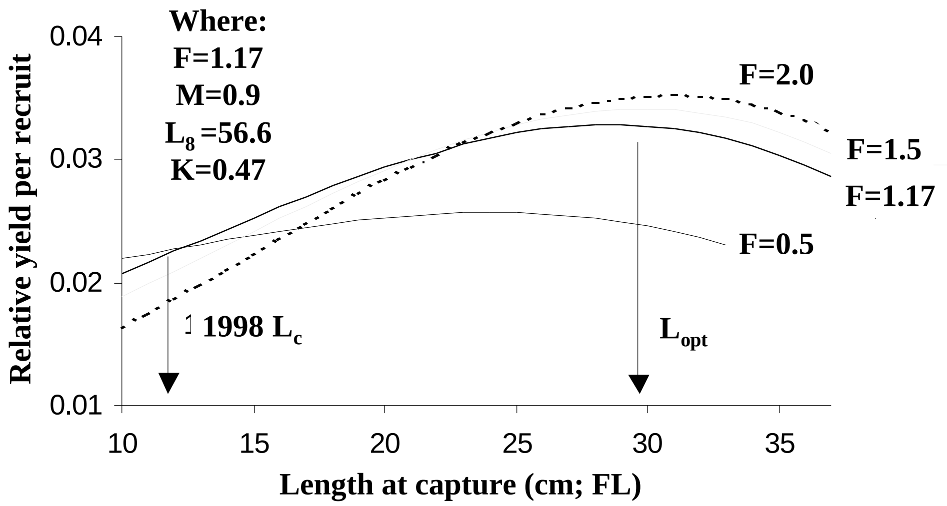

Figure 5. Mean length at capture of *Citharinus citharus* in 1998 (L_c=12.0 cm) was 40 % the size of the optimal length at capture (L_{opt}=29.9 cm). Higher fishing effort at the present size at capture will cause the relative yield per recruit to decline. Mortality and population parameters are from du Feu (2003b); L_c calculated from length-frequency data collected during 1998.

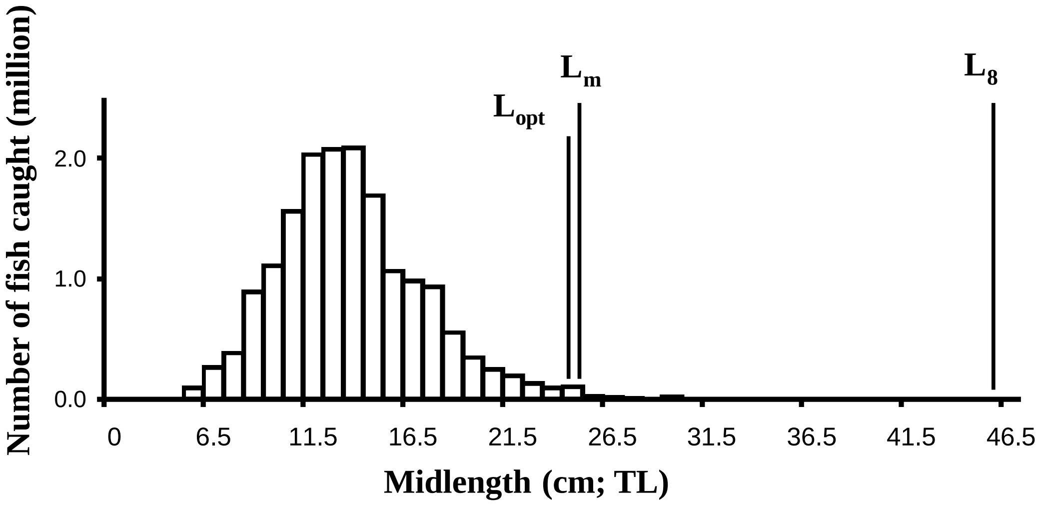

Figure 6. Showing that the modal length of *Sarotherodon galilaeus* caught (13.5 cm) in the Lake Kainji fishery was approximately half the size of optimal length at capture (L_{opt}=25.0 cm; derived from yield per recruit analysis) and below length at first maturity (L_m=25.8 cm; du Feu 2003b). The length frequency distribution is taken from fish lengths sampled from commercial catches between Sept. 1997 and Dec. 1998 (L_∞=45.7 cm; asymptotic length at capture; du Feu, 2003b).

Sarotherodon galilaeus

Tilapia sampled by the catch assessment survey (*Sarotherodon galilaeus*, *Oreochromis niloticus* and *Tilapia zillii*) had the second largest component of the catch after *C. citharus (*Table 2). Between 1995 and 2000, the average annual percentage contribution of Cichlidae to the total yield (excluding Clupeidae) was 14 %, with a maximum contribution to the catch at 16 % in 1996. Among the tilapiines, *S. galilaeus* is the best represented. Although the number of Cichlidae caught between 1995 and 1998 was slightly higher than *C. citharus*, the mean size of the catch was smaller, making the total weight of fish caught comparable (see Table 2). Excluding the Clupeidae, the two groups combined contributed just less than 1/3 of the total lake yield between 1995 and 1998.

The length frequency distribution for *S. galilaeus* is similar to *C. citharus* and indicates comparable sizes of fish caught (Figure 6). Almost all fish were caught below the optimal length at capture, with some 85 % of fish caught below length at first maturity. The modal size of 11.5 to 13.5 cm was less than half the optimal length at capture.

Traps followed by cast nets caught the most fish (Figure 7). Beach seines and cast nets caught the majority of small sized tilapia and gill nets targeted the larger fish. Traps targeted the species during high water and receding lake level when the fish were breeding within the submerged vegetation (Figure 8). Conversely, cast nets targeted *S. galilaeus* during low water when fishing in shallow waters was not obstructed by aquatic vegetation. The fishing effort for *S. galilaeus* in 1998 was at the maximum level required for optimal yield per recruit (Figure 9). Increasing the size of capture is, therefore, the only alternative to increasing yield. One can expect a sharp increase in yield if this is achieved.

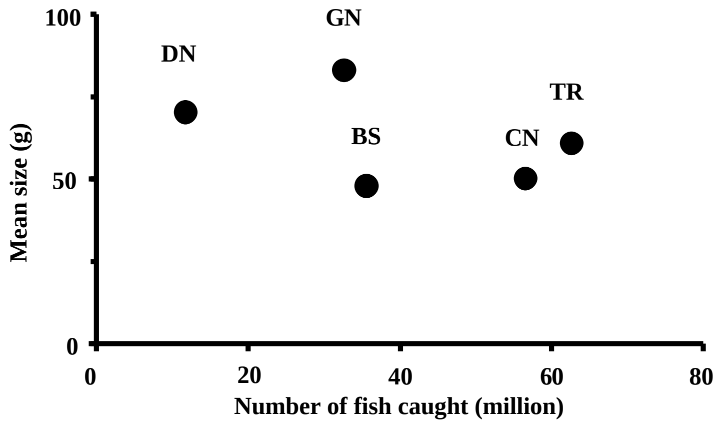

Figure 7. The largest number of *Sarotherodon galilaeus* were caught by fishing traps followed by cast nets; smaller fish were caught by beach seines and cast nets. Total numbers and mean size of fish caught were calculated from the gear based catch assessment survey of Lake Kainji between Jan. 1995 to Dec. 1998.

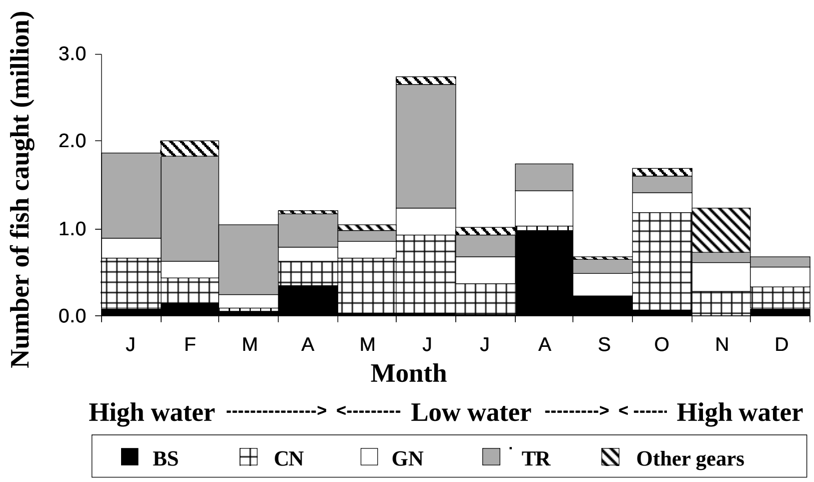

Figure 8. The fishing mortality of *Sarotherodon galilaeus* was spread throughout the year with fishing traps generally catching the most fish. The length frequency distribution is taken from the monthly fish lengths sampled from all commercial gear types during 1998.

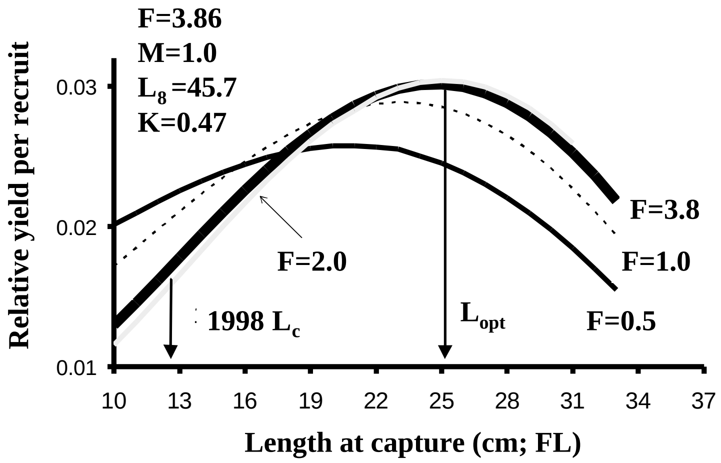

Figure 9. Mean length at capture of *Sarotherodon galilaeus* in 1998 (L_c=12.8 cm) was half the size of the optimal length at capture (L_{opt}=25.0 cm). Increasing the size at capture will result in a marked increase in the relative yield per recruit. Mortality and population parameters are from du Feu (2003b), L_c calculated from length frequency data collected during 1998.

Lates niloticus

Between 1995 and 2000 the annual average contribution of *Lates niloticus* in the catch of the artisanal fishery was around 5 %. The maximum annual contribution was 10 $kg \cdot ha^{-1} \cdot year^{-1}$ in 1998. Although the total weight of *L. niloticus* caught was less than for *C. citharus* and *S. galilaeus*, *L. niloticus* had a higher ‘beach sale’ value. All the *L. niloticus* sampled were caught far below their size at first maturity and optimal length at capture (Figure 10). The most common length caught was 14 to 15 cm, less than 1/5 the size at maturity and 15 % of the optimal size at capture. The mean weight of *L. niloticus* sampled was just 394 g.

Beach seines and gill nets accounted for the largest mortality of small sized *L. niloticus.* Longlines caught fewer fish but at larger sizes (Figure 11).The number of *L. niloticus* caught by the gill net fishery decreased between August and December as the first year cohort was fished out (Figure 12). The pattern of fishing is similar to *C. citharus* in that newly spawned fingerlings are targeted from February onwards by the 25 mm meshed gill net fishery. *L. niloticus* were also caught as bycatch (at a length between 8 and 23 cm) by the beach seines during the low water period. Numbers of fish caught peaked in October due to larger catches by longlines, possibly representing the time of spawning. The high mortality of undersized *L. niloticus* is cause for concern. This possibly reduces the catch by the longline fishery, which targeted the species at larger size.

The size of *L. niloticus* caught was far below L_{opt}. Large increases in yield will result as the size at capture approaches this value (Figure 13). Higher levels of fishing effort at the present length at capture would cause a fall in yield. Increasing the size at capture will result in a higher increase in yield than decreasing fishing effort.

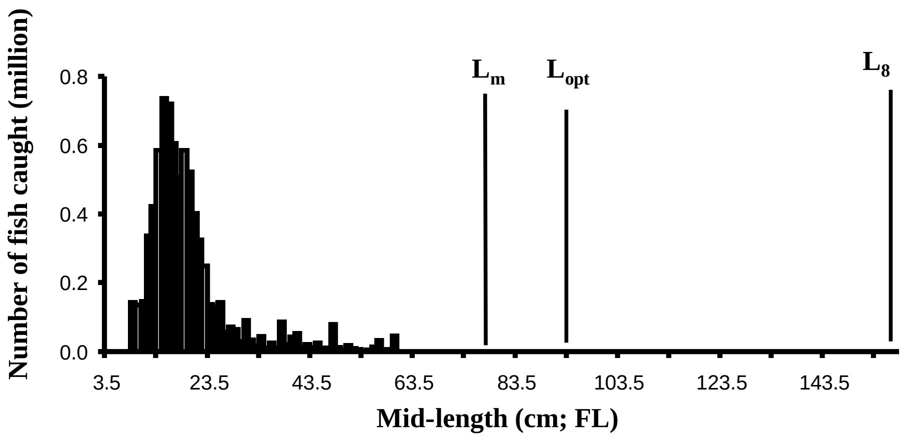

Figure 10. Showing that the modal length of *Lates niloticus* caught (14.5 cm) in the Lake Kainji fishery was 16 % the size of optimal length at capture (L_{opt}=93.0 cm; derived from yield per recruit analysis) and 18 % the size of length at first maturity (L_m=78.9 cm; see du Feu, 2003b). The length frequency distribution is taken from fish lengths sampled from commercial catches between Sept. 1997 and Dec. 1998. (L_∞=158.7 cm; asymptotic length at capture; see du Feu 2003b).

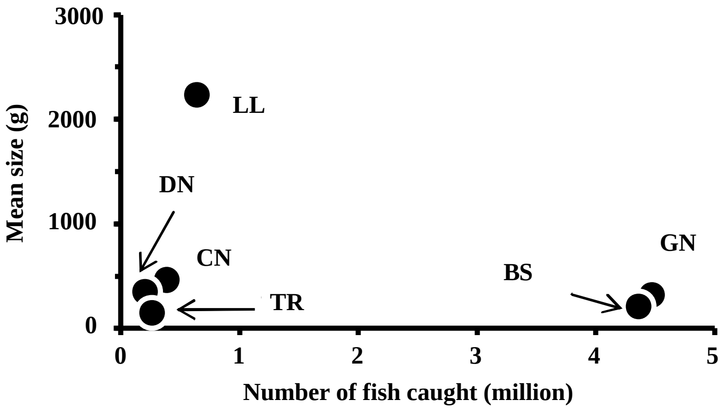

Figure 11. The combined catches of beach seines and gill nets accounted for 85 % of the total catch of *Lates niloticus* at a mean size of 210 g and 320 g, respectively. Total numbers and mean size of fish caught were calculated from the gear based catch assessment survey of Lake Kainji between Jan. 1995 to Dec. 1998.

DISCUSSION

Since the creation of Lake Kainji in 1968, the fishery has largely been unmanaged and has remained open access. Fishers have thus been able to fish with any gear type, mesh size or fishing method they wished. In the case of Lake Kainji, a diversification into gears which targeted small sized species has occurred. This mainly took place after the brief post impoundment boom in production and was possibly caused by fishers trying to maintain daily catch rates as the larger fish species were fished out (du Feu, 2003a). The gears included a higher number of small meshed gill, cast and drift nets and fishing traps that were used to target a greater variety of species and size ranges of fish (du Feu, 2003a). Beach seines, which became popular in the late 1980s and have mesh sizes of just 2 mm, to catch the small pelagic clupeids, provice one such example (du Feu, 2003d).

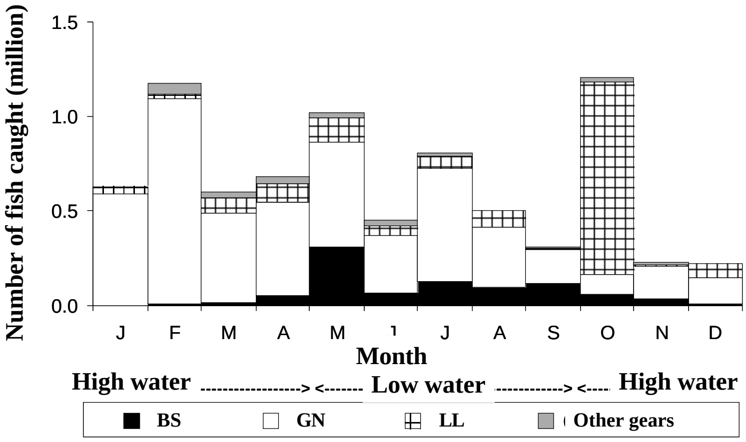

Figure 12. The fishing mortality of *Lates niloticus* was spread throughout the year with gill nets being mainly responsible. Beach seines mainly caught *Lates* as bycatch during the low water period. The length frequency distribution is taken from the monthly fish lengths sampled from all commercial gear types during 1998.

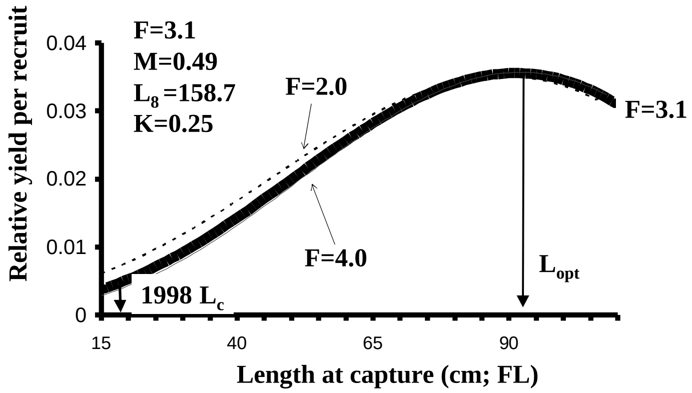

Figure 13. The mean length at capture of *L. niloticus* in 1998 (L_c=14 cm) was 15 % the optimal length at capture (L_{opt}=93.0 cm). Increasing the size at capture will result in a marked increase in the relative yield per recruit. Altering the levels of fishing effort will have only small effect. Mortality and population parameters are from du Feu (2003b). L_c calculated from length frequency data collected during 1998.

The targeting of smaller sized fish in Lake Kainji was also due to social reasons. The fishers preferred to catch fish every day to feed their families. Catch assessment results indicated that, although the monthly catch per unit effort of small meshed nets was less than larger meshes, the smaller meshes did guarantee a more regular catch of fish. This was unlike the larger meshed nets, which caught larger fish, but on a less frequent basis. Eyo and Mdaihli (1997) added that small-sized fish are also easier to process by smoking than those of larger size. The effect on fish catches of the diversification of the fishery was evident from the large number of species and small size of fish that has been highlighted through the analysis of total yield data.

Results of the analysis of length frequency measurements for the fishery indicated that the catches of the three commercial species mainly comprised of undersized fish. These were largely from the first year cohort, which were caught a few months after spawning. FishBase (Froese and Pauly, 2003) was used to compare the length at maturity (L_m), optimal length at capture (L_{opt}) and asymptotic fish length (L_8) with measurements from other water bodies (Table 3). All measurements for *C. citharus* were in approximate agreement, apart from L_8 which was larger for Lake Kainji. In the case of *S. galilaeus* lengths at L_{opt} and L_8 for the species in Lake Chad were smaller than those recorded for Lake Kainji. However, L_m was larger than recorded in other water bodies. Lengths for *L. niloticus* showed the reverse pattern, with L_{opt} and L_8 recorded in Lake Kainji being smaller and L_m being larger than those from other areas.

Table 3. Comparison with estimates from other water bodies of the estimates of length at first maturity (L_m; cm) optimal length at capture (L_{opt}; cm) and the asymptotic fish length (L_8; cm) of the commercial fish species from Lake Kainji, Nigeria using data collected during the sampling of length frequencies between Sept. 1997 to Dec. 1998 with estimates obtained from other water bodies. TL=total length; SL=standard length; data arranged by ascending values of L_∞.

Locality	Country	Length type	L_m (cm)	L_{opt} (cm)	L_8 (cm)	Reference
Citharinus citharus						
Lake Kainji	Nigeria	FL	31.3	29.9	56.6	Present study
Lake Kainji	Nigeria	SL	35.2	–	–	Arawomo (1972)
Lake Kainji	Nigeria	TL	–	28.9	49.0	Moreau *et al*. (1995)
Lake Chad	Chad	TL	–	30.5	49.3	Moreau *et al*. (1995)
Sarotherodon galilaeus						
Lake Kainji	Nigeria	TL	25.8	25.0	45.7	Present study
Fleuvre Sénégal	Chad	TL	–	17.8	30.1	Moreau *et al*. (1995)
Small reservoirs	Burkino Faso	TL	13.8	–	–	Baijot and Moreau (1997)
Lake Volta	Ghana	TL	19.8	–	–	Johnson (1974)
Lake Tiberias	Israel	TL	22.4	–	–	Trewavas (1983)
Lates niloticus						
Lake Kainji	Nigeria	TL	78.9	93.0	158.7	Present study
Nyanza Gulf	Lake Victoria	TL	–	133.8	205.0	Asila and Ogari (1988)
Nyanza Gulf	Lake Victoria	TL	74.0	–	–	Witte and de Winter (1995)
Lake Chad	Chad	SL	52.0	–	–	Lévêque (1997)

For the three sampled species, almost all fish were caught at less than half the size at maturity and far below the optimal size at capture. Yield per recruit analysis indicated that the mean size of the fish presently caught needs to increase from between 44 % and 60 % to attain the lengths that maximise yields. In a separate analysis, du Feu and Abiodun (1998) have shown that the overall present level of fishing effort is 40 % beyond that needed for maximum sustained yield (MSY) from the resource. Short-term yield estimates indicated that catches have already started to decline. Between 1996 and 1998, lake yield fell from 300 to 227 $kg \cdot ha^{-1} \cdot year^{-1}$ (du Feu, 2003a). Total fish yield is likely to decline further given future increases in fishing effort. Effort will increase through the increasing numbers of fishers, both from a rising population and from a greater proportion of women opting to fish, together with a continued rise in the use of fishing methods such as the beach seine, monofilament gill nets and fishing traps (du Feu, 2003a).

Similar diversifications of fisheries and targeting of small sized species as occurred in Lake Kainji are likely to have occurred elsewhere. Examples are reservoirs in Sri Lanka (Sugunan, 1997). High fishing pressure and the use of undersized gill nets has caused the mean size of *O. mossambicus*, the major species, to fall to below 200 mm in one reservoir. Amarasinghe (1987) noted that this is typical of many reservoirs and has led to overexploitation and declining catch rates in the region. Comparable fishing pressure and targeting of small sized fish as Lake Kainji, may possibly have caused other fisheries to collapse long ago. The reason that the Lake Kainji fishery is still relatively high yielding can possibly be explained by the biology and behaviour of the fish species. The high number of fish caught during the sampling period indicates that numerous fingerlings are required to sustain the fishery. This notion is supported by the successful species such as *C. citharus* and *L. niloticus* having relatively high fecundities (Imevbore, 1970; Omorinkoba and du Feu, 1994).

A further aspect influencing recruitment was considered by Balogun (1986) and Lelek (1972) who noted that the large mature fish (particularly of *C. citharus* and *L. niloticus*) inhabit the deeper portions of the lake. The absence of large meshed nets and the rougher water conditions that prohibit regular fishing in the central lake area may decrease the probability of capture of mature fishes of these species (du Feu and Abiodun, 1999). A further aspect influencing the success of species is their ability to use the flooded macrophyte vegetation in the extensive drawdown or floodplain areas for protected nursery grounds, leading to lower natural mortality. High fishing pressure poses more concern to species such as cichlids, because they are targeted at smaller size ranges by fishing trap and cast net fisheries. Cichlidae have a lower fecundity, but a more regular pattern of breeding and need a relatively higher proportion of breeding adults than other highly fecund species to maintain the population size (Imevbore, 1970; du Feu and Abiodun, 1998). The potential of a sudden cichlid stock collapse may therefore be greater than for species such as *C. citharus* and *L. niloticus.*

The high growth rates of the species studied here (du Feu, 2003b) suggest that increases in the size of capture will quickly lead to a rise in yield. Enforcement of management measures targeted at those gears that cause high early mortality such as beach seines, monofilament gill nets, small meshed cast nets and traps will help achieve this. Management intervention therefore appears essential.

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STUDIES ON THE ICHTYOFAUNA OF EHOMA FLOODPLAIN, AFIKPO EASTERN NIGERIA

L'ICHTYOFAUNE DE LA PLAINE INONDABLE D'EHOMA, AFIKPO, NIGERIA ORIENTAL

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ABSTRACT

The ichtyofauna of the Ehoma floodplain, Afikpo, Nigeria, surveyed from January 1991 to February 1992, consisted of 46 fish species belonging to 14 families. The result shows that members of the family Cichlidae dominated the fish fauna (51 %) while Mormyridae (17.3 %) and Clariidae (10 %) made up the two next numerously represented. Hepsetidae recorded the highest mean weight (511 gms.). Four fish species inhabited the open waters and 16 species were found in the swamp zone of the floodplain. Of the 1,200 specimens caught by the different gears, gillnet recorded the highest catch (50.8 %); followed by castnet (21.3 %), hook and line (11.4 %), bagnet (8.4 %), and local traps recorded the lowest catch (8.1 %).

RESUME

La campagne scientifique sur l'ichtyofaune de la plaine inondée d'Ehoma, Afikpo, Nigéria conduite de janvier 1991 au février 1992 a rapporté 46 espèces de poisson réparties sur 14 familles. Les cichlids sont les plus nombreux (51 %) suivient par les mormiridés (17.3 %) et les clariidés (10 %) le plus grand poids moyen est observé ches les hépsétidés (511 gms.). Quatre espèces se trouvent au large et 16 espèces habitant dans les marées de la zone inondée. La repartition des capture (1,200 spécimens échantilonnés) par engine de pêche est la suivante: filet maillant (50.8 %); épervier (21.3 %); hameçon et ligne (11.4 %); filet-sac (8.4 %) ; nasse (8.1 %).

INTRODUCTION

The estimation of the size composition of a fish population is important to the study of a stock's dynamics and in the management of a species (Helser *et al.*, 1994). Density indices of fish stocks are often used in stock assessment. Such methods suffice if there is no need to estimate the absolute stock density (Kesteven, 1973). Numerous types of fishing gears have been employed to sample the size composition of the catch. However, most gears are highly size selective and bias in population descriptors such as growth, mortality, and abundance can be introduced. In multispecies assessments, ecosystem studies and in studies of economically and environmentally important fish species, it is often necessary to know the absolute size of the stock. Thus, there is a strong need to develop methods of reasonable cost for estimations of absolute fish numbers (Auvinen and Juha, 1994). Fisheries stock assessment is primarily used as an input for some form of decision-making process, and as this process becomes more quantitative, the demand on stock assessment are changing (Hilborn *et al.*, 1994). A common problem in stock assessment is that the only data available are life history information on weight, vulnerability, natural mortality and fecundity at age, catch history, with only occasional indices of abundance (Hilborn *et al.*, 1994).

Several methods to estimate current stock size and potential productivity of exploited populations have been developed (see Gulland, 1983; Hilborn and Walters, 1992). The most commonly used model is that developed by Schaefer (1954, 1957) on catch biomass and indices of abundance. While aquatic reserves offer means of survival for some communities, it is in fact the natural heritage of humankind and their conservation that must be linked to the legitimate development of the floodplain and the well being of the people who live there. Careful study must be made of their natural stocks (total fish population) including their biology and ecology (Elliot, 1979). Before embarking on any meaningful fisheries development, it is important to have a fundamental idea about the fishes of the area in question, their phenology, abundance, habits and methods of processing and preserving them as well as their distribution and other biological characteristics (Reed *et al*., 1967).

An evaluation of the fish stocks available in the Ehoma floodplain and knowledge of their biology and species composition is necessary to enhance its management. As very sparse information exists on the ecology and economic exploitation of the fish stock in Ehoma floodplain, this study attempts to provide baseline information on its fish fauna for use in appraising the fisheries potential in the area amd similar ecosystems subjected to similar ecological pressure.

STUDY AREA

Ehoma floodplain is located between 5°46’-5°50’ and 7°55’-7°57’E and about 7 km from Afikpo along Enohia-Nkalu, Ndibe Beach Road River and numerous streams in the area. Since most of the streams that supply water to the floodplain are ephemeral in nature, flows to the floodplain peak during the later months of the early rainy season. The average annual rainfall is about 1,890 mm and is concentrated within the rainy season between the months of April and October. The dry season is often punctuated by few scattered rains, especially in the months of February and March (Uma and Egboka, 1986). Flooding in the plain is a result of the spillage of excess water from the Cross River into the vast area of Ehoma resulting in the formation of the Ehoma floodplain. This flooding brings in the nutrients making the floodplain extremely productive. However, Okoti and Oti (1990) reported reduced productivity from the floodplain in recent years as a result of loss of major elemental compounds due to changing land use.

Uma and Egboka (1986) observed that the area within the floodplain is underlain mainly by argillaceous sediments of middle cretaceous age. There are thick shale units with minor siltstone and calcareous sandstone bed. Sediments mainly of the alluvial origin are deposited into the floodplain basins. Turbidity of the floodplain is high during the peak period (mean Secchi disc transparency=12.0 mm; Egboka and Uma, 1986). Total dissolved solids (TDS) are less than 400 mgl^{-1} caused by solution of carbonates in the matrix of the rock material have been reported, while higher concentrations are due to contamination with saline groundwater from fractures and this found in areas like Okposi, Uburu, Enyigba and Lokopanta found within the basin (Egboka and Uma, 1986). In the dry season, December and January, the average daily temperature may range between 27-30°C. Rainfall is high with 90 % occurring between the months of April and October (Uma and Egboka, 1986).

MATERIALS AND METHODS

From January 1991 to February 1992, intensive sampling was conducted in the floodplain, using hooks and lines. To achieve maximum effectiveness and cost-benefit ratios, it became necessary to use multiple, baited hooks and lines. The size of the hooks was 8 mm diameter, with 7 hooks. The hooks were baited mostly with juvenile mormyrids, sometimes earthworms and insect larvae. Sampling with multiple hooks and line started at 08H00 to 18H00. This was done once weekly throughout the sampling period. Examination of the hooks and line was done at interval for catches and the baits that were ineffective were replaced. The castnets used for the sampling were of 9 m diameter and 20 mm mesh size following the recommendation of Reed *et al.* (1967). Net casting took place between 08H00 and 10H00 once every fortnight at selected sampling zone. The bagnets used had a mesh size of 6 cm and were set daily between 16H30 to 18H30 at strategic positions and examined between 06H00 to 09H00 the following morning. The gillnets had a mesh size of 50 mm and of 3 mm diameter. They were set between 08H00 to 09H00 and examined daily between 11H00 and 12H00. Two separate types of traps were used for sampling, the conical and cylindrical types 1.5 m long, of 60 cm diameter and with 60 mm opening. The traps were set unbaited between 07H00 and 08H00 with the openings facing downstream and inspected once or sometimes twice daily at the peak of the flooding season.

The specimens were identified using keys by Anthony (1982), Lowe-McConnel (1964), Greenwood *et al.* (1966) and Reed *et al.* (1967). Fish were counted, measured with a measuring board in total length (TL) to the nearest centimeter and weighed ungutted with a Salter balance. The type of catch and gear were recorded according to the methods of Gobert (1998) and Chevaillier (1990).

Physico-Chemical Analysis

Surface water temperature in degrees Celsius was measured using a dry thermometer, which was immersed totally below the water surface. The thermometer was allowed to stand for three minutes before the reading was taken to give allowance for stability in reading. The hydrogen-ion concentration (pH) was measured using a temperature-compensated pH meter, Kent Model 6025. Dissolved oxygen (DO) determination was done using the Lovibond Raw Water Analysis kit. The average site depth and width were taken. The water discharge by the floodplain was calculated on the basis of $\mathbf{Q=W \cdot d \cdot v}$, i.e., W=width of the floodplain, d=mean depth at peak period, v=velocity at 1/8 depth and discharge, Q, expressed as $m^3 \cdot s^{-1}$ (Anadu, 1987).

RESULTS

During the study period, atmospheric temperature ranged from 20-28°C, while water temperature ranged from 20.0-27.2°C. Hydrogen-ion concentration did not show significant fluctuations and ranged from 8.0 to 8.6. Dissolved oxygen on the average was 6.5 $mg \cdot l^{-1}$ while the discharge was 3.41 $m^3 \cdot s^{-1}$ (Table 1).

Table 1: Variation in monthly temperature, pH and water discharge in the Ehoma floodplain.

Months 1991	Atmospheric temperature (°C)	Surface water temperature (°C)	Discharge ($m^3 \cdot s^{-1}$)	pH	Dissolved oxygen (mg l^{-1})
January	22.2	22.0	0.30	8.4	6.44
February	23.0	21.4	0.58	8.4	6.73
March	27.0	24.0	0.53	8.4	6.34
April	28.0	27.2	9.00	8.3	6.03
May	25.0	25.0	1.50	8.0	6.83
June	22.0	22.0	4.30	8.0	6.23
July	20.0	20.0	4.00	8.0	6.93
August	23.0	22.0	9.80	8.0	6.34
September	23.1	22.8	8.60	8.0	6.63
October	23.3	23.4	1.40	8.6	6.53
November	20.0	20.0	0.70	8.5	6.44
December	22.0	21.9	0.20	8.5	6.64
Mean	23.2	22.6	3.40	8.2	6.51

The sample catch from Ehoma floodplain consisted of 46 species belonging to 14 families with cichlids making up 40 % of the weight of the catch of the 1,200 specimens sampled (total weight of about 99.3 kg), clariids and alestiids together made up over 30 %, while the rest were distributed among the 11 other families represented in the catch (see Table 2). The biggest fish caught was a specimen of *Citharinus citharus* measuring more than 2 m while lepidosirenids recorded the highest mean total length of the catch at 33.0 cm and anabantids the lowest at 15.0 cm.

Table 2. Composition of the catch from the sampling survey in the Ehoma Floodplain, Afikpo, Nigeria in January 1991 to February 1992.

Family	Species	Habitat	Number	% of total	Total weight (g)	% of total	Mean length (TL; cm)	Mean weight (g)
Cichlidae	*Tilapia zillii*		190	15.7	15,469	15.6	16	81.4
	*Tilapia melanopleura**		98	8.1	8,562	8.6	19	87.1
	Tilapia mariae		34	2.8	6,252	6.3	21	183.8
	Oreochromis nilotus nilotus		121	10.0	6,184	6.2	20	51.1
	Sarotherodon galilaeus galilaeus		58	4.8	2,112	2.1	17	36.4
	Hemichromis fasciatus		42	3.5	1,900	1.9	13	45.2
	Tylochromis jentinki		52	4.3	1,314	1.3	17	25.3
	Pelvicachromis pulcher		15	1.2	320	0.3	4	21.3
Sub-total			610	50.5	42,113	42.4		
Gymnarchidae	*Gymnarchus niloticus*	Open water	23	1.9	617	0.6	31	26.8
Mormyridae	*Mormyrus hasselquistii*		29	2.4	512	0.5	34	17.6
	Mormyrops engystoma	Open water	22	1.8	509	0.5	16	23.1
	Petrocephalus bane bane		12	1.0	460	0.5	15	38.3
	Gnathonemus petersii		16	1.3	402	0.4	13	25.1
	Campylomormyrus tamandua		15	1.2	311	0.3	17	20.7
	Marcusenius abadii	Open water	14	1.2	309	0.3	16	22.0
	Hippopotamyrus psittacus		13	1.1	200	0.2	15	15.3
Sub-total			121	10.0	2,703	2.7		
Claridae	*Clarias gariepinus*	Swamp zone	40	3.3	4,000	4.0	34	100.0
	Clarias anguillaris	Swamp zone	26	2.2	3,195	3.2	21	122.8
	Clarias submarginatus		30	2.5	3,100	3.1	18	103.3
	Heterobranchus bidorsalis	Swamp zone	10	0.8	2,900	2.9	19	2.9
	Heterobranchus longifilis		14	1.2	1,926	1.9	31	137.5
Sub-total			120	9.9	15,121	15.2		
Bagridae	*Bagrus docmak*		12	1.0	1,150	1.2	25	95.8
	Clarotes laticeps	Swamp zone	4	0.3	1,008	1.0	32	252.0
	Auchenoglanis biscutatus	Swamp zone	6	0.5	998	1.0	29	166.3
	Chrysichthys auratus auratus		20	1.7	627	0.6	38	31.2
	Chrysichthys nigrodigitatus	Swamp zone	30	2.5	750	0.8	30	26.0
Sub-total			72	6.0	4,533	4.6		

Table 2. cont.

Family	Species	Habitat	Number	% of total	Total weight (g)	% of total	Mean length (TL; cm)	Mean weight (g)
Mochokidae	*Synodontis nigrita*	Swamp zone	12	1.0	1,750	1.8	18	145.5
	Synodontis omias		3	0.2	1,520	1.5	20	506.6
	Synodontis batensoda		9	0.7	1,411	1.4	21	156.7
	Synodontis eupterus	Swamp zone	12	1.0	1,340	1.3	19	111.6
Sub-total			36	3.0	6,201	6.1		
Citharindae	*Citharinus citharus citharus*	Swamp zone	6	0.5	1,666	1.7	34	2777.6
	Citharinus latus		36	3.0	920	0.9	30	25.5
Sub-total			42	3.5	2,586	2.6		
Hepsetidae	*Hepsetus odoe*	Swamp zone	3	0.2	1,532	1.5	29	510.6
Protopteridae	*Protopterus annectens annectens*		12	1.0	500	0.5	33	41.6
Alestiidae	*Hydrocynus forskhalii*	Swamp zone	9	0.7	5,460	5.5	25	606.6
	Hydrocynus vittatus		3	0.2	3,146	3.2	25	1048.6
	Hydrocynus somonorum		4	0.3	2,945	3.0	24	736.2
	Micralestes acutidens	Swamp zone	6	0.5	2,187	2.2	11	364.5
	Alestes baremoze		4	0.3	940	0.9	10	235.0
	Brycinus nurse	Swamp zone	10	0.8	800	0.8	7	80.0
Sub-total			36	3.0	15,478	15.6		
Malapteruridae	*Malapterurus electricus*	Swamp zone	26	2.2	1,500	1.5	27	75.0
Anabantidae	*Ctenopoma kingsleyae*	Swamp zone	12	1.0	1,800	1.8	15	150.0
Channidae	*Parachanna obscura*	Open water	80	6.6	3,260	3.3	30	405.7
Schilbeidae	*Schilbe mystus*	Swamp zone	8	0.7	814	0.8	20	101.7
	*Eutropius niloticus**		6	0.5	720	0.7	20	120.0
Sub-total			14	1.2	1,534	1.5		
Total			1207		99,298			

*Editors' note: *Tilapia melanopleura* is a synonym of *Tilapia zillii*, *Eutropius niloticus* of *Schilbe mystus*. These entries are retained here since the original data used in the calculation of mean length and weight were not available for recalculation.

Four species, i.e., *Gymnarchus niloticus*, *Mormyrops engystoma*, *Macrusenius abadii* and *Parachanna obscura* were caught in the open water or among floating vegetation while 16 species occurred in the swampy zone (see Table 2). The cichlids were not restricted to any of the zones hence they were caught in both swampy zones and in the open water habitat of the floodplain.

Table 3. Number of fish caught by experimental gear from the Ehoma Floodplain (Afikpo, Nigeria) sampling survey January 1991 to February 1992.

Family	Species	Hook and line	Cast-net	Bag-net	Gill-net	Local trap
Cichlidae	*Tilapia zillii*		92	24	160	2
	Tilapia mariae		20	2	12	
	Oreochromis nilotus nilotus	40	37	6	37	
	Sarotherodon galilaeus galilaeus	6	20		30	2
	Hemichromis fasciatus	10	30		2	
	Tylochromis jentinki		21	7	24	
	Pelvicachromis pulcher		9			6
Gymnarchidae	*Gymnarchus niloticus*	15		1	6	1
Mormyridae	*Mormyrops engystoma*				20	9
	Petrocephalus bane bane	1	6	2	2	1
	Gnathonemus petersii				2	14
	Marcusenius abadii				14	2
	Hippopotamyrus psittacus				13	
Clariidae	*Clarias gariepinus*	1		15	24	
	Clarias anguillaris			10	16	
	Clarias submarginatus			12	18	
	Heterobranchus bidorsalis			12	8	
	Heterobranchus longifilis			4	10	
Bagridae	*Bagrus docmak*					12
	Clarotes laticeps				4	
	Auchenoglanis biscutatus	2			4	
	Chrysichthys auratus auratus				20	
	Chrysichthys nigrodigitatus				30	
Mochokidae	*Synodontis nigrita*				12	
	Synodontis omias				3	
	Synodontis batensoda				9	
	Synodontis eupterus				12	
Citharinidae	*Citharinus citharus citharus*				6	
	Citharinus latus		10	2	24	
Protopteridae	*Protopterus annectens annectens*	3		3	6	
Alestiidae	*Hydrocyanus forskalii*				9	
	Hydrocyanus lineatus					
	Hydrocyanus somonorum				4	
	Micralestes acutidens		6			
	Brycinus nurse		3		7	
	Alestes baremoze				4	
Malapteruridae	*Malapterurus electricus*	6				20
Anabantidae	*Ctenopoma kingsleyae*	3		3	6	
Channidae	*Parachanna obscura*	50		6	8	16
Schilbeidae	*Schilbe mystus*			1	11	2
Total		137	255	101	610	97
%		11.4	21.2	8.4	50.8	8.1
Species represented		11	12	17	37	12

Gill-nets caught half of the sampled specimens with cast-nets following at 21 % and the least number of specimens were caught by local traps (see Table 3). A plot of the monthly fish catches (Figure 1) shows numbers caught peaking in August. This coincides with the second peak in rainfall (water discharge) records, suggesting a correlation between these two variables.

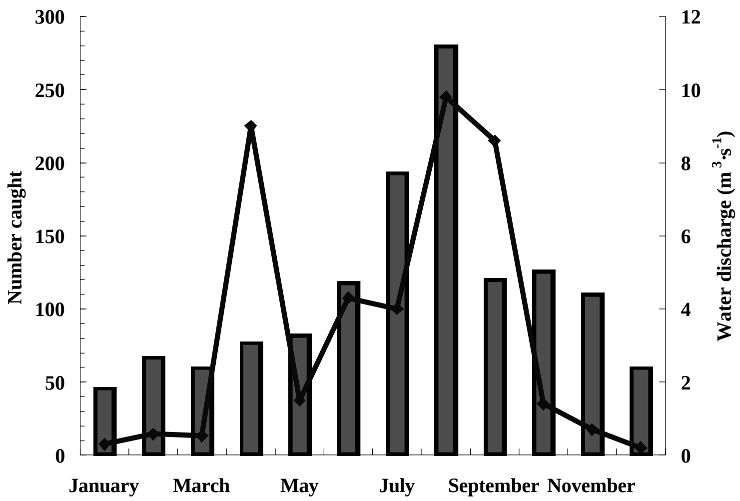

Figure 1. Monthly frequency distribution of sampled catch, consisting of 46 species in 14 families from the Ehoma Floodplain, Afikpo, Nigeria in January 1991 to February 1992. The monthly trend of water discharge (i.e., rainfall) overlain on the monthly catch suggests seasonal changes in fish abundance and hence catches.

DISCUSSION

The interest in this research was spurred by the fact that in the western flank of the Cross River Basin between Abakaliki and Afikpo, the Ehoma Floodplain, stands out clearly as the only floodplain with a variety of unique attributes. Also, there is no record available on its fish fauna except a documentary report contained in the work of Ottenberg (1969), on the history and culture of Afikpo. Greenwood (1984) observed that, in most African freshwater ecosystems, endemicity among members of the family Cichlidae was approaching 99 %. This was attributed to trophic specialisation and associated anatomical and functional specialisation (Fryer and Iles, 1972). Greenwood (1981) noted that cichlids can be bottom-feeding omnivores or benthic/pelagic insectivores showing various degrees of specialisation for feeding on particular life stages on different kinds of food items. In contrast, the non-cichlids fishes, fewer in number of species and with much lower levels of endemicity, show a more muted ecological radiation, especially within any one family (Fryer and Iles, 1972). The prevalence of cichlids in this old floodplain therefore confirms the rich lacustrine specialisation of nature's realm conferred on African water budgets.

The numerical propensity and ecological diversity observed in this floodplain indicates that the cichlids have evolved a wide range of feeding specialisation and occupy virtually every available lacustrine habitat and niche. Similarly, Lowe-McConnel (1964) recorded 44 species of fish in the pools of Rupununi River, South America, of which 84 % were found over only one type of substrate. In this study sixteen species were caught in swamps alone while only four were caught in the open water or with floating vegetation. The predominance of the family Cichlidae (32.8 % of the weight of the catch) can be attributed to the well-established littoral zone as Daddy *et al.* (1988) observed in the Tatabu floodplain. The occurrence of a greater number of the species at the swamp zone could be attributed to the detritus-rich bottom as observed in Mitchell (1976) in Lake Kariba where an all time high of 207 kg·ha^{-1} yield was recorded during rising floods with *Tilapia rendalli* being the species mostly influenced by this phenomenon.

While carrying out regular evaluation of sampling techniques, Backiel (1980) noted that selective gear were principally used by fishermen purposely to catch large and sizeable fish of commercial importance and that their catches may not give full representation of the entire species and families in the catch. The results of this study suggest differences in target species within and between gears, but show that gillnet is a preferred and effective gear and that it is a potentially less biased gear for sampling surveys (Helser *et al*., 1994). Another factor to consider in assessing biases in the catch data is that, during high water levels, most of the fish species dispersed into the flooded forests where they were targeted by inefficient gears. Thus, during the experimental period most of the fish were caught at high water levels between July and September 1991 and at the beginning of the receding water level between October and December 1992 when more than 67 % of the annual fish catches was brought in. The high fish catches can be attributed to the fact that sampling was concentrated in the remaining deep-water zones and the smaller lake within Ehoma Floodplain in which fish often remain trapped after rapid recedence of the water level (Ekman, 1985).

ACKNOWLEDGEMENTS

I wish to thank the Chairman of Afikpo Local Government, Afikpo, Nigeria for sponsoring this research from the beginning to the final preparation of this manuscript. I am also grateful to Dr. Emeka Nwosu and Mr. Kalu Uma for supplying me with the geological information. Finally, many thanks go to Dr. A.A. Adebisi and Prof. Fagade of University of Ibadah for their assistance with fish species identification. And, last but not the least, my gratitude for the assistance I received from local fishers in Afikpo throughout the study period.

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SOME RECORDS ON LAKE TANGANYIKA CLUPEID AND LATID FISH SPECIES

NOTES SUR LES CLUPEIDES ET LATIDES DU LAC TANGANYIKA

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ABSTRACT

A compilation of some available records on Lake Tanganyika clupeid and latid fish species is presented. The information provided consists of the following:local and common names; techniques of fish processing and preservation; the new aquatic habitats for *Limnothrissa miodon*; ecology and biology of *Lates* species; genetic findings for clupeid species, *Lates stappersii* and *Lates mariae*.

RESUME

Une compilation de quelques données disponibles sur les epèces de Clupéidés et Latidés du lac Tanganyika est présentée. L'information porte sur les aspects suivants: noms vernaculaires et d'usage courant des espèces considérées; techniques de traitement et de conservation du poisson; les nouveaux environnements aquatiques de *Limnothrissa miodon*; l'écologie et la biologie des poissons du genre *Lates*; quelques éléments de génétique des espèces de Clupéidés, de *Lates stappersii* et de *Lates mariae*.

INTRODUCTION

In Lake Tanganyika (Figure 1), the fisheries resources consist mainly of six fish species endemic to the lake. These species are the small-sized, short-lived and schooling clupeids, i.e., the 'sardines', *Stolothrissa tanganicae* Regan, 1917 and *Limnothrissa miodon* (Boulenger, 1906), and their four latid[6] predators, i.e., *Lates angustifrons* Boulenger, 1906, *Lates mariae* Steindachner, 1909, *Lates microlepis* Boulenger, 1898 and *Lates stappersii* (Boulenger, 1914). The three former latids are often described as large and long-lived *Lates*, *L. angustifrons* being the largest fish species in the lake. *L. stappersii* is mid-sized, mackerel-shaped and is of an average longevity. Since the 1960s, fishing pressure has drastically decreased the stocks of large *Lates*, especially in the waters of Burundi and Zambia, whereas *L. stappersii* catches increased. There is an apparent seasonal and inter-annual inverse relationship between the abundance of clupeids and latids, particularly between the abundance of *S. tanganicae* and *L. stappersii* (Pearce 1985a and 1988; Roest 1988; Coulter 1991; Coenen 1995).

[6] The *Lates* species were formerly assigned to the family Centropomidae; they were recently transferred in the family Latidae (Mooi and Gill 1995 *in* Kinoshita 1997).

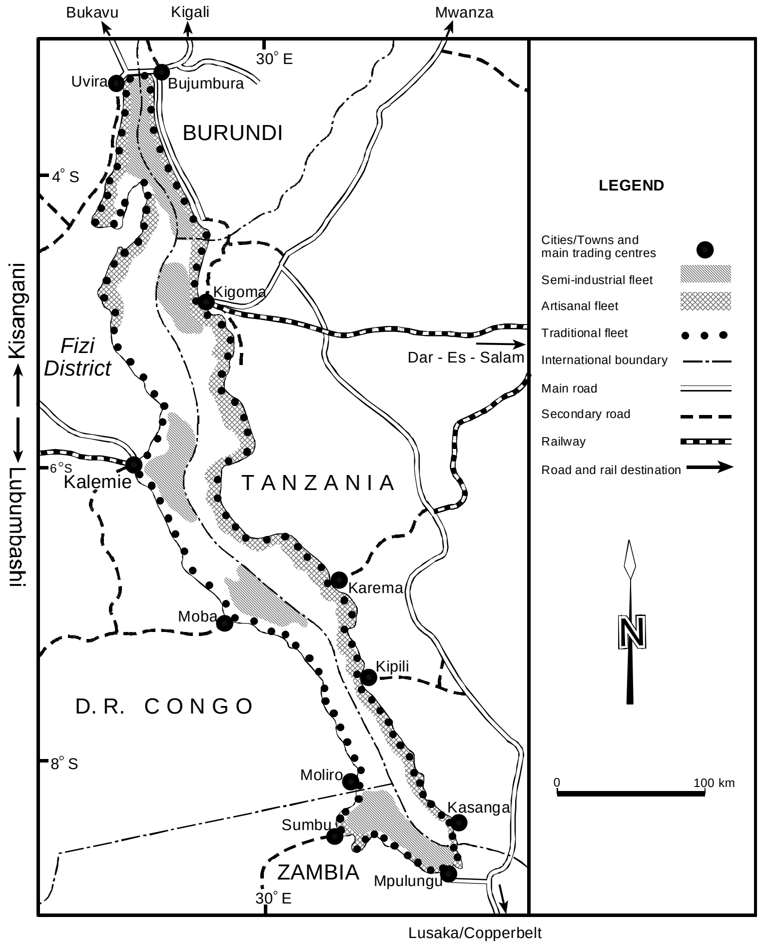

Figure 1. Map of Lake Tanganyika (from Munyandorero, 2002) showing the riparian counties, spatial distribution pattern of fishing activities, transport infrastructures and outlets of fish products (e.g., Kisangani).

The clupeid species and L. stappersii are the main targets of Lake Tanganyika fisheries, contributing well for 65 % and 30 %, respectively, by weight of the total catches from the lake (Reynolds, 1999; Mölsä *et al*., 1999). Their commercial importance and the need for management of their stocks and fisheries aroused much interest and related scientific research in all Lake Tanganyika riparian countries. Conversely, the large *Lates* were to some extent neglected, with the exception of investigations in the Zambian waters in the 1960s, 1970s and early 1980s (Coulter, 1976; Kendall, 1973; Pearce, 1985a&b), as well as recent lake-wide ecological and population genetic studies conducted by doctoral students led by Japanese scientists and by the FAO/FINNIDA funded project on the Research for the Management of the Fisheries on Lake Tanganyika (GCP/RAF/271/FIN). Hanek and Reynolds (1999) and the Lake Tanganyika Research website http://www.fao.org/fi/ltr/ provide an overview and the outputs of this project. Where body length measurements were involved, most authors used fork length (FL), except for Coulter (1976) and Aro and Mannini (1995) and Mannini *et al*. (1996) who employed total length (TL), while Kendall (1973) and Yuma *et al*. (1988) used standard length (SL).

This paper aims to fill knowledge gaps, e.g., in FishBase (see www.fishbase.org) by providing local and common names, techniques of fish processing and preservation, describing the new aquatic habitats for *L. miodon*, the biology and ecology of *Lates* species, and some genetic findings for clupeid species, *L. stappersii* and *L. mariae*.

LOCAL AND COMMON NAMES, FISH PROCESSING AND PRESERVATION

Eccles (1992) and Coulter (1976 and 1991) published pictures of *L. miodon* and *S. tanganicae*, *L. angustifrons*, *L. mariae*, *L. microlepis* and *L. stappersii*. Table 1 lists local and English common names of these species. Some of these names can be found either in Froese and Pauly (1998), FAO (2001), Munyandorero (2002). The local names for Zambia are in Chilungu (Kendall, 1973; Nakaya, 1993).

Both clupeid and latid species are sold either fresh, sun-dried or frozen. Freezing fish by semi-industrial fishing companies is done to suit urban requirements. Smoking was also reported for some *Lates* species (Paffen *et al*., 1995). The common latid *L. stappersii* is not dried and smoked in Zambia (Mudenda, pers. comm.).

NEW AQUATIC HABITATS OF *L. MIODON*

Figure 2 shows different aquatic environments hosting native and introduced populations of *L. miodon*. Between the late fifties and sixties, *L. miodon* has successfully colonised Lake Kivu (Collart, 1960) and Lake Kariba (Bell-Cross and Bell-Cross, 1971). From Lake Kariba, *L. miodon* penetrated Lake Cabora Bassa through the Zambezi River (Bernacsek and Lopes, 1984; Marshall, 1984 and 1991; Gréboval *et al*., 1994; Mtsambiwa, 1996; Losse, 1998). The presence of *L. miodon* in the Middle Zambezi River poses the question of whether it breeds in the Zambezi River or transits to Cabora Bassa (Mtsambiwa, 1996). Losse (1998), however, confirms that *L. miodon* "colonized the river below the Kariba dam and formed a dense population in the lake above the Cabora Bassa dam; here a liftnet fishery has also developed in recent years," a fact that Kenmuir (1975) foresaw.

The capacity of *L. miodon* to adapt to a variety of environmental conditions variety makes it a valuable candidate for stocking other tropical or sub-tropical waters where there is no successful planktivorous fish (Coulter, 1991). For example, in March 1992, Lake Itezhi-Tezhi in Zambia was stocked with 3,950 *L. miodon* fry ranging from 22 and 25 mm (TL) from Mpulungu waters of Lake Tanganyika (Mubamba, 1993). The justifications for this introduction were: a) failure of the indigeneous species in the Kafue River system to colonise the open waters of the lake; b) planktivorous *L. miodon* would benefit from the rich resource in this lake; and c) annual fish catches (then 500-1,000 t) would be increased to 3,000-5,000 t (Mudenda, pers. comm.). *L. miodon* managed to survive and reproduce in Lake Itezhi-Tezhi (Mudenda, pers. comm.). What still remains to be done is to find out if the species will develop a large population to support a viable fishery as is the case in Lake Kivu, Lake Kariba and Cabora Bassa dam.

ECOLOGY AND BIOLOGY OF *LATES* SPECIES

Distribution and abundance

Coulter (1976) summarised different, even conflicting speculations regarding the distribution and abundance of *Lates*. The lack of a comprehensive study compounds the continuing problem created by the frequent confusion between their 'true' abundance and their seasonal/annual catchability, which strongly depends on their feeding/spawning habits and impacted on by fishing strategies/efficiencies (Coulter, 1991). Overall, the distribution of *Lates* species in Lake Tanganyika is discontinuous in terms of both space and time, an observation reported by Mannini (1998a and 1998b) for *L. stappersii*. The following account consists of some major findings on the subject.

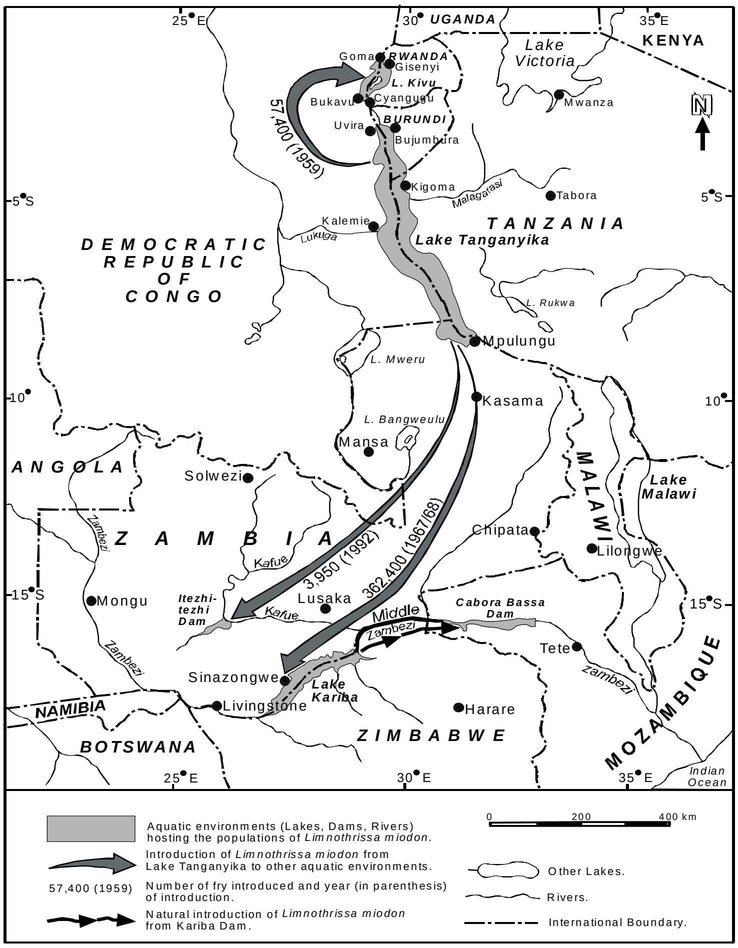

Figure 2. Map of aquatic habitats hosting the populations of *Limnothrissa miodon*.

Latid eggs are abundant near the bottom down to 150 m; being light, they tend to extend their distribution toward the surface (Kinoshita 1995). *Lates* larvae, on the other hand, ranges between 25 m and >50 m during the day with nocturnal migrations and high concentrations in the 25 m depth layer at twilight, suggesting diel vertical feeding migrations following the migratory pattern of zooplankton (Lowe-McConnell, 1975; Coulter, 1976 and 1991; Kondo and Abe, 1989; Furukawa-Tanaka *et al.*, 1995; Abe, 1997; Kinoshita, 1997). Post-larvae (length ≤25 mm) are common in the plankton sampled from pelagic areas. Young *L. stappersii* remain in the pelagic zone, while *L. mariae*, *L. microlepis* and *L. angustifrons* have juvenile inshore phases. For the last three species, individuals 25-180 mm long are abundant in littoral weed patches, which act as nursery areas and are thus influencing their survival rates. This habitat preference is much pronounced for *L. angustifrons*, dominant in short weed beds at wadable depths (e.g., *Vallisneria* spp. in the North of the lake; *Ceratophyllum* dominated-weed in the South) and for *L. mariae*, among tall weed beds (e.g., *Potomageton* spp.) in deeper waters. Very few juveniles of *L. microlepis* inhabit the short weed bed (Abe 1997) as they generally aggregate under drifting weeds in pelagic waters (Kinoshita 1997). Despite these recent findings, Coulter (1976) observed that between *L. mariae*, *L. microlepis* and *L. angustifrons*, the overall abundance ratio in weed beds was about 7:2:1, respectively.

***L. mariae*.** In general, *L. mariae* is the most demerso-benthic of the *Lates* species. From their second and third years and with increasing size, specimens of *L. mariae* occupy deeper, rocky grounds. They are abundant in bottom areas that are well oxygenated, but can survive in depths of 215 m (Coulter, 1976), where the water is less oxygenated. As a result, the biomass of the species is likely to be greater than that of any other species below 100 m (Pearce, 1985b; Coulter, 1991). This species makes diurnal vertical migrations, to as much as 200 m·hour^{-1}. In the Zambian waters, the average temperature for *L. mariae* ranges between 26°C at the surface and 23°C at 200 m. Immature specimens of the species are fully demersal, but can also appear in the pelagic zone more than is the case for *L. microlepis* and *L. angustifrons*. After maturity, some of the demersal specimens migrate at night to the surface and aggregate to prey upon clupeids in pelagic waters. Apart from its size and age-graded distribution with depth, *L. mariae* appears to be rather sedentary.

L. microlepis. Young *L. microlepis* live inshore areas after leaving weed cover. Adults occupy mainly pelagic zones to which they are recruited with maturity at about 500 mm (TL). Large specimens are common at the water surface where there is no significant fishing pressure. The species moves from place to place (up to 10 km·day^{-1}) and tends to concentrate in relation to the abundance of its main prey, *S. tanganicae*. In the Zambian waters, its abundance varies greatly, but tends to be higher in the rainy season, between November and May. Immature fish are rarely caught by pelagic fisheries and are conditioned to stay near shore, where they are commonly caught.

L. angustifrons. Adults of *L. angustifrons* are common in inshore areas. They increasingly occupy deep, rock ground as they grow larger. Large specimens can be found near the bottom close to shore. They are also sedentary and solitary. However, they sometimes aggregate while hunting for clupeid prey in pelagic zones, migrating up nightly from the bottom. Their presence in pelagic water is less prone to seasonal variation.

***L. stappersii*.** This species is almost entirely pelagic throughout its life. Though it is found in different lake habitats, its areas of higher occurrence are deep, steep basins (Coulter, 1991; Mannini, 1998a&b; Phiri and Shirakihara, 1999). Juveniles *L. stappersii* (130-270 mm; 10-22 months) move nearer to the shore to feed on young and maturing *S. tanganicae*; they recruit to the pelagic fishery at 200-290 mm (Roest 1988). Adult *L. stappersii* seem to aggregate more strongly than other *Lates* species, particularly during the main spawning season. In general, the abundance and distribution of both young and adult *stappersii* fluctuate markedly in terms of time and space (Coulter 1991; Phiri and Shirakihara 1999). These fluctuations could be partly attributed to the recruitment variability of the species, its inshore phase in the second year, its extensive lake-wide migrations, its spawning habits or to its prey's availability and abundance (Coulter 1991; Mannini 1998a and 1998b; Phiri and Shirakihara 1999; Reynolds 1999). They may be regulated in complex ways by physical, hydrological, biological and exploitation characteristics (Mölsä *et al.* 1999). For instance, adult *L. stappersii* are denser in the Zambian pelagic waters during the rainy season, November to April, which coincides with the spawning season and the prevalence of preys (i.e., *S. tanganicae* and prawns). Thereafter, the species disperses and becomes scarce in catches over the dry season, June to October (Pearce, 1985a). Phiri and Shirakihara (1999) confirmed this phenomenon by showing that, on average, the *L. stappersii* density in Zambian waters was low from June to August.

Two main contrasting observations, probably associated with the spawning habits and areas, have been noted about the distribution and abundance of *L. stappersii*. Pearce (1985a) reports that the species is rare in the Mpulungu region, Zambia, and abundant only in some years. Nyakageni (1995) observed that young *L. stappersii* seem to occur in the central and especially in the southern part of Lake Tanganyika. Chapman and van Well (1978) also observed that relatively concentrations of small *L. stappersii* occur in the central part of the lake, which may be a nursery area for them. Aro and Mannini (1994), Mannini *et al.* (1996) and Mannini (1998a) have shown that the northernmost part of the lake and the Kigoma region (Tanzania) should be nursery areas of *L. stappersii*, whereas the southern region (Kipili and Mpulungu) should host mature specimens of this species. This possible large-scale age-related distribution needs to be re-assessed in detailed fashion.

Table 1. Local and English names of Lake Tanganyika clupeid and latid fish species assembled from various sources. English common names are those in FishBase (www.fishbase.org).

Species	English name	Kirundi, Burundi	Swahili, Dem. Rep. Congo	Kinyanrwanda, Rwanda	Swahili, Tanzania	Chilungu, Zambia	Comments
Limnothrissa miodon	Lake Tanganyika sardine	Lumpu (LTR, 2003)	Lumpu (Mambona 1995)	Isambaza (Mughanda and Mutamba, 1993)	Dagaa; Lumbu (LTR, 2003)	Kapenta (LTR, 2003)	Adults
			Dagaa (LTR, 2003)			Lumbo (LTR, 2003)	Adults
			Lumbu (LTR, 2003)			Nsembe (LTR, 2003)	Adults
						Chisamba (LTR, 2003)	Adults
				Yorogo			Employed to young fish caught in the inshore zones of Lake Kivu
		Ndagala (Shirakihara and Phiri, 1993)	Ndakala (Mambona, 1995)				Name given to juveniles mixed with *L. stappersii* juveniles
Stolothrissa tanganicae	Lake Tanganyika sprat	Ndagala (LTR, 2003)	Ndagala (LTR, 2003; FAO, 2001)		Dagaa (LTR, 2003)	Kapenta (LTR, 2003)	Adults
					Ndagala (LTR, 2003)	Nsembe (LTR, 2003)	Adults
						Chilwe (LTR, 2003)	Adults
Lates stappersii	Sleek slates	Mukeke (LTR, 2003; Shirakihara and Phiri, 1993)	Mikeke (Shirakihara and Phiri, 1993)		Mikebuka (LTR 2003)	Nvolo	Adults
			Mvolo (LTR, 2003; Shirakihara and Phiri, 1993)			Bukabuka (LTR, 2003	Adults; name of Greek origin (Kendall, 1973)
						Involo (Shirakihara and Phiri, 1993)	Adults
		Nyamunyamu (LTR, 2003),					Juveniles

Table 1. (cont.).

Species	English name	Kirundi, Burundi	Swahili, Dem. Rep. Congo	Kinyanrwanda, Rwanda	Swahili, Tanzania	Chilungu, Zambia	Comments
		Ndagala (Shirakihara and Phiri, 1993)	Ndakala (Mambona, 1995)				Name given to juveniles mixed with clupeid juveniles
Lates mariae	Tanganyika salmon	Sangala (LTR, 2003)			Sangara (LTR, 2003)	Pamba (Kendall, 1973; LTR, 2003)	Adults
						Ngonzi (Kendall, 1973; LTR, 2003)	Adults
						Kalomolomu (Kendall, 1973)	Adults
						Chisosa (Nakaya, 1993)	Adults
Lates microlepis	Forktail lates	Nonzi (LTR, 2003)	Nonzi (LTR, 2003)		Nonzi (LTR, 2003)	Nyunvi (LTR, 2003	Adults
	Tanganyika salmon					Nyumvi (Kendall, 1973), Nyumbi (Nakaya, 1993)	Adults
						Nyumbi (Nakaya, 1993)	Adults
Lates angustifrons	Tanganyika lates	Sangala (LTR, 2003)	Capitaine (LTR, 2003; FAO, 2001)		Sangara (LTR, 2003)	Gomba (LTR, 2003; Kendall, 1973)	Adults
						Pamba (LTR, 2003; Kendall, 1973),	Adults
						Sikiti (LTR, 2003; Kendall, 1973)	Adults
						Mpamba (Mudenda, pers. comm.)	Adults
						Pamba sikiti (Kendall, 1973)	Adults
						Kachechi (Kendall, 1973)	i.e., Golden perch, due to a misidentification between *L. angustifrons and L. mariae*
						Chisoso (Nakaya, 1993)	Small individuals
						Chimizi (Kendall 1973)	Large individuals
						Pamba, Sikiti (Nakaya, 1993)	Large individuals
						Katala wa komonnga	Darker and deep-bodied individuals

Table 2. Some morphological and pigmentation features of larvae and juveniles of Lake Tanganyika latid fish species (after Kinoshita and Tshibangu, 1989; Kinoshita, 1997).

Items	*L. mariae*	*L. microlepis*	*L. angustifrons*	*L. stappersii*
Body form	Slender	Deep	Moderate	Slender
Start position of ossifing in dorsal fin	Anterior	Posterior	Posterior	Posterior
Melanophores:				
Lateral trunk	Absent	Dense	Sparse	Sparse
Lateral tail	Sparse	Sparse	Dense	Sparse
Dorsal marginal trunk	Absent	Sparse	Sparse	Dense
Ventral marginal of tail	Sparse	Sparse	Sparse	Absent

REPRODUCTION

Latid eggs are small, pelagic and spherical in shape (diameter: 0.5-0.6 mm; see Kinoshita, 1995). They show a little previtelline space and could not be identified to species level. The embryo is well differentiated around the yolk. It has a large oil globule (diameter: 0.25 mm) to egg diameter in the anterior part of the yolk. The chorion is thin, colorless and transparent. Dense melanophores are found on the surface of the oil globule; pale xanthophores are visible on the surface of the yolk. The oil droplet in *L. stappersii* eggs indicates that they are planktonic and truly pelagic (Pearce, 1985a; Coulter, 1991).

Post-larvae of *L. stappersii* are easily distinguishable (Coulter, 1991). Kinoshita and Tshibangu (1989) and Kinoshita (1997) have been able to identify larvae and juveniles of the four Lake Tanganyika latid species using morphological features, head spination and melanophore pattern (Table 2). In general, larval latids show diversity and specificity of morphology and melanophore pattern. Morphology and pigmentation-based relationships within larvae and juveniles of Lake Tanganyika *Lates* showed (Kinoshita, 1997) that *L. angustifrons* constitutes a sister group to the other three *Lates*. However, the morphology of *L. microlepis* larvae is unique and this species is hypothesised to be the most specialised member of the *Lates* community.

Ripe males and females in *Lates* species are found throughout the year. Table 3 shows length and ages at first maturity derived from maturity ogives and taken as average lengths and ages at which 50 % of individuals first become mature. The size at first maturity for *L. stappersii* varies throughout the year (Ellis, 1978) and from area to area (Mannini *et al.*, 1996). Its smallest value in both sexes of the species is reached between January and June (Chapman and van Well, 1978). The ratio of length at first maturity / mean asymptotic length in *L. stappersii* is 0.51 (Mannini *et al.*, 1996). This indicates that the species enters the reproductive phase when only about half its potential somatic growth has been achieved. From the results of these authors, it was possible to make crude estimates of TL at which 25 % and 75 % of individuals of *L. stappersii* mature (i.e., L_{25} and L_{75}, respectively). In the Kigoma area (Tanzania), L_{25} was 23.4 cm for females and 24.1 cm for males, and L_{75} was 31.9 cm for females and 31.7 cm for males. In the Mpulungu area (Zambia), L_{25} was 20.7 cm for females and 18.0 cm for males, and L_{75} was 27.1 cm for females and 31.7 cm for males. This led to the following ranges of lengths at first maturity: 8.5 cm for females and 7.6 cm for males in the Kigoma area; 6.4 cm for females and 13.7 cm for males in the Mpulungu area. Munyandorero *et al.* (unpublished data) found the average TL (cm) at maturity, at which 25 % and 75 % of *L. stappersii* were mature and the maturity range as follows: 24.9, 19.0, 30.7 and 11.7, respectively for females; 21.7, 17.8, 25.5 and 7.68, respectively, for males. Males reached maturity at a significantly shorter average TL than females.

Table 3. Length (TL_m; cm) and age-at-maturity (t_m; years) of *Lates* species in Lake Tanganyika.

Species	L_m (cm) Females	L_m (cm) Males	L_m (cm) Both	t_m (year) Both	Lake sector	Source
L. mariae	49	44		4	Zambia	Coulter (1976, 1981)
	42	40		3	Zambia	Pearce (1985a)
				2+	Zambia	Pearce (1985b)
L. microlepis	51	47		3 or 4-5	Zambia	Coulter (1976, 1981)
L. angustifrons	57	50		3 or 4-5	Zambia	Coulter (1976, 1981)
	56	45			Zambia	Pearce (1985a and 1985b)
L. stappersii			18-20		Zambia	Pearce (1985a)
	19.5-22.0	18.0-20.5			Burundi	Ellis (1978)
			29	2.3	Burundi	Roest (1988)
			20		Burundi	Nyakageni (1995)
	26-27	28-29			Lake-wide	Aro and Mannini (1995)
	27.8	27.8		2+	Tanzania (Kigoma)	Mannini *et al*. (1996)
	23.7	25.5		2+	Zambia (Mpulungu)	Mannini *et al.* (1996)
	24.9	21.7			Zambia (Mpulungu)	Munyandorero *et al*. (unpublished data)
	18	15			Tanzania (see note on previous page)	Chapman and van Well (1978)

Spawning occurs in deeper water, even at the bottom (Kinoshita, 1995). In each species, there appears to be a seasonal spawning maximum (Table 4). *L. mariae* and *L. angustifrons* are strongly seasonal spawners with a short spawning season (Pearce, 1985b). For *L. stappersii*, a lot of speculations exist about its breeding pattern and nursery areas: reproduction likely takes place simultaneously in different areas, and this suggests that the species does not perform extensive longitudinal spawning migrations (Mannini, 1994); in the northern part of Lake Tanganyika, spawning of *L. stappersii* likely occurs at least twice a year (Mukirania *et al.* 1988), and its peak shifts from year to year (Roest, 1988); no reproductive pattern of the species can be outlined in the previous part of the lake because mature specimens are very scarce (Mannini, 1994; Aro and Mannini, 1995); Mannini (1998a) has discriminated two *L. stappersii* stocks on the basis of the spawning pattern, i.e., a "northern stock", spawning in the Kigoma sub-basin, and a "southern stock" spawning in the Moba and the East Marungu sub-basins. Overall, Kinoshita (1997) reported that larvae of all *Lates* species were present throughout a one-year sampling period, without any evidence of larval abundance peaks.

The existence of spawning seasons imply seasonal peaks in condition factor and gonadosomatic index (GSI) (Pearce, 1991a; Musonda, 2000) and seasonal changes in pelagic catches (Coulter, 1991). In both sexes of *L. stappersii* in the Mpulungu area, GSI increases with both gonad maturity and fish length (Pearce, 1991a; Musonda, 2000). The GSI-FL (cm) relationship for *L. stappersii* is (Pearce, 1991a): **GSI=1.14+0.103·FL** ($r=0.99$; $p<0.05$).

Some estimates exist of the fecundity of *Lates* species. Overall, which tends to be high because of their small eggs (Pearce, 1985a; Musonda, 2000). For *L. stappersii*, fecundity ranges between 7,600 and 287,000 eggs per fish (average=107,000); relative fecundity ranges from 366 to 1,017 eggs·$g^{-1}$of fish (average: 552 eggs·g^{-1} of body weight) (Pearce 1985a). The species may be a multiple spawner, since these figures refer to one modal group of eggs and as three size groups of eggs were seen in mature ovaries (Pearce, 1985a; Musonda, 2000). Hence, the total number of eggs laid by a female each year may range between 10^5 and two million (Pearce, 1985a). Musonda (2000) found that the partial fecundity of *L. stappersii* ranges from 46,000 eggs for a fish of 20.2 cm TL and 57 g to 839,000 eggs for a fish of 50 cm TL and 1,064 g (average=273,000). He also found that the relative partial fecundity of this species ranges from 441 to 1,685 eggs·g^{-1} (average=914 eggs·g^{-1} of body weight).

Table 4. Seasonal maxima in the spawning activity of *Lates* species in Lake Tanganyika.

Species	Spawning seasons	Probable spawning peak	Lake sector	Source
L. mariae	August-December	September-October	Zambia	Coulter (1976)
	July-September		Zambia	Pearce (1985b)
L. microlepis	August-March	January-February	Zambia	Coulter (1976)
L. angustifrons	August-November		Zambia	Coulter (1976)
	July-September		Zambia	Pearce (1985b)
L. stappersii	November-May	May	Zambia	Pearce (1985a)
	November-May	May	Burundi	Ellis (1978)
	November-January; June-August		Tanzania	Chapman and Van Well (1978)
	November-April	March	Zambia and Rukwa (Tanzania)	Mannini (1994); Aro and Mannini (1995)
	November-March	August	Kigoma (Tanzania)	Mannini (1994); Aro and Mannini (1995)

Table 5 shows the sex-ratio of latid species obtained from commercial catch samples. Overall, the males are about two and half times more abundant than females in *L. mariae*, *L. microlepis* and *L. angustifrons* (Coulter, 1976). On the other hand, Pearce (1985b) suggests that the adult population of *L. mariae* should contain more females than males. He attributes this to the higher growth rates of males that result in higher mortality rates. For *L. stappersii*, the observed overall sex-ratio is close to 1 (Coulter, 1976, 1991; Nyakageni, 1995; Aro and Mannini, 1995; Mannini *et al.*, 1996; Musonda, 2000) with seasonal variations (Pearce, 1985a; Musonda, 2000). Morever, the sex-ratio in *L. stappersii* varies from area to area (Mannini, 1994; Aro and Mannini, 1995). Two contrasting findings were made about its sex-ratio by length classes: in Burundian waters, neither sex dominates particular length classes (Ellis, 1978); in the Zambian ones, the number of males decreases with increase in length and conversely for females (Pearce, 1991a; Musonda, 2000; Table 6). Overall, the assessment of the sex-ratio in *Lates* species is much affected by different growth rates, maximum size or lifespan, and the availability of the stocks with regard to particular fisheries (Pearce, 1985b).

Table 5. The overall sex ratio (percentage) of the latid fish species in Lake Tanganyika obtained from commercial catch samples.

Species	Fraction Female	Fraction Male	Lake sector and time period	Source; remarks
L. mariae	29.0	71.0	Tanzania, 1974	Chapman *et al*. (1974)
	81.0	19.0	Zambia, 1962-1964	Coulter (1976); pelagic
	36.0	64.0	Zambia, 1962-1964	Coulter (1976); benthic
	47.3	52.7	Zambia, 1979-1983	Pearce (1985b)
L. microlepis	32.0	68.0	Tanzania, 1974	Chapman *et al*. (1974)
	30.0	70.0	Zambia, 1962-1964	Coulter (1976)
L. angustifrons	28.0	72.0	Tanzania, 1974	Chapman *et al*. (1974)
	29.0	71.0	Zambia, 1962-1964	Coulter (1976)
	57.1	42.9	Zambia, 1979-1983	Pearce (1985b)
L. stappersii	52.0	48.0	Zambia, 1979-1983	Pearce (1985a)
	55.0	45.0	Burundi, 1971-1974	Ellis (1978)
	46.0	44.0	Tanzania, 1974-1976	Chapman and Van Well (1978)
	50.0	50.0	Burundi, 1983-1984	Nyakageni (1995)
	50.0	50.0	Lake-wide, 1993 -1995	Aro and Mannini (1995)
	54.5	45.5	Zambia, 1993-1995	Aro and Mannini (1995)
	50.0	50.0	Tanzania, 1993-1995	Aro and Mannini (1995)
	53.1	46.9	Zambia, 1999-2000	Musonda (2000)

Table 6. Proportions of males by length class (TL; cm) of *Lates stappersii* (after Pearce, 1991a).

Length class (cm)	12.5	17.5	22.5	27.5	32.5	37.5	42.5
Number of fish	14	117	152	112	98	115	10
% of male	–	92.9	86.3	84.9	66.7	53.1	45.2

AGE, GROWTH AND POPULATION PARAMETERS

Age, growth and population parameters for latid species (Tables 7 and 8) have almost exclusively been derived from length-based methods, with the exception for *L. mariae* for which Coulter (1976) combined the use of both length frequency distributions and scale rings. The following considerations may be taken into account while considering these estimates. Parameters depend critically on the nature of samples (e.g., experimental samples, catch samples from a specific fishery, etc.). Both sexes were combined in most studies. However, females grow better than males, reaching larger size. This is particularly ture in *L. stappersii* (Mannini, 1994; Aro and Mannini, 1995) and *L. angustifrons* (Coulter, 1976). This finding differs from that of Pearce (1985b) for *L. mariae*, a species in which the males have an average maximum length greater than that of females, at least after the age at first maturity.

Where available, the parameters estimated from the SCLA method were preferred from those obtained using the ELEFAN system, as the former method is appropriate for slow-growing and long-lived species (Isaac, 1990), a group of fish to which the *Lates* species belong (de Mérona *et al.*, 1988). The parameter t_0 of the von Bertalanffy growth function was seldom reported in the literature. It was fixed at 0 in recent publications and technical documents where length-based computer softwares (e.g., ELEFAN, SLCA) were used. However, using the FiSAT package (Gayanilo *et al.*, 1995), a re-fitting of the von Bertalanffy growth curve and parameters for *L. mariae* was performed (Figure 3; Table 7), with the constraint of the maximum average asymptotic length L_∞ of 75 cm. This constraint[7]

[7] Without this constraint, the L_∞ value is 95.34 cm for K=0.155 year^{-1}, t_0=-0.24 year and ø'=3.149, and therefore largely exceed the maximum length observed in catch samples.

relied on the upper limit of 75 cm for the largest class length recorded by Coulter (1976). The fitting was based on Coulter's (1976, Figure 3, page 242) average lengths at ages obtained from scale ring reading (i.e., these lengths[8] were for 1 to 7 years: 15.5, 31, 36, 45, 53, 60 and 64 cm, respectively). The weighting factor was fixed at 1 for all ages, as no information was available on the number of specimens studied, nor the standard deviation of average lengths. Thus, in addition to the above L_∞ value, the other growth parameters obtained were: K=0.253 year^{-1} and t_0=+0.094 year. Some growth performance indices (ø') have been estimated here employing the Pauly and Munro's (1984) empirical equation (i.e., **$ø' = \log_{10}K + 2\cdot\log_{10}L_\infty$**). The growth parameters used (i.e., L_∞ cm and K year^{-1}) were taken from the authors cited. Some estimates of fish longevity (t_{max}) were obtained from Pauly's (1980) empirical equation, i.e., $t_{max} \approx 3/K + t_0$. In this equation, t_0 was fixed at 0, and the smallest K values of 0.24 and 0.30 year^{-1} (Table 7) was used for all large *Lates* and *L. stappersii*, respectively. Growth and population parameters of *L. stappersii* varied from year to year and from area to area. Pearce (1985b) found that adult *L. mariae* in the Zambian waters exhibit growth and population parameters, which differ from sex to another and from area to area. The mean growth rates in juveniles *L. angustifrons* and *L. mariae* are 0.60 mm·day^{-1} and 0.54 mm·day^{-1}, respectively (Kondo and Abe, 1989). Lowe-McConnell (1975) reported a growth rate of 1 cm·month^{-1} in juveniles of large *Lates*. For *L. stappersii*, the growth rate is about 15 mm·month^{-1} during the first year of life (Mannini, 1994).

Figure 3. The von Bertalanffy growth curve (in length) for *Lates mariae* from Lake Tanganyika (original data were taken from Coulter, 1976; L_∞ = 75 cm; K = 0.253 * year^{-1}; t_0 = + 0.094 year; R^2 = 0.985; adjusted R^2 = 0.970).

Apart from the length-weight (L-W) relationships estimated by the authors cited, Table 7 also presents L-W relationships established here using Kendall's (1973) data for the period 1960-72. These data were averaged over both sexes and all condition factors. They consisted of mean weights (g) at 1 cm length intervals, i.e., FL (cm) for large *Lates* and SL (cm) for *L. stappersii*. It is clear that the L-W relationship was isometric for *L. angustifrons*, and allometric for other species (Sparre and Venema, 1992).

The length and age at recruitment may be interpreted as the length and age of the smallest and youngest animals that are available (i.e., accessible and vulnerable) to a given fishery. Except in the Kigoma area, the aforementioned lengths and/or age estimates are smaller for the artisanal fisheries than they are for the semi-industrial ones. For *L. mariae*, both sexes recruit to the gill net fishery in Zambia at one year (Pearce, 1985b).

[8] The average length at one year employed here is from Coulter (1976) derived from length frequency data, as ring "one" was not clearly discerned.

Kimura (1991) attempted to determine the age of *L. stappersii* by reading "daily rings" on otoliths. In only three specimens for which he successfully counted these structures, he concluded that length-based methods overestimate age at length. These fish measured 292 mm FL, 191.4 mm FL and 183 mm FL and were 635, 372 and 288 days old, respectively. According to the von Bertalanffy's growth parameters in Table 7, these fish might be at least 800, 470 and 440 days old, respectively.

For further conversions in *L. stappersii*, Mannini *et al.* (1996) established some statistics between TL and SL on one hand, and between TL and FL on the other hand, as follows (lengths were measured in mm): TL=- 0.9087+1.2048·SL (r=0.99; n=198); TL=- 2.5117+1.0845·FL (r=0.99; n=198). Kendall (1973) also established length (cm) conversions for *Lates* species based on linear plots extended to the origin presented in Table 8.

Table 8. Some statistics related to the estimation of the length-weight relationships of *Lates* species using the Kendall (1973)'s data (n: number of observations; r: correlation coefficient; C.I.: Confidence interval of the slope b). Lengths consisted of FL for large *Lates*, and of SL for *L. stappersii*.

Species	FL:SL	TL:SL	CI lower	CI upper	r	n	Length range (cm)	Length type	Weight range (g)
L. mariae	FL=1.18·SL	TL=1.21·SL	2.91	2.96	0.99	66	6-71	FL	3-3,090
L. microlepis	FL=1.14·SL	TL=1.26·SL	3.08	3.11	0.99	64	12-75	FL	18-5,000
L. angustifrons	FL=1.15·SL	TL=1.20·SL	3.00	3.04	0.99	67	11-100	FL	14-10,800
L. stappersii	FL=1.10·SL	TL=1.20·SL	3.13	3.17	0.99	34	5-41	SL	1-820

FEEDING

Most of the earlier records on feeding were mainly taken from Coulter (1976, 1991), Ellis (1978), Kondo and Abe (1989), Nyakageni (1995) and Abe (1997). The recent records were taken from technical documents of the FAO/FINNIDA funded project on the Research for the Management of the Fisheries on Lake Tanganyika. In littoral zones, juveniles of *L. mariae* and *L. angustifrons* feed on zooplankton, shrimps, insects and small cichlids, and are probably nocturnal feeders. They compete with juveniles of *L. microlepis* for the same food items, but the latter species mainly prey on immature inshore clupeids. Young *L. stappersii* (< 70 mm length) feed on pelagic phytoplankton and zooplankton (e.g., *Mesocyclops* sp.) as well as on shrimps (e.g., *Limnocardina* sp.).

***L. mariae*.** Immature *L. mariae* prey on benthic fish and mainly on invertebrates. Adult and mature *L. mariae* prey mainly on benthic small and available cichlids, though there is a seasonal feeding emphasis on clupeids when they are abundant between June and September. In general, *L. mariae* is the top predator in the benthic zone on account of its abundance, its omnivorous feeding habits and the large size of prey taken. Prey fish are taken up to 35 % of *L. mariae* length. *L. mariae* may be nocturnal predator.

Table 7. Growth and population parameters of the latid fish species in Lake Tanganyika. Values in bold characters are results of this study. Sources cited refer to all parameters unless otherwise specified. Length types assumed to be TL unless otherwise specified. Mortality and L_r values refer to semi-industrial/artisanal fisheries. Note that L_r and t_r values refer to the liftnet fishery for the northern part of the lake and the Kipili region and to gillnet fishery in Zambian waters.

Species	Lake sector	Period	L_{max} (cm)	W_{max} (g)	L_∞ (cm)	K ($year^{-1}$)	t_0 (year)	t_{max} (year)	a	b	Z ($year^{-1}$)	M ($year^{-1}$)	F ($year^{-1}$)	L_r (cm)	Sources
L. mariae	Zambia	1960-1972							**0.0114**	**2.94**					This study; FL; cm
	Zambia	1962-1964			72.0	0.240	0.094								Coulter (1976)
	Zambia	1962-1964			**75.0**	**0.253**									This study
	Zambia	1963-1983	86.0	5,400	90.0	0.250		12			1.5	0.52	0.98	54.0/ 46.0	Pearce (1985a; L_r); Pearce (1985b; L_{max}); Kendall (1973; W_{max})
	Zambia	1970-1972							0.0186	2.94					Kendall (1970)
		1979-1983							0.0245	2.86					Pearce (1985b)
	Mpulungu (Zambia)				77.0	0.12					0.91	0.32	0.59		Pearce (1985b); females
	Nsumbu (Zambia)				77	0.12					0.90	0.32	0.58		Pearce (1985b); females
	Mpulungu (Zambia)				78.0	0.26					2.52	0.58	1.94		Pearce (1985b); males
	Nsumbu (Zambia)				78	0.26					1.93	0.58	1.35		Pearce (1985b); males
	Lake-wide							**13**							This study
L. microlepis	Tanzania	1974-1975			88.0										Ndugumbi and Rufli (1976)
	Zambia	1960-1972							**0.0074**	**3.10**					This study; FL; cm
	Zambia	1962-1964	101	12,270	83.0										Coulter (1976)
	Zambia	1963-1983			108.0	0.340					2.57	0.60	1.97	63.0	Pearce (1985a)
	Lake-wide							13							This study

Table 7. (cont.).

Species	Lake sector	Period	L_{max} (cm)	W_{max} (g)	L_{∞} (cm)	K ($year^{-1}$)	t_0 (year)	t_{max} (year)	a	b	Z ($year^{-1}$)	M ($year^{-1}$)	F ($year^{-1}$)	L_r (cm)	Sources
L. angustifrons	Tanzania	1974-1975			100.0										Ndugumbi and Rufli (1976)
	Zambia	1960-1972							**0.0098**	**3.02**					This study; FL; cm
	Zambia	1962-1964	205	80,000	100.0										Coulter (1976; L_{∞}, K, L_{max}); Coulter (1991; W_{max})
	Zambia	1963-1983			195.0	0.250					2.51	0.42	2.09	64.0	Pearce (1985a)
	Zambia	1970-1972							0.0151	3.02					Kendal (1970)
	Zambia	1979-1983							0.0214	2.94					Pearce (1985b)
	Lake-wide							**13**							This study
L. stappersii	Burundi	1971-1974							$4.897 \cdot 10^{-6}$	3.09					Ellis (1978; FL)
	Burundi	1973-1980			47.0	0.400					1.78				Roest (1988)
	Burundi	1982			48.2	0.320					1.95	0.72	1.23		Moreau and Nyakageni (1992)
	Burundi	1983			51.2	0.300					1.60	0.67	0.93		Moreau and Nyakageni (1992)
	Burundi	1982-1983							$4.680 \cdot 10^{-6}$	3.05					Nyakageni (1995)
	Kigoma (Tanzania)	1993-1994	54.5	1033							2.59	0.44	2.15	5.0	Aro and Mannini 1995) ; Mannini (1994; L_r for both artisanal and semi-industrial fishery)
	Kigoma \ (Tanzania)	1994-1995			50.6	0.430					1.18	0.80	0.38	9.7	Mannini *et al*. (1996)
	Kipili (Tanzania)	1993-1994	47.5								0.93	0.39	0.54/ 1.30	5.5	Aro and Mannini (1995); Mannini *et al*. (1996; F); Mannini (1994; artisanal fishery)
	Kipili (Tanzania)	1994-1995			55.0	0.360					2.00	0.70		25.0	Mannini *et al*. (1996)

Table 7. (cont.).

Species	Lake sector	Period	L_{max} (cm)	W_{max} (g)	L_{∞} (cm)	K ($year^{-1}$)	t_0 (year)	t_{max} (year)	a	b	Z ($year^{-1}$)	M ($year^{-1}$)	F ($year^{-1}$)	L_r (cm)	Sources
L. stappersii	Mpulungu (Zambia)	1993-1994	488									0.43	0.14	8.0	Aro and Mannini (1995); Mannini (1994; L_r,)
	Mpulungu (Zambia)	1994-1995			53.0	0.400					0.57-2.35	0.80	1.55	23.9	Mannini *et al*. (1996; L_{∞}, K, M, F, L_r, Z); Aro and Mannini (1995; Z=0.57)
	Tanzania	1974-1976			45.0	0.400					1.20				Chapman and van Well (1978; L_{∞}, K); Henderson (1976; b)
	Uvira (DRC)	1988			48.0	0.380			$9.875 \cdot 10^{-6}$	3.08	2.02	0.79-0.91	1.18-1.24	6.5-7.0/ 4.5	Mulimbwa and Mannini (1993; L_{∞}, K, Z, M, F, E, L_r,); Yuma *et al*. (1988; a, b, SL); Mulimbwa and Mannini (1993; artisanal fishery)
	Zambia	1960-1972							**0.0068**	**3.15**					This study; SL
	Zambia	1963-1983			47.9	0.390					2.02	0.82	1.20	22.0	Pearce (1985a)
	Zambia	1980							0.0140	2.84					Pearce (1985a)
	Zambia	Not given							$3.715 \cdot 10^{-6}$	3.14					Ellis (1978; FL)
	Zambia	1999-2000		1,064					**0.00612**	**3.03**					Raw data from Musonda (2000; a, b, females); Musonda (2000; W_{max} from Mpulungu region)
	Zambia	1999-2000							**0.00814**	**2.95**					Raw data from Musonda (2000; males)
	Lake-wide	1993-1994			52.4	0.400		6.5	$4.680 \cdot 10^{-6}$	3.05	1.80	0.8	1.00		Munyandorero (2001; L_{∞}, K, Z, M; Aro and Mannini (1995a, b, TL); Mannini (1994; t_{max})
	Lake-wide	1994-1995							$6.798 \cdot 10^{-6}$	2.99					Mannini *et al*. (1996; TL)
	Lake-wide							**10**							This study

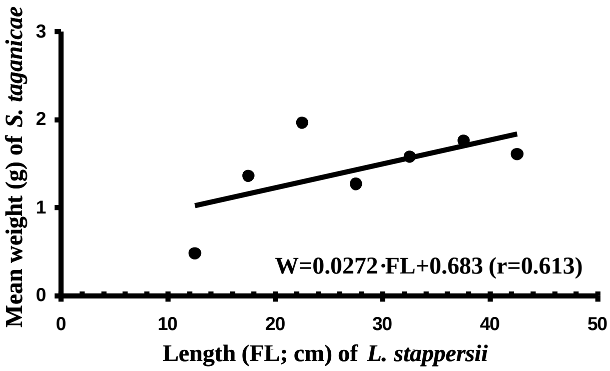

Figure 4. Relationship between fork length (FL) of *Lates stappersii* and mean weight of ingested *Stolothrissa tanganicae* (original data in Pearce, 1991a).

***L. angustifrons*.** The feeding regime of this species is similar to that of *L. mariae*. However, it feeds mainly on cichlid catfishes associated with rocky bottom, and on siluroid fish. Some specimens also swallow stones (personal observation). The role of stones (if any) in the feeding habits of the species needs to be clarified. Coulter (1976, 1991) considers *L. angustifrons* as the most important and largest predator in rocky areas. Prey reach 38 % of predator length. *L. angustifrons* may be nocturnal predator.

***L. microlepis*.** Adult *L. microlepis* feed upon adult clupeids in the pelagic zone. *L. stappersii* with sizes up to about 40 % of the length of the *L. microlepis* predator are also consumed. In general, *L. microlepis* is the top predator in the pelagic zone.

***L. stappersii*.** In this species, fish of length between 70 and 130 mm start preying upon other fish. As they grow larger, they feed either on zooplankton, fish (including members of their species) or shrimps according to the season and availability of the prey (Chapman *et al.*, 1974; Ellis, 1978; Pearce, 1985a, 1991a, 1991b; Nyakageni, 1995; Mannini *et al*, 1996). According to Pearce (1989), the occurrence of stomach contents in the Mpulungu area was: 31 % clupeids, 48 % shrimps and 6 % fish fry of various fish (including *L. stappersii*). Later, Pearce (1991a) showed that the mean monthly proportions to total food contents in *L. stappersii* were 56 % *S. tanganicae* (41.8 % adults and 14.2 % larvae), 3.6 % *L. miodon*, 29.3 % shrimps and 11.1 % other prey. This is indicative of a preference of *L. stappersii* for *S. tanganicae* (Pearce, 1985a), though in certain years, shrimps can constitute the major food item (Pearce, 1989). *S. tanganicae* represents 95 % of diet in the northern part of the lake (Ellis, 1978). Fish prey may reach 40 % of *L. stappersii* length. The relative importance and the size of *S. tanganicae* and *L. miodon* in major food items increase with the size of *L. stappersii* and vice versa for that of the shrimp (Ellis, 1978; Pearce, 1991a; Nyakageni, 1995). Moreover, data from Pearce (1991a) led to a clear relationship between the body fork length class (cm) of *L. stappersii* and the mean weight of *S. tanganicae* (Figure 4).

Investigations carried out in 1994-95 on the feeding ecology of *L. stappersii* in Kigoma and Mpulungu regions led to the following findings (Mannini, 1994; Mannini *et al.*, 1996; Mannini, 1998b; Mannini, 1999):

- Both males and females of the species have the same diet, their feeding activity probably taking place at dusk during first dark hours;

- The pelagic zone is the major feeding ground of *L. stappersii*;

- In the Kigoma region, juveniles (TL<100 mm) prey on copepods (in March) and shrimps; mid-sized specimens (TL between 100 and 200 mm) prey on shrimps and *S. tanganicae* larvae; adults (TL>200 mm) are entirely piscivorous. *S. tanganicae* larvae are important in the diet from May to July, decrease from July to January, when *L. stappersii* feed upon juveniles and adults. In the latter period, *S. tanganicae* is the main target of the fishing activity. The timing of maximum occurrences of *S. tanganicae* larvae and adults in predators' stomachs were thought to reflect the reproductive phase of the prey (in May) and its recruitment period to the pelagic fishery (in July-September), respectively;

- In the Mpulungu region, the diet is made up of clupeids and shrimps. The latter consist mainly of *Palaemon moorei* and *Limnocaridina parvula*, and predominate in some months, mainly in June-July. The commonest clupeid prey is *L. miodon*, *S. tanganicae* being almost entirely absent in the diet. This should be due, to some extent, to the low abundance of *S. tanganicae*, as reflected in recent commercial catches (Coenen *et al.*, 1998). No significant quantity of clupeid larvae was found, as *L. miodon* is expected to spawn in the inshore area, which is not a feeding ground for *L. stappersii*.

Overall, *L. stappersii* is an opportunistic predator, preying upon clupeids (mainly *S. tanganicae*), shrimps or young *L. stappersii*. Its feeding habit is determined by the abundance of the prey. Generally, shrimps seem to be the major prey of *L. stappersii* throughout the year, so that they appear to sustain its stock in the southern basin of the lake. The occurrence of *L. stappersii* is positively correlated with the shrimps' abundance (Mannini, 1998a, 1999).

LIFE HISTORY OF *LATES* SPECIES

Unlike the large *Lates*, *L. stappersii* displays an 'r'-life-history strategy, characterised, among others, by early maturity, high reproduction potential and recruitment, relatively short life cycle and high turn-over rate (Mannini *et al.*, 1996).

GENETIC VARIABILITY IN CLUPEID SPECIES *L. STAPPERSII* AND *L. MARIAE*

The information reported here are results of preliminary studies on the assessment of the genetic structures of pelagic (source and/or transplant) populations of Lake Tanganyika, and the authors stress the need to test their findings. The populations so far investigated are those of clupeids, and of *L. stappersii* and *L. mariae*. Nishida (1988) surveyed genetic variability of 21 enzymes in *L. miodon* and *S. tanganicae* from Lake Tanganyika using gel-electrophoresis. He scored 29 genetic loci controlling 18 enzymes. Complete and nearly complete allele substitution was found at Ah and Ck-2 loci, respectively, between these species. This indicates that they are reproductively isolated each other. However, Nei's genetic distance between them was low (0.055), suggesting that they are closely related. Each species showed moderate genetic variability: average heterozygosity was 6.2 % in *S. tanganicae* and 4.2 % in *L. miodon*.

Hauser (1996) and Hauser *et al.* (1995, 1998) examined the evolutionary phenotypic and genetic differentiation of native and introduced populations of *L. miodon*. The study dealt with samples collected in Lake Tanganyika (native population) and Lakes Kivu and Kariba (introduced populations). Comparisons were made using morphometrics, allozyme electrophoresis and mitochondrial DNA (mtDNA) variations. The following characteristics were recorded in source and transplant populations:

(a) morphological variability was higher in introduced populations, possibly suggesting higher phenotypic variability due to either a lower genetic variability or phenotypic responses to new environments and stunting. In that respect, Kariba *Limnothrissa* have relatively larger heads and small tails than the native fish, which are characteristics of stunted populations; Kivu *Limnothrissa* have deeper bodies and large eyes, possibly as an adaptation to a more structured environment;

(b) there is a distinct clustering of Kivu *Limnothrissa* especially at the morphometric and mtDNA levels;

(c) though Kariba *Limnothrissa* have a small size and a particular life-history, no detectable genetic differentiation was apparent from the native fish in Lake Tanganyika;

(d) higher micro-spatial genetic and morphometric differentiations occurred within Lake Tanganyika, especially in the south of the lake, suggesting the existence of subpopulations and local stocks, which can be isolated with thorough investigations. The highly significant morphological differences among samples suggested that schools were not random-assemblages of fish, but consisted of fish of similar size and shape. Overall, both differentiations in Lake Tanganyika did not show clear discreteness in stock structure on a large geographic scale. This suggests a significant exchange of individuals among different parts of the lake, leading to the possibility of a single stock;

(e) there was similar allozymic diversity in samples from Lake Tanganyika and Lake Kivu, i.e., Lake Tanganyika heterozygosity=0.0658 (mean number of alleles=1.44); Lake Kivu heterozygosity=0.0655 (mean number of alleles=1.48); however, a significant lower mtDNA haplotype diversity was detected in Lake Kivu (Lake Tanganyika = 0.905; Lake Kivu = 0.755). Data suggested that high post-introduction mortality and various demographic factors reduced drastically the effective size of the introduced population (from 57,400 fry to 100-150 fry), resulting in a reduction in genetic diversity and founder effect (see (a) above).

In the same vein, Kuusipalo (1994, 1995, 1999a, 1999b) used the RAPD (Random Amplified Polymorphic)-DNA-PCR method to assess the genetic structure of clupeids and of *L. stappersii* and *L. mariae* from Lake Tanganyika. Her studies revealed rich genetic variations in clupeid species and slight differentiation of local populations (e.g., north *Limnothrissa* subpopulation versus south *Limnothrissa* subpopulation; Nsumbu *Stolothrissa* subpopulation versus Kigoma, Kipili and Bujumbura *Stolothrissa* subpopulation) from the main population. However, heterogeneity among species was too low, and migration levels between different geographical areas appeared to be sufficient to permit gene exchange over the whole lake and to combine presumed subpopulations into one gene pool. Overall, the subpopulations of *S. tanganicae* seemed to be mixing more efficiently than those of *L. miodon* (Kuusipalo, 1994).

As for the *L. stappersii* populations, she detected a single, main, genetic population on a large geographical scale, and a local population in Kigoma, in the Malagarasi estuary. Nevertheless, the Kigoma subpopulation is not fully isolated from the main population, even though it can be easily identified with a high probability in accordance with the presence/absence of fragments. The genetic characteristics of the main population are indicative of the overall high migration level between sites, which prevents genetic separation between presumed subpopulations.

Lastly, the study of the *L. mariae* population showed that the species represents seven genetically diversified populations, six of which were geographically local (diversification was especially important in the south, at Mpulungu and Kipili), while members of the seventh population have a wider area of distribution. Nei's genetic identity between subpopulations varied from 0.650 to 0.905. The origin of differentiation should have started 7 million years ago, during the Miocene, when Lake Tanganyika consisted of small and mostly isolated pools. However, due to migration between subpopulations, there was no absolute evidence of their reproductive isolation being complete.

CONCLUSIONS

This paper summarises some available records on the Lake Tanganyika clupeid and latid species, with a special emphasis on the ecological and biological characteristics of *Lates* species. Most studies dealt extensively with *L. stappersii*, among *Lates* species, as it is one of the major targets of commercial fisheries. In particular, feeding habits show that *L. microlepis* and *L. stappersii* appear to compete in the pelagic zone for the same clupeid preys (Lowe-McConnell, 1975; Coulter, 1991), as is likely the case between *L. mariae* and *L. angustifrons* for different preys in the littoral and benthic areas.

Growth and population parameters of *Lates* species in Lake Tanganyika were estimated using length-based methods. Most of them date back at least twenty years. They also dealt essentially with *L. stappersii*. Their estimates for *L. microlepis* and *L. angustifrons* were empirical and based on growth rates assumed to be identical to that of *L. mariae* (Coulter, 1976, 1981). It is therefore desirable not only to update these parameters but also to find out their reliability by analysing fish samples collected from different parts of the lake. To achieve this, standardised working methods, schemes and schedules should be required, as already noted by Aro and Mannini (1995) and Mannini *et al.* (1996). Emphasis should be on "time discrete" analytical approaches, as population parameters are often age and size-dependent.

Lates species are thought to be very slow growing and long-lived fish (de Merona *et al.*, 1988; Coulter, 1991), for which the age estimates through length-based methods are unlikely to be accurate. It is therefore also desirable to continue determining individual ages. The improvement of preparation and reading techniques of hard parts (e.g., otoliths, scales, etc.) is possible (Coulter, 1976; Kimura, 1991). In conjunction with the diagnosis on the exploitation patterns, such techniques might result in reliable estimates of growth and populations parameters.

Finally, recent interest in genetic populations of clupeid and latid species are likely expected to shed some light for proper management of the fisheries resources in Lake Tanganyika. To supplement this effort, other comprehensive studies including monitoring investigations on breeding grounds, fecundity, detailed parameters on size/age-maturity relationships, spawning biomasses, feeding cycles, migration rates between national sectors or reference zones and a multispecies trophic relationships need also to be undertaken.

ACKNOWLEDGEMENT

The authors are very grateful to Mr. H.G. Mudenda (University of Zambia, Department of Biological Sciences) for his encouragement. The junior author of this paper, Mr. Leonard Mwape, passed away in 2003, before the paper was published. The senior author dedicates this paper in the memory of Mr. Leonard Mwape. May his soul rest in peace.

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ON THE BIODIVERSITY AND THE DISTRIBUTION OF FRESHWATER FISH OF NAMIBIA: AN ANNOTATED UPDATE

LA BIODIVERSITE ET DISTRIBUTION DES POISSONS D'EAU DOUCE DE NAMIBIE: UNE MISE A JOUR ANNOTEE

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ABSTRACT

This present study looks at the biodiversity of freshwater fish in Namibia. It discusses the distribution of such fish fauna in the perennial and ephemeral rivers as well as in small lakes and swamps in the interior of Namibia. The freshwater fishes of Namibia are grouped into 11 orders, consisting of 29 families, 61 genera and 138 species. Of these, 89 species occur in the upper Zambezi, 78 in the Okavango, 77 in the Kunene, 56 in the Chobe, 53 in the Kwando, 19 in the Orange Rivers, as well as 44 in the Cuvelai system. There are at least 7 species alien to Namibian waters, 6 translocated, 7 endemic, 8 endangered and 2 rare species. The presence of one undescribed *Clariallebes* sp. from the Kunene River and one *Nothobranchius* sp. from the Caprivi pans are recorded. The presence of two hybrid fish species in the lower Orange River is mentioned. Several new distributions are also mentioned.

RESUME

Cette étude examine la biodiversité des poissons d'eau douce en Namibie. Elle discute la distribution de cette faune de poissons dans les fleuves permanents et éphémères ainsi que dans les petits lacs et marécages à l'intérieur de la Namibie. Les poissons d'eau douce de la Namibie sont groupés dans 11 ordres, compris dans 29 familles, de 61 genres et de 138 espèces. Parmis ces derniers, 89 espèces se trouvent dans le Zambezi supérieur, 78 dans l'Okavango, 77 dans le Kunene, 56 dans le Chobe, 53 dans le Kwando, 19 dans les branches du Fleuve Orange, ainsi que 44 dans le système de Cuvelai. Il y a au moins 7 espèces exogènes en Namibie, 6 transférées, 7 endémiques, 8 espèces en danger et 2 rares. La présence d'une nouvelle espèce de *Clariallebes* dans le Fleuve Kunene et de *Nothobranchius* dans le bassin de Caprivi sont enregistrées. La présence de deux espèces hybrides de poissons dans le fleuve Orange inférieur est mentionnée. Plusieurs nouvelles distributions sont également mentionnées.

INTRODUCTION

Namibia is largely made up of a semi-arid plateau at an average elevation of 1,100 m, the Namib Desert on the southwestern Atlantic coast and the Kalahari Desert in the East. The climate is hot and dry with highly restricted rainfall most of the year, i.e., annual rainfall in the Namib Desert along the coast has been recorded to be 51 mm, mostly falling in summer, October to March. The average annual temperature is 17 and 21ºC at the coast and inland, respectively. There are no large natural fresh water lakes in Namibia, except perhaps for Lake Liambei in Caprivi, associated with Linyanti Swamp which was the largest natural lake; it is now dried up. Currently existing are the unique, small lakes of the interior, Lake Guinas, Lake Otjikoto and Aigamas Cave lake (near Otavi). Namibia is also blessed with swamps, floodplains and natural rivers, which flow along the borders of the country: the Zambezi, the Orange, the Kunene and the Okavango. Seasonal and ephemeral rivers, floodplains and swamps supply water to several impoundments (reservoirs), e.g., Hardap, Naute, von Bach, and

Swakoppoort, to name a few, and some private farm reservoirs. Finally, Namibia has two very important coastal lagoons, Walvis Bay and Sandwich Harbours, and two river or estuaries formed by the Kunene and the Orange rivers.

The biodiversity and the distribution of freshwater fishes in Namibia have been described by several authors, either as wetlands checklists (Bethune and Roberts, 1991; Holtzhausen, 1991), or as a species list for specific river systems, such as the Kunene (Skelton, 1993; Hay *et al.*, 1999), the Cuvelai (Omatako Omuramba; van der Waal, 1991), the Okavango (Barnard, 1948; Hay *et al.*, 1996), upper Zambezi and Caprivi (Kuando, Linyanti; van der Waal 1998, 1990; van der Waal and Skelton, 1984), the Fish (Hay, 1991), and the Orange (Jubb and Farquharson, 1965; Cambray, 1984; IUCN, 1994). General information regarding the biodiversity and the distribution of southern African freshwater fishes (including Namibia), has also been dealt with, notablyby Jubb (1964), Gabie (1965), Bell-Cross (1966, 1982), Gaigher and Pott (1973), and Skelton (1985, 1994). Recent surveys by the Ministry of Fisheries and Marine Resources in Namibia resulted in new distribution records as well as the collection of an undescribed catfish, and a species of *Nothobranchius* (Hay *et al.*, 1999; P.H. Skelton, pers. comm.). The translocation of several fish species within Namibia has also been recorded (Gaigher, 1975; Schrader, 1985; Skelton, 1985; Coppola *et al.*, 1994). Distribution records of alien species are not quite complete. Thus, as a contribution for the management of our natural resources, an annotated update on the biodiversity and the distribution of freshwater fishes of Namibia are presented.

METHODS

This annotated update is the result of intensive literature, museum and field data collection. Eschmeyer (1990) is followed for the classification of species, with some modifications and exceptions: the characins are included into the family Characidae following Nelson (1994); in contrast to Nelson (1994), Gery (1977) is followed in accepting the genus *Brycinus* Valenciennes (in Cuvier and Valenciennes), 1849 as distinct from *Alestes* Müller and Troschel, 1844; the Distichodidae are treated as a family in accordance to Vari (1979); the correct spelling from the International Code of Zoological Nomenclature (1985), is followed for the type genus *Distichodus* (Gery, 1977); *Aplocheilichthys* and related forms are placed in the family Aplocheilichthyidae according to Sethi (1960) and the results from Meyer and Lydeard (1993); the Poeciliidae are recognised as listed in Eschmeyer (1990), i.e., not as Aplocheilichthyidae; the Mastacembelidae were relocated from the Perciformes, to the order Synbranchiformes by Gosline (1983) and Travers (1998).

Spelling of names were counter-checked from several sources, which also included the original descriptions whenever possible. The scientific name is followed by names of authorities (and date when available) recording the information on respective fish species. The scientific names are also accompanied by the most appropriate (at least acceptable in southern African Region, SADC) English common name where available.

Comments on the status of the fish are given, where available, based on the ‘red list’ of the International Union for Conservation of Nature (IUCN), i.e., vulnerable, near threatened, threatened, endangered, among its categories. Exotic fish species are also indicated as alien to those water bodies they currently occupy. Fish of marine origin occurring in lagoon, estuary and marine littoral zones, and which may enter into fresh waters, were also recorded.

RESULTS AND DISCUSSION

At least 11 orders of 29 families, consisting of 61 genera and 138 fish species occur in Namibia freshwaters (Table 1). Fifteen of these families consist of at least 123 species which are entirely freshwater, while 10 families consist of at least 15 species which enter into freshwater from marine, lagoon and estuarine areas. The most abundant freshwater species occurring in Namibia belong to the family Cyprinidae (42 species), followed by the family Cichlidae (27) then, Mochokidae (9), Clariidae (8), Mormyridae(6) and Aplocheilichthyidae (6).

Table 1. Order and number of genera and species in families of freshwater fish known to occur in Namibia. Fish families containing species which enter into fresh water system from marine, lagoon and estuary systems are identified by an asterix (*). Totals are: Orders=11; Families=29; Genera=61; Species=138.

Order	Family	Genera	Species
Osteoglossiformes	Mormyridae	5	6
Gonorynchiformes	Kneriidae	1	2
Cypriniformes	Cyprinidae	7	42
Characiformes	Distichodidae	2	3
Characiformes	Characidae	4	4
Characiformes	Hepsetidae	1	1
Siluriformes	Claroteidae	1	1
Siluriformes	Austroglanididae	1	1
Siluriformes	Schilbeidae	1	2
Siluriformes	Amphiliidae	2	3
Siluriformes	Clariidae	2	8
Siluriformes	Ariidae*	1	1
Siluriformes	Mochokidae	2	9
Cyprinodontiformes	Aplocheilichthyidae	2	6
Cyprinodontiformes	Poeciliidae	2	2
Cyprinodontiformes	Aplocheilidae	1	1
Synbranchiformes	Mastacembelidae	1	2
Atheriniformes	Atherinidae*	1	1
Perciformes	Centrarchidae	1	1
Perciformes	Cichlidae	10	27
Perciformes	Mugilidae*	2	3
Perciformes	Eleotridae*	2	2
Perciformes	Gobiidae*	3	3
Perciformes	Polynemidae*	1	1
Perciformes	Haemulidae*	1	1
Perciformes	Sciaenidae*	1	1
?Percidae	Anabantidae	1	2
?Percidae	Carangidae*	1	1
Beloniformes	Exocoetidae*	1	1

Perennial rivers are very important to the freshwater fishes of Namibia (Table 2). Most species occur in the upper Zambezi (at least 89 species), Okavango (at least 78) and Kunene (at least 77). Two rivers, Kwando and Chobe, in the upper Zambezi system, support almost the same number of fish species each (at least 53 and 56, respectively). The Cuvelai, in the Kunene system supports at least 44 fish species; the species composition of the Cuvelai is closer to the Kunene River than to any other river system. The rest of the freshwater species (at least 20) occur in the interior in lakes, cave lakes, ephemeral rivers and farm reservoirs. There are 5 unique categories of biodiversity and distributional patterns of Namibian freshwater fishes, viz.: introduced, translocated, endemic, red listed, undescribed, and hybrid. Seven species were introduced into Namibia for forage: *Barbus anoplus* (Dixon and Blom, 1974); esthetics: *Carassius auratus* (Hay *et al.*, 1999), *Poecilia reticulata* and *Xiphophorus helleri* (Coppola *et al.*, 1994); aquaculture: *Cyprinus carpio* (Gaigher, 1975); and angling/sports: *Micropterus salmoides* and *Oreochromis mossambicus* (Schrader, 1985). At least 6 species, *Clarias gariepunus* and *Oreachromis macrochir* (Hay *et al.*, 1999), *Pseudocrenilabrus philander* (Skelton, 1991), *Tilapia guinasana* (Skelton, 1993), *Tilapia rendalli* (van der Bank *et al.*, 1989), and *Tilapia sparrmanii* (Hay *et al.* 1999), were translocated within Namibian waters. Seven species are considered endemic to Namibian waters: *Barbus hospes* (lower Orange River; IUCN, 1990), *Clariallabes platyprosopos* (upper Zambezi and Okavango Rivers; IUCN 1994), *Nothobranchius* sp. (Caprivi pans and upper Zambezi River; Hay *et al.*, 1999), *Orthochromis machadoi* (Kunene River; van Oijen *et al.*, 1991), *Thoracochromis albolabris* (Kunene River; Cuvelai system; van Oijen *et al.* 1991), *Thoracochromis buysi* (Kunene River; Cuvelai system; van Oijen *et al.*, 1991), and *Tilapia guinasana* (Lake Guinas; Skelton, 1993).

Table 2. Annotated list of scientific, recommended English common names, authorities and distribution of freshwater fish of Namibia. Authority name and date are isolated by a comma according to the International Code of Zoological Nomenclature (1985). Fish species the classification, common name and occurrence of which is uncertain is designated by question mark (?). Fish species which enter into fresh water from marine, lagoon and estuary systems are identified by an asterix (*). Citations of distribution also cover some synonyms.

Order	Family	English name	Species	Author	English name	Distribution and comments
Osteoglossiformes	Mormyridae	Snout fishes	*Hippopotamyrus ansorgii*	(Boulenger, 1905)	Slender stone basher	Kunene, Cuvelai, Okavango, upper Zambezi (Bethune and Roberts, 1991).
			H. discorhynchus	(Peters, 1852)	Zambezi parrotfish	Kunene, Okavango, Kwando, upper Zambezi (Hay *et al*., 1999).
			Marcusenius macrolepidotus	(Peters, 1852)	Bulldog	Kunene (Bethune and Roberts, 1991), Cuvelai (Coll. D. Okeyo), Okavango, Kwando, Chobe, upper Zambezi (Hay *et al*., 1999).
			Mormyrus lacerda	Castelnau, 1861	Western bottlenose	Kunene, Cuvelai, Okavango, Kwando, Chobe, upper Zambezi (Hay *et al*., 1999). FishBase (20 Nov 1998) lists common name as Western bottlenose mormyrid.
			Petrocephalus catostoma	(Günther, 1866)	Churchill; Kunene	Cuvelai, Okavango, Kwando, Chobe, upper Zambezi (Hay *et al*., 1999).
			Pollimyrus castelnaui	(Boulenger, 1911)	Dwarf stonebasher	Kunene, Okavango (Skelton, 1993), Chobe, upper Zambezi (Hay *et al*., 1999) and the Cuvelai system (Coll. D. Okeyo). Ornamental fish species.

Table 2. (cont.).

Order	Family	English name	Species	Author	English name	Distribution and comments
Gonorynchiformes	Kneriidae	Knerias	*Kneria maydelli*	Ladiges and Voelker, 1961	Kunene kneria	Endemic to Kunene River system, in range (Skelton, 1993, 1994). FishBbase (20 Nov 1998) lists the fish common name as Cunene kneria. According to Skelton (1993), only one member of this family, *K. maydelli*, has been recorded within the boundaries of Namibia., This and two more species of *Knerias* (*K. polli* Trewavas, 1936, *Parakneria fortuita* Penrith, 1973) occur in Namibia, according to Hay *et al*. (1999). Skelton (1994) indicates that the phylogenetic interrelationships and distribution of these species are uncertain making any biogeographical conclusions difficult.
			K. polli	Trewavas, 1936	Northern kneria	Kunene, Okavango, upper Zambezi (Skelton, 1993; Hay *et al*., 1999).
Cypriniformes	Cyprinidae	Barbs, Yellowfishes , Minnows and Labeos	*Barbus aeneus*	(Burchell, 1822)	Smallmouth yellowfish	Lower Orange (Hay *et al*., 1999); interior, State dams, e.g., Hardap (Holtzhausen, 1991).
			B. afrohamiltoni	Crass, 1960	Hamilton's barb	Upper Zambezi (Skelton, 1993).
			B. afrovernayi	Nichols and Boulton, 1927	Spottail barb	Kunene, Okavango, Chobe, upper Zambezi (Hay *et al*., 1999).

Table 2. (cont.).

Order	Family	English name	Species	Author	English name	Distribution and comments
Cypriniformes	Cyprinidae	Barbs, Yellowfishes, Minnows and Labeos	*B. anoplus*	Weber, 1897	Chubbyhead barb	Interior: *B. anoplus* was identified from the Gaub River (Dixon and Blom, 1974), a tributary of the Kuiseb River, but is in need of confirmation (P.H. Skelton, pers. comm.). Introduced ornamental fish from South Africa for forage (Coppola *et al.,* 1994).
			B. barnardi	Jubb, 1965	Blackback barb	Kunene (Bethune and Roberts, 1991), Cuvelai (Coll. D. Okeyo), Okavango, Kwando, Chobe, upper Zambezi (Hay *et al*., 1999).
			B. barotseensis	Pellegrin, 1920	Barotse barb	Kunene, Okavango, Chobe, upper Zambezi (Hay *et al*., 1999).
			B. bellcrossi	Jubb, 1964	Gorgeous barb	*B. bellcrossi* is listed only from the upper reaches of Zambezi river (Skelton, 1993).
			B. bifrenatus	Fowler, 1935	Hyphen barb	Ornamental freshwater fish found in the Kunene, Okavango, Kwando, Chobe, upper Zambezi Rivers and in the Cuvelai system (Skelton, 1993; Hay *et al*., 1999).

Table 2. (cont.).

Order	Family	English name	Species	Author	English name	Distribution and comments
Cypriniformes	Cyprinidae	Barbs, Yellowfishes, Minnows and Labeos	*B. breviceps*	Trewavas, 1936	Shorthead barb	Found in Kunene and Okavango Rivers (Skelton, 1993). Very little is known about *B. breviceps*. Skelton (1993) indicates that it appears to be similar to the chubbyhead group, which is confined to the southern fauna, preferring cooler conditions. This species is, however, strictly confined to the Zambezi Province and was first sampled from a brook 100 km south-east of Quibala, Angola, in the Longa River System (Trewavas, 1936). *B. breviceps* prefers fountain habitats. This was emphasised during a survey to the Kunene River when this species was sampled from similar habitats (Hay, *pers.obs*.).
			B. brevidorsalis	Boulenger, 1915	Dwarf barb	Okavango, upper Zambezi (Hay *et al*., 1999).
			B. codringtonii	Boulenger, 1908	Upper Zambezi yellowfish	Okavango, upper Zambezi (Bethune and Roberts, 1991).
			B. dorsolineatus	Trewavas, 1936	Kunene barb	Kunene (Skelton, 1993).
			B. eutaenia	Boulenger, 1904	Orangefin barb	Kunene, Okavango, upper Zambezi (Hay *et al*., 1999).
			B. cf. eutaenia		"Orangefin-like" barb	Okavango, upper Zambezi (Hay *et al*., 1999).
			B. fasciolatus	Günther,1868	Red barb	Kunene, Okavango, Kwando, Chobe, upper Zambezi (Hay *et al*., 1999).

Table 2. (cont.).

Order	Family	English name	Species	Author	English name	Distribution and comments
Cypriniformes	Cyprinidae	Barbs, Yellowfishes, Minnows and Labeos	*B. haasianus*	David, 1936	Sickle-fin barb	Okavango, Chobe, upper Zambezi (Hay *et al*., 1999).
			B. hospes	Barnard, 1938	Namaqua barb	Endemic to lower Orange (IUCN, 1990). Red data fish species (IUCN, 1994). Lower risk, near threatened.
			B. kerstenii	Peters, 1868	Redspot barb	Kunene, Cuvelai, Okavango, Chobe, upper Zambezi (Hay *et al*., 1999).
			B. kimberleyensis	Gilchrist and Thompson, 1913	Largemouth yellowfish	Lower Orange. Vulnerable (IUCN, 1994).
			B. cf. kimberleyensis		"Largemouth yellowfish-like" barb	Hybrids species in the lower Orange River and Hardap dam (Hay *et al*., 1999).
			B. lineomaculatus	Boulenger, 1903	Line-spotted barb	Kunene, Okavango, Chobe, upper Zambezi (Hay *et al*., 1999).
			B. mattozi	Guimaraes, 1884	Papermouth	Kunene (Bethune and Roberts, 1991), Cuvelai (Buthune and Roberts, 1991; Coll. D. Okeyo), Kwando (Hay *et al*., 1999).
			B. miolepis	Boulenger, 1902	Zigzag barb	Okavango, upper Zambezi (Skelton, 1993).
			B. multilineatus	Worthington, 1933	Copperstripe barb	Kunene, Okavango, Kwando, Chobe, upper Zambezi (Hay *et al*., 1999).

Table 2. (cont.).

Order	Family	English name	Species	Author	English name	Distribution and comments
Cypriniformes	Cyprinidae	Barbs, Yellowfishes, Minnows and Labeos	*B. paludinosus*	Peters, 1852	Straightfin barb	Kunene, Cuvelai (Coll. D. Okeyo), Okavango, Kwando, Chobe, upper Zambezi, lower Orange, interior (e.g. in four State dams: Hardap, Naute, Swakoppoort and Von Bach (Hay *et al*., 1999). Has a much wider distribution throughout Namibia Interior distribution also includes the occurrence in the ephemeral rivers. Distribution in the ephemeral rivers in Namibia is sporadic and depends on very good rains. The species composition of these rivers is limited to B. *paludinosus*, *Clarias gariepinus*, *Oreochromis mossambicus* and *Cyprinus carpio*. When these rivers recede to pool habitats, the conditions deteriorate and it is only the most tolerant fish species, which are able to survive.
			B. poechii	Steindachner, 1911	Dashtail barb	Cuvelai (Coll. D. Okeyo), Okavango, Kwando, Chobe, upper Zambezi (Hay *et al*., 1999).

Table 2. (cont.).

Order	Family	English name	Species	Author	English name	Distribution and comments
Cypriniformes	Cyprinidae	Barbs, Yellowfishes, Minnows and Labeos	*B. radiatus*	Peters, 1853	Beira barb	Kunene (Buthune and Roberts, 1991), Cuvelai (Coll. D. Okeyo), Okavango, Kwando, Chobe, upper Zambezi (Hay et al., 1999).
			B. thamala-kanensis	Fowler, 1935	Thamalakane barb	Ornamental freshwater fish found in the Okavango, Kwando, Chobe, upper Zambezi rivers (Skelton, 1993).
			B. trimaculatus	Peters, 1952	Threespot barb	Kunene (Coll. D. Okeyo), lower Orange (Jubb and Farquharson, 1965).
			B. unitaeniatus	Günther, 1866	Longbeard barb	Kunene, Cuvelai, Okavango, Kwando, Chobe, upper Zambezi (Hay *et al*., 1999).
			Carassius auratus	(Linnaeus, 1758)	Goldfish	Alien fish with isolated populations in the interior. *C. auratus* is present mainly in ponds in several towns in Namibia. Do not currently pose a threat to the indeginous fish species (Hay *et al*., 1999).
			Coptostomabarbus wittei	David and Poll, 1937	Upjaw barb	Cuvelai, Okavango, Kwando, Chobe, upper Zambezi (Hay *et al*., 1999).

Table 2. (cont.).

Order	Family	English name	Species	Author	English name	Distribution and comments
Cypriniformes	Cyprinidae	Barbs, Yellowfishes, Minnows and Labeos	*Cyprinus carpio*	Linnaeus, 1758	Common carp	Alien (introduced) to State dams: Hardap, Otjivero, Swakoppoort, and Von Bach (Hay *et al*., 1999), and Goreangab dam (Municipality of Windhoek; Coll. D. Okeyo); Omatako drainage. May eventually enter Okavango River drainage. May occur in all Namibian ephemeral rivers and lower Orange River, Omatako Omuramba and farm dams. Ornamental aquaria fish (Coppola *et al.*, 1994). Introduced into Namibia by early settlers (Gaigher, 1975). Introduced from South Africa for aquaculture. Distribution in the ephemeral rivers in Namibia sporadic and depends on rains. FishBase (20 Nov 1998) as subspecies *Cyprinus carpio carpio*.

Table 2. (cont.).

Order	Family	English name	Species	Author	English name	Distribution and comments
Cypriniformes	Cyprinidae	Barbs, Yellowfishes, Minnows and Labeos	*Labeo ansorgii*	Boulenger, 1907	Kunene labeo	Restricted to Angola in the Quanza and Kunene rivers (Hay *et al*., 1999). Also occurs in Cuvelai system (Skelton, 1993; Coll. D. Okeyo). FishBase (20 Nov. 1998) lists common name as Cunene labeo. The species composition of the Cuvelai system is closer in comparison with the Kunene River than with any other river system. This is emphasised by the presence of *L. ansorgii*, *L. ruddi*, *Thoracochromis albolabris*, *T. buysi* and *Sargochromis coulteri*. However, the artificial linkage between these two systems may have contributed to this (Hay, *in press*).
			L. capensis	(A. Smith, 1841)	Orange River mudfish	Lower Orange (Skelton, 1993); interior, e.g. two State dams, namely Hardap and Naute (Holtzhausen, 1991).
			L. capensis x umbratus		"Orange River mudfish-like"	Hybrid species in the lower Orange River (Hay *et al*., 1999).
			L. cylindricus	Peters, 1852	Redeye labeo	Okavango, Chobe, upper Zambezi (Hay *et al.*, 1999).
			L. lunatus	Jubb, 1963	Upper Zambezi labeo	Okavango (Bethune and Roberts, 1991), Chobe, Kwando, upper Zambezi (van der Waal, 1980, 1990; van der Waal and Skelton, 1984).

Table 2. (cont.).

Order	Family	English name	Species	Author	English name	Distribution and comments
Cypriniformes	Cyprinidae	Barbs, Yellowfishes, Minnows and Labeos	*L. ruddi*	Boulenger, 1907	Silver labeo	Kunene (Gaigher and Pott, 1973; Hay *et al.*, 1999), Cuvelai (Coll. D. Okeyo). The species composition of the Cuvelai System is closer in comparison with the Kunene River than with any other river system. This is emphasised by the presence of *L. ruddi, L. ansorgii, Thoracochromis albolabris, T. buysi* and *Sargochromis coulteri*. However, the artificial linkage between these two systems may have contributed to this (Hay, *in press*).
			L. umbratus	(A. Smith, 1841)	Moggel	Lower Orange (Gaigher and Pott, 1973); Occurs in one State dam, Hardap, in the interior (Hay *et al.*, 1999).
			Mesobola brevianalis	(Boulenger, 1908)	River sardine	Kunene (Bethune and Roberts, 1991), Cuvelai (van der Waal 1991; Coll. D. Okeyo), Okavango, upper Zambezi, lower Orange (Skelton, 1993).
			Opsaridium zambezense	(Peters, 1852)	Barred minnow	Okavango, Kwando (Hay *et al.* 1999), upper Zambezi (Skelton, 1993).

Table 2. (cont.).

Order	Family	English name	Species	Author	English name	Distribution and comments
Characiformes	Distichodidae	Citharines	*Hemigrammo-charax machadoi*	Poll, 1967	Dwarf citharine	Kunene, Cuvelai, Okavango, Kwando, Chobe, upper Zambezi (Hay *et al.*, 1999).
			H. multifasciatus	Boulenger, 1923	Multibar citharine	Kunene, Okavango, Kwando, Chobe, upper Zambezi (Hay *et al.*, 1999).
			Nannocharax macropterus	Pellegrin, 1925	Broadbar citharine	Okavango, upper Zambezi. *N. macropterus* is not present in the Kunene River, but being a habitat specialist, further surveys in the upper reaches of this system may reveal its presence (Hay *et al.*, 1999).
Characiformes	Characidae	Characins	*Brycinus lateralis*	(Boulenger, 1900)	Striped robber	Kunene (Bethune and Roberts, 1991), Cuvelai (van der Waal, 1991; Coll. D. Okeyo), Okavango, Kwando, Chobe, upper Zambezi (Hay *et al.*, 1999). The occurrence in Namibia of another characin fish, *Brycinus macrolepidotus* Valenciennes, 1850, as recorded in FishBase (20 Nov 1998) is doubtful.
			Hydrocynus vittatus	Castelnau, 1861	Tigerfish	Okavango, Kwando, Chobe, upper Zambezi (Hay *et al.*, 1999).
			Micralestes acutidens	(Peters, 1852)	Silver robber	Kunene, Cuvelai, Okavango, Kwando, Chobe, upper Zambezi (Hay *et al.*, 1999).

Table 2. (cont.).

Order	Family	English name	Species	Author	English name	Distribution and comments
Characiformes	Characidae	Characins	*Rabdalestes maunensis*	(Fowler, 1935)	Slender robber	Kunene, Cuvelai, Okavango, Kwando, Chobe, upper Zambezi (Hay *et al.*, 1999).
Characiformes	Hepsetidae	African pikes	*Hepsetus odoe*	(Bloch, 1794)	African pike	Kunene, Cuvelai, Okavango, Kwando, Chobe, upper Zambezi. Only species of the family Hepsetidae which is known to occur in Africa (Skelton, 1993). It has a low invasion potential (Roberts, 1975). Despite this handicap it is well distributed throughout Africa.
Siluriformes	*Claroteidae*	*Clarotid Catfishes*	*Parauchenoglanis ngamensis*	(Boulenger, 1911)	Zambezi grunter	Okavango, Kwando, Chobe, upper Zambezi (Hay *et al.*, 1999).
	Austroglani-didae	Rock catfishes	*Austroglanis sclateri*	(Boulenger, 1901)	Rock catfish	Red listed fish species (IUCN, 1994), which is at present only in the lower Orange River (Hay *et al.*, 1999). Only species of the three, from the family Austroglanididae (all occurring in southern Africa), which is listed in Namibia.
Siluriformes	Schilbeidae	Butter catfishes	*Schilbe intermedius*	Rüppel, 1832	Silver/butter catfish	Kunene, Cuvelai, Okavango, Kwando, Chobe, upper Zambezi (Hay *et al.*, 1999).
			S. yangambianus	(Poll, 1954)	Yangambi butterbarbel	*S. yangambianus* is known only from one locality in the upper reaches of the Upper Zambezi (Skelton, 1994).

Table 2. (cont.).

Order	Family	English name	Species	Author	English name	Distribution and comments
Siluriformes	Amphiliidae	Mountain catfishes	*Amphilius uranoscopus*	(Pfeffer, 1889)	Common mountain catfish, Stargazer mountain catfish	Okavango, upper Zambezi (Bethune and Roberts, 1991).
			Leptoglanis cf. dorae	(non Poll, 1967)	Chobe sand catlet	Okavango, Kwando, upper Zambezi (Skelton, 1993). FishBase (20 Nov 1998) lists the fish species as *Leptoglanis dorae*, and the name of the authority and date as Poll, 1967 (outside brackets).
			L. rotundiceps	(Hilgendorf, 1905)	Spotted sand catlet	Kunene, Okavango, upper Zambezi (Skelton, 1993).
Siluriformes	Clariidae	Air-breathing catfishes	*Clariallabes platyprosopos*	Jubb, 1964	Broadhead catfish	Endemic to the Okavango and the upper Zambezi rivers (P.H. Skelton, *pers. comm.*). Red data species in Okavango and upper Zambezi rivers (IUCN, 1994). FishBase (20 Nov 1998) records the authority date as 1965.
			Clariallabes sp.		Broadhead-like catfish	Undescribed *Clariallabes* sp. in the Kunene River, the status of which is not known (P.H. Skelton, pers. comm.).

Table 2. (cont.).

Order	Family	English name	Species	Author	English name	Distribution and comments
Siluriformes	Clariidae	Air-breathing catfishes	*Clarias cavernicola*	Trewavas, 1936	Cave catfish	Known from only one, dark underground lake in Aigamas near Otavi in the interior (Teugels, 1986; Skelton, 1990, 1993, 1994). Freshwater, ornametal fish, endemic to the Aigamas caves near Otavi. Closest relative to *Clarias theodorae* which is present in the Kunene, Okavango and Upper Zambezi Rivers. *C. cavernicola* is listed as a red data and rare species, in the interior (IUCN, 1994). Critically endangered; severely threatened by the depletion of water levels in local Karstland aquifers, which has caused lake levels in Aigamas Cave to decrease by about 20 m since 1921. Fishing pressure by aquarists could further threaten this species. Conservation action includes prohibiting the translocation of alien fishes and the pollution of cave lakes; and the access to the cave or collection of specimens should have permit from the owner of Aigamas farm (Bruton, 1995) or the concerned Ministry.

Table 2. (cont.).

Order	Family	English name	Species	Author	English name	Distribution and comments
Siluriformes	Clariidae	Air-breathing catfishes	*C. gariepinus*	(Burchell, 1822)	Sharptooth catfish	Wider distribution throughout Namibia. Ttranslocated everywhere, i.e., for aquaculture. Occurs in the Kunene, Cuvelai, Okavango (Teugels, 1986; Hay *et al.*, 1999), Kwando, Chobe, upper Zambezi, lower Orange and in the interior (all major State dams: Hardap, Naute, Otjivero, Swakoppoort, Von Bach and introduced into Omatako) (Hay *et al.*, 1999).Collected by D. Okeyo from Goreangab Reservoir (Municipality of Windhoek). Interior distribution, also include occurrence in ephemeral rivers. Occurrence in Namibian ephemeral rivers sporadic and depends on very good rains. Species composition of these rivers limited to *C. gariepinus*, *Barbus paludinosus*, *Oreochromis mossambicus* and *Cyprinus carpio*. Deteriorating river conditions allow survival of most tolerant fish species. Known as North African catfish (FishBase, 20 Nov 1998), described as venomous, i.e., dangerous to humans. Known as sharptooth catfish in aquaculture, a highly recommended food fish in Africa. Name “North African catfish” may thus belong to another species.

Table 2. (cont.).

Order	Family	English name	Species	Author	English name	Distribution and comments
Siluriformes	Clariidae	Air-breathing catfishes	*C. liocephalus*	Boulenger, 1898	Smoothhead catfish	Kunene, Okavango, Kwando, Chobe, upper Zambezi (Hay *et al.*, 1999).
			C. ngamensis	Castelnau, 1861	Blunttooth catfish	Kunene, Cuvelai, Okavango, Kwando, Chobe, upper Zambezi (Hay *et al.*, 1999).
			C. stappersii	Boulenger, 1915	Blotched catfish	Kunene, Okavango, upper Zambezi (Skelton, 1993).
			C. theodorae	Weber, 1897	Snake catfish	Kunene (Coll. D. Okeyo), Okavango, Kwando, Chobe, upper Zambezi. Nearest relative to *Clarias cavernicola* (Hay *et al.*, 1999).
Siluriformes	Ariidae	Sea catfishes	*Arius latiscutatus*	Günther, 1864	Rough-head sea catfish	Marine fish species, occasionally occurring in the lower Kunene River (Bianchi *et al.*, 1993). The occurrence of another sea catfish, *Galeichthys feliceps* Valenciennes, 1840, southwards from Walvis Bay, which is recorded in FishBase (20 Nov 1998) and Taylor (1986) is doubtful. Although ornamental and sometimes considered aquaria fish (Bianchi *et al.*, 1993), the fish is venomous and can be dangerous to humans (van der Elst, 1993).

Table 2. (cont.).

Order	Family	English name	Species	Author	English name	Distribution and comments
Siluriformes	Mochokidae	Squeakers, Suckermouth catlets and Upside-down catfishes	*Chiloglanis fasciatus*	Pellegrin, 1936	Okavango suckermouth, Rock catlet	Okavango, Kwando system. Although not listed for the upper Zambezi, was identified from the Kwando River that forms part of the upper Zambezi system (Hay *et al.*, 1999). *C. fasciatus* has replaced *Chiloglanis neumanni* Boulenger, 1911, in the Okavango River.
			C. neumanni	Boulenger, 1911	Newman's suckermouth, Rock catlet	Kunene, upper Zambezi (Gosse, 1986; Skelton, 1993). Replaced by *C. fasciatus* in the Okavango River. The latter has also been recorded from the Kwando River.
			Synodontis leopardinus	Pellegrin, 1914	Leopard squeaker	Kunene, Cuvelai (Bethune and Roberts, 1991), Okavango, Kwando, Chobe, upper Zambezi (Hay *et al.*, 1999).
			S. macrostigma	Boulenger, 1911	Largespot squeaker	Kunene, Cuvelai, Okavango (Bethune and Roberts, 1991), Kwando, Chobe, Zambezi (Hay *et al.*, 1999).
			S. macrostoma	Skelton and White, 1990	Largemouth squeaker	Found in the Kunene (Skelton, 1993), Okavango River (at Mbabi Clinic, Kavango), upper Zambezi River (at Katima Mulilo, Caprivi) and Chobe River (at Kabuta, Caprivi) (Skelton and White, 1990).

Table 2. (cont.).

Order	Family	English name	Species	Author	English name	Distribution and comments
Siluriformes	Mochokidae	Squeakers, Suckermouth catlets and Upside-down catfishes	*S. nigro-maculatus*	Boulenger, 1905	Spotted squeaker	Okavango, Kwando, Chobe, upper Zambezi (Gosse, 1986). Ornamental fish species. FishBase (20 Nov 1998) and Gosse (1986) list the fish common name as Blackspotted squeaker.
Siluriformes	Clariidae	Air-breathing catfishes	*S. thamala-kanensis*	Fowler, 1935	Bubblebarb squeaker	Okavango, upper Zambezi (Skelton, 1993).
			S. vanderwaali	Skelton and White, 1990	Finetooth squeaker	Found in the Kunene River (below Ruakana Falls), Okavango River drainage (Rundu; Mbabi Clinic and Mkena, Kavango) and the upper Zambezi River drainage (Kwando River, Caprivi) (Skelton and White, 1990).
			S. woosnami	Boulenger, 1911	Upper Zambezi squeaker	Kunene, Cuvelai, Okavango, Kwando, Chobe, upper Zambezi (Hay *et al.*, 1999).

Table 2. (cont.).

Order	Family	English name	Species	Author	English name	Distribution and comments
Cyprinodontiformes	Aplocheilichthyidae	Topminnows and lampeyes	*Aplocheilichthys hutereaui*	(Boulenger, 1913)	Topminnow	Occurs in the Okavango system (Skelton, 1993); Kwando, Chobe, upper Zambezi (Huber, 1996). Ornamental fish species. FishBase (20 Nov 1998) lists the fish species under wrong family heading, Poeciliidae. FishBase (20 Nov 1998) also lists the fish common name as Meshscaled topminnow. Hay *et al.* (1999) list *Aplocheilichthys hutereaui*, *A. johnstoni*, A. *katangae*, *A. macrurus*, *A. moeruensis* and *Hypsopanchax jubbi* under the family Cyprinodontidae.
			A. johnstoni	Günther, 1893	Johnston's topminnow	Kunene, Cuvelai, Okavango, Kwando, Chobe, upper Zambezi (Huber, 1996). Ornamental fish. FishBase (20 Nov 1998) and Huber (1996) list the authority name and date as (Günther, 1894, in brackets). FishBase (20 Nov 1998) lists the fish species under wrong family heading, Peociliidae.
			A. katangae	(Boulenger, 1912)	Striped topminnow	Occurs in the Atlantic flowing river drainages (i.e., the Kunene) and in the Chobe River drainage in northern Namibia (Huber, 1996); also occurs in the Okavango, Kwando and upper Zambezi rivers. Ornamental fish species. FishBase (20 Nov 1998) lists the fish species under wrong family heading, Poeciliidae.

Table 2. (cont.).

Order	Family	English name	Species	Author	English name	Distribution and comments
Cyprinodontiformes	Aplocheilichthyidae	Topminnows and lampeyes	*A. macrurus*	(Boulenger, 1904)		Kunene (Skelton, 1993). The taxonomic status of *A. macrurus* is still unclear (P.H. Skelton, pers. comm.). The group is currently under investigation.
			A. moeruensis	(Boulenger, 1914)		Identified from the Okavango River (Hay *et al.*, 1996). The taxonomic status of the species is still unclear and in need of review (P.H. Skelton, pers. comm.).
			Hypsopanchax jubbi	Poll and Lambert, 1965	Southern deepbody	Upper Zambezi (Skelton, 1993). Very little is known about *H. jubbi* except that it is present in the upper reaches of the upper Zambezi.
Cyprinodontiformes	Poeciliidae	Live-bearers	*Poecilia reticulata*	Peters, 1859	Guppy	Alien species to the interior (Coppola *et al.*, 1994). Introduced into the Kuraman Eye and Lake Otjikoto. Introduced from unknown sources for ornamental purposes. Liked as aquarium fish. Does not currently pose a threat to indigenous fish species (Hay *et al.*, 1999). FishBase (20 Nov 1998) lists the authority date as 1860.

Table 2. (cont.).

Order	Family	English name	Species	Author	English name	Distribution and comments
Cyprinodontiformes	Poeciliidae	Live-bearers	*Xiphophorus helleri*	Heckel, 1848	Swordtail	Alien fish species to the interior and Lake Otjikoto (Coppola *et al.*, 1994). Introduced from unknown sources for ornamental purposes. Well-liked aquarium fish. Does not currently pose threat to indigenous fish species (Hay *et al.*, 1999). FishBase (20 Nov 1998) records the fish specific name as *hellerii*, and the fish common name as Green swordtail.
Cyprinodontiformes	Aplocheilidae	Nothobran-chius	*Nothobran-chius* sp.		Caprivi killifish	Endemic to the Caprivi in northeastern Namibia (where it inhabits temporary rainpools, Caprivi pans) and to the upper Zambezi River. This is an undescribed species. It is also red listed (IUCN, 1994). FishBase (20 Nov 1998) lists the fish species, *Nothobranchius polli* Wildekamp 1978, as occurring in Namibia, which is doubtful.
Synbranchiformes	Mastacembelidae	Spiny eels	*Aethiomastacembelus frenatus*	(Boulenger, 1901)	Longtail spiny eel	Okavango, Kwando, Chobe, upper Zambezi (Hay *et al.*, 1999).
			A. vanderwaali	(Skelton, 1976)	Ocellated spiny eel	Red listed species in the Okavango and upper Zambezi (Hay *et al.*, 1999).

Table 2. (cont.).

Order	Family	English name	Species	Author	English name	Distribution and comments
Atheriniformes	Atherinidae	Silversides	*Atherina breviceps*	Valenciennes, 1835	Cape silverside	Marine, brackishwater fish, occurring in the coastal estuaries and lakes, mainly off southern Namibia, but ranging from Orange River northwards to Luderitz (Bianchi *et al.*, 1993). Seldom caught for food (van der Elst, 1993). Maily caught for bait (Bianchi *et al.*, 1993).
Perciformes	Centrarchidae	Sunfishes and freshwater basses	*Micropterus salmoides*	(Lacepède, 1802)	Largemouth bass	Only species of the Centrarchidae known to occur in Namibia, is an alien with its first introduction recorded in 1932 (Schrader, 1985). Widely distributed within central Namibian impoundments and farm dams (e.g. the Omatako Omuramba, Von Bach dam; Hay *et al.*,1999) and river drainages of Omatako and Swakop. Ornamental fish (Coppola *et al.*, 1994) mainly present in central Namibia, where the high turbidity appears to be a limiting factor in the distribution of this species. The reason for the initial introduction was for angling/sports.

Table 2. (cont.).

Order	Family	English name	Species	Author	English name	Distribution and comments
Perciformes	Cichlidae	Cichlids	*Chetia welwitschi*	(Boulenger, 1898)	Angola happy	Kunene. Known only from a few museum specimen. Status not well known (P.H. Skelton, *pers. comm.*).
			Hemichromis elongatus	(Guichenot, 1859)	Banded jewelfish	Freshwater ornamental fish. Occurs in rivers Okavango, Kwando, upper Zambezi systems (van der Bank *et al.*, 1989). FishBase (20 Nov 1998) lists this fish species as *Hemichromis faciatus* (Peters, 1858).
			Oreochromis andersonii	(Castelnau, 1861)	Threespot tilapia	Kunene, Cuvelai (Coll. D. Okeyo), Okavango, Kwando, Chobe, upper Zambezi (de Moor and Bruton, 1988). FishBase (20 Nov 1998) lists the fish common name as Three spotted tilapia.
			O. macrochir	(Boulenger, 1912)	Greenhead tilapia	Kunene, Cuvelai (Coll. D. Okeyo), Okavango, Kwando, Chobe, upper Zambezi (Hay *et al.*, 1999); introduced into Swakoppoort dam in the interior (Hay *et al.*, 1999).

Table 2. (cont.).

Order	Family	English name	Species	Author	English name	Distribution and comments
Perciformes	Cichlidae	Cichlids	*O. mossambicus*	(Peters, 1852)	Mozambique tilapia	The only ornamental alien cichlid with wide distribution in Namibia: present in several small lakes and impoundments, e.g., Lake Otjikoto and all major State dams: Hardap, Naute, Omatako, Otjivero, Swakoppoort, and Von Bach (Hay *et al.*, 1999), and the Cuvelai system (Omuramba Omatako and Owamboland). Collected by D. Okeyo from Goreangab Reservoir (Municipality of Windhoek). Present in the Nossob/Olifants system, west flowing (ephemeral) rivers and lower Orange River (Lever, 1996; Hay, *in press*). Poses a serious threat of genetic pollution in Kunene and Okavango Rivers: breeds with *O. andersonii* (Jackson, 1961). Declared as an international pest (Bruton and van As, 1986), high fertility increases the danger of invasion. First introduced into Namibia from the Cape in 1947 for angling/sport (Schrader, 1985). Distribution in Namibian ephemeral rivers sporadic and depends on good rains.

Table 2. (cont.).

Order	Family	English name	Species	Author	English name	Distribution and comments
Perciformes	Cichlidae	Cichlids	*Orthochromis machadoi*	(Poll, 1967)	Kunene dwarf happy	Potential ornamental cichlid, endemic to Kunene River and the Cuvelai system (van Oijen *et al.*, 1991; Coll. D. Okeyo). Hay *et al.* (1999) lists genus name as *Schwetzochromis*. FishBase (20 Nov 1998) lists genus name as *Haplochromis*, common name as Cunene (with a "C") dwarf happy and date of the authority without brackets.
			Pharyngo-chromis acuticeps	(Steindachner, 1866)	Zambezi happy	Okavango, Kwando, Chobe, upper Zambezi (Hay *et al.*, 1999). FishBase (20 Nov 1998) lists this species as *P. darlingi* (Boulenger, 1911).
			Pseudocrenilabrus philander	(Weber, 1897)	Southern mouthbrooder	Okavango, Kwando, Chobe, upper Zambezi, Orange. Translocated to Namibian interior. Indigenous species (Trewavas, 1936; Skelton, 1991) to Lake Otjikoto where five of six species are aliens. Presence in the Kunene River doubtful (P.H. Skelton, pers.comm.), however widely distributed within Southern Africa. It appears to be replaced by *Orthochromis machadoi*. Further studies to clarify the situation. FishBase (20 Nov 1998) lists a fish *P. p. luebberti* (Hilgendorf, 1902) to also occur in Namibia.

Table 2. (cont.).

Order	Family	English name	Species	Author	English name	Distribution and comments
Perciformes	Cichlidae	Cichlids	*Sargochromis carlottae*	(Boulenger, 1905)	Rainbow happy	Okavango, Kwando, Chobe, upper Zambezi (van der Bank *et al.*, 1989). FishBase (20 Nov 1998) records genus name as *Serranochromis*.
			S. codringtonii	(Boulenger, 1908)	Green happy	Okavango, Kwando, Chobe, upper Zambezi (Goldstein, 1973). FishBase (20 Nov 1998) records the genus name as *Serranochromis.*
			S. coulteri	(Bell-Cross, 1975)	Kunene happy	Endemic to Kunene River and the Cuvelai system (Skelton, 1993). FishBase (20 Nov 1998) records common name as Cunene happy and genus name as *Serranochromis*. The species composition of the Cuvelai System is closer in comparison with the Kunene River than with any other river system. This is emphasised by the presence of *S. coulteri* (Coll. D. Okeyo), *Labeo ansorgii*, *Labeo ruddi*, *Thoracochromis albolabris*, *T. buysi*. However, the artificial linkage between these two systems may have contributed to this (Hay, *in press*).
			S. giardi	(Pellegrin, 1903)	Pink happy	Kunene, Cuvelai (Coll. D. Okeyo), Okavango, Kwando, Chobe, upper Zambezi (Skelton and Teugels, 1991). FishBase (20 Nov 1998) records genus name as *Serranochromis.*

Table 2. (cont.).

Order	Family	English name	Species	Author	English name	Distribution and comments
Perciformes	Cichlidae	Cichlids	*S. gracilis*	Greenwood, 1984	Slender happy	Recorded from Cutato River, tributary of the Okavango River in Angola, and also from Kunene River (Greenwood, 1984; Skelton, 1993). The taxonomy of this fish species is currently under review and the genus is likely to change (Skelton, 1993).
			S. greenwoodi	(Bell-Cross, 1975)	Greenwood's happy	Okavango, Kwando, upper Zambezi (Skelton and Teugels, 1991). FishBase (20 Nov 1998) records genus name as *Serranochromis.*
			S. mortimeri	(Bell-Cross, 1975)	Mortimer's happy	Upper Zambezi (Skelton, 1993).
			Serrano-chromis altus	Winemiller and Kelso-Winemiller, 1990	Humpback largemouth	Kunene (Hay *et al.*, 1999); recorded from Okavango drainage (Winemiller and Kelso-Winemiller, 1991), and upper Zambezi (Skelton, 1993). FishBase (20 Nov 1998) records the authority date as 1991.
			S. angusticeps	(Boulenger, 1907)	Thinface largemouth	Freshwater ornamental fish, occurring in the Kunene, Cuvelai, Okavango, Kwando, Chobe and upper Zambezi drainage systems (Goldstein, 1973). FishBase (20 Nov 1998) lists common name as Thinface cichlid.
			S. longimanus	(Boulenger, 1911)	Longfin largemouth	Okavango, Kwando, upper Zambezi (Skelton, 1993).
			S. macro-cephalus	(Boulenger, 1899)	Purpleface largemouth	Kunene, Cuvelai, Okavango, Kwando, Chobe, upper Zambezi (Goldstein, 1973).

Table 2. (cont.).

Order	Family	English name	Species	Author	English name	Distribution and comments
Perciformes	Cichlidae	Cichlids	*S. robustus*	(Günther, 1864)	Nembwe, Tsungwa	Okavango, Kwando, Chobe, upper Zambezi (Skelton and Teugels, 1991). FishBase (20 Nov 1998) lists a fish *S. r. jallae* (Boulenger, 1896) as also occurring in Namibia; but which is only a subspecies.
			S. thumbergi	(Castelnau, 1861)	Brownspot largemouth	Kunene, Cuvelai (Coll. D. Okeyo), Okavango, Kwando, upper Zambezi (Goldstein, 1973).
			Thoraco-chromis albolabris	(Trewavas and Thys van den Audenaerde, 1969)	Thicklipped happy	Endemic to the Kunene River and Cuvelai system. FishBase (20 Nov 1998) and van Oijen *et al.* (1991) list genus name as *Haplochromis*, and the name of the authority and date without brackets.
			T. buysi	(Penrith, 1970)	Namib happy	Endemic to the Kunene River and Cuvelai system. FishBase (20 Nov 1998) and van Oijen *et al.* (1991) list genus name as *Haplochromis*, and the names of the authority and date without brackets.

Table 2. (cont.).

Order	Family	English name	Species	Author	English name	Distribution and comments
Perciformes	Cichlidae	Cichlids	*Tilapia guinasana*	(Trewavas, 1936)	Otjikoto tilapia	Translocated to Lake Otjikoto, many reservoirs and several farm dams in northern Namibia. Endemic to Lake Guinas. Freshwater, ornamental fish. Critically endangered in the interior (IUCN, 1994) by use and depletion of local groundwater resources and the potential impact of introduced fishes. Valuable for evolutionary studies (Skelton 1993).
			T. rendalli	(Boulenger, 1896)	Redbreast tilapia	Kunene, Cuvelai (Coll. D. Okeyo), Okavango, Kwando, Chobe, upper Zambezi (van der Bank *et al.*, 1989; translocated to the interior (e.g. Swakoppoort dam; Hay *et al.*, 1999) and the lower Orange River (van der Bank *et al.*, 1989). Freshwater ornamental fish, can tolerate brackish water conditions. FishBase (20 Nov 1998) records the authority date as 1897.
			T. ruweti	(Poll and Thys van den Audenaerde, 1965)	Okavango tilapia	Okavango, Kwando, Chobe, upper Zambezi (Hay *et al.*, 1999).

Table 2. (cont.).

Order	Family	English name	Species	Author	English name	Distribution and comments
Perciformes	Cichlidae	Cichlids	*T. sparrmanii*	A. Smith, 1840	Banded tilapia	Kunene, Cuvelai (Coll. D. Okeyo), Okavango, Kwando, Chobe, upper Zambezi, lower Orange (de Moor and Bruton, 1988); translocated to the interior (e.g. Swakoppoort dam; Hay *et al.*, 1999). FishBase (20 Nov 1998) records the authority name as Smith (without the initial "A.").
Perciformes	Mugilidae	Mullets	*Liza falcipinnis*	(Valenciennes, 1836)		Lower Kunene. Marine species occasionally entering lower reaches of River Kunene (Hay *et al.*, 1999).
			L. richardsoni	(Smith, 1846)	South African mullet	Lower Orange. Marine, brackish water fish with a coastal range from the Kunene River southwards (Smith and Smith, 1986) and occasionally entering the lower reaches of Orange River. Caught with beach seine and other artisanal gear for sports or game or bait (Bianchi *et al.*, 1993).
			Mugil cephalus	Linnaeus, 1758	Flathead mullet	Lower Kunene estuary, lower Orange. Marine, brackish water ornamental fish, occasionally entering freshwaters of the lower reaches of Rivers Kunene (estuary) and Orange; fishery caught with beach seines and other artisanal gear (Bianchi *et al.*, 1993).

Table 2. (cont.).

Order	Family	English name	Species	Author	English name	Distribution and comments
Perciformes	Eleotridae	Sleepers	*Batanga lebretonis*	(Steindacher, 1870)		Lower Kunene. Marine fish, occasionally entering lower reaches of River Kunene (Hay *et al*., 1999).
			Eleotris vittata	Duméril, 1858		Lower Kunene. Marine fish, occasionally entering lower reaches of River Kunene (Hay *et al*., 1999).
Perciformes	Gobiidae	Gobies	*Chonophorus guineensis*	(Peters, 1876)		Lower Kunene. Marine fish, occasionally entering lower reaches of River Kunene (Hay *et al*., 1999).
			Ctenogobiuslepturus	Pfaff, 1933		Lower Kunene. Marine fish, occasionally entering lower reaches of River Kunene (Hay *et al*., 1999).
			Nematogobius ansorgei	Boulenger, 1910		Lower Kunene. Marine fish, occasionally entering lower reaches of River Kunene (Hay *et al*., 1999).
Perciformes	Polynemidae	Threadfins	*Galeiodes decadactylus*	(Bloch, 1795)	Lesser African threadfin	Lower Kunene. Marine fish, occasionally entering lower reaches of River Kenene (Hay *et al*., 1999).
Perciformes	Haemulidae	Rubberlips and grunters	*Pomadasys jubelini*	(Cuvier, 1830)	Sompat grunt	Lower Kunene. Marine fish species, occasionally entering lower reaches of River Kunene. Bethune and Roberts (1991) lists common name as Atlantic spotted grunter.
Perciformes	Sciaenidae	Croakers and drums	*Argyrosomus coronus*	Griffiths and Heemstra, 1995		Lower Kunene. Marine, brackish water fish, occasionally entering lower reaches of River Kunene; Sports or game fishery (Griffiths and Heemstra, 1995).

Table 2. (cont.).

Order	Family	English name	Species	Author	English name	Distribution and comments
Perciformes	Anabantidae	Labyrinth fishes	*Microcteno-poma intermedium*	(Pellegrin, 1920)	Blackspot climbing perch	Okavango, Kwando, Chobe, upper Zambezi. Included in IUCN Red List, an ornamental species in the Okavango, Kwando, Chobe Rivers and upper Zambezi River drainage (Skelton, 1993); Hay *et al.* (1999) lists the species as *Microctenopoma intermedium* (Pellegrin, 1920).
			Ctenopoma multispine	Peters, 1844	Many spined climbing perch	Okavango, Kwando, Chobe, upper Zambezi (Hay *et al.*, 1999). Skelton (1993); listed as *Ctenopoma intermedium* (Pellegrin, 1920).
Perciformes	Carangidae	Jacks and pompanos	*Lichia amia*	(Linnaeus, 1758)	Leerfish	Lower Kunene, lower Orange. Marine and brackish water fish, common at the Kunene River mouth and occasionally entering the lower reaches of Orange River (Bianchi *et al.*, 1993); sport or game fishery caught on hook-and-line; flesh edible (van der Elst, 1993).
Beloniformes	Exocoetidae	Flying fishes	*Cheilopogon milleri*	Gibbs and Staiger, 1970)	Guinean flyingfish	Lower Kunene. Marine fish, occasionally enters lower reaches of River Kunene. Schneider (1990) lists same fish as *Cypselurus milleri* Gibbs and Staiger, 1970, i.e., deletes brackets about authors' names.

At least 8 Namibian species are included in the IUCN Red List (IUCN, 1994): *Barbus hospes*, *Barbus kimberleyensis* and *Austroglanis sclateri* (lower Orange River), *Clariallabes platyprosopos* (Okavango and upper Zambezi Rivers), *Clarias cavernicola* (Lake Aigamas Cave, near Otavi), *Nothobranchius* sp. (Caprivi pans and upper Zambezi River), *Tilapia guinasana* (Lake Guinas), and *Microctenopoma intermedium* (Okavango, Kwando, Chobe, upper Zambezi rivers). Two are listed as rare species: *Aethiomastacembelus vanderwaali* (Okavango and upper Zambezi rivers), and *Clarias cavernicola* (Lake Aigamas cave near Otavi) and another two are yet to be described: *Clariallabes* sp. (Kunene River; P.H. Skelton, pers. comm.) and *Nothobranchius* sp. (Caprivi pans and upper Zambezi River; Hay *et al.*, 1999). At least two have been determined as hybrids: *Barbus cf. kimberleyensis* (lower Orange River and Hardap Reservoir; Hay *et al.*, 1999) and *Labeo capensis x umbrutus* (lower Orange River; Hay *et al.*, 1999).

Further investigations on biodiversity and distribution of the freshwater fish of Namibia are highly recommended, notably, on seasonal feeding habits and habitat preferences. Additional collections and curation of specimens, representative of all fish of Namibia, should occur at the National Museums of Namibia. More Africans need to gain taxonomic as well as systematic expertise through training and research. The Namibian Government should allocate resources to this and to negotiate training packages with relevant institutions, such as the JLB Smith Institute of Ichthyology, Grahamstown in the Republic of South Africa; the Natural History Museum in London, UK; the Royal Museum of Central Africa in Tervuren, Belgium; and the American Museum of Natural History in New York, USA, to mention a few.

ACKNOWLEDGEMENT

The initial idea for this study on updating of the information on the freshwater fish of Namibia emerged during the Training Course on Strengthening of Fisheries and Biodiversity Management in African, Caribbean, and Pacific (ACP) Countries. The African, Caribbean, Pacific-European Union (ACP-EU) Fisheries Research Initiative provided personnel and financial assistance including that of the Initiative’s SADC Project Training coordinator and sent out invitation. Ministry of Fisheries and Marine Resources partially provided facilities. The University of Namibia, under the auspices of the Department of Biology, agreed to participate in the project for a period of three years. Clinton Hay made useful comments and corrections on the manuscript, for which he is thanked.

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THE STATUS OF THE CONCH FISHERY OF THE BAHAMAS

STATUT DE LA PÊCHE AUX CONQUE DES BAHAMAS

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ABSTRACT

The Queen conch (*Strombus gigas*) has long been and continues to be an important marine resource for The Bahamas. The species, though still found in significant numbers throughout the country, has begun to show evidence of decline in some areas. To prevent this trend from continuing, the Bahamas Government has embarked on various initiatives including increased research on the species, with the goal of ensuring the continued sustainability of this resource.

RESUME

Le lambi (*Strombus gigas*) est depuis toujours une ressource marine importante pour les Bahamas. Toutefois, bien que le lambi sont encore présentent dans tout le pays, un déclin dans quelques populations aux Bahamas s'est mis en évidence. Pour empêcher cette tendance de continuer, le gouvernement des Bahamas s'est embarqué dans diverse initiatives, y compris la recherche accrue sur l'espèce, afin d'assurer la pérennité de cette ressource.

INTRODUCTION

The Queen conch (*Strombus gigas*) has long been exploited as a staple food item in The Bahamas. The resource is not only an important protein source but also an important revenue earner for commercial fishers. Although conch stocks still appear to be relatively abundant throughout the country, evidence of localised depletions has begun to appear, especially in the north and central areas of the country. To combat this trend, the government has taken several steps to protect the species. Efforts currently underway include the establishment of research programs to determine the status and sizes of the stocks, the review and implementation of regulations governing the harvesting of the species and public education programs.

THE FISHERY

The Queen conch is primarily harvested by breath-hold and hookah diving, but in some parts of the country the basic method of using a conch staff is still in use. The conch staff is a pole up to 9 m (30 ft) in length with normally two prongs at one of the ends. The prongs are used to hook the conch and bring it to the surface. Bahamian law permits use of a dive mask (goggles), swim fins and a snorkel for diving purposes. Authorised divers may be assisted in their harvesting efforts by the use of an air compressor or hookah gear during the period 1st August through 31st March. The conchs, once caught, are either laced together with twine in numbers of tens, then transported to the market alive and in the shell or alternately shelled, skinned, eviscerated, placed in poly bags, frozen and then taken to market. In increasingly rare instances, the conch may be 'corned', i.e., sun-dried before being delivered to market.

The majority of conch, approximately 60-70 % of the total yearly landings, is harvested during the seasonal closure of the lobster fishery, i.e., between 1st April and 1st August. The main fishing areas for conch are the Little Bahama Bank and the waters of the Berry Islands and Andros Island areas, which are located on the Great Bahama Bank. The major local markets for the species are located at New Providence, Grand Bahama, Abaco and Andros Islands.

The recorded statistical data collected by the Department of Fisheries, which are acknowledged to be incomplete, indicate that conch landings in the Bahamas has increased by some 292 % in less than 20 years, i.e., from 218 t in 1979 to 638 t in 1997 (Ehrhardt and Deleveaux, 1999). The statistics are deemed to be incomplete because no records exist defining the quantities of conch that are caught in the local recreational and subsistence fishery, the foreign sports fishing sector or which is harvested by foreign vessels fishing illegally in Bahamian waters.

The government, having regarded that the Queen conch takes about three and one half years before it becomes sexually mature (Appeldoorn, 1988) and that some temporary localised depletions have begun to appear (Stoner and Ray, 1996) has initiated appropriate efforts to insure that prudent management and conservation tools are put in place to insure the sustainability of the resource.

CONTROLS

Institution of export quotas

Prior to 1992 the commercial export of conch was prohibited and except for limited quantities that were exported by private individuals, all conchs landed were destined for local consumption. Thus, although conch was landed in significant quantities, local market forces controlled the harvests. As a result of the lifting of the export ban, there was a significant increase in conch landings during 1993 and 1994. During 1993, a total of approximately 214 t of conch meat was allowed to be exported. During the following year, approximately 350 t of the product were exported. In 1995, the government, given that it did not have information necessary to ensure the sustainability of the fishery, adopted a precautionary approach and established a quota system to limit the export of the resource. The establishment of quotas resulted in the expected decline in total conch landings (see Figure 1), as only the approved quantities were permitted to be exported and local market forces again took effect.

Fisheries regulations

The regulations governing the harvesting of conch in The Bahamas are:

- No capture, possession or sale of conch without a well-formed flaring lip;
- No commercial export of conch or conch by-product without a license issued by the Minister responsible for Fisheries;
- Non-commercial exports are limited to 10 lbs. per person and should be a part of that person's personal baggage at his time of departure from the country;
- Foreign fishers visiting the country are not allowed to harvest more than 10 conchs per person at any point in time, once the vessel has cleared through an official port of entry and has been licensed for sports fishing purposes;
- Air compressors may be used for the harvesting of conchs but only during the period 1st August – 31st March inclusive;
- The taking of conch is prohibited in marine parks.

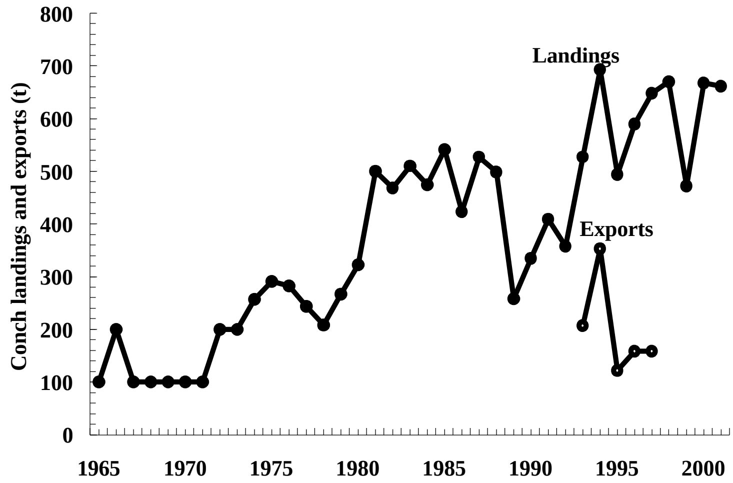

Figure 1. Conch landings in 1965-2001 (based on FAO database; see www.seaaroundus.org) and exports in 1993-1998 (from Ehrhardt and Deleveaux, 1999) indicating the effects of the establishment of an export limit.

Government sponsored research

In 1997, the Government of The Bahamas initiated a three-year research project to study the status of conch in Bahamian waters. The project, which is focused on the conch stocks of the Little Bahama Bank has been entitled, "Assessment of the Conch (*Strombus gigas*) Fisheries in The Bahamas and Development of Fishery Management Options for the Exploited Stocks." The goal of the project is to define alternative options to manage the Queen Conch Fisheries of The Bahamas. To accomplish this goal, the following objectives were defined for the project:

1. To develop statistical and mathematical algorithms that can be used to assess the impact of fishing on the sustainability of conch populations;

2. To design and implement a strategic data gathering system that will result in a database consistent with the information requirements of the algorithms developed to satisfy objective 1;

3. To integrate all existing knowledge on the queen conch population dynamics, which is of relevance to the application of the stock assessment algorithms developed in Objective 1 and the database created under Objective 2;

4. To assess the status of exploitation of conch stocks in the Bahamas and to quantify the consequences of expanding fishing pressure on the breeding populations; and

5. To carry out sensitivity analysis of the consequences of adopting different fishery management scenarios to the conch fisheries contained in Objective 4.

As mentioned previously, the duration of this project is three years. Objectives 1 and 3 were designed to be implemented in years 1 and 2 of the project while Objective 2 was planned for the full length of the project (3 years). Objective 4 is to be implemented in years 2 and 3 while Objective 5 will be implemented in year 3.

The second year of the project has been completed[9], so far, the preliminary reports generated give rise to concerns relating to the sustainability of the conch resources located in the focused area, i.e., the Little Bahama Bank. Initial reports indicate that the majority of conchs that are harvested in the area mentioned are immature individuals. This, if allowed to continue, could have drastic negative consequences on conch populations and the fishery based in the area.

CITES and the conch fishery

The Queen conch is considered to be endangered throughout most of its range. The Convention on International Trade in Endangered Species of Wild Fauna and Flora, (CITES), to which The Bahamas is a member, has placed restrictions on the international trade relating to the species and by-products derived from them. CITES has listed the Queen Conch under its Appendix II. For international trade to occur involving the species, exporting countries are required to certify to CITES that domestic stocks are able to be harvested in a sustainable manner. Further, each country is to assure that each export of the listed species or any by-product is accompanied by a CITES Export Certificate.

The CITES Secretariat has recently supported the efforts currently underway that have been led by the Caribbean Fishery Management Council (CFMC) to raise awareness regarding the status of the Queen conch. The CFMC is a branch of the United States government, under the Department of Commerce's National Oceanic and Atmospheric Administration (NOAA). The main purpose of the efforts is to promote a regional wider Caribbean management scheme for the Queen conch. The Bahamas has participated fully in all of the meetings and workshops that have been coordinated by the CFMC over the past years.

In The Bahamas, there is a developing lucrative industry based on the conch shells discarded after removal of the meat for local consumption. In the conch shell souvenir industry, selected conch shells are cleaned, polished and sold directly to tourists. The conch shell jewelry manufacturing industry uses the same discarded shells to produce items such as brooches, earrings and cameos from Queen conch as well as other shells, which are also purchased by tourists. In both instances, the tourist items purchased may be eventually exported and hence require CITES certification. The conch shell jewelry manufacturing industry was developed through former technical assistance received from the Government of Taiwan, Republic of China and is based wholly on discarded conch shells. This industry serves not only to bring in much needed foreign exchange but to also lead to a fuller utilisation of the resource.

Currently, many countries, potential markets for the mentioned items, although they are signatories to the CITES Convention, have not begun to enforce the various protocols. Also, The Bahamas has not yet put in place a mechanism to adequately address the numbers of CITES Export Certificates required to meet the needs of the exporting industries.

CONCLUSION

The Queen conch (*Strombus gigas*) fishery is important to The Bahamas socio-economically. Based on the preliminary findings of the project, the steps taken by the government appear to be prudent and if properly implemented, should insure the sustainability of Bahamian Queen conch resources. Should they fail or should Bahamian fishers do not gain an appreciation for what the government is attempting to do, then the nation's conch resources are headed in a similar path as those of the majority of other Caribbean nations that have experienced the near extinction of the species. It is therefore very important that all Bahamians be watchful and mindful of matters relating to the status of the local populations of Queen conch.

[9] Editorial note: this was written in 1998.

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[10] Editorial note: Two web sites, www.savetheconch.org and http://oakhammockbooks.com provide detailed information on the status of the Queen conch throughout its ranges (including the Bahamas) and relevant publications.

AN INVESTIGATION OF THE IMPACTS OF FISHING ON THE INSHORE FISHERIES OF TRINIDAD, WEST INDIES (1908-1997)

UNE ETUDE SUR L'IMPACT DE LA PECHE ARTISANALE SUR LES RESSOURCES COTIERES DE TRINIDAD, ANTILLES (1908-1997)

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ABSTRACT

Historical data on fisheries landings and associated species composition derived from administrative and technical reports (1908 to 1961) and estimated landings from the Fisheries Statistical Database of the Fisheries Division (1962 to 1997) were examined for Trinidad, West Indies. The trends observed were a reflection of both the operations and focus of the data collection system as well as ecosystem changes as a result of fishing. Estimated landings were found to increase during the early period (1908 to 1942), but suffered a drastic decline in the early to mid-1940s, due to World War II. Subsequently (1947 to 1997) landings increased generally, with cyclical reductions every 10 to 12 years as a result of changes in abundance of pelagic species which comprise the bulk of the landings. Several factors related to changes in fishing effort, introduction of new gear types, distribution, marketing and subsidisation of fishing activities might have promoted the increase in landings, though it is difficult to quantify the relative effects. Generally mean trophic level decreased with increased landings being 3.86 in 1908 and 3.62 in 1997. Greatest changes in mean trophic level and mean maximum length over time occurred between 1962 and 1997, when several gear types contributing to the increased capture of bycatch were introduced.

Changes in the species focus of the data collection system and the grouping of species of lesser importance into broad categories, as well as the non-inclusion of information on quantities and species discarded at sea affect the degree to which the results reflect true trends. These factors mask the impact of fishing on the ecosystem. Indications are that fishing down the food web may be a feature of the fishery but the magnitude of these changes and the relative responses of individual species remain unclear.

RESUME

Des données historiques des débarquements de pêche et leur composition par espèce à partir des rapports administratifs et techniques (1908 à 1961) et des débarquements estimés de la base de données statistique de pêche de la Division de Pêche (1962 à 1997) ont été examinées pour l'Île de Trinidad, dans les Antilles. Les tendances observées impliquent l'implémentation des opérations et la structure du système de collecte de données ainsi que des changements d'écosystème en raison de la pêche. Les débarquements estimés ont augmenté pendant la période entre 1908 à 1942, mais ont souffert un déclin au début des années 40 dû à la 2ème guerre mondiale. Par la suite, de 1947 à 1997, les débarquements ont généralement augmenté, avec des réductions cycliques tous les 10 à 12 ans en

raison des changements dans l'abondance des espèces pélagiques qui représentent une fraction considérable des débarquements. Plusieurs facteurs liés aux changements de l'effort de pêche, de l'introduction de nouveaux engins de pêche, la distribution, au marketing et à la subvention des activités de pêche ont favorisé l'augmentation des débarquements, bien qu'il soit difficile de mesurer les effets relatifs. Le niveau trophique moyen des prises a généralement diminué avec l'augmentation des captures, de 3,86 en 1908 à 3,62 en 1997. Les plus grands changements du niveau trophique moyen et de la longueur maximum moyenne se sont produits entre 1962 et 1997, pendant lequel l'introduction de nouveaux engins de pêche a contribué à l'augmentation des captures accessoires.

Les changements d'espèce cible du système de collecte de données et le re-classement de l'espèce peu importante en catégories plus larges, ainsi que l'exclusion d'information sur des quantités de chaque espèce capturée et des espèces jetées en mer affectent le degré de réalisme des tendences observées. Ces facteurs masquent l'impact de pêche sur l'écosystème. Il est possible que le phénomène de 'fishing down the food web' se soit produit dans ce système, mais l'importance de ces changements et des réponses relatives de différentes espèces reste peu claire.

INTRODUCTION

Inshore fisheries resources are affected by a number of activities associated with the multi-sectoral use of the coastal zone. Though the impacts of many of these activities remain difficult to quantify, it is possible to examine the responses of the fishery to fishing activity or fishing effort. The monitoring of catch and effort is an essential element of fisheries resource management and conservation (Caddy and Griffith, 1995). It remains one of the most common ways to infer the status of the resources in time and space (King, 1996). The value of historic catch and effort data in demonstrating changes in species composition associated with ecosystem changes and diversity, was shown in the recent analysis of FAO's global, historical, time series of catch and effort data for the period 1950 to 1994 (Pauly *et al.*, 1998). A general shift in landings from high trophic level demersal fish to low trophic level demersals, invertebrates and pelagic planktivorous species indicated major changes in the ecosystem manifested as changes in marine food webs even though catches increased or were sustained.

This study proposes a similar analysis for the inshore fisheries of Trinidad, West Indies. The objectives are to (1) examine the impacts of fishing on the average trophic level of the catch, (2) investigate associated changes in average trophic level of commercial fisheries and average maximum length of fish in the catch over time. The intention is to determine whether or not fishing has contributed to changes in the ecosystem and to estimate the magnitude of such changes based on the criterea selected.

STUDY AREA

Trinidad and Tobago are located at the southern end of the Caribbean chain of islands (Figure 1). Together they constitute the two main islands of this archipelagic state situated on the continental shelf off north east South America, some 8 miles east of Venezuela. This location is at the confluence of major oceanographic influences. The islands lie downstream of the outflow of 17 South American rivers including the Amazon and Orinoco, and are affected by major ocean currents such as the North Equatorial current (Fabres, 1983).

Figure 1: Geographic location of Trinidad and Tobago in relation to the wider Caribbean. This study pertains only to Trinidad.

OUTLINE OF THE FISHERIES

Ecological habitats range from coral reef formations off the north coast of Tobago to muddy bottom, brackish water habitats off the south coast of Trinidad. Marine fisheries resources are similarly diverse. Fisheries are multigear and multispecies, e.g., trawling for shrimp and associated groundfish; gillnetting for pelagics such as flying fish and mackerels, and demersals; fish potting for snappers and associated species; seining and a range of hook and line methods. There are four fleet types which harvest these resources. These range from artisanal vessels powered by outboard engines with manual gear operations to industrial type vessels with electronic navigation systems and mechanisation of gear operations.

FISHERY STATISTICAL DATA COLLECTION SYSTEM

The collection of fisheries statistics was reported to commence in 1945 (Anon., 1948). However, the establishment of a Fisheries Department as an entity separate from the Department of Agriculture within which it was formerly incorporated was only conceptualised in 1955 (Fiedler, 1955) and formalised in 1957 (Anon., 1957). Kenny (1955) expressed the need for an island-wide fishery statistical service to collect and collate information on fish production and distribution. In 1954 a data collection system was established at the major wholesale fish market in Port of Spain documenting the quantities, species of fish landed, landing port, fish prices (Kenny and Lagois, 1961). By 1958 fisheries statistics were collected at 16 of the 53 landing sites and major markets and data collected expanded to include details of fishing trips (Anon., 1958). Prior to the 1940s, the only accounts of fisheries landing statistics were available from individuals with vested interest in the fishery (Vincent, 1910) and Colonial Fisheries Advisors (Luke, 1957; Macpherson, 1947; Stockdale, 1945) reporting on 'Development and Welfare' in the region. The system established in the 1950s remained unchanged until the 1990s.

In 1992 analytical procedures were refined under and FAO/UNDP Project entitled "Establishment of Data Collection Systems and Assessment of Marine Fisheries Resources." Zonation of landing sites based on fishery types and fishing practises enabled more efficient use of resources in sampling the landings and the standardisation of a procedure for estimation of total landings based on the statistics so collected. In the mid 1990's under the CARICOM Fisheries Resource Assessment and Management Programme (CFRAMP) an enhanced supervisory mechanism for field data collectors contributed to improving precision in reporting.

The purpose of data collection has changed throughout the years. Initially the objective was to determine the capacity of the then British Colony to provide food for itself, thereby providing a basis for determining the colony's requirements for imported salted and smoked fish products from abroad. Fishing was then mainly a subsistence activity. The subsidisation of imported, canned and preserved products, lack of motorisation and inadequate distribution and marketing arrangements acted as disincentives to further development. Leading up to the present time data collection was aimed at documenting development of the fishery and identifying possible avenues for further development. It was only as recent as the 1980s that management and conservation type objectives were considered, given related global trends. No doubt, greater focus was given to the species of major importance nationally and regionally since then.

SPATIAL, TEMPORAL AND FISHERY LIMITS OF THE STUDY

The study focuses on landings of the fishery operating in Trinidad and thus excludes Tobago. Data collection is confined to the artisanal fishery operating in inshore areas. The analyses, however, include estimates of landings by the semi-industrial and industrial shrimp trawl fleet (Ferreira, 1999). Development of the semi-industrial and industrial fleets of pelagic longliners and multigear vessels commenced in the 1980s. The latter are known to compete at times with the inshore fleet, however; there are few records of their activities.

For the period 1958 to 1997, the data collection system covered 25 %-30 % of the fish landing sites and between 35 % and 45 % of the vessels. The analyses of this study pertain to the landed portion of the catch only. Prior to the introduction of new technology, the quantities of by-catch were minimal and discards were not an important issue. However, with the increase in technology from the mid-1950s onwards, especially associated with the introduction of the otter trawl and monofilament gill nets (in the artisanal fishery), the capture and discard of by-catch species has become but stark reality. The quantites and species composition of discarded by-catch of the trawl fishery were examined by Maharaj (1989), Amos (1990) and Fisheries Division (1996) for the artisanal, semi-industrial and industrial fleets (Gulf of Mexico type), respectively. Maharaj (1989) showed that 94 % of the bycatch by weight, i.e., 1,500 of 1,594 t was discarded. Amos (1990) stated that 25 species of finfish comprised 62 % of the bycatch of semi industrial trawlers and almost 60 % of the total finfish catch was discarded. For large, industrial, Gulf of Mexico type trawlers, it was estimated that up to 64 % of finfish bycatch is discarded. (Fisheries Division, 1996). The activities of foreign fleets known to fish in the waters of Trinidad and Tobago have not been quantified and are therefore not included in the analysis.

METHODOLOGY

Data Sources

Historical, administrative and technical reports provided annual point estimates of total landings, e.g., 1908, 1933, 1942, 1945 and 1954 were obtained from Vincent (1910), Anon. (1935), Stockdale (1943), Stockdale (1945) and Kenny (1955), respectively. Kenny (1955) also provided data on the species composition of the landings. The fisheries landings and effort statistical data collection system provided data on quantities of individual fish species landed by boat and gear type at selected sites within defined sample zones for the period 1962 to 1997. Estimates of total landings for sampled sites were derived by application of a raising factor, which accounted for non-sampled days. The ratio of the number of boats involved in the respective fisheries at sampled and non-sampled sites was used to derive estimates of total landings for the latter. The average species composition of nominal landings for the respective fishing methods was applied to the estimate of total landings. The estimates of landings of the industrial trawl fleet from the trawl fishery database were obtained using data from a logbook programme, which was implemented in 1991. A series of boat censuses for 1959, 1980, 1985 and 1991 provided information on boat activity and involvement in different fishery types at all landing sites. The most recent census also documented the seasonality of fishing associated with major gear types. This was used to derive estimates of total landings for non-sampled sites described in 2. FishBase '98 (Froese and Pauly, 1998) provided estimates of trophic level and associated standard error and mean total length for each species group in the International Standard Statistical Classification of Aquatic Animals and Plants (ISSCAAP) as used by the FAO for their fisheries statistics.

Data Analyses

Fish landings data from the FAO statistical database were entered in Microsoft EXCEL spreadsheet by species or taxonomic group by ISSCAAP code. For each 'species item', trophic level and associated standard error as well as mean total length for the group, obtained from FishBase '98, were also entered. The following relationships were tested: total catch vs. time in years (data for the years between 1908 and 1933; 1934 and 1941; 1943, 1946 and 1953 and 1955 and 1961 were extrapolated for each species group represented); mean trophic level vs. total catch (1908-1997); mean trophic level vs. time (1908-1997); and mean maximum length vs. time (1908-1997).

Assumptions

For the period 1908 to 1956, the quantities of fish handled at the major fish market, derived from landing sites in the west, north and north west of the island, are taken as representative of total landings. Commercial fishing activity was concentrated at these sites, fishing being a subsistence activity in other areas. Another assumption is that the description of fisheries provided in Vincent (1910) gives accurate weight to the respective species groups at the time, from which an estimate of species composition of the landings can be derived. In so doing pelagic species are assigned the highest rank, the associated fishing methods of pelagic lines and harpoons being the most popular. For the period 1960 to 1997, the monthly average catch rate of boats utilising similar gear types within a statistical zone is assumed the same for non-recorded boats as it is for recorded boats. The fishing activities of boats using similar gear at non-enumerated sites is assumed the same as at enumerated sites. The species composition of the recorded landed portion of the catch is assumed representative of the species composition of the non-recorded component of the landings for the respective gear types.

RESULTS AND DISCUSSION

Total landings

Generally annual total landings increased over the 87 year period covered here, with 10 to 12 year cyclical reduction in landings from 1959 to the present time (Figure 2). Prior to 1962, available data provided only point estimates for 1908, 1933, 1942, 1945 and 1955. Nevertheless, these do indicate the general direction of fisheries development. A marked decline in landings was apparent in the mid to late 1940s, and cyclical reductions of a less drastic nature in 1958, between 1968 and 1973, 1985 and later in 1995.

A development of fisheries in the absence of technology improvements occurred between 1908 and the early 1940s. This may be attributable to an increase in the number of boats involved in the fishery, and can be confirmed through a review of additional historical documents which may also facilitate quantification of this development.

The dramatic decrease in landings in the early 1940s is most probably a result of events and activities associated with World War II. The establishment of a US naval base and affiliated military installations in the north west peninsula, from which the most lucrative fishing grounds were reported to be accessed (Vincent, 1910), certainly disrupted fishing activity. Fishing communities in this area were consequently displaced. As a result of the war, imported materials for making nets became scarce, the price of fishing gear was therefore very high. As a consequence nets could neither be replaced nor repaired (Stockdale, 1943). In addition, a ban was placed on night fishing and many fishers sought employment in building construction and other industries associated with the naval base (Hickling, 1949). These would have contributed to the decline in landings reported here (Figure 2), though this remains to be verified.

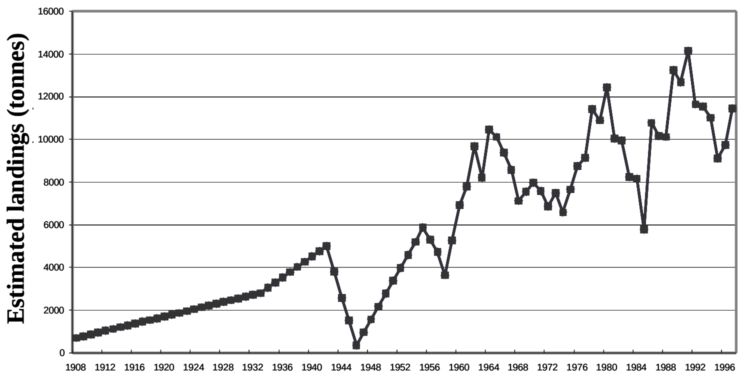

Figure 2: Annual total landings in tonnes for the period 1908-1995 in Trinidad.

The increase in landings throughout the late 1940s early 1950s may be attributable to a number of factors. The removal of the government's price control on fish (Hess, 1961; Anon., 1953), implemented during the war period as a measure to ensure the supply of fish to persons of low income, and the government's subsidisation of fishing gear (Brown, 1942) were certainly incentives for increased fishing activity. Boat mechanisation increased from 6 % in 1946 to 74 % in mid 1961 (Hess, 1961), and several new gear types were being promoted during the period, notably, trawl (Kenny and Lagois, 1961; Anon., 1957a; Stockdale, 1945) and fish-pots (Anon., 1948). Gear modification such as the use of outriggers for trolling (Anon., 1953) may have also contributed to increased landings.

The decline in landings in the late 1950s was possibly due to the poor demand for fresh fish which forced fishers to limit their catches, the elasticity of demand with respect to prices being practically negligible (Salmon, 1958). It is to be noted that in the Caribbean region the import of fish products (canned, preserved) was heavily subsidised, while consumer preferences did not encourage the development of fisheries for non-traditional species. Another factor which may account for the decline in landings over the period, was the high fishing operation costs associated with boat mechanisation (Anon., 1957c).

The trend of increasing landings observed form 1959 and between 1961 and 1963 may be related to a number of factors. Actual data were available for 1960, as noted by Kenny and Lagois (1961). These authors also reported that efforts were directed at improving the data collection system from 1957. In addition there were fisheries developmental activities which should be mentioned: though the duty-free importation of fishing gear was discontinued in 1953 (Anon., 1953), by 1956 a fuel and oil rebate scheme was in operation (Anon., 1957b). Also, the Agriculture Development Bank was providing loans (Anon., 1973) to facilitate the development of fisheries. The introduction of diesel motors and the associated decrease in the cost of fishing as well as the provision of landing facilities by the government and the improvement of distribution and marketing schemes (Anon., 1973) were added incentives to development.

From the late 1960s to the present time, several fisheries developmental activities may have contributed to sustaining increased landings. The mechanisation of trawl gear, increases in fish prices, addition of new boats to the fishery, increased government financial assistance by provision of tax refunds on fuel and oil, exemption of purchase tax and duty on commercial fishing boats and engines. The government established the National Fisheries Company in 1972. Transparent, monofilament gillnets were introduced in 1986 to promote development of an artisanal shark fishery. The development of an industrial fishery was promoted through the provision of loans by the Agricultural Development Bank (Anon., 1973).

The cyclical nature of the landings may be linked to fluctuations in landings of pelagic species such as mackerels, herrings and jacks. *Scomberomorus brasiliensis* is the largest contributor to landings in the artisanal fishery and is the major, targeted, fin fish species in this fishery. Generally this species accounts for about 20 to 35 % of the total artisanal landings. Fluctuations in pelagic fish catches are both well known and documented; Sturm *et al*. (1984) reported that such cyclical variations may be due to variations in year class size in response to natural oceanographic changes.

Changes in the data collection system with regard to the spatial coverage may have had some effect on the observed trends. Prior to 1960 data were collected at the major fish markets only. In that year the system was extended to include other markets. By 1962 the system was changed to focus on the collection of catch and effort data at the fish landing sites associated with the wholesale and retail markets as well as additional fish landing sites (Kenny and Lagois, 1961).

Mean trophic level and landings

The relationship between mean trophic level and total catches (tonnes) for the period 1908 to 1997 is presented in Figure 3. It shows a backward bending signature with two major phases. The first phase is characterised by low landings coupled with comparatively high mean trophic levels relative to the second phase. The highest landings are generally associated with lower mean trophic levels.

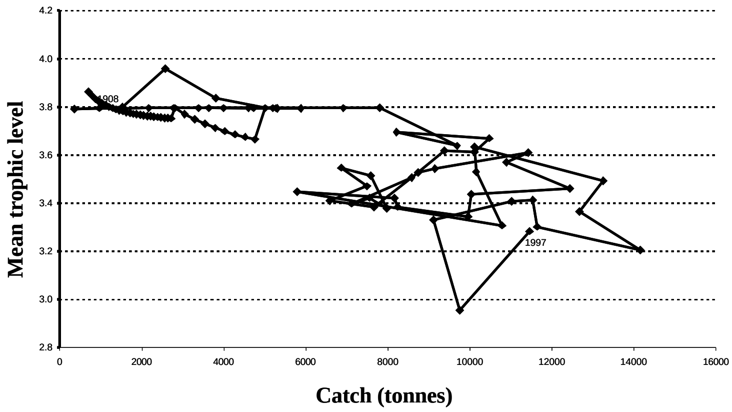

Figure 3: Mean trophic level vs. catch in tonnes in Trinidad for 1908-1997.

Changes in mean trophic level (1908-1997)

Two phases were observed in the plots of mean trophic level with time (Figure 4.). The first phase (1908 to 1961) is typified by relatively higher trophic levels than the second phase (1963 to 1997). The major shift occurs around the 1960s. This is perhaps coincident with the extended use of the otter-trawl at many of the major sites, with species of lower trophic levels (shrimp) being predominant in the landings. It may also be due to the availability of more detailed fish landing statistics at the time, allowing for more detailed investigation of species composition of the landings.

In 1908 the mean trophic level was 3.86; by 1997, it was 3.28. The highest mean trophic level of the landings was observed in the mid 1940s. At that time, fishing activities were depressed and lines and harpoons, used for capturing large top predators, were the predominant gear types employed. The general trend in mean trophic level of the landings between 1963 and 1997 was a decline from 1962 to the mid-1970s, early 1980s and an increase thereafter. In 1985 monofilament gillnets were introduced and attained widespread use two years later. This, coupled with increasing demand for traditional species for export has resulted in the landing of non-traditional, unclassified by-catch which may account for the intermediate increase in trophic level from 1996 to 1997.

Pauly *et al.* (1998) proposed several reasons for the backward-bending feature of plots of trophic levels versus landings in their analysis, which are also applicable to this analysis. These included: artifacts due to the data, method and assumptions taken; large and increasing catches that go unreported; massive discarding of by-catches comprising predominantly of fish at low trophic levels; reduced catchability because of decreasing average size of exploitable organisms and fisheries induced changes in the food web from which landings were extracted.

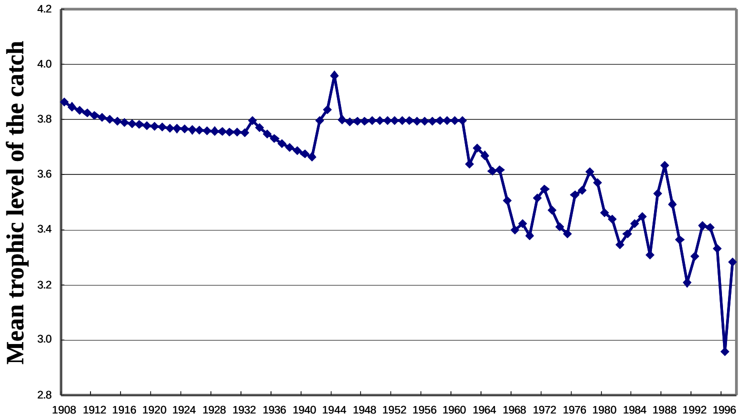

Figure 4: Average trophic level of the catch in Trinidad for 1908-1997.

Changes in maximum length (1908-1997)

Figure 5 shows the decreasing trend in mean maximum size from 90 cm in 1908 to 77 cm in 1997, with the lowest values recorded for the mid 1970s to mid 1980s. There appears to be a cyclical trend similar to that observed for total estimated landings. This may be because the major component of the catch (20-25 %) comprised of pelagic species (e.g., *Scomberomorus brasiliensis*; Henry and Martin, 1992), which are recruited to the fishery at sizes ranging between 42 to 48 cm. (Julien *et al.*, 1984). This graph however, does not necessarily imply on changes in average maximum length of the catch, since significant portions of the trawl fishery bycatch are discarded and/or unreported. The apparent increase in average maximum size after 1995 may be associated with the increasing importance of non-traditional species as new markets become available. These species were previously classified as “mixed fish” or “choice fish”.

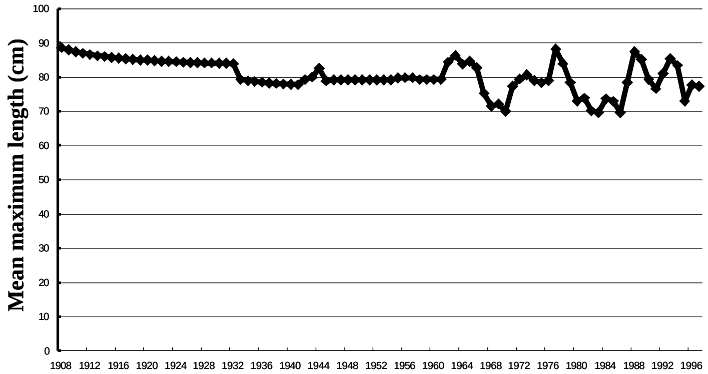

Figure 5: Average maximum length in landings in Trinidad (1908-1997).

CONCLUSIONS AND RECOMMENDATIONS

The results of the analysis of these data demonstrate the importance of historical catch data in mapping resource use and events, which affect the harvesting of these resources. In analysing the data, one major shortcoming was the broad categorisation of species groups in the landings. The category of "mixed fish" (here: "marine fish not elsewhere included") includes a range of species of various trophic levels. These factors, combined with the exclusion of information on discards at sea means that the plots of average trophic levels on time and catch give an incomplete representation of the situation. The indications are that fishing down the food web may be a feature of the fisheries of Trinidad. However, where components of the fishery are grouped in statistical records and there are substantial quantities of unreported bycatch, the extent of this feature may go unrecognised and extensive ecosystem changes may be taking place with new baselines being established for species diversity and relative abundance.

Since the development of one fishery may mask the decline of another, because the analyses consider the overall landings and mean trophic levels from all fisheries together, it is suggested that future analyses focus on specific fisheries. In so doing any changes in relative species composition and trophic levels would be more relevant and informative. Further, the ecosystem in the Gulf of Paria off Trinidad's west coast is quite different from the north, east and south coasts. It would be interesting therefore to examine the data by ecosystem type rather than by combining all data for the island.

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FISHERIES MANAGEMENT INFORMATION SYSTEM (FISMIS): A TOOL FOR FISHERIES MANAGEMENT AND POLICY MAKING IN THE CARIBBEAN

LE SYSTEME D'INFORMATION POUR LA GESTION DES PECHES (FISMIS): UN OUTIL POUR LA GESTION DE PECHE ET POUR LA POLITIQUE DE DECISION DANS LES CARAÏBES

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ABSTRACT

In 1993 the Fisheries Division in Trinidad and Tobago established the Fisheries Division Information Centre which provides access to bibliographic information to the CARICOM member countries in the Caribbean. Financially supported by the International Development Research Centre (IDRC), the Information Centre developed the Fisheries Management and Information System (FISMIS). This is a comprehensive database system that comprises a number of bibliographic databases with references on a range of fisheries topics such as: resource assessment, policy and legislation, biology, ecology and management of stocks, aging techniques and processing. The information is obtained from the primary literature as well as from publications of international organisations, universities and fisheries research institutions. FISMIS also covers extensively "gray literature" on Caribbean finfish and crustacean species, such as publications and reports produced by fisheries divisions and regional organisations in the Caribbean. The majority of the bibliographic references are maintained in an archived reprint collection. FISMIS has contributed greatly to the consolidation of basic information for fisheries resource assessment and management in the Caribbean. It has also helped to reduce duplication of research and has thereby allowed a better utilisation of limited funds allocated to the fisheries research sector.

RESUME

En 1993, la Division de pêche de Trinité-et-Tabago a établi un centre d'e l'information qui permet d'accéder à l'information bibliographique sur les pays membres de CARICOM dans les Caraïbes. Financièrement soutenu par le centre international de recherches de développement (IDRC), ce centre a développé le système d'information pour la gestion de la pêche (FISMIS). C'est un système complet de base de données, composé d'un certain nombre de bases de données bibliographiques comprenant des références d'une large gamme d'œuvres relatives à la pêche, par exemple, l'évaluation des ressources, la politique et la législation, la biologie, l'écologie et la gestion des stocks, les techniques de détermination d'âge et le traitement du poisson. L'information a été obtenue à partir de la littérature primaire aussi bien qu'à partir des publications des établissements internationaux de recherches, d'universités et et des organismes de pêche. FISMIS couvre également intensivement la littérature 'grise' sur les téléostéens et les crustacés des Caraïbes, telle que des publications et des rapports produits par des divisions de pêche et des organismes régionaux dans les Caraïbes. La majorité des références bibliographiques sont maintenues dans une collection archivée de tirés à part. FISMIS a contribué considérablement à la consolidation d'information de base pour l'évaluation de ressource de pêche et de gestion dans les Caraïbes. Il a également aidé à réduire la duplication de la recherche et de ce fait a permis une meilleure utilisation des fonds limités assignés au secteur de recherches de pêche.

INTRODUCTION

Fisheries play an important economic role in the Caribbean region, yielding more than 70,000 t of fish annually and providing employment for some 40,000 people. Fisheries management in the Caribbean faces the usual problems of tropical fisheries: multi-species, multi-gear nature of the fisheries and the migratory habits of many of the commercially important species. International industrial fishing fleets operate within Caribbean waters and many Caribbean countries do not have the resources to monitor these catches or to enforce regulations governing foreign fishing within their 200 miles Exclusive Economic Zone (EEZ). Beside these factors the relative closeness of many of the neighboring countries makes many of the exploited fish stocks a shared resource, calling for the collaboration between the Fisheries Divisions of Caribbean countries to implement practical management strategies. An essential prerequisite for such cooperation, though, is convenient and evenly shared access to information on the biology, ecology and status of the fish stocks.

In response to this increased need for information the Marine Fisheries Analysis Unit (MFAU) of the Fisheries Division in Trinidad and Tobago established at their premises the Fisheries Division Information Centre. The Information Centre provides a range of information services to scientists and fisheries managers in the region. Given the prohibitive cost related to the subscription to scientific journals, these services concentrate primarily on giving access to bibliographic and other database distributed on Compact Disks such as Aquatic Science and Fisheries Abstracts (ASFA), Fish and Fisheries Worldwide (FFWW), WAVES, Fishes of the Caribbean, FishBase (www.fishbase.org) and ReefBase (www.reefbase.org).

FISMIS: A DATABASE OF CARIBBEAN FISHERIES INFORMATION

In 1989 the Fisheries Division implemented a project to create an integrated 'Fisheries Management Information System for Trinidad and Tobago'. The project received funding from the International Development Research Centre (IDRC) of Canada. The scope of the databases has since been expanded to become a comprehensive repository of bibliographic information on marine finfish and crustacean species of commercial importance in the Caribbean. The databases were developed and continue to be maintained using a customised version of CDS/ISIS 3.0, a software package developed by the United Nations Educational, Scientific and Cultural Organization (UNESCO). It is a menu-driven information retrieval system which allows users to browse, search and print bibliographic references.

As a consequence of the regional scope of the databases, FISMIS benefited from the financial and technical assistance supplied under the CARICOM Fisheries Resource Assessment and Management Program (CFRAMP) - Data and Information Sub-Project. This project made it possible to acquire the services of a Fisheries Documentalist who was stationed at the Information Centre during 1996 and 1997, to service the CARICOM member states and access information from these countries for the databases.

Bibliographic references in FISMIS are obtained from monographs, journals, conference proceedings, newspaper articles, publications from international organisations such as FAO and ICLARM (now the WorldFish Center); university theses and publications from fisheries research institutions. More importantly, on a regional level, FISMIS is noted for its comprehensive coverage of "gray literature" on Caribbean finfish species and publications and reports produced by the Fisheries Divisions and other regional organisations in the Caribbean. Secondary information such as bibliographies and references from scientific papers are also included in FISMIS. Beside the bibliographic references, the Information Centre has in many cases also acquired hard copies of the referenced source maintained in an archived collection consisting mainly of reprints. Provision of some of these references may require written approval of the author or organisation.

Structure of FISMIS

FISMIS comprise seven databases, six of which contain bibliographic information on a wide range of biological, economic and fisheries management topics related to the artisanal, semi-industrial and industrial fishing activities in the Caribbean. One database (GUIDE) gives information on human resources related to aquatic research activities in the Caribbean. The other six components are:

<u>Stock</u>

This database contains at present some 11,500 bibliographic references, dealing primarily with resource assessment, policy and legislation, biology and management of Caribbean commercial species. The coverage of this particular database is extensive and represents a repository of information on Caribbean Fishes found nowhere else in the region. It is a clearinghouse for information dating back as early as the 1800s. Approximately 60% of the references in the STOCK database are archived as hard copies at the Fisheries Division Information Centre.

<u>Info</u>

The Database contains over 2,600 bibliographic citations dealing with the management of fisheries, providing a sound overview of biological, oceanographic, and environmental data. Subject matter includes fisheries computer programs, fishery statistics, biological sampling, catch effort systems, data collection surveys, data management and information systems (geographic and coastal). It is planned to also make this database available as hardcopy.

<u>Ageing</u>

This Database (487 records at the time of writing) was created to support the project on aging of selected commercial Caribbean species at the Institute of Marine Affairs (IMA) in Trinidad and Tobago. This database is still in its development phase and the Fisheries Division Information Centre is actively seeking access to information for this database by requesting documents from scientists and research organisations whose research includes the aging of tropical finfish.

<u>Fispro</u>

A small database containing approximately 605 records at the time of writing, which includes bibliographic citations on fish processing practices, methodology and related areas. The database covers fish processing practices such as salting, drying and smoking of fish and post harvest practices.

<u>Cruise</u>

This is an inventory of fishery and oceanographic research cruises conducted in the Caribbean region. Based on cruise reports, it provides a record of the vessels used, the type of data recorded, area covered and gear employed. Where available, major objectives of the cruise and summary of the results are also given.

<u>Gulp</u>

The Gulf of Paria database was created as part of an Integrated Coastal Zone Management Project jointly carried out by FAO and the Government of Trinidad and Tobago. There are approximately 1,200 records of published information on the Gulf of Paria, which is situated between Trinidad and Venezuela. This area represents the most important commercial fishing ground for Trinidad and is an important nursery area for juvenile commercial species. The database contains information on the fisheries, oceanography and bathymetry of the area. Information is also available on environmentally sensitive areas, industrial and chemical pollution and other coastal zone activities, thus allowing assessment of environmental impacts of industries located on the coast of the Gulf of Paria.

The Use of FISMIS

FISMIS has increasingly been recognised as a source of valuable information as well as a tool to identify available sources of information. Its wide coverage of the biology of commercial species, international and regional legislation, stock assessment and management practices implemented by Caribbean countries, has provided a solid information base for fishery manager and researchers in the Caribbean. FISMIS has also helped to reduce the duplication of research and allowed a better utilisation of funds allocated to the fisheries research sector in Trinidad and Tobago. There is therefore an information foundation from which CARICOM countries can access fisheries related data and information to formulate policies and assist in research on fisheries resources of the Caribbean.

With the availability of Internet and e-mail facilities at the Fisheries Division Information Centre in 1996, there has been a marked increase in the quantity and efficiency of accession and dissemination of information contained in FISMIS (see Table 1). Scientists and fisheries managers from Caribbean countries – at least to the extent that they have access to the Internet - can now request searches by e-mail as well as submit titles and documents, and even Annual Reports of their respective departments via e-mail.

Outlook

The Fisheries Division's continued efforts to maintain and develop the databases and CFRAMP's assistance under the Data and Information Sub-project has made researchers and policy makers in the Caribbean more aware of the data and wealth of information available on the fisheries of their countries and research being conducted in neighboring islands. In recognition of this important role, the Fisheries Division Information Centre in Trinidad and Tobago was designated the Regional Centre for fisheries and fisheries related information in the Caribbean.

However, on conclusion of CFRAMP's Data and Information Subproject, assistance from CFRAMP could no longer be sustained. The Fisheries Division of Trinidad and Tobago is still dedicated to servicing the needs of Caribbean counterparts. This is especially so in light of recent approaches to sustainable fisheries management which focus on the establishment of historical baselines for sustainability contained in past descriptions of the fisheries, found in the literature. The Division is actively seeking financial assistance to support the continuation of this important work.

Table 1: Number of searches conducted by FISMIS staff, by year

Year	Requests received locally	Requests received from the region
1994	36	20
1995	20	34
1996	41	100
1997	225	101

ACKNOWLEDGEMENT

The authors wish to acknowledge the contribution of Mr. Boris Fabres, CFRAMP, to the FISMIS project. His vision of a comprehensive information system for the Caribbean and his continued support were instrumental in making the project a success.

LOCAL NAMES AND TRADITIONAL KNOWLEDGE

NOMS COMMUNS DES POISSONS COMMERCIAUX DES HAUTS BASSINS DU FLEUVE VOLTA AU BURKINA FASO

COMMON NAMES OF COMMERCIAL FISH SPECIES OF THE UPPER VOLTA BASIN IN BURKINA FASO

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RESUME

Dans les fleuves des Hauts Bassins de la Volta au Burkina Faso, 63 espèces piscicoles sont capturéés à des fins commerciales. Elles appartiennent à 37 genres et 19 familles. Leur appellation commune dans les deux principales langues locales du pays (Mòoré et Dioula) ainsi que la signification de ces noms ont été enregistrées après une enquête auprès des communautés de pêcheurs. L'enquête a, par ailleurs, montré que les organes mous ou calcifiés de *Protopterus annectens, Gymnarchus niloticus, Malapterurus electricus* et *Lates niloticus* sont utilisés dans certaines pratiques rituelles au Burkina Faso.

ABSTRACT

A total of 63 commercial fish species from 37 genera and 19 families were sampled in the Volta tributaries in Burkina Faso. Common names used in two major local languages (Mòoré and Jula) and their meanings were recorded. This survey also investigated the use of certain soft or calcified organs of *Protopterus annectens*, *Gymnarchus niloticus*, *Malapterurus electricus* and *Lates niloticus* in certain rituals in Burkina Faso.

INTRODUCTION

Les poissons constituent le groupe de vertébrés le plus important de notre planète avec environ 30 000 espèces dont 41 % vivent en eau douce et 59 % en eau de mer (Maître-Allain, 1992). Toutes ces espèces ont un nom, soit scientifique ou commun. Si les noms scientifiques ont fait l'objet de nombreux travaux d'harmonisation et de codification, les noms communs ont longtemps été négligés, bien qu'il existe des catalogues de noms commerciaux (noms communs) dans certaines régions de pêche (FAO, 1994). Ces noms communs peuvent dériver du nom latin, d'une langue nationale ou régionale, ou ont été tout simplement inventé. Il a été montré que les origines des noms communs étaient parfois obscure (Maître-Allain, 1995). Cette absence de rigueur dans la formation des noms communs constitue une source de nombreuses confusions pour une même espèce (imprécision, multiplicité d'appellation).

Pour le Burkina Faso, pays sahelo-soudannien sans tradition de pêche, la connaissance des noms communs de poisson est très récente (moins de 30-40 ans) et donc très imparfaite. Une étude, déjà ancienne (Roman, 1966), avait établie 121 espèces de poissons dans les Hauts Bassins de la Volta, le plus important réseau hydrographique du pays. De cette diversité piscicole, seule les espèces les plus couramment pêchées sont connues et nommées par les pêcheurs, les commerçants et, à un degré moindre, les consommateurs.

L'objet de cette note est de documenter que les poissons d'intérêt commercial ont une appellation dans les deux principales langues nationales parlées au Burkina Faso, que les noms communs utilisés ont une signification dans ces langues et enfin, vérifier la place du poisson dans les pratiques socio-culturelles.

MATERIEL ET METHODES

Les données utilisées dans ce travail ont été extraites d'un rapport interne à la Direction de la Pêche et de la Pisciculture (Anon., 1981). Ces données sont collectées à partir des captures effectuées par les pêcheurs exerçant dans les Hauts Bassins de la Volta, situés entre le 9° et 14° de latitude Nord et de 0° à 5° de longitude Ouest. Les coordonnées géographiques des plans d'eau de pêche sont indiquées au Tableau 1. Les poissons commerciaux de ce bassin fluvial ont été enregistrés d'une part dans les pêcheries artisanales et d'autre part, dans les poissonneries des centres urbains où les gros spécimens sont écoulés. Pour chaque espèce ou groupe d'espèces, les informations relatives au nom scientifique de l'époque, les tailles et poids maximaux enregistrés et le lieu de capture ont été notés. Les poissons d'intérêt commercial vendus dans les pêcheries et dans les centres urbains sont aussi marqués.

Tableau 1: Localisation des cours d'eau de captures des poissons dans les Hauts Bassins de la Volta.

Cours d'eau	Latitude Nord	Longitude Ouest
Massili	12° - 13°	0° - 2°
Bougouriba	10° - 11°	2° - 4°
Mouhoun	9° - 13°	3° - 5°
Nazinon	11° - 13°	1° - 2°
Nakambé	11° - 14°	0° - 2°
Kou	10° - 11°	4° - 5°

La base de données FishBase (voir www.fishbase.org) a été utilisée pour vérifier et valider les noms scientifiques des poissons au moment de leur enregistrement. Cette base de donées permet, pour chaque espèce, de retrouver les anciens noms (synonymie) et le nom actuellement valide.

Les noms communs des poissons dans les deux principales langues nationales (Mòoré et Dioula) ont été établis en partie sur la base de travaux antérieurs de Traoré (1994) et de Ouattara et Janssen (1997). Des planches de poissons extraites de l'ouvrage de Levêque *et al.* (1990, 1992) ont été présentées aux pêcheurs et commerçants pour faciliter l'identification et l'appellation des poissons dont les noms communs ne sont pas encore disponibles dans la littérature. Les mêmes planches ont été utilisées pour confirmer ou clarifier certaines appellations communes. La translittération et la transcription orthographique de ces noms en langue française a été revue et corrigée par les services de l'Institut National d'Alphabétisation (INA).

Une entrevue sous forme de questionnaire non structuré et ouvert avec les communautés de pêcheurs dans les pêcheries, puis avec les commerçants de poissons dans les poissonneries urbaines, a permis d'établir pour certaines espèces (ou groupe d'espèces), la signification ou la traduction du nom commun, puis les usages du poisson dans les pratiques socio-culturelles.

RESULTATS

Caractéristiques des poissons commerciaux dans les Hauts Bassins de la Volta

L'utilisation de FishBase (version CD-ROM de 1998) a montré des changements qualitatifs dans la nomenclature des poissons commerciaux des Haut Bassins de la Volta. A la suite de cette validation, 10,5 % des familles ont changé de noms, tandis que 16 % des genres et 9,5 % des espèces changeaient d'appellation. En tenant compte de ces changements, les poissons d'un intérêt commercial dans les Hauts Bassins de la Volta au Burkina ont été classés dans 19 familles, comprenant 37 genres et 63 espèces. Les tailles de ces espèces commerciales sont très variables d'une famille à une autre et entre genres et espèces de la même famille (Tableau 2). Les plus grandes tailles sont observées chez les Gymnarchidae (1 670 mm), les Centropomidae (1 280 mm) et les Clariidae (1 250 mm) alors que la plus petite taille est observée chez *Barbus ablabes*, un Cyprinidae de 90 mm. La majorité des espèces et des captures proviennent du fleuve Mouhoun et de ces affluents, la Bougouriba et le Kou.

Les noms communs et leurs significations

La totalité des poissons exploités à des fins commerciales ont un nom en langues nationales Mòoré (Tableau 3) et Dioula (Tableau 4), les deux principales langues parlées par les populations rurales du Burkina Faso. Ces noms ne sont pas propres à une espèce, mais désignent le plus souvent un groupe d'espèces appartenant au même genre ou à la même famille (Polypteridae, Bagridae, Mochokidae, Distichodontidae). La formation de ces noms utilise plusieurs critères. Ainsi, certains noms sont établis par analogie avec les animaux terrestres ou des objets terrestres mieux connus des pêcheurs; c'est le cas de *Polypterus* sp. dont le nom se réfère au serpent dans les deux langues. Cela est également valable pour *Hydrocynus* et le *Gymnarchus* dont les noms font référence au chien et au cheval, deux animaux domestiques. La conformation anatomique de certains organes du poisson sont aussi utilisée pour le nommer. Cela est rencontré chez les Mormyridae, où la diversité de conformation de la bouche permet de nommer et de différencier les espèces de cette famille aussi bien en Mòoré qu'en Dioula. Un autre critère de nomination des poissons est la coloration du poisson entière ou d'une partie du poisson. En Dioula, la coloration est utilisée pour différencier certaines espèces de Mochokidae (*Hemisynodontis, Synodontis clarias, S. schall*) et de Cichlidae (*Oreochromis niloticus, Sarotherodon galilaeus* et *Tilapia zillii*). En fin l'éthologie du poisson est aussi utilisé. Les noms communs de *Hepsetus odoe* et *Parachana obscura* en Dioula se réfèrent à leur comportement. Le comportement pélagique de *Sarotherodon* ou benthique des espèces d'*Oreochromis* et de *Tilapia* permet de les nommer en Mòoré. Il existe bien d'autres éléments de comparaison que les pêcheurs utilisent pour nommer les poissons régulièrement rencontrés.

Les poissons dans les pratiques socio-culturelles au Burkina Faso

Les pêcheurs ont rapportés l'utilisation de quelques rares poissons dans les pratiques culturelles. Quatre espèces de poissons ont été citées: *Protopterus annectens, Gymnarchus niloticus, Malapterurus electricus* et *Lates niloticus*. Les organes mous ou calcifiés de ces poissons sont utilisés sous diverses modalités à des fins thérapeutique ou mystique (Tableau 5).

COMMENTAIRES

Cette étude rapporte pour la première fois l'appellation commune et sa signification pour les poissons d'intérêt commercial, pêchés dans les fleuves et rivières du Burkina Faso, plus particulièrement les poissons des Hauts Bassins de la Volta. Elle rapporte également les utilisations du poisson dans les pratiques socio-culturelles des populations rurales. Les données rapportées dans cet article ne peuvent cependant être extrapolées à l'ensemble du pays, les langues choisies ne reflétant pas toute la diversité ethnique et linguistique du pays. En effet, le Burkina Faso compte une soixantaine d'ethnies parlant des langues bien distinctes (Anon., 1998). Par ailleurs, le Dioula n'est pas une langue propre au Burkina; c'est une langue commerciale, parlée dans la sous-région ouest-africaine: en Côte d'Ivoire, au Mali, en Guinée, en Gambie et au Sénégal (Casamance).

Malgré ces limites, les résultats suggèrent que de nombreux poissons des cours d'eau du Burkina Faso ont un nom commun dans les deux langues nationales majoritairement parlées.

Tableau 2: Les poissons commerciaux pêchés dans les Hauts Bassins du fleuve Volta au Burkina Faso.

Espèce	Famille	Taille (mm)	Poids (g)	Lieu de capture (Plan d'eau)
Protopterus annectens annectens	Protopteridae	960	2 465	Massili
Polypterus senegalus senegalus	Polypteridae	260	130	Bougouriba
Polypterus bichir lapradei		350	392	Mouhoun
Polypterus endlicheri endlicheri		430	975	Mouhoun
Mormyrus rume	Mormyridae	700	3 000	Bougouriba
Mormyrus hasselquistii		510	408	Bougouriba
Mormyrops macrocephalus		220	–	Bougouriba
Mormyrops breviceps		353	–	Mouhoun
Mormyrops anguilloides		620	2 000	Mouhoun
Hippopotamyrus pictus		200	58	Mouhoun
Hippopotamyrus psittacus		144	–	Mouhoun
Campylomormyrus tamandua		345	–	Bougouriba
Brienomormyrus niger		110	160	Mouhoun
Marcusenius abadii		173	–	Bougouriba
Marcusenius senegalensis gracilis		250	192	Bougouriba
Petrocephalus bovei		160	–	Bougouriba
Pollimyrus isidori		80	70	Nazinon
Hyperopisus bebe occidentalis		460	1 000	Mouhoun
Gymnarchus niloticus	Gymnarchidae	1 670	18 500	Massili
Heterotis niloticus	Osteoglossidae	810	7 000	Nakambé
Labeo coubie	Cyprinidae	520	2 550	Mouhoun
Labeo senegalensis		360	1 000	Mouhoun
Labeo parvus		230	925	Bougouriba
Barbus ablabes		90	–	Nakambé
Barbus bynni occidentalis		470	3 000	Mouhoun
Hydrocynus brevis	Characidae	720	6 000	Bougouriba
Hydrocynus forskalii		560	2 500	Bougouriba
Alestes dentex		355	–	Mouhoun
Alestes baramoze soudaniensis		240	290	Bougouriba
Brycinus macrolepidotus		410	1 400	Mouhoun
Brycinus nurse		190	170	Bougouriba
Distichodus brevipinnus	Distichodontidae	540	5 000	Mouhoun
Distichodus rostratus		480	3 500	Mouhoun
Hepsetus odoe	Hepsetidae	380	320	Bougouriba
Bagrus bayad	Bagridae	370	610	Bougouriba
Bagrus docmak		780	11 000	Mouhoun
Bagrus filamentosus		260	–	Bougouriba
Chrysichthys nigrodigitatus	Claroteidae	290	480	Bougouriba
Chrysichthys walkeri		510	3 000	Mouhoun
Clarotes laticeps		580	4 000	Bougouriba
Auchenoglanis occidentalis		410	1 595	Bougouriba
Schilbe mystus	Schibeidae	225	240	Bougouriba
Clarias anguillaris	Clariidae	690	4 000	Nakambé
Heterobranchus bidorsalis		1 050	12 000	Mouhoun
Heterobranchus longifilis		1 250	27 000	Mouhoun
Citharinus citharus citharus	Citharinidae	480	–	Mouhoun
Malapterurus electricus	Malapteruridae	460	2 000	Bougouriba
Lates niloticus	Centropomidae	1 280	53 000	Bougouriba
Parachanna obscura	Channidae	380	845	Mouhoun
Hemisynodontis membranaceus	Mochokidae	320	1 030	Bougouriba
Synodontis clarias		175	160	Bougouriba
Synodontis schall		230	280	Bougouriba
Synodontis violaceus		210	230	Bougouriba
Synodontis ocellifer		270	–	Bougouriba
Synodontis velifer		190	230	Bougouriba
Synodontis arnoulti		160	90	Bougouriba
Synodontis nigrita		220	230	Kou

Tableau 2: (cont.).

Espèce	Famille	Taille (mm)	Poids (g)	Lieu de capture (Plan d'eau)
Synodontis sorex		210	205	Bougouriba
Oreochromis niloticus	Cichlidae	290	920	Mouhoun
Sarotherodon galilaeus		300	545	Mouhoun
Tialapia zillii		270	890	Bougouriba
Hemichromis bimaculatus		100	–	Mouhoun
Hemichromis fasciatus		175	195	Bougouriba

Tableau 3 : Noms communs en Mòoré des poissons commerciaux des Hauts Bassins de la Volta.

Nom scientifique	Nom commun translittération	Nom commun transcription	Signification/ traduction
Protopterus annectens	Reologo	Reoolgo	Poisson autophage
Polypterus senegalus	Kuilwaafo	Kuilwaafo	Serpent du marigot
Polypterus bichir	Kuilwaafo	Kuilwaafo	Serpent du marigot
Polypterus endlicheri	Kuilwaafo	Kuilwaafo	Serpent du marigot
Mormyrus rume	Toulibri	Tulibri	Poisson à petite bouche
Mormyrus hasselquistii	Yalguensoouga	Yalgen-suuga	Large comme le couteau
Mormyrops macrocephalus	Yalguennongondgo	Yalgen-no-gondgo	Bouche recourbée
Mormyrops breviceps	Yemdélé	Yemdele	Copine de l'hippopotame
Mormyrops anguilloides	Yemdélé	Yemdele	Copine de l'hippopotame
Hippopotamyrus pictus	Yalguensablaga	Yalgen-sablga	Flottant noir
Hippopotamyrus psittacus	Yalguennonkiougou	Yalgen-no-kiuugu	Bouche courte
Campylomormyrus tamadua	Yalguennonwoko	Yalgen-no-woko	Bouche allongée
Brienomyrus niger	Yalguenpelpoudou	Yalgen-peel-puudu	Petit blanc flottant
Pollimyrus isidori	Yalguenfo	Yalgenfo	Flottant
Marcusenius senegalensis gracilis	Yalguenlemgondogo	Yalgen-lem-gondgo	Menton replié
Marcusenius abadii	Yalguenlemgondogo	Yalgen-lem-gondgo	Menton replié
Petrocephalus bovei	Yalguennonpoudou	Yalgen-no-puudu	Bouche mousseuse
Hyperopisus bebe occidentalis	Yalguensablaga	Yalgen-sablga	Flottant noir
Gymnarchus niloticus	Memenego	Memenego	–
Heterotis niloticus	Rakako	Rakako	Dur comme l'écorse
Barbus ablabes	Bindempouré	Bedempuure	Intestin plein d'excrément
Barbus bynni occidentalis	Bindempouré	Bedempuure	Intestin plein d'excrément
Labeo coubie	Bindempouré	Bedempuure	Intestin plein d'excrément
Labeo senegalensis	Bindempouré	Bedempuure	Intestin plein d'excrément
Labeo parvus	Bindempouré	Bedempuure	Intestin plein d'excrément
Hydrocynus brevis	Basoaka	Basoaka	Chien sautant
Hydrocynus forskalii	Basoaka	Basoaka	Chien sautant
Alestes dentex	Mimbré	Mimbre	–
Alestes baremoze soudaniensis	Kamandé	Kamande	Maïs
Brycinus macrolepidotus	Tantanré	Tatare	Perlé (beauté de)
Brycinus nurse	Tantanré	Tatare	Perlé (beauté de)
Distichodus brevipinnis	Zangpoumpoumdé	Zagpumpumde	Fruit de kapokier
Distichodus rostratus	Zangpoumpoumdé	Zagpumpumde	Fruit de kapokier
Hepsetus odoe	Basoaka	Basoaka	Chien sautant
Bagrus bayad	Kuilsiougou	Kuilsiuugu	Moustaches du marigot
Bagrus docmak	Kuilsiougou	Kuilsiuugu	Moustaches du marigot
Bagrus filamentosus	Kuilsiougou	Kuilsiuugu	Moustaches du marigot
Chrysichthys nigrodigitatus	Kuilkienka	Kuilkeka	Epines du marigot
Chrysichthys walkeri	Kuilkienka	Kuilkeka	Epines du marigot
Clarotes laticeps	Kuilvosgré	Kuilvosgre	Kapoc du marigot
Auchenoglanis occidentalis	Kuildéogo	Kuildeogo	Phacochère du marigot
Schilbei mystus	Tidga	Tidga	Piquant
Clarias anguillaris	Saalé	Saale	Glissant (poisson)
Heterobranchus bidorsalis	Sienga ou Guioko	Seega bi Giyoko	–

Tableau 3 : (cont.).

Nom scientifique	Nom commun translittération	Nom commun transcription	Signification/ traduction
Heterobranchus longifilis	Sienga ou Guioko	Seega bi Giyoko	–
Citharinus citharus citharus	Kuilmiisgou	Kuilmiisgu	Galette du marigot
Malapterurus electricus	Zesgo	Zesgo	Qui donne froid
Lates niloticus	Zangré	Zagre	Combattant
Parachana obscura	–	–	–
Hemisynodontis membranaceus	Pougbetiim	Pugbetiim	Ventre noir (médicament)
Synodontis clarias	Kuilkienka	Kuilkeka	Epines du marigot
Synodontis schall	Kuilkienka	Kuilkeka	Epines du marigot
Synodontis violaceus	Kuilkienka	Kuilkeka	Epines du marigot
Synodontis ocellifer	Kuilkienka	Kuilkeka	Epines du marigot
Synodontis velifer	Kuilkienka	Kuilkeka	Epines du marigot
Synodontis arnoulti	Kuilkienka	Kuilkeka	Epines du marigot
Synodontis nigrita	Kuilkienka	Kuilkeka	Epines du marigot
Synodontis sorex	Kuilkienka	Kuilkeka	Epines du marigot
Oreochromis niloticus	Tingapinré	Tegr-pere	Tilapia de fond
Sarotherodon galileaus	Gnigrépinré	Yigr-pere	Tilapia de surface
Tilapia zillii	Tingapinré	Tegr-pere	Tilapia de fond
Hemichromis bimaculatus	Pinraogo	Pe-raoogo	Tilapia mâle
Hemichromis fasciatus	Pinraogo	Pe-raoogo	Tilapia mâle

Tableau 4: Noms communs en Dioula des poissons commerciaux des Hauts Bassins de la Volta.

Nom scientifique	Nom commun translittération	Nom commun transcription	Signification/ traduction
Protopterus annectens	Wondo	Woodo	Qui s'enterre (poisson)
Polypterus senegalus	Sadjiguè	Sajigɛ	Poisson serpent
Polypterus bichir	Sadjiguè	Sajigɛ	Poisson serpent
Polypterus endlicheri	Sadjiguè	Sajigɛ	Poisson serpent
Mormyrus rume	Nanadadjan	Nanadajan	Bouche longue (Nana à)
Mormyrus hasselquistii	Nanadasouroun	Nanadasurun	Bouche courte (Nana à)
Mormyrops macrocephalus	–	–	–
Mormyrops breviceps	–	–	–
Mormyrops anguilloides	Bounguè	Bungɛ	–
Hippopotamyrus pictus	–	–	–
Hippopotamyrus psittacus	–	–	–
Campylomormyrus tamadua	Nanadakouroun	Nanadakurun	Bouche recourbée (Nana à)
Brienomyrus niger	Nanadenin	Nanadenin	Petit nana
Pollimyrus isidori	Nanadenin	Nanadenin	Petit nana
Marcusenius senegalensis gracilis	Nanani	Nanani	Petit nana
Marcusenius abadii	Nanani	Nanadenin	Petit nana
Petrocephalus bovei	Nanadenin	Nanadenin	Petit nana
Hyperopisus bebe occidentalis	Nanadasouroun	Nanadasurun	Bouche courte
Gymnarchus niloticus	Sodjiguè	Sojigɛ	Poisson cheval
Heterotis niloticus	Faanan	Faanan	Grosse écaille
Barbus ablabes	Meri	Meri	–
Barbus bynni occidentalis	Meri	Meri	–
Labeo coubie	Bobiréfing ou Bama	Bobirefin	Intestin plein d'ecrément
Labeo senegalensis	Bobirégouè ou Bama	Bobiregwɛ	Intestin plein d'ecrément
Labeo parvus	Bobirédenin ou Bama	Bobiredenin	Intestin plein d'ecrément
Hydrocynus brevis	Wouloudjiguè	Wulujigɛ	Poisson chien
Hydrocynus forskalii	Wouloudjiguè	Wulujigɛ	Poisson chien
Alestes dentex	Foonon	–	–
Alestes baremoze soudaniensis	Foonon	–	–
Brycinus macrolepidotus	Farabanin	Farabanin	Charnu à grosse écaille
Brycinus nurse	Kouwouélé	Kuwulen	Queue rouge

Tableau 4: (cont.).

Nom scientifique	Nom commun translittération	Nom commun transcription	Signification/ traduction
Distichodus brevipinnis	Bignimidjiguè/galiya	Binjimijigɛ/Galiya	Poisson herbivore
Distichodus rostratus	Bignimidjiguè/galiya	Binjimijigɛ/Galiya	Poisson herbivore
Hepsetus odoe	Woulougangan	Wulugangan	Chien méchant
Bagrus bayad	Samougouè	Samugwɛ	Samu blanc
Bagrus docmak	Samoufing	Samufin	Samu noir
Bagrus filamentosus	Samugouè	Samugwɛ	Samu blanc
Chrysichthys nigrodigitatus	Boolo	–	–
Chrysichthys walkeri	Boolo	–	–
Clarotes laticeps	Keren	Keren	–
Auchenoglanis occidentalis	Korokoto	Korokoto	–
Schilbei mystus	Gari/Schegouè	Gari/Siyɛgwɛ	–
Clarias anguillaris	Manogo	–	Sale (poisson)
Heterobranchus bidorsalis	Poliyo	–	–
Heterobranchus longifilis	Poliyo	–	–
Citharinus citharus citharus	Taala	Taala	–
Malapterurus electricus	Tiguini	Tiginin	Poisson électrique
Lates niloticus	Saalen	Saalen	–
Parachana obscura	Sinogodjiguè	–	Poisson dormant
Hemisynodontis membranaceus	Konkongouè	–	Konkon blanc
Synodontis clarias	Konkonfing	–	Konkon noir
Synodontis schall	Konkonwouélé	–	Konkon rouge
Synodontis violaceus	Konkon	–	Konkon
Synodontis ocellifer	Konkon	–	Konkon
Synodontis velifer	Konkon	–	Konkon
Synodontis arnoulti	Konkon	–	Konkon
Synodontis nigrita	Konkon	–	Konkon
Synodontis sorex	Konkon	–	Konkon
Oreochromis niloticus	Tebenfing	Tɛbɛnfin	Tilapia noir
Sarotherodon galileaus	Tebengouè	Tɛbɛngwɛ	Tilapia blanc
Tilapia zillii	Dissiwouélé	Disiwulen	Poitrine rouge
Hemichromis bimaculatus	Kerebougou	Kerbugu	–
Hemichromis fasciatus	Kerebougou	Kerebugu	–

Tableau 5 : Quelques poissons utilisés dans les pratiques socio-culturelles au Burkina Faso.

Poisson	Organes utilisés	Modalités	Indications
Protopterus annectens	Muscles dorsaux;		Traitement des douleurs lombaires; Traitement de l'impuissance masculine.
	Intestins	Calcination et broyage	Extraction de corps étranger dans un organe.
Gymnarchus niloticus	Os de la colonne vertébrale	Port d'un morceau de vertèbre au cou, à la taille ou au poignet à l'aide d'un fil	Traitement des maladies articulaires (rhumatisme!) chez les enfants.
Malapterurus electricus	Peau	Macération;	Accélération de la parturition chez la femme en travail languissant.
		Préparation mystique	Conjurer les mauvais sorts (protection contre la foudre, les sorciers); Protection contre les blessures par les armes blanches.
Lates niloticus	Peau;	Macération (liquide);	Accélération de la parturition chez la femme en travail languissant;
	Yeux	Préparation mystique	Détection des sorciers (jeteurs de mauvais sorts).

La pêche est une activité « introduite » au Burkina dans les années 1950, et n'est donc pas pratiquée de père en fils comme c'est le cas pour l'agriculture et le pastoralisme. Il n'existe donc pas de transmission linéaire (père → fils) des techniques de pêche et de la connaissance du poisson. Aussi, les appellations communes du poisson sont, soit empruntées des langues allochtones (Bozo, Haoussa, Djerma), soit formulées sur la base des analogies zoologiques terrestres, des conformations anatomiques de certains organes, de la coloration ou du comportement du poisson. L'absence de rigueur dans cette formation des noms communs, est ici confirmée pour les poissons d'eau douce du Burkina Faso. Par ailleurs, la méconnaissance de la signification des noms communs de poisson par de nombreux pêcheurs nationaux a pu être vérifiée au cours de la présente étude.

Les insuffisances observées au niveau des pêcheurs nationaux, tant dans l'appellation des poissons que de la connaissance profonde de ce nom, montrent toute la nécessité d'entreprendre des études complémentaires et une formation des acteurs de la pêche. Le travail réalisé ici constitue donc un préambule indispensable pour cette étude. La connaissance du poisson commence par son appellation appropriée, soit dans le langage scientifique ou dans la langue nationale qui est un élément culturel. Cette connaissance de la faune ichtyologique entamée ici, peut être intéressante pour les vulgarisateurs, qui disposent d'un outil de sensibilisation à la protection du patrimoine piscicole dans les zones rurales (esprit de la Convention sur la diversité biologique). Cependant, ce travail devra s'étendre aux autres langues parlées du pays. Par ailleurs, une harmonisation de ces appellations communes pourrait être envisagée au niveau national.

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TRADITIONAL KNOWLEDGE OF FRESHWATER FISHES IN SOME FISHING COMMUNITIES IN GHANA

LE SAVOIR TRADITIONEL SUR LES POISSONS D'EAU DOUCE DE QUELQUES COMMUNITES DE PECHEURS AU GHANA

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ABSTRACT

Local names of freshwater fishes of Ghana were compiled from different fishing communities by interviewing fishers and from existing literature. The aim was to find out the meaning of these names and the criteria for assigning them. Local names exist for almost all freshwater fishes in the localities where interviews were conducted viz: Battor, Anloga, Avuto and Ada. Some of the names, however, differ from locality to locality. Almost invariably, the names either reflected some morphological feature or behavioural activity of the fish. The various names indicated that local fishers have a good idea about the behaviour and biology of the fishes they deal with.

RESUME

Les noms régionaux des poissons d'eau douce du Ghana ont été compilés à partir des différentes communautés de pêche, sur base d'entretiens avec des pêcheurs ainsi qu'à partir des sources bibliographiques à fin de découvrir leurs significations. Des noms régionaux existent pour presque tous les poissons d'eau douce dans ces localités où des entrevues ont été conduites, à savoir: Battor, Anloga, Avouto et Ada. Certains noms diffèrent selon la ville ou la localité. Les noms reflètent presque toujours la morphologie ou comportement des poissons. Les divers noms indiquent que les pêcheurs locaux ont une bonne idée du comportement et de la biologie des poissons qu'ils exploitent.

INTRODUCTION

Fishing and fish related activities are important in Ghana, where they have long been a major source of livelihood for most riparian communities.

Active fishing is normally undertaken by men while women and children engage themselves in the processing and marketing of the products. It is, however, not uncommon to find women actively involved in fishing, especially for invertebrates. A good number of people, especially the old, also earn their living through the construction or weaving of various fishing gears. As for any other commodity, local names exist for the fishes caught by fishers. This study sought to find out the variations in these local names from one locality to the other, and their meaning.

Table 1. Common names of freshwater fishes of Ghana.

Scientific name	Local name	Meaning of local name	Location	Source
	Ewe			This study
Protopterus annectens	Age	ground fish; 'a burrower'	Battor	*idem*
	Ahe	'of little importance'	Anloga	*idem*
	Ahe		Avuto	*idem*
Polypterus senegalus	Deka	'you can't fight me'	Battor	*idem*
	Adeke		Anloga	*idem*
	Adeke		Avuto	*idem*
Polypterus endlicheri	Tsimina		Battor	*idem*
	Nortsa		Anloga	*idem*
	Tsamina		Avuto	*idem*
	Deka	'rope-like'	Ada	*idem*
Heterotis niloticus	Efa	'can't stay down'; because it keeps jumping out of water	Battor	*idem*
	Efa	*Idem*	Anloga	*idem*
	Efa	*Idem*	Avuto	*idem*
Mormyrus spp.	Lewoe	General name for species of the genus *Mormyrus*	Battor	*idem*
Mormyrus rume	Lewoe-Gordorgor	'long-bent mouth'	Battor	*idem*
	Lewoe-Gordorgor	'long-bent mouth'	Avuto	*idem*
Mormyrus macrophthalmus	Lewoe-Agamata	'chameleon head-like shape'	Battor	*idem*
	Gordorgor-Nukpui	'short mouth'	Avuto	*idem*
	Liwe/Avakili	*Idem*	Amedica	Irvine (1947)
Marcusenius spp.	Lewoe Nukpui	*Idem*	Battor	This study
	Lewoe Nukpui	*Idem*	Avuto	*idem*
Marcusenius abadii	Liwe	*Idem*	Senchi	Irvine (1947)
Hippopotamyrus spp.	Lewoe Nukpui	*Idem*	Battor	This study
Hippopotamyrus psittacus	Wakalevi	*Idem*	Avuto	*idem*
	Awakelevi	*Idem*	Anlo	*idem*
Hippopotamyrus pictus	Lobokoe	*Idem*	Avuto	*idem*
	Lobokoe	*Idem*	Anloga	*idem*
Mormyrops spp.	Dawoe	'snake fish'	Battor	*idem*
Petrocephalus spp.	Lobokoe	'short – mouth'	Avuto	*idem*
Pollimyrus spp.	Lobokoe	*Idem*	Avuto	*idem*
Gymnarchus niloticus	Eyor	'lice'	Battor	*idem*
	Eyor	*Idem*	Anloga	*idem*
	Eyor	*Idem*	Avuto	*idem*
Hepsetus odoe	Lixe (Lihe)	'if you dare, come to where I am'	Battor	*idem*
	Lixe/Dzaru	*Idem*	Anloga	*idem*
	Avuwo (Lihe)	'dog-like teeth'	Akpabla	*idem*
Hydrocynus spp.	Avuwo	*Idem*	Battor	*idem*
	Avuwo	*Idem*	Avuto	*idem*
	Avuwo	*Idem*	Not indicated	Irvine (1947)
Alestes baremoze	Asenti	–	Battor	This study
	Asenti	–	Avuto	*idem*
Alestes dentex	Asenti	–	Battor	*idem*
	Asentiwe	–	Atimpoku	Irvine (1947)
Brycinus leuciscus	Simegbogboe	'bush fish', i.e., because it prefers to stay among weeds	Battor	This study
Brycinus longipinnis	Wuganutewoe	–	Battor	*idem*

Table 1. (cont.).

Scientific name	Local name	Meaning of local name	Location	Source
Brycinus nurse	Atewoe	–	Battor	*idem*
	Dzogbla	'very fast'	Anloga	*idem*
	Dzogbla	*Idem*	Avuto	*idem*
Brycinus imberi	Dzogbla	*Idem*	Kpong	Irvine (1947); This study
Brycinus brevis	Dzafla	*Idem*	Avuto	This study
Micralestes spp.	Hadidi	–	Anloga	*idem*
Distichodus spp.	Agbasra	'fatty smell'	Avuto	*idem*
Distichodus engycephalus	Kpogbasra	'short-thick-shaped body'	Battor	*idem*
	Agbasralebe	'elongated body'	Battor	*idem*
	Agbasra	*Idem*	Senchi/Kpong	Irvine (1947)
Distichodus rostratus	Agbasrakpoe	'short body'	Battor	This study
Nannocharax sp.	Sakisi	'scissors'	Battor	*idem*
Neolebias unifasciatus	Sakisi	*Idem*	Battor	*idem*
Citharinus spp.	Va / Eva	–	Battor/Avuto	*idem*
Citharinus eburneensis	Wavihie	'whitish in colour'	Battor	*idem*
Citharinus citharus	Waviyibor	'darkish in colour'	Battor	*idem*
Raiamas senegalensis	Norgbeforfor	'soft-skinned'	Battor	*idem*
Raiamas nigeriensis	Norgbeforfor	*Idem*	Battor	*idem*
Labeo parvus	Nyalete	–	Battor	*idem*
Labeo coubie	Agbogboyibor	'darkish in colour'	Battor	*idem*
Labeo senegalensis	Agbogbohie	'whitish in colour'	Battor	*idem*
Barbus spp.	Hadidi	–	Avuto	*idem*
Parailia pellucida	Genua	'bearded fish'; 'with long barbels'	Battor	*idem*
Siluranodon auritus	Genua	*Idem*	Battor	*idem*
	Trafanye	–	Anloga	*idem*
	Trafanye	–	Avuto	*idem*
Irvinea voltae	Akotsogada	'frog fish'	Battor	*idem*
	Tasaa	–	Senchi	Irvine (1947)
Schilbe spp.	Agadavi	–	Avuto	This study
	Amugadavi	'deep water dwellers'	Battor	*idem*
	Gada (Agada)	'catches by pinching with spines'	Senchi	Irvine (1947); This study
Bagrus spp.	Yalefo	'big mouth'	Battor	This study
	Yalefo	*Idem*	Avuto	*idem*
Chrysichthys spp.	Blolo	'hunter', i.e., because of its spines	Battor	*idem*
	Blolo	*Idem*	Avuto	*idem*
	Blolo	*Idem*	Anloga	*idem*
	Blolo	*Idem*	Kpong	Irvine (1947)
Auchenoglanis occidentalis	Kpolo	'big mouth'	Battor	This study
	Kpolo	'hunch back'	Ada	*idem*
	Kpolo	*Idem*	Avuto	*idem*
Heterobranchus spp.	Wonyi/Adawudza	–	Battor	*idem*
	Henyi	–	Anloga	*idem*
	Henyi	–	Avuto	*idem*
Clarias sp.	Adawu	'living in mud'	Battor	*idem*
	Adewu	*Idem*	Avuto	*idem*
	Adehe	'wringling movement'	Anloga	*idem*
	Adehe	'slippery skin'	Not Indicated	Irvine (1947); This study
Clarias agboyiensis	Asriwi	–	Battor	This study

Table 1. (cont.).

Scientific name	Local name	Meaning of local name	Location	Source
Clarias ebriensis	Asriwi	–	Battor	*idem*
	Nudordoe	–	Avuto	*idem*
Malapterurus electricus	Dzidzi/Ani	'don't play or joke with me'	Battor	*idem*
	Dzidzi	*Idem*	Avuto	*idem*
	Dzidzi	*Idem*	Anloga	*idem*
	Ani	–	Not indicated	Irvine (1947)
Synodontis spp. (big)	Tsetse	'I would wound or hurt you', i.e., apparently refering to its strong spines	Battor	This study
	Tsetse	*Idem*	Avuto	*idem*
	Tsetse	*Idem*	Anloga	*idem*
Synodontis spp. (small)	Kpotokui	–	Battor	*idem*
	Kpotokui	–	Avuto	*idem*
	Kpotokui	–	Anloga	*idem*
Hemisynodontis membranaceus	Tsetsegohie	Whitish colour	Battor	*idem*
	Tsetsegohie	Whitish colour	Avuto	*idem*
	Togomekpo	Bottom dweller	Amedica	Irvine (1947); This study
Synodontis sorex	Afini	–	Battor	This study
	Afinoe	–	Anloga	*idem*
Aphyosemion spp.	Torngorwoe	'surface feeders or dwellers'	Anloga	*idem*
Aplocheilichthys spp.	Torngorwoe	*Idem*	Anloga	*idem*
Epiplatys spp.	Torngorwoe	*Idem*	Anloga	*idem*
Parachanna obscura	Norti	'nose', i.e., referring to its nasal appendage	Battor	*idem*
	Norti	*Idem*	Anloga	*idem*
	Norti	*Idem*	Avuto	*idem*
Lates niloticus	Lesi	–	Battor	*idem*
	Leshie	–	Anloga	*idem*
	Leshie	–	Avuto	*idem*
	Lesi	'if you see me comming, run away'		Irvine (1947); This study
Steatocranus irvinea	Depe	–	Battor	This study
	Dempe	–	Avuto	*idem*
Tylochromis jentinki	Akpadekui	–	Battor	*idem*
Chromidotilapia guntheri	Boto	–	Battor	*idem*
	Bonto	–	Avuto	*idem*
	Akpa-tsu	'hard skin'	Kpong	Irvine (1947)
Hemichromis fasciatus	Boryi	'servant'	Battor	This study
	Aboryi	*Idem*	Anloga	*idem*
	Boryi	*Idem*	Avuto	*idem*
	Aboye	*Idem*	Kpong	Irvine (1947); This study
Hemichromis bimaculatus	Sokpe	–	Battor	This study
	Adzorvia	–	Anloga	*idem*
	Adzorvia	–	Avuto	*idem*
Tilapia busuman	Silla	–	Battor/Avuto	*idem*
Tilapia dage	Silla	–	Battor/Avuto	*idem*
Tilapia zillii	Silla	–	Battor/Avuto	*idem*
Tilapia guineensis	Silla	–	Battor/Avuto	*idem*

Table 1. (cont.)

Scientific name	Local name	Meaning of local name	Location	Source
Tilapia spp.	Akpa	–	Anloga	*idem*
Tilapia zillii	Akpatsu	'male tilapia', i.e., characterised by its red throat	Anloga	*idem*
Tilapia guineensis	Akpatsu	*Idem*	Anloga	*idem*
Sarotherodon melanotheron	Akpanoe	'female tilapia', i.e., characterised by its black throat	Anloga	*idem*
	Akpanoe	'prostitute'	Battor	*idem*
	Ditsame	–	Avuto	*idem*
Sarotherodon galilaeus	Akpahie	'white tilapia'	Battor	*idem*
	Akpahie/Kpalogo	–	Avuto	*idem*
Oreochromis niloticus	Logokpa	'hard skinned tilapia'	Battor	*idem*
	Logokpa/Gbolonu	*Idem*	Avuto	*idem*
	Gbolonu	–	Anloga	*idem*
Ctenopoma pетherici	Klefoe	–	Battor	*idem*
	Klefui	–	Avuto	*idem*
	Aklofui	–	Anloga	*idem*
Dormitator lebretonis	Kemenuti	'sandy-skinned fish'	Battor	*idem*
Eleotris vittata	Ekulo	'dead fish'	Battor	*idem*
Tetraodon lineatus	Wuwluwoe	–	Battor	*idem*
	Agede	'drumer'	Avuto	*idem*
	Agede	*Idem*	Anloga	*idem*
	Agede	'swollen stomach'	Ada	*idem*
	Adangme			*Idem*
Polypterus endlicheri	Sanmeki	'fish that stings'	Ada	Irvine (1947); This study
Hyperopisus bebe	Menyu	'fatty and sweet'	Ada	*idem*
Mormyrus macrophthalmus	Nemeli/Numeli	'small mouth opening'	Ada	*idem*
Mormyrops anguilloides	Nua gbemazu	–	Amedica	Irvine (1947)
Marcusenius abadii	Balakoto	–	Senchi	*idem*
Hepsetus odoe	Akao/akawo	'attacker' or 'predator'	Akpabla	Irvine (1947); This study
	Akawo nyagbe	'dog-like teeth'	Ada	This study
Hydrocynus forskalii	Akao/akawo	'attacker' or 'predator'	Kpong	Irvine (1947)
	Akawo	'attacker' or 'predator'	Ada	This study
Alestes dentex	Tewe	–	Atimpoku	Irvine (1947)
	Tewe	–	Ada	This study
Alestes macrolepidotus	Dzaplapa	'catcher of flies and small fishes' on water surface (surface feeder)	Ada	Irvine (1947); This study
Brycinus imberi	Tewe-kpiti	'short body'	Kpong	*idem*
	Tewe-kpiti	*Idem*	Ada	This study
Citharinus citharus	Mleke	'shining skin' or 'with skin that reflects'	Ada	Irvine (1947); This study
Distichodus engycephalus	Gbasra	'fatty smell that can make one vomit'	Ada	*idem*
Labeo senegalensis	Adublaku	–	Kpong	Irvine (1947)
Labeo coubie	Agbombo	'big' or 'bulky structure'	Ada	Irvine (1947); This study

Table 1. (cont.).

Scientific name	Local name	Meaning of local name	Location	Source
Bagrus docmac	Yalefo	'does things slowly like a sick person'	Ada	*idem*
Chrysichthys nigrodigitatus	Kpotue	'slippery skin'	Ada	*idem*
Auchenoglanis occidentalis	Kpo	–	Kpong	Irvine (1947)
	Kpolo	'hunchbacked'	Ada	This study
Schilbe mystus	Tasaa	'good but can't stay for long' or 'deteriorate easily'	Ada	Irvine (1947); This study
Irvinea voltae	Agbeho	'palatable' or 'enjoyable'	Ada	This study
Clarias spp.	Deno	'able to stay both in water and in cool places on land'	Ada	Irvine (1947)
Synodontis schall	Kpo	–	Kpong	*idem*
Hemisynodontis mebranaceus	Kpohia	–	Kpong	*idem*
	Kpohio	'white synodontis'	Ada	This study
Malapterurus electricus	Dzidzi	'no fish can follow its path', i.e. no fish can come near where it is because of shocking effect	Ada	Irvine (1947); This study
Lates niloticus	Dzo	–	Kpong	Irvine (1947)
	Dzo	'catches and carries away its prey fast'	Ada	This study
Hemichronis fasciatus	Loku	–	Kpong	Irvine (1947)
	Loku	'escapes slowly' or 'secretive'	Ada	This study
Chromidotilapia guntheri	Lue	–	Kpong	Irvine (1947)
Sarotherodon melanotheron	Lue	–	Kpong/Atimpoku	*idem*
	Lue	–	Ada	This study
Oreochromis niloticus	Logokpa	–	Ada	Irvine (1947)
Steatocranus irvinei	Odeme	–	Senchi	*idem*
Eleotris lebretonis	Wowe	'bountiful', i.e., wherever they occur they can be found in high numbers	Ada	Irvine (1947); This study
Ctenopoma petherici	Tetepleki	'selfish', i.e., hides to feed	Ada	*idem*
Parachanna obscura	Huati	'hua', i.e., a stick-like plant; i.e., this fis prefers to stay among the 'hua'	Ada	*idem*
Tetroadon lineatus	Kookoe	–	Kpong	Irvine (1947)
	Kookoe	'laughing fish'	Ada	This study

THE STUDY AREA

Fishers from communities along the river Volta in the localities of Battor, Avuto, Anloga and Ada were interviewed. The people in the first three communities are Ewes, while those from the Ada community are mainly Adangmes. The Battors are renowned fishers in inland waters, and they can be found along the entire length of the Volta River in Ghana. The Avuto community is located near the Avu lagoon, which is fed by the Volta River while Anloga is situated at the south-western part of Keta lagoon. Keta lagoon is also connected to the Volta through various channels and streams and it is the largest lagoon in Ghana. The fourth community, Ada, where Adangme is the spoken laguage, is situated near the Volta estuary. The Adangmes are mainly sea fishers.

METHODS

Interviews were held at four localities with fishers to identify fishes in their local languages and explain why a name was assigned to a particular fish. Existing literature were also consulted to complete some of the etymology of these names, such as those presented in Irvine (1947).

RESULTS AND COMMENTS

Local names from the different localities and their meaning as well as their source are presented in Table 1. From the interview conducted, it was evident that the local people are very much aware of differences of the various fish species they use or encounter. This is manifested by the fact that in most cases, each species has its own name in the local language.

Local fish names and their meanings generally differ among the different communities, but there are instances where, for the same language, a name and its meaning are used in the same way irrespective of locality. For example, in the three Ewe communities of Battor, Anloga and Avuto, *Heterotis niloticus* is called ‘Efa’ (i.e., ‘can’t stay down’), referring to the jumping and splashing behaviour of the fish. There are also instances where differing names assigned to one species have the same meaning irrespective of the languages. For example, *Hepsetus odoe* is known as ‘Akawo nyagbe’ in Adangme and called in some Ewe communities as ‘Avuwo’ or ‘Lixe’, with both names having the meaning ‘dog-like teeth’.

Sometimes, the etymology of a local name is vague and could not be explained. Though it is known that tradition dictates the giving of names for a purpose, the oral tradition of recounting history may have lost track of some of these elements. Thus, there might be a need to document such information from the old folks before they are completely lost to future generations.

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LES NOMS DES POISSONS MARINS DU TOGO EN LANGUE EWE

NAMES OF MARINE FISHES OF TOGO IN THE EWE LANGUAGE

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RESUME

Le peuple Ewe est l'une des 45 ethnies qui composent la population du Togo. Il se retrouve principalement au Togo, au Ghana et au Bénin. La langue Ewe est riche en vocabulaire relatif à plusieurs domaines d'activités dont la pêche et ses captures. Les noms donnés aux hommes, aux animaux et aux choses et particulièrement aux poissons sont, pour la plupart du temps, liés à la tradition qui semble évoluer avec le temps et les contacts avec d'autres peuples ayant des coutumes différentes. La tendance passée de séparer la science et la tradition a évolué, le savoir du « passé » est maintenant consulté pour élaborer des règles dans plusieurs domaines, dont la pêche qui a actuellement besoin, plus que jamais, de règles de gestion pour survivre. Le présent document donne les noms scientifiques, commerciaux et Ewes d'une cinquantaine d'espèces sur les 168 que compte le Togo. Toutes ces espèces sont connues du peuple Ewe du Togo depuis longtemps pour leur potentialité alimentaire et divers autres usages. Du sens profond de ces noms Ewes pourront surgir les autres usages auxquels les Ewes destinaient ces poissons.

ABSTRACT

The Ewe, one of 45 ethnic groups composing the population of Togo, are found mainly in Togo, Ghana and Benin. The Ewe language has a rich vocabulary relating to fishing activities with words describing humans and animals, particularly fishes, being linked to traditional activities. It has evolved over time and consequently as a result of interactions with other cultures. The tendency of separating traditional from scientific knowledge has now been overcome, and past knowledge is more frequently used in our days in policy making, notably in the management of fisheries resources. This contribution presents a list of scientific, commercial and Ewe common names for about 50 species of the 168 that are found in Togo. These species are those that have been consumed and used for other purposes for a long time by the Ewe people in Togo and the closer examination of these common names may provide more information on how else the Ewe used these fishes.

INTRODUCTION

Le peuple Ewe habite le sud du Togo, du Bénin et du Ghana. Au Togo, ils représentent environ 25 % de la population; c'est donc l'ethnie la plus importante du pays qui en compte 45. Leur langue, l'Ewe, est parlée et comprise par plusieurs ethnies dans presque tout le pays. La langue Ewe est lue, écrite et enseignée dans les établissements scolaires et universitaires aux niveaux national et international. Des dictionnaires « Ewe-Français, Français-Ewe »; « Ewe-Anglais, Anglais-Ewe »; « Ewe-Allemand, Allemand-Ewe » ont été assemblés par plusieurs auteurs et couvrent plusieurs domaines d'activités, dont la pêche, surtout maritime.

La proximité des plans d'eau fluvial, lagunaire et surtout maritime a permis probablement aux Ewes d'enrichir leur langue en vocabulaire relatif à l'halieutique, notamment avec des noms variés de différentes espèces de poissons. Les noms donnés aux poissons ont des significations particulières et varient d'un milieu Ewe à un autre et d'une période à une autre. Le présent document donne des noms de poissons en trois langues. L'Ewe étant peu connue des milieux scientifiques, pour en faciliter la lecture, des informations utiles sont données ci-après sur l'alphabet Ewe.

METHODOLOGIE

Une liste de noms scientifiques des poissons marins couramment débarqués a été établie à partir des fiches d'identification des espèces aquatiques vivantes de la FAO (Schneider, 1992) et de l'ORSTOM (Seret et Opic, 1981). Les noms commerciaux tirés de ces documents ont fait l'objet d'une vérification auprès des pêcheurs, des commerçants, des consommateurs et de la population riveraine du pays, afin de voir si localement ces noms sont les mêmes. Après cette vérification, seuls les noms commerciaux locaux sont retenus. Cette même liste a ensuite été distribuée en milieu Ewe pour établir les correspondances avec les noms Ewe des poissons.

En avril 1999, lors d'un atelier sur la gestion des pêcheries et de la biodiversité, organisé à Dakar (Sénégal), la liste issue des enquêtes a été améliorée par le Dr Daniel Pauly, Professeur au Centre Halieutique de l'Université de Colombie Britannique (UBC) au Canada. La base de données FishBase, ainsi que des dictionnaires Ewes ont été utilisés pour trouver la signification des noms Ewes en français. Cette dernière liste a encore été soumise aux groupes cibles évoquées ci-dessus, notamment les personnes âgées. Les dictionnaires Ewes - Français consultés sont ceux du Révérant Père E. Riebstein des Missions Africaines de Lyon, missionnaire au Togo publié en 1923 et celui d'Adzomada (1967). Le document présente les résultats de cette démarche. Les informations utiles pour lire les noms des poissons en Ewe sont données dans le Tableau 1.

RESULTATS

Le répertoire synonymique des poissons marins débarqués au Togo est donné dans le Tableau 2. Les résultats des travaux montrent que le peuple Ewe a des noms pour désigner tous les poissons qu'il connaît; certaines espèces en ont même deux. Généralement, les noms sont donnés plutôt au genre, qu'à l'espèce. La vérification de ces noms dans les dictionnaires a permis de découvrir que seules trois espèces trouvent leur appellation en Ewe dans ces dictionnaires. Les enquêtes menées auprès des pêcheurs, des commerçants et des consommateurs Ewes, surtout auprès des personnes âgées, montrent que les générations actuelles utilisent, presque tous les jours, des noms de poissons en Ewe sans en connaître la signification.

De ce premier travail, il se dégage que le poisson n'est pas utilisé uniquement comme nourriture. En effet, *Pseudupeneus prayensis* ou rouget en français et *Alχ* en Ewe est utilisé comme médicament pour activer la locution ou l'intelligence, surtout chez les enfants. Il en est de même pour *Brachydeuterus auritus* ou friture en français et *Degbenu madui* en Ewe; cette espèce a une signification mystique pour le Clan Degbenu qui refuse de la consommer.

Tableau 1: Quelques informations sur l'alphabet Ewe.

Caractère	Prononciation en Ewe
a	comme "a" en français (exemple: "a" dans le mot "papa")
ã	"a" nasalisé, mais se prononce comme "an" ou "en"
b	comme "b" en français (exemple: "b" dans le mot "boubou")
d	comme "d" en français (exemple: "d" dans le mot "dada")
xxx	se prononce comme "d" dur avec la langue appuyée fortement contre le palais supérieur
dz	se prononce comme "dj" (exemple: "dz" comme "dj" dans le nom "Djiop" du Sénégal ou comme "j" dans le mot anglais "jump")
e	comme "e" en français, mais comme "e" avalé (exemple: "e" à la fin de forte)
xxx	c'est le "è" nasalisé et se prononce "ein" (comme dans le mot "feindre"), mais sans le signe ~ sur la tête il se prononce comme "è" en français
f	comme "f" en français. (exemple: "f" dans le mot "France")
ƒ	se prononce comme si on souffle avec une bouche presque fermée par exemple sur une flamme de bougie pour l'étendre
g	comme "g" dans le mot français "gari" qui signifie farine de manioc
gb	ici le "g" s'entend très peu (exemple: "gb" dans le nom "Gbagbo" de la Côte d'Ivoire)
h	comme "h" en français (exemple: "h" dans le mot français "hache")
i	comme "i" en français (exemple: "i" dans le mot français "lit")
˜i	c'est un "i" nasalisé
k	comme "k" en français (exemple: "k" dans le mot français "kaki")
kp	ici le "k" s'entend à peine. Le son produit s'entend comme si on tire un coup de pistolet
l	comme "l" en français (exemple: "l" dans le mot français "laine")
m	comme "m" en français (exemple: "m" dans le mot français "mangue")
n	comme "n" en français (exemple: "n" dans le mot français "neige")
ny	se prononce comme "gn' (exemple: "gn" dans le mot français "pagne")
xxx	c'est un son spécial qui ressemble à la terminaison "ng" dans le mot anglais « sing »
o	comme "o" en français (exemple: "o" dans le mot français "drôle")
xxx	se prononce comme " o" dans les mots français "hors" ou "lotte"
xxx	c'est le "χ" nasalisé et se prononce comme dans le mot français "long"
p	comme "p" en français (exemple: "p" dans le mot français "payant")
r	comme "r" en français (exemple: "r" dans le mot français "roi")
s	comme "s" en français (exemple: "s" dans le mot français "soleil")
t	comme "t" en français (exemple: "t" dans le mot français "tailleur")
ts	se prononce comme "tch" dans le mot français "match" mais plus dur
u	se prononce toujours comme "ou" en français
û	c'est "u" nasalisé de la langue Ewe ou plus précisément Eυe
v	Comme "v" en français (exemple: "v" dans le mot français "vélo")
υ	c'est un son spécial qui se prononce comme "v" sur les lèvres maintenues très légèrement ouvertes
w	Comme "w" dans le mot anglais "we " qui désigne "nous" en français
x	c'est un son ressemblant au son produit par quelqu'un qui coure en soufflant par la bouche grandement ouverte
y	Comme "y" dans le mot français "Bayonne"
z	Comme "z" en français (exemple: "z" dans le mot français zèbre)

CONCLUSION

Dans le domaine de la pêche, le peuple Ewe possède un vocabulaire riche; mais cette richesse est très peu reflétée dans les dictionnaires Ewe-Français. Par ailleurs, la signification des noms de poissons en Ewe échappe, la plupart du temps, aux utilisateurs de ces noms. Par conséquent, des questions se posent quant à l'origine de ces noms, à leur évolution, et à l'importance que le peuple Ewe actuel accorde à sa langue, surtout dans le domaine de la pêche. La connaissance de la signification exacte des noms de poissons par les Ewe permettra de découvrir davantage les autres usages de ces poissons. Ce document avait pour objectif de susciter des réactions qui permettront d'améliorer les travaux de cette nature.

Tableau 2 : Répertoire synonymique des poissons marins débarqués au Togo.

Noms scientifiques	Noms commerciaux en français	Noms en Ewe	Dictionnaire Ewe	Signification en Ewe
Balistes carolinensis	Baliste	Akpãgba		Caractéristiques de sa peau
Boops boops	Bogue	Afinχ		Bouche ressemblant à la souris
Brachydeuterus auritus	Fritures	Hawui		
Brachydeuterus auritus	Fritures	Degbenu madui		[Interdit au clan Degbenu]
Caranx hyppos	Carangue	Glamata		
Caranx hyppos	Carangue	Pãpã		
Caranx hyppos	Carangue	Pãpãkpoe		Pãpã court (Voir carrangue)
Chloroscombrus chrysurus	Plat plat, petit carangue	Dzudzui	Volant ou ailes	Volant ou ailes
Chloroscombrus chrysurus	Plat plat, petit carangue	ngogba	Front écrasé	Volant ou ailes
Coryphaena equisetis	Caméléon	Agama		Portant des marques de caméléon
Cynoglossus senegalensis	Sole	Afχƒome		La planche de pied
Dactylopterus volitans	Faux poisson volant	Dzodzodroe	Oui	Qui saute et se pose en même temps
Dasyatis margarita	Raie	Tatra		
Dasyatis margarita	Raie	Adadu		
Decapterus rhonchus	Chinchard	Tsiyi		
Dentex macrophtalmus	Gros yeux	Adzetχvi		Yeux comme ceux d'un petit sorcier
Drepane africana	Disque	Kpenukpa		Poisson des rochers
Engraulis encrasicolus	Anchois	Abχbi		Très abondant; en grand groupe
Ephippion guttifer	Perroquet	Ako		Ayant un bec de perroquet
Epinephelus aeneus	Mérou	Tχbokχ		Charlatan marin
Epinephelus goreensis	Mérou	Tχbokχ		Charlatan marin
Ethmalosa fimbriata	Ethmalose	Folevi		
Euthynnus alletteratus	Bonite	Kpoku		Qui tombe raide mort facilement
Exocoetus volitans	Poisson volant	Dzodzodroe	Oui	Qui saute et se pose en même temps
Galeoides decadactylus	Hornose ou Petit capitaine	Tsikoe		
Hemiramphus balao	Demi bec	Adχ⊗eka		Un bec, un seul bec
Ilisha africana	Rasoir	Kafla		
Lagocephalus laevigatus	Perroquet	Gede		Son produit par un tam-tam des Ewe
Lethrinus atlanticus	Dorade grise	Tsiplι		
Liza grandisquamis	Mulet	Gesu		
Lutjanus goreensis	Carpe rouge ou Lutjanus	Hã		
Pagellus bellottii	Pageot	Sikasikavi		Le petit Sikasika (Voir dorade rose)
Paraconger notialis	Congre	Ableku		
Polydactylus quadrifilis	Capitaine	Tsikχ		
Pomadasys jubelini	Pristipoma	Kχkχvi		
Pseudotolithus senegalensis	Bar	Ekã		
Pseudotolithus typus	Bar	Ekã		
Pseudupeneus prayensis	Rouget	Alχ		Qui fait parler comme une pie
Raja miraletus	Raie	Tatra		
Sardinella aurita	Sardinelle	υetsim		Je suis fatigué du fretin
Sardinella maderensis	Hareng	Mãvi		
Scomber japonicus	Maquereau	Salom°		Qui fait penser au poisson "saumon"
Selar crumenophthalmus	Chinchard	Akpala		
Selene dorsalis	Vomer	∏gogba		Front écrasé
Solea senegalensis	Sole	Afχƒome		La planche de pied
Sparus caeruleostictus	Dorade rose	Sikasika		Le corps brillant comme de l'or
Sphyraena afra	Brochet	Lizi		
Sphyraena guachancho	Brochet	Lizi		
Squalus spp.	Requin	Agblolui	Oui	Le ventru
Syacium micrurum	Turbot	Alχƒome		La paume de la main
Thunnus albacares	Thon	Gegu		
Trachurus trecae	Chinchard	Akpala		
Tylosurus crocodilus crocodilus	Orphie	Dayi		
Xiphias gladius	Espadon	Hatalikofi		

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NOMS COMMUNS DE POISSONS TCHADIEN EN LANGUE KIM

COMMON NAMES OF FISHES OF CHAD IN THE KIM LANGUAGE

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RESUME

Ce document présente des noms communs de poissons en langue Kim, parlée le long de la rivière Logone, au Tchad. Ces noms sont extraits d'une étude antérieure de J. Blache (1964, « Les poissons du bassin du Tchad et du bassin adjacent du Mayo-Kebbi », Mem. ORSTOM, 4(2):485 p.), et remis à jour et/ou vérifiés en consultation avec des pêcheurs Kim. Les noms scientifiques des espèces de poisson concernées ont été mis à jour en utilisant FishBase (www.fishbase.org).

ABSTRACT

This document presents common names of fish in Kim, a language spoken along the Logone River, Chad. These names were extracted from a previous study by J. Blache (1964, "Les poissons du bassin du Tchad et du bassin adjacent du Mayo-Kebbi", Mem. ORSTOM, 4(2):485 p.), but were updated and/or verified through interviews with Kim speaking fishers. The scientific names of the fish species in question were updated using FishBase (www.fishbase.org).

INTRODUCTION

Plusieurs de contribution incorporées dans le présent volume insistent sure la nécessité pour les chercheurs et gestionnaires de la pêche, d'utiliser les noms communs des poissons, plutôt que les noms savants, dans leurs interactions avec les pêcheurs et autres professionnels de la pêche. La langue Kim est parlée au Tchad par les pêcheurs travaillant le long de la rivière Logone. Dans cette contribution, je présente les noms de poissons en langue Kim initialement inclus dans l'étude de Blache (1964), que nous avons vérifiés et mis à jour, et que nous avons associés à des noms scientifiques qui eux aussi, ont été remis à jour (en utilisant FishBase; www.fishbase.org). Nous avons aussi saisi l'opportunité de questionner des pêcheurs Kim afin de relier à des croyances locales quelques noms communs relevés ici. L'ensemble de nos résultats est présenté sous forme d'un tableau (Tableau 1), par espèce et village, afin de saisir la variabilité spaciale des noms communs Kim.

Tableau 1. Répertoire synonymique des noms de poisson en langue Kim au Tchad.

Espèces	Village	Nom en Kim	Signification et usage traditionnel
Xenomystus nigr	**Djoumané**	Mamafirgo	Pagaie des êtres qui vivent sous l'eau (génies de l'eau)
	Eré	Mamafirgo	
	Kim	Mamafirgo	
	Kolobo	Momafrigo	
Heterotis niloticus	**Djoumané**	Pwon	La légende raconte que ce poisson dit au pêcheur, que tant qu'il n'est pas encore entré dans la marmite, il ne lui appartient pas.
	Eré	Paï	
	Kim	Poï	
	Kolobo	Pwon	

Tableau 1. (cont.).

Espèces	Village	Nom en Kim	Signification et usage traditionnel
Hyperopsis bebe chariensis	**Djoumané**	Zeing	
	Eré	Zeïn	
	Kim	Zia	
	Kolobo	Zeing	
Hyperopisus occidentalis tenuicaud	**Djoumané**	Zeing	
	Eré	Seïn	
	Kim	Zia	
	Kolobo	Zeing	
Mormyrus hasselquisti	**Djoumané**	Allômur	
	Eré	Guluwa	
	Kim	Zomol	
	Kolobo	Gulwa	
Mormyrus rume	**Djoumané**	N'djon	
	Eré	N'djaï	
	Kim	Nrii, Rîn	
	Kolobo	N'djon	
Mormyrus caschive	**Djoumané**	N'djon	
	Eré	N'djaï	
	Kim	Nrii, Rîn	
	Kolobo	N'djon	
Mormyrops anguilloides (deliciosus)	**Djoumané**	Gulum	
	Eré	Rîn, Nrii	
	Kim	Rîn, Nrii	
	Kolobo	Rîn, Nrii	
Campylomormyrus (Gnathonemus) tamandua	**Djoumané**	Ndallégüil	
	Eré	Kakago, Mamasini	
	Kim	Gulwak	
	Kolobo	Gulwa	
Hyppopotamyrus (Gnathonemus) harringtoni	**Djoumané**	Kabring	
	Eré	Kabre	
	Kim	Kabre	
	Kolobo	Kawring	
Hippopotamyrus (Gnathonemus) pictus	**Djoumané**	Kabring	
	Eré	Kabre	
	Kim	Kabre	
	Kolobo	Kawring	
Brienomyrus (Gnathonemus) niger	**Djoumané**	Kabring	
	Eré	Kabre	
	Kim	Kabre	
	Kolobo	Kawring	
Marcusenuis (Gnathonemus) senegalensis gracilis	**Djoumané**	Kabring	
	Eré	Kabre	
	Kim	Kabre	
	Kolobo	Kawring	
Marcusenius (Gnathonemus) cyprinoides	**Djoumané**	Kabring	
	Eré	Kabre	
	Kim	Kabre	
	Kolobo	Kawring	

Tableau 1. (cont.).

Espèces	Village	Nom en Kim	Signification et usage traditionnel
Petrocephalus simus	**Djoumané**	Siel	La légende rapporte que c'est lui qui était chargé de distribuer de la graisse aux poissons. Il en a tous donné aux autres de telle sorte qu'il n'a fait nettoyer ses mains sur sa tête. Voilà pourquoi il a de la graisse à la tête mais pas au ventre.
	Eré	Sial	
	Kim	Sehel	
	Kolobo	Siel	
Petrocephalus bovei bovei	**Djoumané**	Siel	*idem*
	Eré	Sial	
	Kim	Sehel	
	Kolobo	Siel	
Petrocephalus bane bane	**Djoumané**	Siel	*idem*
	Eré	Sial	
	Kim	Sehel	
	Kolobo	Siel	
Pollimyrus (Marcusenius) isidori isidor	**Djoumané**	Siel	*idem*
	Eré	Sial	
	Kim	Sehel	
	Kolobo	Siel	
Pollimyrus (Marcusenius) thuysi	**Djoumané**	Fun Dirip	*idem*
	Eré	Fwu Gôbo	
	Kim	Fup	
	Kolobo	Fun	
Gymnachus niloticus	**Djoumané**	Mining	
	Eré	Kenene	
	Kim	Kianene	
	Kolobo	Mining	
Tetraodon lineatus (fahaka)	**Djoumané**	Bwol	
	Eré	Pôpobe	
	Kim	Pôpobe	
	Kolobo	Bwol	
Hepsetus odeo	**Djoumané**	Kurmisia	
	Eré	Kurmisia	
	Kim	Kurmisia	
	Kolobo	Kurmising	
Hydrocynus (Hydrocyon) forskali	**Djoumané**	Hiding Azolo	
	Eré	Hidi Gurlua	
	Kim	Hidi	
	Kolobo	Hiring	
Hydrocynus vittatus (Hydrocyon lineatus)	**Djoumané**	Hiding	
	Eré	Hidi Dare	
	Kim	Hidi	
	Kolobo	Hiring	
Hydrocynus (Hydrocyon) brevi	**Djoumané**	Hiding Madara	
	Eré	Hidi Mandol	
	Kim	Hidi	
	Kolobo	Hiring	
Hydrocynus (Hydrocyon) somonorum	**Djoumané**	Hiding Donbow	
	Eré	Hidi Dongahal	
	Kim	Hidi	

Tableau 1. (cont.).

Espèces	Village	Nom en Kim	Signification et usage traditionnel
Hydrocynus (Hydrocyon) somonorum	**Kolobo**	Hiring	
Alestes dentex	**Djoumané**	Van	
	Eré	Vaï	
	Kim	Vore	
	Kolobo	Van	
Alestes baramose	**Djoumané**	Van	
	Eré	Vaï	
	Kim	Vore	
	Kolobo	Van	
Brycinus (Alestes) macropidotus	**Djoumané**	Adjamdjor	
	Eré	Gamle	
	Kim	Kadjianre	
	Kolobo	Adjamdjer	
Brycinus (Alestes) leuciscus	**Djoumané**	Han	
	Eré	Haï	
	Kim	Haï	
	Kolobo	Han	
Brycinus nurse (Alestes dageti)	**Djoumané**	Han	
	Eré	Haï	
	Kim	Haï	
	Kolobo	Han	
Brycinus (Alestes) nurse	**Djoumané**	Han	
	Eré	Haï	
	Kim	Haï	
	Kolobo	Han	
Ichthyborus besse besse	**Djoumané**	Kurmisia	
	Eré	Kurmisia	
	Kim	Kurmisia	
	Kolobo	Kurmising	
Citharinus citharinus	**Djoumané**	Won	
		Kabaring	Nom utilisé pour les juvéniles
	Eré	Woïn	
		Kabah	Nom utilisé pour les juvéniles
	Kim	Woïn	
		Kabare	Nom utilisé pour les juvéniles
	Kolobo	Won	
		Babani	Nom utilisé pour les juvéniles
Citharinus latus	**Djoumané**	Walgan	
		Kabaring	Nom utilisé pour les juvéniles
	Eré	Wale	
		Kabah	Nom utilisé pour les juvéniles
	Kim	Wole	
		Kabare	Nom utilisé pour les juvéniles
	Kolobo	Walgan	
		Babani	Nom utilisé pour les juvéniles
Distichodus niloticus	**Djoumané**	Bagan-Djoborso	Eclaireur
	Eré	Bage-Baraw	Eclaireur
	Kim	Bagaï-bogolo	
	Kolobo	Bagan-adjoborso	
Distichodus brevipinnis	**Djoumané**	Bagan	
		Kamputum	Nom utilisé pour les juvéniles
		Alele	
	Eré	Bage	

Tableau 1. (cont.).

Espèces	Village	Nom en Kim	Signification et usage traditionnel
Distichodus brevipinnis	**Kim**	Bagaï	
	Kolobo	Bagan	
		Kamputum	Nom utilisé pour les juvéniles
		Alele	
Barbus occidentalis foureaui	**Djoumané**	Bahiding	
	Eré	Bahirim	
	Kim	Kolmia	
	Kolobo	Bahiring	
Barbus lepidus	**Djoumané**	Beger	
	Eré	Bege	
	Kim	Beger	
	Kolobo	Beger	
Barbus leonensis	**Djoumané**	Dale-madaga	
	Eré	Dale-madarmege	
	Kim	Nde	
	Kolobo	Dale-Madagde	
Babus anema	**Djoumané**	Djaraï	
	Eré	Djaraï	
	Kim	Djaraï	
	Kolobo	Djaraï	
Labeo senegalensis	**Djoumané**	Guhul	
	Eré	Guhul	
	Kim	Guhul	
	Kolobo	Gohol	
Labeo lerensis	**Djoumané**	Teing	
		Tobol	Nom utilisé pour les juvéniles
	Eré	Taï	
	Kim	Te	
	Kolobo	Teing	
		Tobol	Nom utilisé pour les juvéniles
Labeo parvus (tibesti)	**Djoumané**	Guhul-seng	
	Eré	Guhul-sahal	
	Kim	Guhul-sahal	
	Kolobo	Gohol-seng	
Labeo coubie	**Djoumané**	Teing	
		Tobol	Nom utilisé pour les juvéniles
	Eré	Taï	
	Kim	Te	
	Kolobo	Teing	
		Tobol	Nom utilisé pour les juvéniles
Labeo coubie (pseudocoubie)	**Djoumané**	Teing	
	Eré	Taï	
	Kim	Te	
	Kolobo	Teing	
Bariluis senegalensis (loati)	**Djoumané**	Kâ	
	Eré	Kâhago	
	Kim	Kâhago	
	Kolobo	Kâ	
Barilius senegalensis (orientalis)	**Djoumané**	Kâ	
	Eré	Kâhago	
	Kim	Kâhago	
	Kolobo	Kâ	
Bagrus docmak (docmac docmac)	**Djoumané**	Deïng	
	Eré	Daï	
	Kim	De	
	Kolobo	Deïng	

Tableau 1. (cont.).

Espèces	Village	Nom en Kim	Signification et usage traditionnel
Bagrus bajad (bayad bayad)	**Djoumané**	Deïng	
	Eré	Daï	
	Kim	De	
	Kolobo	Deïng	
Chrysichthys auratus aratus	**Djoumané**	Kor	
	Eré	Lër	
	Kim	Lër	
	Kolobo	Gening-mat	
Chrysichthys nigrodigitatus	**Djoumané**	Kor	
	Eré	Lër	
	Kim	Lër	
	Kolobo	Gening-mat	Roi de l'hivernage
Clarotes laticeps	**Djoumané**	Bingbing	
	Eré	Bibing	
	Kim	Bibing	
	Kolobo	Bingbing	
Clarotes laticeps (macrocephalus)	**Djoumané**	Gagaï	
	Eré	Pein	
	Kim	Pia	
	Kolobo	Gagaï	
Auchenoglanis biscutatus	**Djoumané**	Sohon, Soin	
	Eré	Swaï	
	Kim	Swaï	
	Kolobo	Sohon, Soin	
Clarias anguillaris	**Djoumané**	Vering	
	Eré	Vere	
	Kim	Gol, Gwol	
	Kolobo	Vering	
Clarias lazera	**Djoumané**	Vering	
	Eré	Vere	
	Kim	Gol, Gwol	
	Kolobo	Vering	
Clarias walkeri	**Djoumané**	Vering	
	Eré	Vere	
	Kim	Gol, Gwol	
	Kolobo	Vering	
Heterobranchus bidorsalis	**Djoumané**	Buhun	
	Eré	Boï, Boin	
	Kim	Bô	
	Kolobo	Buhun	
Schilbe mystus	**Djoumané**	Doring	
	Eré	Zare	
	Kim	Longre	
	Kolobo	Dening	
Schilbe (Eutropius) niloticus	**Djoumané**	Badigri	
		Let	Nom utilisé pour les juvéniles
	Eré	Badigri	
	Kim	Badigri	
	Kolobo	Badigri	
		Let	Nom utilisé pour les juvéniles
Siluranodon auritus	**Djoumané**	Balii	
	Eré	Djohol	
	Kim	Balaï	
	Kolobo	Paring	
Parailia (Physailia) pellucida	**Djoumané**	Lengre lengre	
	Eré	Lode	
	Kim	Lode	
	Kolobo	Legre Legre	

Tableau 1. (cont.).

Espèces	Village	Nom en Kim	Signification et usage traditionnel
Synodontis batensoda	**Djoumané**	Al	
		Eh-ere	Nom utilisé pour les juvéniles
		Walseng	
Synodontis batensoda	**Eré**	Al	
		Walsal	Nom utilisé pour les juvéniles
	Kim	Araï	
	Kolobo	Al	
Synodontis membranaceus	**Djoumané**	Kom	Nom utilisé pour les juvéniles
		Eh-ere	
	Eré	Hul	
	Kim	Wul	
	Kolobo	Kom	
Synodontis clarias	**Djoumané**	Mengelte	
		Eh-éré	Nom utilisé pour les juvéniles
	Eré	Kôsogol	
	Kim	Zomol	
	Kolobo	Gohgoï	
Synodontis sorex	**Djoumané**	Lër	
		Eh-ere	Nom utilisé pour les juvéniles
	Eré	Lêr	
	Kim	Lêr	
	Kolobo	Lêr	
Synodontis nigrita	**Djoumané**	Djaraï	
	Eré	Djaraï	
	Kim	Djaraï	
	Kolobo	Djaraï	
Synodontis eupterus	**Djoumané**	Bandëling	A fait perdre le filet. La légende dit que quand les pêcheurs l'ont capturé pour la première fois, chacun d'eux le voulait pour lui. Pendant qu'ils discutaient, l'eau a emporté leur filet. D'où l'origine de son nom.
		Eh-ere	Nom utilisé pour les juvéniles
	Eré		
	Kim		
	Kolobo		
Synodontis schall	**Djoumané**	Yeing	
		Eh-ere	Nom utilisé pour les juvéniles
	Eré	Yaï	
	Kim	Yaï	
	Kolobo	Yeng	
Synodontis gambiensis	**Djoumané**	Yeing	
		Eh-ere	Nom utilisé pour les juvéniles
	Eré	Yaï	
	Kim	Yaï	
	Kolobo	Yeng	
Synodontis courtei	**Djoumané**	Mamkadumde	
		Eh-ere	Nom utilisé pour les juvéniles
	Eré	Mamkadubgu	
	Kim	Mamkabgu	
	Kolobo	Momkadumbe	
Malapterurus electricus	**Djoumané**	Nding	
	Eré	Dji	
	Kim	Dji	
	Kolobo	Nding	

Tableau 1. (cont.).

Espèces	Village	Nom en Kim	Signification et usage traditionnel
Aplocheilichthys loati (schoelleri)	**Djoumané**	Doh-sing	
	Eré	Dog-sini	
	Kim	Dog-si	
	Kolobo	Doh-sing	
Lates niloticus	**Djoumané**	Fel	
	Eré	Fel	
	Kim	Fon'dolâ	
Lates niloticus	**Kolobo**	Namal	
Hemichromis fasciatus	**Djoumané**	Dworing	
	Eré	Dware	
	Kim	Kome	
	Kolobo	Mbubling	
Hemichromis bimaculatus	**Djoumané**	Guring	
	Eré	Tihil	
	Kim	Tihil	
	Kolobo	Guring	
Sarotherodon galilaeus galilaeus (Tilapia galilaea)	**Djoumané**	Biering-seing	
	Eré	Bere-saal	
	Kim	Biare-saal	
	Kolobo	Sohn-seing	
Oreochromis niloticus niloticus (Tilapia nilotica)	**Djoumané**	Biering-pill	
	Eré	Sale	
	Kim	Sale	
	Kolobo	Peng-pill	
Oreochromis aureus(Tilapia monodi)	**Djoumané**	Biering-pill	
	Eré	Sale	
	Kim	Sale	
	Kolobo	Sohn-pill	
Oreochromis aureus (Tilapia lemassoni)	**Djoumané**	Biering-pill	
	Eré	Sale	
	Kim	Sale	
	Kolobo	Sohn-pill	
Tilapia zillii (multiradiata)	**Djoumané**	Guring	
	Eré	Tihil	
	Kim	Tihil	
	Kolobo	Guring	
Tilapia zillii	**Djoumané**	Guring	
	Eré	Tihil	
	Kim	Tihil	
	Kolobo	Guring	
Tilapia zilli (melanopleura)	**Djoumané**	Biering	
	Eré	Bere	
	Kim	Biare	
	Kolobo	Sohn	
Ctenopoma muriei muriei	**Djoumané**	Kamdagar	Poisson capable de tuer l'éléphant. car l'éléphant en s'abreuvant peut l'aspirer par la trompe mais est incapable de le rejeter. Il peut s'en suivre la mort du Pachyderme.
	Eré	Kamdaga	
	Kim	Kamdaga	
	Kolobo	Kirmi-ndagre	

Tableau 1. (cont.).

Espèces	Village	Nom en Kim	Signification et usage traditionnel
Ctenopoma petherici	**Djoumané**	Kamdagar	*idem*
	Eré	Kamdaga	
	Kim	Kamdaga	
	Kolobo	Kirmi-ndagre	
Ophicephalus obcurcus	**Djoumané**	Dôgol	
	Eré	Muhuri	
	Kim	Muhuri	
	Kolobo	Dôgol	
Caecomastacembelus lönnbergii (Mastacembelus lönnbergi)	**Djoumané**	Mamadîîl	Aiguille des génies de l'eau (être vivant sous l'eau)
	Eré	Mamadîîl	
	Kim	Mamadîîl	
	Kolobo	Momadîîl	
Polypterus senegalenis senegalensis	**Djoumané**	Gong Kekerte	Il sert de bois de chauffe aux êtres de l'eau (génies de l'eau). La légende dit qu'il mesure sa taille avec celle de la pirogue.
	Eré	Gong Kakarte	
	Kim	Gong Kakarte	
	Kolobo	Gong Kekerte	
Polypterus bechir bechir	**Djoumané**	Gong Koïn	Il sert de bois de chauffe aux êtres de l'eau (génies de l'eau).
	Eré	Gong Dongââl	
	Kim	Gong Gââl	
	Kolobo	Gong Koïn	
Polypteurus endicheri endicheri	**Djoumané**	Gong Mofol Gong agusum	*idem*
	Eré	Gong Mapual	
	Kim	Gong Agusum	
	Kolobo	Gong Agusum	
Polypterus anectens	**Djoumané**	Eling	La femme en grossesse ne le mange pas de peur que son enfant ne bave sans arrêt.
	Eré	Ele	
	Kim	Ele	
	Kolobo	Eling	

REMERCIEMENTS

Nous souhaitons exprimer ici nos sincères remerciements à tous ceux, qui de près ou de loin, ont contribué à la production du document et adressons une pensée particulière aux pêcheurs qui ont contribué à la vérification des noms des poissons dans les différentes langues. Il s'agit, en particulier, de Bongor Amos et de Kaïba Simon de Djoumane; de Akonso André, de Dogounmo Josué et de Alaïna Michel de Eré; de Madaye Pierre et de Docbaïgo Philippe de Kim (Kossop) et de Adjogorm David et de Gabrang Michel de Kolobo.

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NOMS COMMUNS D'ESPECES IMPORTANTES DE POISSON EN LANGUE FANG, GABON

COMMON NAMES OF IMPORTANT FISH SPECIES IN THE FANG LANGUAGE, GABON

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RESUME

Le présent document se propose d'améliorer la base de données sur les poissons du Gabon. Il donne pour chaque espèce le nom scientifique et les équivalents en français et en Fang, une des langues locales la plus utilisée dans le milieu pêcheur des eaux continentales du Gabon. La consultation des données concernant le Gabon et contenues dans FishBase 98 (www.fishbase.org) a permis de constater des lacunes dans cette base de données. Ce document constitue donc une première contribution nationale des techniciens du secteur impliqués dans le projet ACP-UE intitulé « Renforcement de la gestion des pêches et de la biodiversité dans les pays ACP ».

ABSTRACT

A list of common names was prepared as a contribution to the knowledge on the names of fishes in Gabon, indicating their scientific, French and Fang names. Fang is a language used by inland fishers in Gabon. The list of fishes of Gabon was obtained from FishBase (see www.fishbase.org) and used here to identify missing common names as well as identifying species occurring in, but which have not yet been assigned to, Gabon. This is one of the first contributions by national fisheries officers to the ACP-EU Project "Strengthening fisheries and biodiversity management in ACP countries".

INTRODUCTION

Un nombre d'études existent qui décrivent les ressources aquatiques (surtout marines) du Gabon, et leur utilisation par la pêche (voir FishBase; www.fishbase.org), mais la plupart on été publiées par des auteurs étrangers. Il n'est donc pas surprenant qu'aucune étude n'ait été publiée sur les noms communs locaux des espèces en question.

Vu l'importance des noms communs de poissons pour une communication effective entre les gestionnaires et le pêcheurs, nous présentons ici un répertoire synonymique des poissons les plus importants pour la pêche continentale et côtière du Gabon, comprenant les noms scientifiques, les noms commerciaux (en français) et les noms en Fang, une des langues principales du pays, surtout dans la zone côtière (Tableau 1).

Table 1. Répertoire synonymique de quelques poissons du Gabon.

Nom scientifique	Nom commercial en français	Nom en Fang
Brycinus kingsleyae	Tétra africain	Mbara
Alestes longipinis	Tétra africain	Obar
Alestes mactrolepidotis	Tétra africain	Fabara
Aphyosemion australe	Killi	Mbonha
Atopochilus savorgnani	Atopochilus	Nlaghle
Barbus compinei	Barbus	Indo
Barbus condei	Barbus nain	Indo
Barbus guirali	Barbus	Indo
Barbus holotaenia	Barbus	Indo
Boulengeromyrus knoepfferi	Mormyre	Anène
Brienomyrus longicaudatus	Mormyre	Ntotom
Coecomastacembelus flavomarginatus	Petite anguille	Ngwong
Coecomastacembelus marchei	Petite anguille	Ngwong
Chiloglanis camerunensis	Chiloglanis	Nlaghle
Chrisichthys nigrodigitatus	Mâchoiron	Nsong-Nsong
Chrisichthys walkeri	Mâchoiron	Keme
Citharichthys stampflii	Perpeire lisse	–
Clarias buthupogon	Silure	Ngoloungô
Clarias gabonensis	Silure	Ngol
Clarias gariepinus	Silure	Andouma
Congocharax gossip	Charan nain	–
Ctenopoma kingsleyae	Perche grimpeuse	Amogh
Ctenopoma nanum	Perche grimpeuse	Agnene
Dasyatis ukpam	Raie pastenague	Nkogli
Distichodus notospilus	Distichodus	Nzemengoue
Doumea typical	Doumé	–
Epiplatys sexfasciatus	Epiplatys à 6 rayons	Mbonha
Ethmalosa fimbriata	Sardine des Estuaires	Mvélé
Eucinostomus melanopterus	Friture argentée	–
Hemichromis bimaculatus	Hémichromis à deux tâches	Essoumesso
Hemichromis fasciatus	Hémichromis rayé	Esso
Hepsetus odoe	Brochet	Nsoul ou nso
Heterotis niloticus	–	–
Ivindomyrus opdenboschi	Mormyre	Ntotom
Liza falcipinnis	Mulet	Bone
Lutjanus endecantathus	Rouge	Engil
Malapterurus electricus	Silure électrique	Anya
Microsynodontis batesii	Synodontis Nain	Ngong
Nannocharax intermedins	Nannochorax	–
Nannaethiops unitaeniatus	Nannaethiops	–
Nannochrax ogoensis	Nannochorax	–
Neolebias ansorgii	Néon	–
Neolebias unifasciatus	Néon	–
Oreochromis machrochir	Carpe	Ekouni
Oreochromis niloticus	Carpe	Ekouni
Oreochromis schwebischi	Carpe	Ekouni
Parrachana obscura	Lotte, ou poisson à tête de serpent	Ntoumounsog
Parauchenoglanis boutchangai	Bambonga	–
Peleonula vorax	Sardine	Nzombimbi
Petrocephalus simus	Mormyre	Adoua
Physailia occidentalis	Poisson de verre	Nguemboue
Pomadasys jubelini	Dorade grise	Woroworé
Pristis microdon	Poisson scie	Mvag
Protopterus dolloi	Protoptère	Evonha
Sicydium drevifile	Gobie	–
Tilapia ogowensis	Carpe	Ekouni
Tilapia rendalli	Carpe	Ekouni

Table 1. (cont.).

Nom scientifique	Nom commercial en français	Nom en Fang
Stomatorhinus walkeri	Mormyre	Ntotom
Tilapia cabrae	Carpe	Ekouni
Tilapia guineensis	Carpe	Ekouni
Tilapia tholloni	Carpe	Ekouni
Xenocharax pilurus	Xenocharax	Efouegne
Xenomystus nigri	Poisson couteau	Nfabla

BEMBA LOCAL NAMES OF LAKE FISHES IN NORTHERN ZAMBIA

NOMS LOCAUX BEMBA DE POISSONS LACUSTRES DU NORD DE LA ZAMBIE

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ABSTRACT

The Bemba speaking people live in the Northern and Luapula provinces of Zambia, which includes lakes Mweru, Bangweulu, Mweru-wa-ntipa and Tanganyika. The main rivers are the Chambeshi and Luapula. The Bemba language includes fourteen dialects and most of the fish names are common to all. Names are based on colour, relative sizes, economic importance and shape. In some cases, a group of species has been given one common name while for some species; different names are given to different life stages. Overall, this paper documents the common Bemba names of 63 fish species belonging to 15 families occurring in the lakes and rivers of Northern Zambia.

RESUME

Les peuples de langue Bemba vivent dans les provinces du nord et de Luapula de la Zambie, qui incluent les lacs Mweru, Bangweulu, Mweru-wa-ntipa et Tanganyika. Les principaux fleuves sont le Chambeshi et le Luapula. La langue Bemba possède quatorze dialectes et la plupart des noms de poissons sont commun à tous. Les noms sont basés sur la couleur, la taille relative, l'importance économique et la forme. Dans certains cas, un groupe d'espèces porte le même nom tandis que, pour certaines espèces, des noms différents sont donnés aux différentes phases de vie. Ce travail documente les noms communs en langue Bemba de 63 espèces de poissons appartenant à 15 familles présentes dans les lacs et rivières du nord de la Zambie.

INTRODUCTION

Local knowledge is very important in any study of natural resources. In fisheries management, accurate knowledge about behaviour, biology and ecology of the species caught are vital prerequisites. Indeed, local knowledge, notably of local taxonomies, provides a good foundation for any biological study (Berlin, 1992).

The Northern and Luapula provinces of Zambia are regions of great lakes of Zambia. In this region lie Zambia's natural lakes: Mweru, Bangweulu, Mweru-wa-ntipa and Tanganyika. The main rivers are the Chambeshi and Luapula. It is in this region that we find the Bemba speaking people. The Bemba language which belongs to the Southern Bantu group (Ruhlen, 1991) includes fourteen dialects, corresponding to fourteen tribal grouping, the Bwile, Shila, Lunda, Chishinga, Aushi, Kabende, Ng'umbo and Unga in Luapula Province and the Tabwa, Lungu, Mukulu, Bisa and Bemba in Northern Province.

Fishing is the main activity of the Bemba speaking people living along these rivers and lakes where they catch a wide range of fish species. They have named these fishes basing on their colour, relative sizes, economic importance or shape. In some cases, a group of species has been given one common name, while for some fish species different names were given to different life stages. Some species acquire a different name after they have been caught and processed.

This paper aims to document the common Bemba names of the fish occurring in the lakes and rivers of Northern Zambia for eventual introduction into FishBase (Froese and Pauly, 2000).

METHODS

Vernacular names of local fish species were compiled from field manuals developed over time by the field stations of Lake Bangweuru Research Unit, Lake Mweru-Luapula Research Unit, Lake Mweru-Wa-Ntipa Research Unit and Lake Tanganyika Research Unit and verified during interviews where informants were also consulted for the meaning of various names. All scientific and English common names were verified using FishBase (www.fishbase.org).

RESULTS AND DISCUSSION

Altogether names were identified for 63 species in 15 families. Table 1 summarises the results, by area (fisheries) viz: (1) Lake Bangweulu and Chambeshi River, (2) Lake Mweru, Lake Mweru-Wa-Ntipa and Luapula River and (3) Lake Tanganyika. Not all the species of the region are listed, but only those, which the local fishers encounter most frequently.

The meaning of names could be established for only four species, viz:

- *Marcusenius discorhynchus* (parrotfish): Chipumamabwe from 'chipuma' (hitting) and 'mabwe' (stone or rock). This name applies to *M. stappersii* as well, both species being perceived as one 'kind';

- *Limnothrissa miodon* (sardine): 'kapenta' refers to 'ladies who put make up', i.e., sex workers. 'Kapenta' also applies to *Stolothrissa tanganicae*, which is perceived as one 'kind' with *L. miodon* in the Bangweulu and Mweru areas. *L. miodon* is also called 'chisamba' (swimming fish) in the Tanganyika area referring to their occurrence on surface waters on the early hours of the day (and hence the visibility of their swimming behaviour).

We look forward to the above information being included into FishBase, and thus becoming available to a wider community.

Table 1. Scientific, English and Bemba names of lake fishes in Northern Zambia. English names marked with asterisk are from FishBase (www.fishbase.org).

Scientific Name	English Name	Bemba Name: Bangweuru or Chambeshi	Bemba Name: Mweru-Luapula or Mweru-Wa-Ntipa	Bemba Name: Tanganyika
PROTOPTERIDAE	Lungfishes	–	–	–
Protopterus annectens	Lungfish	Nsompo	–	–
MORMYRIDAE	Snout-fishes	–	–	–
Mormyrus caballus	Snout-fish	Mbubu	Kafutwe	–
Mormyrus longirostris	Snout-fish	Mbubu	Kafutwe	–
Mormyrops anguilloides	Cornish jack	Lombolombo	Milobe	Mulobe
Campylomormyrus tamandua	Wormjawed mormyrid*	Chongomumbi	–	–
Gnathonemus petersii	Elephantnose fish*	–	Kalimulimo	–
Marcusenius macrolepidotus	Bulldog	Nchesu	Lububu	–
Marcusenius monteiri	Bulldog	Muntesa,	Lusa	Lusa
Petrocephalus simus	–	Chise	Lububu	–
Hippopotamyrus discorhynchus	Parrot-fish	Chipumamabwe	Chipumamabwe	–
Pollimyrus stappersii stappersii	–	Chipumamabwe	Chipumamabwe	–

Table 1. **(cont.).**

Scientific Name	English Name	Bemba Name: Bangweuru or Chambeshi	Bemba Name: Mweru-Luapula or Mweru-Wa-Ntipa	Bemba Name: Tanganyika
CLUPEIDAE	Herrings, shads, sardines, menhadens*	–	–	–
Limnothrissa miodon	Sardine	Kapenta	Kapenta	Chisamba
Stolothrissa tanganicae	Sardine	Kapenta	Kapenta	Chilwe
Poecilothrissa moeruensis	Sardine	–	Kasepa	–
Potamothrissa acutirostris	Sardine	–	Chisense	–
HEPSETIDAE	–	–	–	–
Hepsetus odoe	Pike	–	Mibombo	–
ALESTIIDAE	African tetras*			
Alestes grandisquamis	Pinkfin	Mutula	Chitololo	–
*Alestes humili*s	–	–	Ntuntu	–
Alestes macrophthalmus	Silver alestes	Manse	Misebele	Mibanse
Brycinus imberi	Spot-tail alestes	Nsaku	Nsakwila	–
Hydrocynus vittiger	Tiger-fish	Manda	Mcheni	–
CITHARINIDAE	Moonfishers	–	–	–
Distichodus maculatus	Spotted citharinid*	Lubala	Mukakabala	–
CYPRINIDAE	Minnows or carps*		–	–
Labeo simpsoni		Kolongwe	–	–
Barbus stappersii		–	Lupeshe	–
Barbus trachypterus	Gorge fish	Pifu	Pifu	–
Barbus paludinosus	Straightfin barb*	Kasepa	Kasenga	–
Barbus eutaenia	Orangefin barb*	Kasepa	Kasenga	–
Barbus radiatus	Redeye barb*	Mimbulwe	–	–
SCHILBEIDAE	Butter fishes	–	–	–
Schilbe mystus	Silver catfish	Lupata	Lupata	–
Schilbe banguelensis	Silver catfish	Lupatapaba	Ibanga	–
CLARIIDAE	Airbreathing catfishes*	–	–	–
Heterobranchus boulengeri	–	–	Katondwa	–
Clarias gariepinus	Catfish	Muta	Mulonge	Mulonge
Clarias ngamensis	Blunt-toothed African catfish*	Nkosi	Akabukula	–
Clarias theodorae	Snake catfish*	Mulonfi	–	–
Clarias buthupogon	–	Bomba	–	–
MOCHOKIDAE	Squeakers or upside-down catfishes*	–	–	–
Euchilichthys royauxi	–	–	Ngansha	–
Synodontis polystigma	Squeaker	–	Bongwe	–
Synodontis ornatipinnis	Squeaker	Nsengemabwe	Bongwe	–
Synodontis unicolor	Squeaker	–	Bongwe	–
Synodontis nigromaculatus	Squeaker	Chinyimba	Bongwe	–
BAGRIDAE	Bagrid catfishes	–	–	–
Chrysichthys mabusi	–	Mfusu	Monde	–
Auchenoglanis occidentalis	Bubu*	Mbowa	Mbowa	–
CICHLIDAE	Breams	–	–	–
Oreochromis macrochir	Green-headed	Pale	Pale	–
Tilapia rendalli	Red-breasted	Mpende	Mpende	–
Tilapia sparrmanii	Banded	Chituku	Chituku	–
Serranochromis angusticeps	Thinfaced	Polwe	Polwe	–
Serranochromis macrocephalus	Purpleface largemouth*	Makobo	Makobo	–
Serranochromis robustus robustus	Yellow bream	Nsuku	–	–

Table 1. **(cont.).**

Scientific Name	English Name	Bemba Name: Bangweuru or Chambeshi	Bemba Name: Mweru-Luapula or Mweru-Wa-Ntipa	Bemba Name: Tanganyika
Serranochromis mellandi	Snaileater*	Mbilia	Mbilia	–
Cyphotilapia frontosa	Humphead cichlid*	–	–	Changongo
Hemibates stenosoma	–	–	–	Mpande
Oreochromis tanganicae	–	–	–	Mpende
Boulengerchromis microlepis	Yellow belly, English-fish	–	–	Nkupi
ANABANTIDAE	Climbing gouramies*	–	–	–
Ctenopoma multispine	Manyspined ctenopoma*	Nkomo	Nkomo	–
MASTACEMBELIDAE	Spiny eels*	–	–	–
Aethiomastacembelus moeruensis	Spiny eel	Muchili	Muchili	Muchili
Aethiomastacembelus signatus	Cross-marked spiny eel	Muchili	Muchili	Muchili
Aethiomastacembelus stappersii	Stappers spiny eel	Muchili	Muchili	Muchili
MALAPTERURIDAE	Electric catfishes*	–	–	–
Malapterurus electricus	Electric catfish*	–	–	Nkunta
CENTROPOMIDAE	Snooks*	–	–	–
Lates mariae	Bigeye lates*	–	–	Pamba ngonzi
Lates microlepis	Forktail lates*	–	–	Nyunvi
Lates angustifrons	Tanganyika perch	–	–	Pamba sikiti
Lates stappersii	Sleek lates*	–	–	Nvolo

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TAXONOMY, COMMON NAMES AND DISTRIBUTION OF FISH IN THE EASTERN ARM OF THE RIFT VALLEY DRAINAGE, KENYA

TAXINOMIE, NOMS COMMUNS ET DISTRIBUTION DES POISSONS DU BASSIN ORIENTALE DE LA RIFT VALLEY, KENYA

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ABSTRACT

This paper attempts to update information on scientific and recommended English common names and the distribution of fish species of Kenya occurring in the Eastern Arm of the Rift Valley drainage system. At least 20 fish families from 35 genera and 66 species occur in the drainage system, with Lake Turkana catchment having the richest species diversity at 50 (76 %). Five (8 %) fish species have been introduced into the drainage, mostly for commercial purposes and sports, *viz*: in Lake Naivasha, largemouth bass, *Micropterus salmoides*; blue spotted tilapia, *Oreochromis leucostictus*; Athi River tilapia, *Oreochromis spilurus niger*; Zill's tilapia, *Tilapia zillii*; and in Lake Nakuru, a species tolerant to high salinities, the Lake Magadi tilapia, *Oreochromis alcalicus grahami*. These introductions may have caused, e.g., the extinction of the Naivasha lampeye, *Aplocheilichthys* sp. from Lake Naivasha. Most fishes occurring in the drainage are at times capable of living in both lacustrine as well as riverine conditions, except three (5 %), which tend to be entirely riverine. Two minnows, (i) Loveridge's barb, *Barbus loveridgii* occurs in Amala River, an affluent of Lake Baringo; and (ii) Newmayer's barb, *Barbus neumayeri* is spread out in several rivers, i.e., Suam in Mount Elgon, Subukia in the Lake Bogoria catchment, Seya in Isiolo district, Sinet near Loitoktok, Waseges in the Lake Bogoria catchment, and Kerio affluent in the Lake Turkana catchment. One cichlid, the Suguta tilapia, *Oreochromis niloticus sugutae* occurs in Suguta River and its tributaries. The exact distribution in northern Kenya of the Ethiopian barb, *Barbus intermedius intermedius* is lacking. Notes are included for selected fish species to clarify and to correct erroneous information occurring in the literature.

RESUME

Cette contribution essaye de mettre à jour l'information sur des noms scientifiques et noms communs anglais et la répartition géographique des espèces de poissons du Kenya au bras oriental du bassin versant de Rift Valley. Il y a au moins 20 familles dont 35 genres et 66 espèces de poissons dans ce bassin, la région du Lac Turkana étant la plus riche, avec 50 (76 %) espèces. Cinq (8 %) espèces ont été introduites dans ce bassin, surtout pour la pêche de loisir ainsi que commerciale, à savoir: au Lac Naivasha, Achigan à grande bouche, *Micropterus salmoides*; Tilapia aux points bleus, *Oreochromis leucostictus*; Tilapia d'Athi, *Oreochromis spilurus niger*; Tilapia de Zill, *Tilapia zillii*; et dans le Lac Nakourou, une espèce tolérante aux salinités élevées, Tilapia du Lac Magadi, *Oreochromis alcalicus grahami*. Ces introductions ont pu avoir causé, par exemple, l'extinction de l'aplochéilidé de Naivasha, *Aplocheilichthys* sp.. La plupart des poissons qui se reproduisent dans le drainage sont parfois capables de vivre dans les lacs et les rivières, excepté trois (5 %), qui tendent à être entièrement riverine. Deux vairons, (i) *Barbus loveridgii* se trouve dans le fleuve d'Amala, un affluent du Lac Baringo; et (ii) *Barbus neumayeri* vit dans plusieurs fleuves: le Souam dans le Mont Elgon, le Subukia dans le Lac Bogoria, le Seya dans le Département d'Isiolo au barrage du Lac Bogoria, le Sinet près de Loitoktok, le Waseges dans le barrage du Lac Bogoria, et le Kerio dans le Lac Turkana.

Un cichlidé, le Tilapia de Suguta, *Oreochromis niloticus sugutae* vit dans le Suguta et ses tributaires. Le Barbeau, *Barbus intermedius intermedius*, n'a pas sa distribution au Kenya définie. Des notes sont inclues pour quelques espèces de poissons, qui clarifient et corrigent des informations publiées.

INTRODUCTION

The Eastern Arm of the Rift Valley begins in Jordan in the Middle East and extends southwards through East Africa and Mozambique into the Indian Ocean. The Eastern Arm is joined in Malawi by a Western Arm which arches northwards and ends in western Uganda. Low areas of the Rift Valley are characterised by a chain of saline or brackishwater lakes, high areas (escapements) supplying springs, streams and rivers, especially during rainy seasons. The chain of lakes found in the Kenyan portion of the Eastern Arm of the Rift Valley drainage are Turkana, Ogipi, Baringo, Bogoria, Nakuru, Elementaita, Naivasha, Magadi, Kabongo and Natron. The main rivers supplying the drainage are Turkwell, Suam, Kerio, Suguta, Seya, Sinet, Molo, Perakera, Subukia, Waseges, Njoro, Kariandusi, Malewa, Gilgil and South Uaso Nyiro.

The human population in Africa is predicted to increase by about 3 to 4 times by 2030, mainly in coastal regions and lake and river basins, and will bring about ecosystem degradation, along with exotic organisms (Craig, 1992). There is thus an urgent need to study the biodiversity of the watersheds of this region.

The current knowledge of the fish species of Kenya occurring in the Eastern Arm of the Rift Valley drainage is largely based on updates of comprehensive surveys carried out since the late 19th century (Kersten, 1869; Boulenger, 1909, 1911, 1915, 1916; Worthington and Ricardo, 1936; Trewavas, 1953; Copley, 1958; EAFRO, 1962; EAFFRO, 1976; KMFRI, 1981). This study attempts to fill certain gaps by listing the scientific and recommended English common names and distribution of fish of this important and unique drainage of Kenya, thus complementing the study recently done on the fishes of Kenya in the Athi-Galana-Sabaki drainage systems (Okeyo, 1998). It is hoped that the results will be useful to fisheries managers, students of fish taxonomy and ecology, curators and researchers working on African fish.

METHODS

The Kenyan portion of the Eastern Arm of the Rift Valley forms one the largest Kenyan drainages, especially in terms of the number of individual catchment areas and it consists of a series of lakes and rivers (Figure 1). Lake Turkana, like almost all Rift Valley lakes, is situated in an interior basin with no outlet. Its largest affluent is the Omo River in the North, which is situated entirely in Ethiopian territory. Rising from Mount Elgon in the southwest of Lake Turkana, is the Turkwell River which does not regularly reach the lake, but stays dry at time of reduced rainfall. This is also true for the Kerio and Suguta Rivers which flow northwards in the Rift Valley; especially, the Suguta only rarely reaches Lake Turkana.

Lake Baringo is situated in one of the interior basins of the Rift Valley. There are some smaller seasonal rivers, mainly in the south such as the Molo and the Perakera Rivers, bringing water into the lake. Lake Bogoria is normally a salt water lake, but the Waseges River, which enters the lake from the North, contains fresh water. The river dries up in dry periods. Ol Bolosat Swamp exists to the North-East of Lake Nakuru. The ecology of the swamps is not yet well studied. Lake Nakuru has only a very small catchment and dries up sometimes. The main natural drainage into Lake Nakuru is fed by the River Njoro; waste waters from Nakuru Town also contribute a great deal of inflows to the lake, sometimes polluting it. Lake Elementaita is a salt lake; the main drainage into Lake Elementaita is the River Kariandusi, originating from the Aberdare Mountain ranges. The river carries with it some effluent water of the Kariandusi Diatomite Mines and factories located nearby along the main Nairobi-Nakuru road. Other drainages into Lake Elementaita come from the opposite Mau Escapement. Lake Naivasha has fresh water; the Malewa and Gilgil Rivers bring water from the Aberdare Mountains into the lake. It is believed that the bulk of Lake Naivasha water is contributed by supplies from some underground springs as well as outlets in the form of underground seepage. Lake Magadi sits in the hot semi and arid high salt catchment areas of the southern part of the drainage. High evaporation rates occur, leaving behind salt crystals exploited by the Magadi Soda Company. The main sources of water supply into the lake are underground freshwater springs. Lake Natron's basin occupies the largest part of the southern areas of the Kenyan portion of the East Arm of the Rift Valley drainage. The Southern Uaso Nyiro rises in the Mau Escapement and flows southwards to empty into Lake Natron, via the Shombole Swamps, just at the Kenya/Tanzania border.

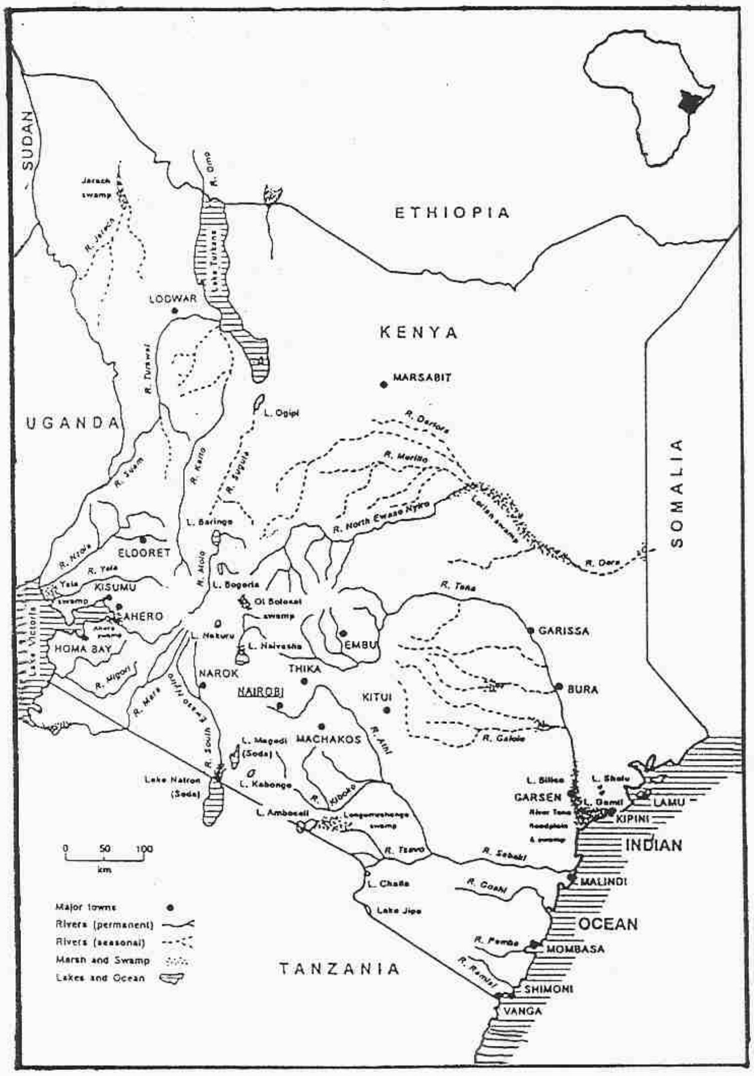

Figure 1. The major water drainages of Kenya. The Kenyan East Arm of the Rift Valley system ranges from Lake Turkana in the north to Lake Natron in the South.

This study is based on intensive literature search and examination of museum collections. It also involved field visits to collect fish. All fish were subjected to standard methods of systematic and taxonomic field as well as laboratory analysis (Boulenger, 1911; 1916).

The taxonomic revisions on fish species of the Kenyan portion of the Eastern Arm of the Rift Valley drainage system published by various naturalists (Peters, 1868; Boulenger, 1909-1916; Worthington, 1932; Worthington and Ricardo, 1936; Trewavas, 1933; EAFRO, 1949; EAFFRO, 1964; UFFRO, 1977; TAFIRI, 1984; KMFRI, 1981) all considered here were using the database of the British Museum of Natural History, London. As well, Eschmeyer (1990) was widely followed with some modifications and exceptions. For example, Characidae were considered as independent families, following Nelson (1994). In contrast to Nelson (1994), however, Myers (1929), Gery (1977) and Paugy (1986) were followed in accepting the characins, genus *Brycinus* Valenciennes in Cuvier and Valenciennes, 1849 as distinct from the genus *Alestes* Muller and Troschel, 1844. Distichodidae are treated as a family in accordance with Vari (1979). Mo (1991) was followed in recognising the family Claroteidae as separate from the family Bagridae. The Eastcoast lampeye, genus *Pantanodon*, is placed in the family Aplocheilichthyidae (topminnows or lampeyes) according to Sethi (1960) and in accordance with information from Meyer and Lydeard (1993). Mastacembelidae (spiny eels) was recognised as a family under the order Synbranchiformes, and not the order Perciformes, in accordance to Gosline (1983) and Travers (1984a, b). All spellings of fish names follow the original descriptions. The scientific name is followed by the most appropriate English common name where possible. Names of the authorities who recorded (original) information on respective fish species are included.

Data were also collected on the general distribution of fish in the drainage system with respect to the lakes, rivers and associated swamps of the drainage. This was aimed at providing general patterns of local fish distribution. However, data from the Southern Uaso Nyiro catchment area is not included in this contribution.

RESULTS AND DISCUSSION

Diversity

A total of at least 20 fish families with 35 genera and 66 species occur in the Kenyan portion of the Eastern Arm of the Rift Valley (Table 1). Of these, at least 17 (26 %) belong to the family Cyprinidae (barbs, minnows, labeos), 13 (20 %) are Cichlidae (cichlids), 9 (14 %) Characidae (characins), 3 (5 %) each of Mochokidae (squeakers, suckermouths) and Aplocheilichthyidae, 2 (3 %) each of Polypteridae (bichirs), Mormyridae (snoutfishes), Bagridae, Claroteidae, Clariidae (catfishes), and Centropomidae and 1 (2 %) each of Osteoglossidae (bonytongues), Gymnarchidae (gymnarchids), Distichodidae, Citharinidae, Schilbeidae (butter catfishes), Amphiliidae (mountain catfishes), Melapteruridae (electric catfishes), Centrarchidae (sunfishes, freshwater basses), and Tetraodontidae (puffers). At least 61 (92 %) fish species reported from the drainage occur in their natural water bodies; 5 (8 %) fish species with the highest number for commercial and sports values have been introduced into Lake Naivasha (e.g., Largemouth bass, *Micropterus salmoides* (Lacepede, 1802), Blue spotted tilapia, *Oreochromis leucostictus* (Trewavas, 1933), Athi River tilapia, *Oreochromis spilurus niger* (Gunther, 1894), Zill’s tilapia, *Tilapia zillii* (Gervais, 1848) (Trewavas, 1933), and fish species tolerant to high salinities, i.e., Lake Magadi tilapia, *Oreochromis alcalicus grahami* (Boulenger, 1912), introduced into Lake Nakuru (Vareschi, 1979; Table 2). There were a few fish species which naturally occurred in the Lake Naivasha catchment area (e.g., lampeyes of the genus *Aplocheilichthys*, and Straightfin barb, *Barbus paludinosus* Peters, 1852). The Naivasha lampeye, *Aplocheilichthys* sp. has been extinct from the lake since the introductions.

Distribution

The general distribution (Table 2) of fish species of the drainage shows more concentration (at least 50 species or 76 %) in the Lake Turkana catchment area, 38 (58 %) of which are mainly lacustrine and which tend to be restricted only to the lake (e.g., Nile bichir, Sénégal bichir, African bonytongue, Ngai, Aba aba, Nile barb, Turkana barb, Turkana sardine, Turkana minnow, Nile ditichodus, Turkan citharine, Egyptian robber, Nile robber, Large-toothed Turkana robber, Large-scaled robber, Dwarf Turkana robber, Nurse tetra, Elongate tigerfish, Tigerfish, Elongate robber, Black Nile-catfish, Sudan catfish, Golden Nile-catfish, Egyptian buttercatfish, Whiptailed Nile-catfish, Vundu, Electric catfish, Dwarf Nile-catfish, Sudan squeaker, Nile squeaker, Turkana lampeye, Turkana perch, McConnel’s haplo, Lake Rudolf haplo, Lake Turkana mouthbrooder, Nile jewel cichlid, Galilaea tilapia, Nile puffer). At least 14 (21 %) species in the Lake Turkana catchment area are lacustrine as well as riverine and may occur elsewhere in the drainage (e.g., Elephant-snout fish, Neumayer’s barb, Midspot barb, Redeye labeo, Assuan labeo, Nile labeo, Nile minnow, Bottego’s minnow, Giraffe catfish, Sharptooth catfish, Omo lampeye, Nile perch, Turkana tilapia, Zill's tilapia). The bulk of Lake Turkana fishes are exploited commercially.

Table 1. Fishes of Kenya known to occur in the Eastern Arm of the Rift Valley drainage system. Fish families containing representatives of introduced fish species are designated by asterix (*).

Family	Genera	Species
Ploypteridae	1	2
Osteoglossidae	1	1
Mormyridae	2	2
Gymnarchidae	1	1
Cyprinidae	5	17
Distichodidae	1	1
Citharinidae	1	1
Characidae	4	9
Bagridae	1	2
Claroteidae	2	2
Schilbeidae	1	1
Amphiliidae	1	1
Clariidae	2	2
Melapteruridae	1	1
Mochokidae	2	3
Aplocheilichthyidae	1	3
Centropomidae	1	2
Centrarchidae*	1	1
Cichlidae*	5	13
Tetraodontidae	1	1
TOTAL	35	66

Two (3 %) species occurring in the drainage (Line-spotted barb, *Barbus lineomaculatus* Boulenger, 1903, and Sharptooth catfish, *Clarias gariepinus* (Burchell, 1822), are caught exclusively within Lake Baringo and 4 (6 %) species occur in the Lake Baringo catchment area (Baringo barb, *Barbus intermedius australis* Banister, 1973, Zanzibar barb, *Barbus zanzibaricus* Peters, 1868, redeye labeo, *Labeo cylindricus* Peters, 1852, Baringo tilapia, *Oreochromis niloticus baringoensis* Trewavas, 1983).

No fishes naturally occur in Lake Bogoria; but 2 freshwater species occur in the Waseges River which enters the lake from the North (Neumayer's barb, *Barbus neumayeri* Fischer, 1884; Sharptooth catfish, *Clarias gariepinus* (Burchell, 1822). The river dries up in dry periods; but evidently there must remain some restwater pools for the fishes to prosper in the river. Lake Nakuru also experiences periods of drying. The sole species, repeatedly introduced but which is able to live in the alkaline waters of Lake Nakuru is the Lake Magadi tilapia, *Oreochromis alcalicus grahami* (Boulenger, 1912).

There are no fishes which naturally occur in the catchment area of the salty Lake Elementaita. There are, however recent reports of unidentified tilapia species, which may have been introduced (Kenneth Mavuti, University of Nairobi, Kenya, pers. comm.) through effluents from aquaculture ponds which exist at the banks of the lake's main drainage system, the River Kariandusi. Lake Magadi is the natural habitat for the Lake Magadi tilapia, *Oreochromis alcalicus grahami* (Boulenger, 1912). The life of the fish in the lake is only made possible by the springs which supply relatively fresh water. Lake Magadi has historically been the source for seedfish used for introduction into Lake Nakuru.

Table 2. Scientific, recommended English common names and authorities of fishes of Kenya in the Eastern Arm of the Rift Valley drainage system. Authority and date are isolated by a comma according to the International Code of Zoological Nomenclature (1985). Pagination is included for convenience. Fish species with uncertain occurrences are designated by question mark (?); (-) indicates no suggested common name. Included are some taxonomic notes on selected fish species; citations of distribution may refer to some synonyms.

No.	Order	Family	English name	Scientific name	Author	English name	Distribution
1	Polypteriformes	Polypteridae	Bichirs	*Polypterus bichir bichir*	Geoffroy Saint Hilaire, 1802	Nile bichir	Lake Turkana (Boulenger, 1909: 7; Hopson and Hopson, 1982: 291).
2				*Polypterus Sénégalus Sénégalus*	Cuvier, 1829	Sénégal bichir	Lake Turkana (Boulenger, 1909: 15; Hopson and Hopson, 1982: 289)
3	Osteoglossiformes	Osteoglossidae	Bonytongues	*Heterotis niloticus*	(Cuvier, 1829)	African bonytongue	Lake Turkana (Boulenger, 1909: 151; Hopson and Hopson, 1982: 291)
4		Mormyridae	Snout fishes	*Hyperopisus bebe*	(Lacepède, 1803)	Ngai	Lake Turkana (Hopson and Hopson, 1982: 292)
5				*Murmyrous kannume*	Forsskal, 1775	Elephant-snout fish	Turkwell River and Lake Turkana (Hopson and Hopson, 1982: 290)
6		Gymnarchidae	–	*Gymnarchus niloticus*	Cuvier, 1829	Aba aba	Lake Turkana (Boulenger, 1909:145; Hopson and Hopson, 1982:294)
7	Cypriniformes	Cyprinidae	Barbs, minnows and labeos	*Barbus bynni*	(Forsskal, 1775)	Nile barb	Lake Turkana (Pellegrin, 1905; Hopson and Hopson, 1982: 309). Note: Pellegrin, 1905: 293 refers to it as *Barbus meneliki*.

Table 2. (cont.).

No.	Order	Family	English name	Scientific name	Author	English name	Distribution
8				*Barbus intermedius intermedius*	Ruppell, 1835	Ethiopia barb	Northern Kenya (Banister, 1973). Note: the date of publication of Rüpp paper is discussed by Banister (1973: 47) who assumed 1837 as the corr date. Lévêque and Daget in Daget *et al.*, 1984 (CLOFFA 1) assessed 18 the correct date of publication while in Daget *et al.*, 1986 (CLOFFA 3) t publication is dated 1835. Rüppell's article in fact should appear in volu of the publication "Museum Senckenbergianum". This volume was pub in at least two parts. The last part which completed the volume appearec 1837 (Richter, 1935). This part contained the title page bearing the date year 1837. The first part, containing pages 1 to 116, and hence the articl Rüppell (pages 1-28), however was published already in 1836 (hand wri note in a copy of volume 2 of Mus. Senckenb. of the Zoologisches Muse Berlin, which is confirmed by Dean, 1917: 369). The publication date o Museum Senckenbergianum article of Rüppell therefore is 1836 and not as assumed by Banister (1973) or listed in many library catalogues, incl Richter (1935). Rüppell evidently wanted his article to be published as s possible and did not want to wait until the regular issue of Mus. Sencke was distributed. On his own costs, and therefore not listed in Richter (19 he ordered separates. Those preprints are clearly dated 1835 on the title as cited in Banister (1973: 4). This date of publication is to be adopted a correct in the absence of evidence to the contrary, and hence the date of publication of the paper of Rüppell is 1835 according to article 21 (b) ar of the International Code of Zoological Nomenclature (1985).
9				*Barbus intermedius australis*	Banister, 1973	Baringo barb	Lake Baringo drainage. Note: Lake Baringo is the type locality.
10				*Barbus lineomaculatus*	Boulenger, 1903	Line-spotted barb	Lake Baringo (Mann, 1971: 30)
11				*? Barbus loveridgii*	Boulenger, 1916	Loveridge's barb	"Amala River", an affluent of Lake Baringo, Kenya (Greenwood, 1962: Mann, 1971). Note: This species is known from the types only (Greenw 1962: 182). The type locality "Amala River", is in doubt (Mann, 1971).

Table 2. (cont.).

No.	Order	Family	English name	Scientific name	Author	English name	Distribution
12				*Barbus neumayeri*	Fischer, 1884	Neumayer's barb	Suam River (Mount Elgon), Subukia River (Lake Bogoria drainage), River (Isiolo district), Sinet River near Loitoktok (Greenwood, 1962: Waseges River (Lake Bogoria drainage) (Mann, 1971: 29); Kerio aff Lake Turkana drainage. Note: The status of *Barbus neumayeri* is yet resolved; it is unclear if the species at present known under this name identical with the species as represented by the type specimens. At pr species is considered to be *Barbus neumayeri* of which the specimens populations show a variable pattern of black spots along the midline. populations there are fish with three such black spots of irregular size sports may merge with each other and even form an interrupted longi band. According to Fischer (1884: 31) the upper part of the body was black, the lower part light to whitish in the types of *Barbus neumayer* size of the two types is 10.1 and 11 cm which is enormous for *Barbu* *neumayeri* in the present sense. The more recent collections from the Uaso Nyiro, Kenya, which are at the British Museum of Natural Hist (BMNH) contained barbs with well corresponding colouration as des Fischer; the specimens, however, did not show a black midlateral bar black spots. It is therefore at present unclear if the black spotted/band previously described for East Africa, and the Southern Uaso Nyiro fi colour morphs of one species only or if both are distinct.
13				*Barbus paludinosus*	Peters, 1852	Straightfin barb	Lakes and rivers in the drainage (Greenwood, 1962). Note: actually *I* *paludinosus* occurs in lakes and rivers throughout Kenya.
14				*Barbus stigmatopygus*	Boulenger, 1903	Midspot barb	Lake Turkana drainage (Boulenger, 1911: 169; Hopson and Hopson, 312). Note: *Barbus werneri* Boulenger, 1905 is a synonym of *Barbus stigmatopygus* according to Banister (1987).
15				*Barbus turkanae*	Hopson and Hopson in Hopson, 1982	Turkana barb	Lake Turkana. Note: Lake Turkana is the type area.
16				*Barbus zanzibaricus*	Peters, 1868	Zanzibar barb	Lake Baringo drainage.
17				*Chelaethiops bibie*	(De Joannis, 1835)	Turkana sardine	Lake Turkana (Hopson and Hopson, 1982: 314).
18				*Labeo cylindricus*	Peters, 1852	Redeye labeo	Lake Baringo drainage (Worthington and Ricardo, 1936: 385; Mann, 31); upper reaches of Turkwell/Kerio systems (Hopson and Hopson, 308).

Table 2. (cont.).

No.	Order	Family	English name	Scientific name	Author	English name	Distribution
19				*Labeo horie*	Heckel, 1846	Assuan labeo	Lake Turkana drainage (Worthington and Ricardo, 1936: 370; Hops Hopson, 1982: 307).
20				*Labeo niloticus*	(Forsskal, 1775)	Nile labeo	Lake Turkana (Reid, 1985: 66). Note: Hopson and Hopson mentione *Labeo* species from the Lake Turkana drainage only: *Labeo cylindri* Peters, 1852 from the upper reaches of rivers flowing into the lake a *Labeo horie* Heckel, 1946 from the lake itself. The problem encomp the identity of the Lake Turkana labeo(s) is therefore not sufficiently
21				*Leptocypris niloticus*	(De Joannis, 1835)	Nile minnow	Lake Turkana drainage (Worthington and Ricardo, 1936: 371; Hops Hopson, 1982: 312). Note: Hopson and Hopson, 1982: 312 recorded name of the fish species as *Barilius niloticus*.
22				*Neobola bottegoi*	(Vinciguerra, 1895)	Bottego's minnow	Lake Turkana drainage, Omo River (Howes, 1984).
23				*Neobola stellae*	(Worthington, 1932)	Turkana minnow	Lake Turkana (Hopson and Hopson, 1982: 313). Note: Lake Turkan type area. Hopson and Hopson, 1982: 313 recorded the name of the species as *Engraulicypris stellae*.
24	Characiformes	Distichodida e	Distichodines	*Distichodus niloticus*	(Linnaeus, 1762)	Nile distichodus	Lake Turkana (Günther, 1896: 223; Hopson and Hopson, 1982: 307 Günther, 1896: 223 recorded the name of the fish species as *Distich rodolphi*.
25		Citharinidae	Citharines	*Citharinus citharus intermedius*	Worthington, 1932	Turkana citharine	Lake Turkana (Hopson and Hopson, 1982: 306). Note: Late Turkana type area. This apparently is the fish species Hopson and Hopson, 19 recorded its name as *Citharinus citharus*.
26		Characidae	Characins	*Alestes baremoze*	(De Joannis, 1835)	Egyptian robber	Lake Turkana (Boulenger, 1909: 196; Hopson and Hopson, 1982: 29
27				*Alestes dentex*	(Linnaeus, 1758)	Nile robber	Lake Turkana (Boulenger, 1909: 194; Hopson and Hopson, 1982: 29
28				*Brycinus ferox*	(Hopson and Hopson in Hopson, 1982)	Large-toothed Turkana robber	Lake Turkana (Hopson and Hopson, 1982: 299). Note: Lake Turkan type area. The fish was originally described as *Alestes ferox*, but is c placed in the genus *Brycinus* by Lévêque *at al.* (1991: 134).
29				*Brycinus macrolepidotus*	(Valenciennes in Cuvier and Valenciennes, 1849)	Large scaled robber	Lake Turkana (Hopson and Hopson, 1982: 304). Note: Fowler (193 reported this fish species also to occur in Lake Victoria, using only c specimen of a total length of 328 mm, collected from Kitala, Ugand in Daget *et al.* (1984: 154) gives Lake Victoria as a locality; but thes reports are doubtful. There is no substantiated indication that the fish is present in Lake Victoria.

Table 2. (cont.).

No.	Order	Family	English name	Scientific name	Author	English name	Distribution
30				*Brycinus minutus*	(Hopson and Hopson in Hopson, 1982)	Dwarf Turkana robber	Lake Turkana (Hopson and Hopson, 1982: 302). Note: Lake Turkan type area. The original name of the fish species was described as *Ale minutus* Hopson, 1982, which is currently placed in the genus *Brycir* Lévêque *et al.* (1991: 134).
31				*Brycinus nurse*	(Ruppell, 1832)	Nurse tetra	Lake Turkana (Boulenger, 1909: 207; Pellegrin, 1935: 133; Hopson Hopson, 1982: 298). Note: Pellegrin, 1935: 133 recorded the fish spe *Alestes nurse* var. *nana* Pellegrin, 1935 "Nanoropus (lac Rodolphe)"
32				*Hydrocynus forskahlii*	(Cuvier, 1819)	Elongate tigerfish	Lake Turkana (Boulenger 1909: 181; Hopson and Hopson 1982: 29 Boulenger (1909: 181) Recorded the fish species as *Hydrocyon forsk* Boulenger, 1909.
33				*Hydrocynus vittatus*	Castelnau, 1861	Tigerfish	Lake Turkana (Worthington and Ricardo, 1936; Hopson and Hopsor 296). Note: Hopson and Hopson, 1982: 296 recorded the nameof the species as *Hydrocynus lineatus* Hopson and Hopson, 1982; as to the of this species see Brewster (1986) and Paugy and Guegan (1989).
34				*Micralestes elongatus*	Daget, 1957	Elongated robber	Lake Turkana (Hopson and Hopson, 1982: 305). Note: Hopson and 1982: 305 recorded the name of the fish species as *Micralestes acuti* (Peters, 1952). *Micralestes acutidens*, however, does not naturally o the Nile System to which Lake Turkana belongs. The characin listed Hopson and Hopson (1982: 305) under the name *Micralestes acutid* fact is *Micralestes elongatus* according to Paugy (1990: 80) and Lév *al.* (1991).
35	Siluriformes	Bagridae	Bagrid catfishes	*Bagrus bajad*	(Forsskal, 1775)	Black Nile catfish	Lake Turkana (Worthington and Ricardo, 1936: Hopson and Hopsor 315).
36				*Bagrus docmak*	(Fosskal, 1775)	Sudan catfish	Lake Turkana (Hopson and Hopson, 1982: 316).
37		Claroteidae	Calaritid catfishes	*Auchenoglanis occidentalis*	(Valenciennes in Cuvier and Valenciennes, 1840)	Giraffe catfish	Lake Turkana drainage (Vinciguerra, 1898: 250; Boulenger, 1911: 3 Hopson and Hopson, 1982: 318). Notes: Vinciguerra, 1898: 250 rec the fish species name as *Oxyglanis sacchii* Vinciguerra, 1898 "fiume Murzu".
38				*Chrysichthys auratus*	(Geoffroy Saint Hilaire, 1809)	Golden Nile catfish	Lake Turkana (Hopson and Hopson, 1982: 317).
39		Schilbeidae	Butter catfishes	*Schilbe uranoscopus*	Ruppell, 1832	Egyptian butter catfish	Lake Turkana (Worthington and Ricardo, 1936; Hopson and Hopsor 319).

Table 2. (cont.).

No.	Order	Family	English name	Scientific name	Author	English name	Distribution
40		Amphiliidae	Mountain catfishes	*Andersonia leptura*	(Boulenger, 1900)	Whiptailed Nile catfish	Lake Turkana (Hopson and Hopson, 1982: 320).
41		Clariidae	Catfishes	*Clarias gariepinus*	(Burchell, 1822)	Sharptooth catfish, Common catfish	All habitable lakes and rivers; Lake Turkana (Worthington and Rica 1936, Hopson and Hopson, 1982: 320); Suguta River (Mann, 1971: : Lake Baringo (Worthington and Ricardo, 1936); Waseges River, Lal Bogoria drainage (Mann, 1971: 32). Note: Occurs throughout the dra system. Mostly listed in the literature under its synonym *Clarias mossambicus* Peters, 1852 (Teugels, 1986). Hopson and Hopson, 19 recorded the fish species name as *Clarias lazera* Valenciennes, 1840 lake.
42				*Heterobranchus longifinis*	Valenciennes in Cuvier and Valenciennes, 1840	Vundu	Lake Turkana (Hopson and Hopson, 1982: 321)
43		Melapterurid ae	Electric catfishes	*Malapterurus electricus*	(Gmelin, 1789)	Electric catfish	Lake Turkana (Pellegrin, 1935: 136; Hopson and Hopson, 1982: 320
44		Mochokidae	Squeakers and suckermouths	*Mochokus niloticus*	De Joannis, 1835	Dwarf Nile-catfish	Lake Turkana (Vinciguerra, 1898: 254; Boulenger, 1911: 494; Hops Hopson, 1982: 325). Note: Vinciguerra, 1898: 254 recorded the nam fish species as *Rhinoglanis vannutelli* Vinciguerra, 1998 "lago Rodo
45				*Synodontis frontotus*	Vaillant, 1895	Sudan squeaker	Lake Turkana (Vinciguerra, 1898: 247; Hopson and Hopson, 1982:3 Note: Vinciguerra, 1898: 247 recorded the name of the fish species a *Synodontis citernii* Vinciguerra, 1898.
46				*Synodontis schall*	(Bloch and Schneider, 1801)	Nile squeaker	Lake Turkana (Günther, 1896: 222, pl. IX; Hopson and Hopson, 198 Note: Günther, 1896: 222, pl. IX recorded the name of the fish speci *Synodontis smithii* Günther, 1896.
47				*Aplocheilichthys jeanneli*	(Pellegrin, 1935)	Omo lampeye	Lake Turkan drainage (Hopson and Hopson, 1982: 326). Note: Lake Turkana is the type area. There is an *Aplocheilichthys* species in the basin (Mann, 1971: 32; Seegers, 1986, photo) which may be *Aplocheilichthys jeanneli*.
48				*Aplocheilichthys rudolfianus*	(Worthington, 1932)	Turkan lampeye	Lake Turkana (Hopson and Hopson, 1982: 326). Note: Lake Turkan type area.
49				*Aplocheilichthys* sp.	"Naivasha" (Extinct species)	Naivasha lampeye	Lake Naivasha. Note: This fish species is extinct from the Lake Naiv This fish species was named *Aplocheilichthys antinorii*.

Table 2. (cont.).

No.	Order	Family	English name	Scientific name	Author	English name	Distribution
50		Centropomidae	Nile perch and related forms	*Lates (Lates) longispinis*	Worthington, 1932	Turkana perch	Lake Turkana (Hopson and Hopson, 1982: 328). Note: Lake Turkana type area.
51				*Lates (Lates) niloticus*	(Linnaeus, 1758)	Nile perch	Lake Turkana (Worthington, 1932: 133; Hopson and Hopson, 1982: 3 Note: Worthington, 1932: 133 recorded the name of the fish species as *niloticus rudolfianus* Worthington, 1932.
52		Centrarchidae	Sunfishes and freshwater basses	*Micropterus salmoides*	(Lacepède, 1802)	Largemouth bass	Introduced into Lake Naivasha.
53		Cichlidae	Cichlids	*Haplochromis (Thoracochromis) macconneli*	Greenwood, 1974	McConnel's haplo	Lake Turkana (Hopson and Hopson, 1982: 336). Note: Lake Turkana type area.
54				*Haplochromis (Thoracochromis) rudolfianus*	Trewavas, 1933	Lake Rudolf haplo	Lake Turkana (Hopson and Hopson, 1982: 334). Note: Lake Turkana type area.
55				*Haplochromis (Thoracochromis) turkanae*	Greenwood, 1974	Lake Turkana mouthbrooder	Lake Turkana (Hopson and Hopson, 1982: 335). Note: Lake Turkana type area.
56				*Hemichromis letourneuxi*	Sauvage, 1880	Nile jewel cichlid	Lake Turkana (Trewavas, 1933: 320, Fig. 4; Hopson and Hopson, 198 330). Note: Trewavas, 1933: 320, Fig. 4 recorded the name of the fish species as *Pelmatochromis exsul* Trewavas, 1933. Hopson and Hopso 1982: 330 recorded the name of the fish species as *Hemichromis bimaculatus* (Boulenger, 1915).
57				*Oreochromis alcalicus alcalicus*	(Hilgendorf, 1905)	Lake Natron tilapia	Lake Natron drainage: Shombole Swamps (Fischer 1884: 28; Coe 196 Note: Lake Natron drainage is the type area. Fischer 1884: 28 record name of the fish species as *Chromis niloticus* var. *mossambicus* Fisch 1884.
58				*Oreochromis alcalicus grahami*	(Boulenger, 1912)	Lake Magadi tilapia	Lake Magadi; introduced into Lake Nakuru in 1953, 1959 and 1962 (Vareschi 1979: 322). Note: Lake Magadi is the type area.

Table 2. (cont.).

No.	Order	Family	English name	Scientific name	Author	English name	Distribution
59				*Oreochromis leucostictus*	(Trewavas, 1933)	Blue spotted tilapia	Introduced into Lake Naivasha.
60				*Oreochromis niloticus baringoensis*	Trewavas, 1983	Baringo tilapia	Lake Baringo drainage (Worthington and Ricardo, 1936; Seegers, 1986).
61				*Oreochromis niloticus sugutae*	Trewavas, 1983	Suguta tilapia	Suguta river and tributaries. Note: Suguta River and tributaries is the type area.
62				*Oreochromis niloticus vulcani*	(Trewavas, 1933)	Turkana tilapia	Lake Turkana drainage (Arambourg, 1948: 472, pl. 38, figs. 1,5,6; pl. 39, fig. 5; Hopson and Hopson, 1982: 332). Note: Lake Turkana drainage is the type area. Arambourg, 1948: pl. 38, figs. 1,5,6; pl. 39, fig. 5 recorded the name of the fish species as *Tilapia crassispana* Arambourg, 1948 (fossil fish). Hopson and Hopson, 1982: 332 recorded the name of the fish species as *Sarotherodon niloticus* (Harbott, 1982).
63				*Oreochromis spilurus niger*	(Günther, 1894)	Athi River tilapia	Intrduced into Lake Naivasha in 1925 (Trewavas, 1933: 312). Note: Trewavas, 1933: 312 recorded the name of the fish species *Tilapia nigra* (Boulenger, 1899).
64				*Sarotherodon galilaeus galilaeus*	(Linnaeus, 1758)	Galilaea tilapia	Lake Turkana (Worthington and Ricardo, 1936; Hopson and Hopson, 1982: 333).
65				*Tilapia zillii*	(Gervais, 1848)	Zill's tilapia	Lake Turkana (Boulenger, 1915: 199; Hopson and Hopson, 1982: 330; ? introduced into Lake Naivasha.
66	Tetraodontiformes	Tetraodontidae	Puffers	*Tetraodon lineatus*	Linnaeus, 1758	Nile puffer	Lake Turkana (Sterba, 1959: 605; Hopson and Hopson, 1982: 337). Note: Sterba, 1959: 605 recorded the name of the fish species as *Tetraodon fahaka rudolfianus* Sterba, 1959. Hopson and Hopson recorded the name of the fish species as *Tetraodon fahaka* Rüppell, 1829.

The Lake Natron basin occupies the largest part of the southern area of the Kenyan portion of the East Arm of the Rift Valley. The southern end of the Kenyan portion of the East Arm of The Rift Valley is concluded by this lake, and the Shombole Swamps which are situated to the North of the lake; the Shombole Swamps is home for one fish species, the Lake Natron tilapia, *Oreochromis alcalicus alcalicus* (Hilgendorf, 1905).

The exact distribution of 3 (5 %) species in the Kenyan portion of the Eastern Arm of the Rift Valley drainage is not determined in this paper. The occurrence of the Ethiopian barb, *Barbus intermedius intermedius* Rüppell, 1835, may spread out throughout northern Kenya and into Ethiopia, while the Straightfin barb, *Barbus paludinosus* Peters, 1852 and the Sharptooth catfish, *Clarias gariepinus* (Burchell, 1822), occur in almost all habitable lakes and rivers.

Endemism

There are at least 3, (5 %) species, 2 minnows and 1 cichlid, in the entire drainage system which are exlusively riverine: Loveridge's barb, *Barbus loveridgii* Boulenger, 1916, occurring in "Amala River", an effluent of Lake Baringo, Newmayer's barb, *Barbus neumayeri* Fischer, 1884, which is spread out in several rivers (Suam, Mount Elgon; Subukia, Lake Bogoria catchment; Seya, Isiolo District; Sinet, near Liotoktok; Waseges, Lake Bogoria catchment; Kerio affluent, Lake Turkana catchment), and Suguta tilapia, *Oreochromis niloticus sugutae* Trewavas, 1983, occurring in Suguta River and tributaries. These rivers dry up when rains are low, but some pools of water are maintained, which support the fish populations. It is not yet clear why the riverine fishes have not adapted to living in the lakes associating with these rivers.

ACKNOWLEGEMENTS

The idea of updating information on the fish species of Kenya in the Eastern Arm of the Rift Valley was highly encouraged during thorough discussions with officials of the Ministry of Regional Development (MRD), Kenya (Mr. N. Odero, Mr. S. Oburu, Ms. J. Kinya), the South African Institute of Aquatic Biodiversity, Grahamstown (Prof. P.H. Skelton), the Natural History Museum, London (the late Dr. H.P. Greenwood, Dr. R. McConnell, Dr. D.J. Siebert), the Museum of Central African Fisheries, Tervuren (Dir. D.F.E. Thys van den Audenaerde, Dr. G.G. Teugels, Dr. J. Snoeks) and the American Museum of Natural History, New York (Dr. M.L.J. Stiassny) to whom I owe special thanks. Dr. Lothar Seegers made comments on some results during the study. Part of the study was carried out at the Natural History Museum (NHM), London, and in the field in Kenya: I am grateful to the entire staff of the fish section and the library (NHM), to the personnel of the MRD (i.e. at the Department of Fisheries, Kenya Marine and Fisheries Research Institute, Development Authorities) and to my academic colleagues and students, for their kind assistance during the study. Part of this study was sponsored by the Association of Commonwealth Universities, KE FO34, through Kenyatta University, Nairobi, Kenya, and the British Council, KE/0003/29.

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SCIENTIFIC DATA IN THE PUBLIC DOMAIN

THE NEED TO MAKE SCIENTIFIC DATA PUBLICLY AVAILABLE – CONCERNS AND POSSIBLE SOLUTIONS

LE BESOIN DE RENDRE LES DONNEES SCIENTIFIQUES PUBLIQUEMENT ACCESSIBLE – PREOCCUPATIONS ET SOLUTIONS POSSIBLES

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ABSTRACT

The paper argues the necessity to render scientific data available in the public domain in order to prevent loss of knowledge associated with institutional discontinuities and poor archiving and conversely to support higher level analyses of biodiversity and ecosystems, often beyond the original scope of data collection. The concerns of data custodians are discussed, e.g. loss of competitiveness, publication by others, copyright and public acceptability of interpretations. Among the solutions suggested to address these are e.g. delayed public access, aggregation of data; proper use agreement and read-only access. It concludes that such public access policy should be in place for all scientific data collected with public funding.

RESUME

Ce travail souligne la nécessité de rendre les données scientifiques publiques afin d'éviter la perte des connaissances suite à des discontinuités institutionnelles et des faiblesses d'archivage, mais aussi afin de permettre des analyses plus poussées sur la biodiversité et les écosystèmes, souvent au-delà de ce qui avait été l'objectif initial de l'échantillonnage. Les préoccupations des gardiens de données sont examinés, telles que la perte de compétitivité, le risque de publication par d'autres, le droit d'auteur et l'acceptabilité publique des interprétations. Parmi les solutions proposées en vue de les prendre en compte figurent le retard d'accès public, l'aggrégation des données, des accords appropriés d'utilisation et un accès limité à la lecture. La conclusion est qu'il serait souhaitable d'avoir des politiques en place sanctionnant de telles solutions pour toutes les données scientifiques collectées avec des fonds publics.

INTRODUCTION

Traditional individual or institutional accumulation of scientific data has caused great losses of knowledge over time, due to lack of long-term archiving and accessibility by both the scientific community and society at large (Pauly, 2001; Zeller *et al*,. 2004). Generally, the fact that data can be used for many more and often unforeseen purposes has largely been ignored. This is especially true for the biological sciences and may explain the lack of effective international cooperation in this field and thus, e.g., the lack of global ecosystem models, in striking contrast to oceanography and climatology, where data sharing and archiving has a long tradition and where results from global models are widely used and accepted (see e.g. Dittert *et al*., 2001; Froese and Reyes, 2003). The Committee on Data for Science and Technology (CODATA) of the International Council of Scientific Unions has suggested almost a decade ago that "scientists supported by public money should make their data available without delay after publication", and that "full and open data access means that not only is there no discrimination in data access, but that the cost is within the reach of scientists in all countries" (CODATA, 1995). The success of FishBase (www.fishbase.org), an online database with over 12 million hits per month and over 300 citations in the scientific literature, demonstrates that a well designed information system that is freely available on the Internet can serve science as well as civil society. The Global Biodiversity Information Facility GBIF (www.gbif.org) and the Ocean Biogeographic Information System OBIS (www.iobis.org) are two recent prominent examples of global data sharing in biological sciences. In contrast, the International Council for the Exploration of the Seas (ICES) requires individual scientists to request access to data through the ICES official channels, including detailed descriptions of what they intend to do with the data. Any cost for data extraction has to be covered by the scientist. A recent offer by FishBase to publicly disseminate ICES data was rejected. Two of the reasons given for this can serve as general examples of concerns of data custodians: "… there is a risk that [open access] will interfere with the willingness of parties to submit data…"; "… data are sensitive and therefore need to be treated correctly and not misinterpreted…" A similar request for access to Russian survey data resulted in an answer that only data for non-commercial species may be made available. Data custodians who gathered at a recent workshop in Barcelona, Spain, expressed a variety of additional concerns. The purpose of this contribution is to understand and list these concerns, to present options that appear suitable for addressing them, and to give examples of the advantages that result from sharing of data.

CONCERNS OF DATA CUSTODIANS

Concerns of data custodians relate to control over data, confidentiality issues, potential misuse of data, lack of trust, and lack of resources. Below we list these concerns together with the typical phrase in which they are expressed.

1. Loss of competitiveness: "If others have access to my data I will lose an advantage e.g. when submitting proposals;"
2. Publication by others: "Someone else will publish my data;"
3. Copyright issues, intellectual property rights (IPR): "I will lose ownership and recognition of my work;"
4. Commercial use of data: "Someone else will make money out of my data;"
5. Public acceptability of conclusions: "The public will dismiss analyses and conclusions when they see the errors and problems in the underlying data (without fully understanding the context);"
6. Manipulation or misreporting of data becoming visible, such as catch statistics derived by adding a fixed percentage every year: "Data are only for internal use;"
7. Problematic data becoming visible: "They will see that we sometimes catch protected species such as turtles. They will see that we sometimes fish outside allowed areas;"

8. Confidentiality of original data providers: "Fishers will stop voluntary data provision if confidentiality can be broken;"
9. Data used for deriving fishing quota are considered sensitive: "We can be sued for misinterpretation of the data;"
10. Misuse of data by others: "They will catch the last existing specimens if we tell them where they are;"
11. Misinterpretation of accuracy of data: "They don´t understand the limitations and assumptions;"
12. Errors in the data becoming visible: "We need time to fix the errors first;"
13. Lack of trust: "They will come and catch our fish if we tell them where they are;"
14. Lack of trust and/or communication between data providers and analysers: "They will make it look as if these were their data;"
15. Lack of benefits: "What do I get out of it?"
16. Limited ability to provide data following standardised concepts and formats: "I need someone to re-structure the data;"
17. Additional work load: "I have no staff to deal with this."

SOLUTIONS

The concerns expressed above are real-world concerns and thus have to be taken seriously. Not all of the raised issues can be resolved completely. However, a number of solutions have emerged that have proven satisfactory to data custodians. These are presented below.

1. Dissemination delay: Several concerns (2, 4, 6, 7, and 10) relate mostly to recent data. Allowing for a dissemination delay of e.g. 3-5 years can address these concerns. Also, laps of time will typically make 'inappropriate behaviour' or violation of rules (concern 7) less relevant politically or legally. Important is that release of data after the respective delay is automatic (programmed in the respective database) and not dependent on administrative procedures. Dissemination delay may not be appropriate for data which are time-sensitive; delaying the release of such data may render them of little use, e.g. for regional management purposes or climate change studies. For such data spatial or temporal aggregation may be a better solution;

2. Aggregation of data: Several concerns (7, 10, and 13) related to the misuse of data, e.g. by poachers or illegal fishers. Allowing for a certain degree of aggregation of sensitive data, e.g. by lumping data in space or time, or blurring exact localities by reporting them in integer degrees. These two approaches are used routinely by, e.g, the U.S. National Marine Fisheries Service for marine fisheries catch data. Such blurring may be permanent if the sensitivity relates to, e.g., occurrence of rare and threatened organisms or spawning aggregations. Data aggregation should be temporary if the sensitivity relates to policy or confidentiality issues, such as what vessel has caught what fish where and when (concern 8); eventually such data should be published with full detail. Again, desegregation after a certain time should be automatic;

3. Data use agreement: Several concerns (1-4, 14, and 15) relate to ownership of data and recognition of work. These concerns can be addressed by making users accept a 'Data Use Agreement' which, among other, explicitly states that copyright and intellectual property rights remain with current owners; fair use of data is permitted under the condition that the source of the data is properly cited; and commercial use needs special and explicit permission from the data custodian;

4. Disclaimer: Several concerns (5-7, 11, and 12) related to errors and possible misinterpretation of data. This is a general problem with all data and the standard solution is attaching a disclaimer regarding the quality of data, including full details of the concepts and definitions used,

acknowledgement of known problems, appropriate measures to deal with errors, best tools for proper analysis, and other relevant meta-data;

5. Read-only access: Several concerns (5, 9, and 11) relate to potential manipulation of data by others. Data distributors such as GBIF, OBIS or FishBase have a policy of not modifying data owned by others: adding, editing and deleting is done ONLY by the data provider, who provides new public versions in regular intervals. On the World Wide Web, data are typically extracted on demand from underlying databases; online users are restricted to "read only" access, i.e., while they can download the data and then manipulate them for their own use, they can not temper with the data presented publicly on the web;

6. Respect agreements on confidentiality (concern 8): Confidentiality may be safeguarded by hiding confidential elements of the data-sets such as names of vessels or collectors or by aggregating data as suggested above;

7. Give credit: Several concerns (1-3, 14, and 15) deal with lack of recognition of data providers. FishBase has an internal policy of giving 'more credit than expected' to data providers, such as showing citations, logos and link to web sites of partners in several places. As a result FishBase includes more 'data or photos owned by others' than any comparable information system;

8. Include data owners: Several concerns (1, 2, 14, and 15) relate to the lack of direct benefits for data custodians. Data-dependent projects should include data owners already in the design phase and make sure that data custodians get their due share of support and recognition. However, such projects shall also make explicit when and where data will be made publicly available, and who is responsible for long-term archiving and accessibility. There is an increasing number of projects which have avoided this issue and where data were ultimately lost at great cost to science and society (Zeller *et al*., 2004);

9. Assist data owners: Several concerns (16 and 17) related to lack of capabilities and staff time to make data available. Data distributors such as GBIF, OBIS or FishBase typically provide assistance in form of conversion tools or schemas, or offer to do all necessary conversions themselves.

Advantages of sharing data

As mentioned above, the solutions presented here will not satisfy all aspects of the listed concerns. However, there are a number of advantages resulting from data sharing that typically outweigh any remaining disadvantages and most data custodians who have made their data publicly available will agree that in hindsight that move has been overall beneficiary to themselves and their institutions. For example, FishBase gives very prominent credit to data providers. As a result books that were completely contained in FishBase have sold better than expected and photographers who made their photo collections available have received more requests including from commercial publishers.

Many data owners use public access as a no-cost means of having their data peer-reviewed: feed-back from users helps identifying weaknesses in the data and assists in correcting errors.

Online availability of data usually reduces the number of general requests for information, e.g. in specimen collections, because much of what users need to know is readily available online. On the other hand, visits by specialists—a prime justification for maintaining expensive collections—are increasing as the holdings of collections become better known.

In summary, more exposure typically results in more visibility, recognition, invitations, citations and projects.

CONCLUSIONS

In conclusion we want to stress the principle that scientific data that were established with public funding have to be properly archived and made publicly available. We trust that the concerns of data custodians can be largely addressed by the solutions suggested above. We believe that remaining problems and disadvantages are more than compensated by the advantages resulting from sharing of data.

ACKNOWLEDGEMENTS

We thank David Cross for useful comments on the manuscript and the suggestion to stress advantages of data sharing in a dedicated paragraph. This study was supported by the European Commission, DG Research, within the scope of an INCO Accompanying Measure (ICA4-CT-2002-50001, ECOFISH).

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Appendix 1: Participants of the ACP-EU Training Programme on Fisheries and Biodiversity Management

Appendice 1 : Participants au programme ACP-UE de formation a la gestion des peches (ou pecheries) et de la biodiversite

The addresses of the authors (with asterisk before name) among the participants were updated. The others were left as they were at the time the respective workshops were held. Names of participants preceeded with the symbol † have passed away.

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The ACP-EU Fisheries Research Initiative

The ACP-EU Fisheries Research Initiative was requested by the ACP-EU Joint Assembly, composed of Members of the European Parliament and Representatives of African, Caribbean and Pacific (ACP) Countries, in a Resolution on 'Fisheries in the Context of ACP-EEC Cooperation', adopted in October 1993. A series of dialogue sessions was conducted between ACP and European aquatic resources researchers, managers and senior representatives of European cooperation, using a draft baseline paper for the Initiative produced by intra-European consultation. The Initiative aims at promoting sustainable economic and social benefits to resource users and other stakeholders, while preventing or reducing environmental degradation. It has set an agenda for voluntary collaborative research based on mutual responsibility and benefits. It promotes commitment to addressing the most crucial problems of restoring resource systems and their ecological and economic productivity with the objective of informing and supporting more directly economic and political decision making through pro-active and high quality research and stakeholder participation.

In the meantime, the principles have been successfully used in wider scientific cooperation with other developing countries and regions as a result of bi-regional dialogue e.g. with East and Southeast Asia (ASEM), Mediterranean (MOCO) and Latin America and the Caribbean (ALCUE).

Suitable instruments to fund research, capacity building and/or implementation are, among others, the European Development Fund (EDF), International Scientific Cooperation (INCO) as part of the EU RTD Framework Programmes, the Global Environment Facility (GEF), European Member States' bilateral research and cooperation programmes and partner institutions' own resources.