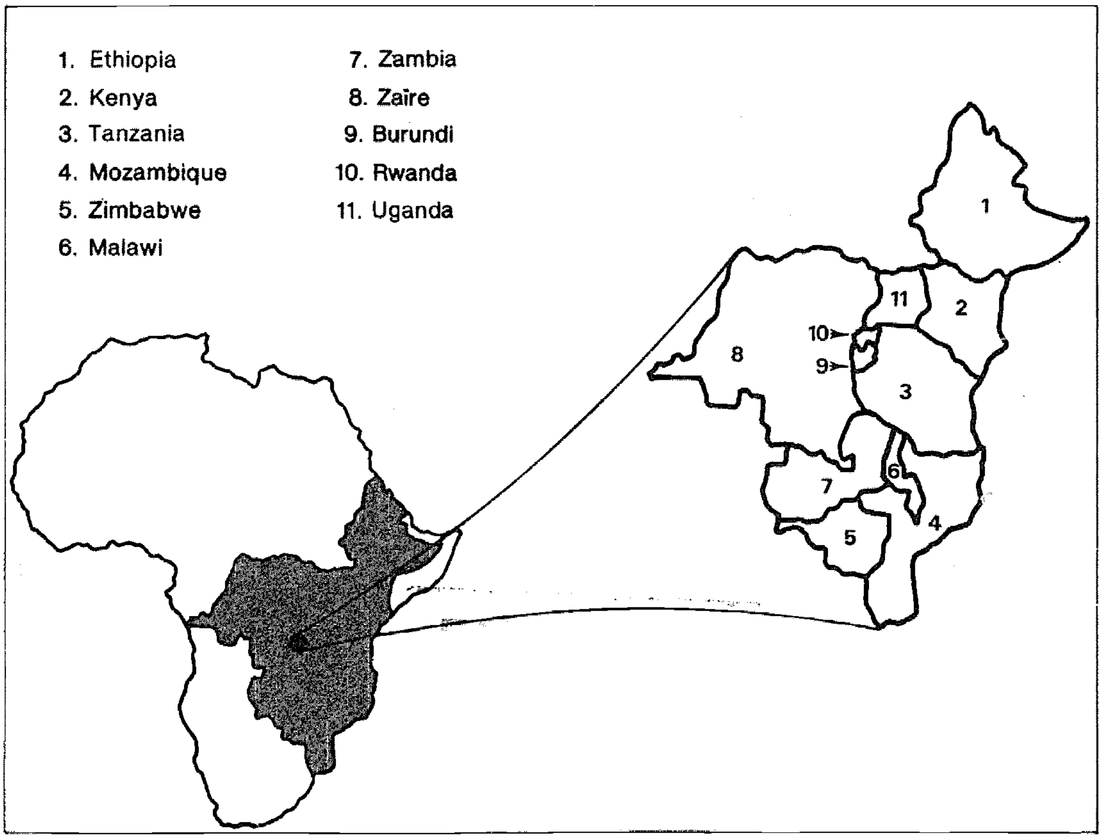
REGIONAL PROJECT FOR INLAND FISHERIES PLANNING, DEVELOPMENT AND MANAGEMENT IN EASTERN/CENTRAL/SOUTHERN AFRICA (I.F.I.P.)

IFIP PROJECT

RAF/87/099-TD/38/92 (En) May 1992

The Lake Victoria Dagaa (Rastrineobola argentea)

Report of the First Meeting of the Working Group on Lake Victoria *Rastrineobola argentea*



UNITED NATIONS DEVELOPMENT PROGRAMME

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

UNDP/FAO Regional Project
for Inland Fisheries Planning
Development and Management in
Eastern/Central/Southern Africa

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The Lake Victoria Dagaa (Rastrineobola argentea)

Report of the First Meeting of the Working Group on Lake Victoria *Rastrineobola argentea*

Edited by

P. Mannini
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FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
UNITED NATIONS DEVELOPMENT PROGRAMME
Bujumbura, May 1992

PREFACE

The IFIP project started in January 1989 with the main objective of promoting a more effective and rational exploitation of the fisheries resources of major water bodies of Eastern, Central and Southern Africa. The project is executed by the Food and Agriculture Organisation of the United Nations (FAO), and funded by the United Nations Development Programme (UNDP) for a duration of four years.

There are eleven countries and three intergovernmental organisations participating in the project: Burundi, Ethiopia, Kenya, Malawi, Mozambique, Uganda, Rwanda, Tanzania, Zambia, Zaire, Zimbabwe, The Communauté Economique des Pays des Grands Lacs (CEPGL), The Preferential Trade Area for Eastern and Southern African States (PTA) and the Southern African Development Coordination Conference (SADCC).

The immediate objectives of the project are: (i) to strengthen regional collaboration for the rational development and management of inland fisheries, particularly with respect to shared water bodies; (ii) to provide advisory services and assist Governments in sectoral and project planning; (iii) to strengthen technical capabilities through training; and (iv) to establish a regional information base.

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PREPARATION OF THE DOCUMENT

This report includes the proceeding of the first meeting of the Working Group on Lake Victoria *Rastrineobola argentea*, held in Kisumu (Kenya) from 9 to 11 December 1991. Research activities on *Rastrineobola* stock were considered of the highest priority at the Fifth Session of the FAO Sub-Committe for the Development and Management of the Fisheries of Lake Victoria, held in September 1989. The Working Group is constituted by fisheries biologists of the Riparian States and an IFIP representative. The purpose of the meeting was to obtain a broad overview of the status of *Rastrineobola* fisheries and to establish a common research programme to improve the knowledge of the biological characteristics of the stock. This work is being sponsored by the IFIP Project.

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IFIP PUBLICATIONS

Publications of the IFIP project are issued in two series:

A series of technical documents (RAF/87/099-TD) related to meetings, missions and research organized by the project.

A series of working papers (RAF/87/099-WP) related to more specific field and thematic investigations conducted in the framework of the project.

For both series, reference is further made to the document number (38), the year of publication (92) and the language in which the document is issued: English (En) or French (Fr).

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I. INTRODUCTION

Rastrineobola argentea is a small pelagic cyprinid endemic to Lake Victoria. This species was not of commercial interest prior to the early 1980's when its exploitation began to increase strongly in Tanzania and Kenya.

Nowadays *R. argentea* is the second highest commercial species of Lake Victoria fishery (20% of the lake's total catch in 1989), which is at the present dominated by the impressive catch rates of the introduced Nile perch (*Lates niloticus*).

There are two main reasons why this small pelagic species is so important. It is a relatively cheap source of animal protein as nourishment for man and livestock. At the same time *Rastrineobola* plays a crucial role within the ecosystem of Lake Victoria being one of the main prey species of Nile perch, which is by far the most important commercial species of the lake supplying about 60% of the total catch of 506,929 tons in 1989. Therefore *R. argentea* is the link between the zooplankton production and the apex predator.

Scientific knowledge on biology and ecology of *Rastrineobola* is lacking and insufficient for the management of the stock. In consideration of the fast development of this promising fishery, the Fifth Session of the FAO CIFA Sub-Committee for the Development and Management of the Fisheries of Lake Victoria, held in September 1989, assigned highest priority to research work on population dynamics of *Rastrineobola*.

On this basis the IFIP Project has supported the establishment of an *ad hoc* Working Group made up of fisheries biologists from the riparian states, Kenya Marine and Fisheries Research Institute (KMFRI), Uganda Freshwater Fisheries Research Organization (UFFRO), Tanzania Fisheries Research Institute (TAFIRI) and the IFIP project representative (fisheries biologist).

The main aims of the Working Group are to implement lakewide research work on a cooperative regional basis to fill the many gaps existing in the biological knowledge of the *Rastrineobola* stock. Additionally, to ensure a continuous flow of information and data resulting from the established common research activities between the national institutions of the riparian states.

This document includes observations of the *R. argentea* Working Group by national sectors, the five working papers presented at the meeting (Appendix 4) as well as the common research programme established by the Working Group members (Appendix 3).

II. NOTES ON OBSERVATIONS MADE DURING THE MEETING

A. KENYA

R. argentea Fishery (Dagaa or Omena)

The dagaa fishery in Kenya is concentrated around known fishing grounds, basically offshore, and carried out at night with or without light attraction. The former method is practiced mostly towards the outer portion of the gulf while the latter is found within the middle and inner area of the gulf. Dagaa nets in Kenya are up to 100m long, with mostly 5mm stretched mesh size, 10mm mesh are rare (government regulation on mesh size is 5mm).

The main processing method is sun-drying. Mosquito nets are used to spread out the catch after landing. Some are spread on rocks and stony areas in beaches where these are available. Drying is also carried out using papyrus mats. Little information is available on marketing of dagaa but it is known that over 50% of the total landings are utilized in fishmeal for livestock and poultry feed.

The consumers preference for dagaa compared to other species is possibly determined by economical factors other than taste or availability. Dagaa is significantly cheaper than Nile perch and other fish species in Kenya.
It is noted that a fair amount of data is available in Kenya on annual landings, catch rates and catch/effort statistics.

BIOLOGY

Very little biological information is available on dagaa from the Kenyan portion of Lake Victoria. Information on various aspects of dagaa should be collected and disseminated to formulate long term guidelines for rational exploitation, development and management of this fishery in all the three riparian states. Areas that need urgent attention are hereafter listed.

Population dynamics:

Length frequency analysis should be adopted for dagaa around Lake Victoria. Attempts should be made to acquire data for surplus production models. Besides being less expensive, these methods yield important results within a relatively short time. These results can be used to predict changes in the fishery under varying fishing patterns and exploitation rates.

Feeding habits:

In light of recent changes in the ecosystem and possibly the food web of Lake Victoria since the introduction of Nile perch, it is important to study the feeding ecology of dagaa with reference to frequency of occurrence of dominant food items and food availability. It may be possible to correlate distribution, vertical migration and other observable phenomena to breeding and feeding habits of dagaa in Lake Victoria.

Reproductive biology:

Information of breeding seasons is required for regulation of the fishery and protection of breeding population. It is recommended that initial data acquisition should be based on simple techniques which are less expensive. Information of fecundity over longer periods, sex ratio and the relative condition factor should be collected over longer periods. It is also recommended that studies on maturity be initiated using histological techniques.

Egg and larval surveys:

It is recommended that investigations on breeding habits, habitat, nursery ground and survival rates in the early life stages be carried out by egg and larval surveys. This information is necessary for protecting the breeding grounds, nursery grounds and formulating sound management policies.

Distribution and biomass estimates:

Information on distribution of any species in time and space as well as accurate biomass estimation of fish stocks may require much more labor and resources, it is still imperative that initial surveys be carried out using available opportunities. It is recommended that controlled surveys should be carried out by hiring artisanal fishermen from time to time for a small gratuity. However, a lakewide survey will be eventually necessary. This information can be used to estimate the standing stock as well as predicting maximum economic yield for this fishery.

FISHERIES STATISTICS

The existing 22 landing beaches covered by Catch Assessment Survey (CAS) in the Kenyan portion are inadequate for reasonable statistical significance. The number of beaches covered should be increased while the methods of supervision should be improved. The fishing grounds should be mapped out and compared. Besides, data on economic implications should be incorporated in the survey.

SOCIO-ECONOMIC ASPECTS

Standard questionnaires should be designed to assess on site aspects of dagaa processing, processing capacities, marketing strategies, investment and maintenance costs, returns and post-harvest losses against other land-based socio-economic activities. Besides providing economic indices on dagaa fishery, this could be used to provide technical advice on socio-economic development of the dagaa fishery.

EXCHANGE OF INFORMATION ON *Rastrineobola*

The exchange of information between the riparian states should be strengthened through personal communication, seminars, workshops and symposia.

B. UGANDA

R. argentea Fishery (Mukene)

Rastrineobola fishery was insignificant up to early 1980's. It became important from mid 1980's coinciding with the virtual disappearance of many haplochromines species.

The fishery was adversely affected by a ban imposed on beach seining and night fishing in 1988 (not yet repealed but no longer enforced). The Fisheries Department of Uganda did not originally take catch records even when Mukene's contribution to total catch had became obviously significant. UFFRO started recording landing statistics at Masese fish landing since 1988. Masese records show that in 1990 Mukene was second to Nile perch, its contribution being around 35% of the total catch for Masese landings.

Fishing activities are more intense in the eastern area than the western side of the lake. The major fishing grounds are:

a) around Buvuma Island and the adjoining islands e.g. Sigulu, Dagusi;

b) in the various bays along the shoreline, especially the eastern part; and

c) around the Sesse Islands.

Fishing is done using 10mm and 5mm mesh-sized nets as beach seines or boat seines (Lampara net). Fishing is halted for about 2 weeks per month during full moon.

Continuous rising cost of inputs has negative effects on the actual fishing and marketing activities. Mukene caught in Uganda is used for:

a) export to Kenya, Zaire and Southern Sudan;

b) feed in the livestock industry; and

c) human consumption especially in the North, North West and North Eastern parts of Uganda.

BIOLOGY

Some headway has been made in studies and observations carried out so far. The 5mm net used as beach seine catches proportionately more immature mukene and other by-catch species than the 10mm. Over the last 3-4 year period there has been a general decrease in the modal length of the fish caught. R. argentea apparently breeds throughout the year but with two peaks around April-May and September (corresponding to the rains).

The most important studies to be undertaken are:

a) assessment of stock;

b) life-history patterns (growth, reproduction and feeding);

c) a well planned biometrics data collection.

FUTURE TRENDS OF MUKENE FISHERY

A fisheries statistics unit is now established in Entebbe for collection, compilation and analysis of data to enable monitoring trends. Rising cost of inputs (canoes, fuel) will continue to limit the exploitation of dagaa/mukene. There is also concern about optimum exploitation due to the influx of many investors when there is still little knowledge on the stock. Besides, *R. argentea* is an important source of food for the predatory Nile perch.

C. TANZANIA

R. argentea Fishery (Dagaa)

Most common types of gear are the scoop net and the dagaa seine but lift nets and boat seines are becoming more popular, although their initial costs are rather important. All types use light for attracting and concentrating the fish during moonless nights but the dagaa seine may occasionally be used during the day when shoals of *R. argentea* are spotted near the shore.

Mesh size commonly used is the 10mm stretched mesh. Smallest mesh sizes of 4 - 8mm are sometimes used, especially for boat seine (commonly known as "hurry-up").

BIOLOGY

Biological information of *R. argentea* is very scanty on the Tanzanian side and most recent data were collected more than two years ago. Cost effective monitoring of the biological data on the species is recommended i.e. information that would be obtained with the available limited funds, e.g. length frequencies, sex determination, maturity stages, fecundity, food habits, condition factor.

There is a need to investigate further the role of *R. argentea* as a forage base for the Nile perch in an attempt to assess its impact on perch population. Studies are required on spatial and temporal migrations as well as on the role of *R. argentea* as a link between herbivores and carnivores.

FISHERIES STATISTICS

Presently no dagaa statistics are collected at beach level by fish recorders. Some data are available from sales of dried dagaa recorded at buying centers. The dry weight is then converted to wet weight by a raising factor of three.

Dagaa is landed during the night and spread out to dry from dawn. It would therefore be necessary for the recorder to be on the landing sites at night. Furthermore most landing sites are not easily accessible and some are located in far off islands. Hence, only few stations can be visited for sampling and recording.

Direct weighing of the samples is impossible; one has to rely on the fishermen's measurement unit, the "debe" or thin (about 20 kg).

STOCK ASSESSMENT AND MANAGEMENT TRENDS

No stock assessment work has been done on this species, although such investigation is much needed. It should be noted that this exercise is expensive and needs collaboration between riparian states and donor agencies.

Mesh size below 10mm have been considered destructive as they include a good proportion of juveniles. A proposal has been raised to ban them, except for research purposes. The Fisheries Division will require additional funds and manpower to implement this measure.

APPENDIX 1: LIST OF PARTICIPANTS

Name of Participant	Designation	Address
D. L. Ocenodongo	Dep. Director, UFFRO	Box 343 Jinja, Uganda
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S. B. Wandera	Research Officer, UFFRO	Box 343 Jinja, Uganda
D.E.R. Chitamwebwa	Officer in Charge, TAFIRI	Box 46 Shirati, Tanzania
J. O. Manyala	Research Officer, KMFRI	Box 1881 Kisumu, Kenya
C. O. Nyawade	Research Officer, KMFRI	Box 1881 Kisumu, Kenya
C. O. Rabuor	Research Officer, KMFRI	Box 1881 Kisumu, Kenya
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APPENDIX 2: MEETING AGENDA

Meeting of the Working Group Network on Lake Victoria
Rastrineobola argentea

Kisumu 9-11 December 1991

Date	Time	Programme
Monday 9 December	09.30	Opening of the Meeting
	10.00	Coffee break
	10.30	Administrative Arrangements
	12.00	Lunch break
	14.00	Presentation and discussion of a paper on "Biological and fishery aspects of *Rastrineobola argentea* in the southern part of Lake Victoria".
	15.00	Presentation and discussion of a paper on "The fishery of *Rastrineobola argentea* in southern sector of Lake Victoria".
	15.45	Coffee break
	16.15	Presentation of a paper on "The dagaa (*Rastrineobola argentea* Pellegrin) fishery in the Kenyan waters of Lake Victoria: a national review and proposal for future research".
Tuesday 10 December	08.30	Discussion of the last paper presented the previous day.
	09.15	Presentation and discussion of a paper on " A study of *Rastrineobola argentea* in the Ugandan lakes".
	10.00	Coffee break
	10.15	Presentation and discussion of a paper on "Some characteristics of small pelagic species and possible affinities to *Rastrineobola argentea* population of Lake Victoria".
	11.15	General discussion of the data and results presented.
	12.00	Lunch break
	14.00	Presentation of the IFIP project research work proposal on *Rastrineobola*.
	15.15	Coffee break
	15.45	Discussion and finalization of the research programme on *Rastrineobola*

<u>Wednesday 11 December</u>	08.30	Presentation and discussion of conclusions on <u>Rastrineobola</u> fisheries in the three countries.
	09.30	Presentation and discussion of the finalized research programme.
	10.30	Coffee break
	11.00	Visit Dunga landing beach.
	14.30	Approval of the research programme. Approval of the next activities calendar.
	16.00	Closing of the meeting.

APPENDIX 3: RESEARCH PROGRAMME PROPOSAL ON LAKE VICTORIA *R. argentea*

The common research programme on *R. argentea* is supposed to start at the end of 1992 or beginning 1993. The research work has to be carried out by national biologists participating in the Working Group and coordinated by IFIP project. A small financial budget will be supplied by IFIP to support research work, organization and attendance to the next meetings of Working Group.

The research work is strongly limited by financial means, but it could play a significant role in the perspective of strengthening cooperation between the riparian countries in the field of scientific work and common resource management.

Data collection activity will last for 12 months. Standard data recording forms are reported at the end of this appendix. After 6 months of activity a workshop is envisaged to be held in Jinja (Uganda) hosted by Ugandan Freshwater Fisheries Research Institute (UFFRO) and organized by IFIP Project. Three months after the end of the research a seminar (about a week) will be held to compare and discuss results and to undertake further analysis of the data.

Every three months copies of the collected data will be forward to the IFIP Project in Bujumbura which is in charge of assuring data distribution between national institutions and fisheries biologists involved in the research work. This system is aimed at implementing an effective and continuous flow of data and information between the researches of the three riparian states to achieve a better knowledge and pursue proper management actions of this common fish resources.

The research programme to be simultaneously carried out by UFFRO, KMFRI and TAFIRI is mainly based on the following points:

1) The commercial fishing gear used for sampling purposes is the boat seine, which is a common net to Uganda, Kenya and Tanzania. The mesh size of 5mm (stretched) is used because of its low selectivity characteristics.

2) In Kenya, 5 or 6 landing beaches will be sampled, in Uganda and Tanzania, due to logistical and financial constraints of UFFRO and TAFIRI, only 3 landing beaches per country were chosen for sampling. As much as possible samples will be obtained from both offshore and inshore waters.

3) Length (standard length, SL) frequency data will be collected twice per month. The length class interval adopted is 1 mm SL. Sample size is 500 g and catch weight is recorded.

4) Once per month, 5 specimens for each 1 mm length class are sub-sampled for the needs of length-weight relationship and sexual maturity analysis.

5) Considering previous experiences and practical work aspects the following gonadal maturity stages were established and adopted by the Working Group:

Stage I: Undetermined. Gonads are not yet well formed. Not possible to distinguish testis from the ovary.

Stage II: Immature. In both sexes gonads are small and lying against the back of the body cavity. Testis appear as a thin threadlike structure whose anterior tip extends into the gill region of the fish. The ovary is more flattered and ends into a blunt tip. These gonads tend to be covered by some fat which develops around them.

Stage III: Maturing. Testis are beginning to grow larger, evenly rounded. Ovaries are showing eggs of mean sizes and when ovary is pieced the eggs are held together by the interstitial tissue with many transparent egg structures.

Stage IV: Mature almost ready to spawn or spawning. Testis large and tend towards flattening. Some times develop folds. Spawning individuals may have part of the testis empty (mainly the anterior end) with the remaining milt concentrated towards the pore. Ovaries are enlarged with large eggs of almost uniform size. When the ovary is punctured the eggs separate easily.

Stage V: Resting. Females: eggs have been shed and the few remaining are reabsorbed ending in a flat firm structure similar to the immature stage. Males: testis do not completely loose their milt but grow smaller and appear as seen in stage III. They also tend to be covered by fat which accumulates around them.

6) Other types of gear used in *Rastrineobola* fishery are sampled once per month (length frequency data, catch and sample weight), possibly in the same day of the boat seine sampling, for comparative analysis of the sampled populations.

7) One hundred specimens will be used to determine the fresh/dried weight relationship.

8) Catch and effort data are collected from Fisheries Departments.

The whole programme will last for a period of about 16 months comprehensive of data collection, processing and analysis. The analysis will have to be performed both on a comparative and global basis. Some of the basic expected results are:

1) Information on population structure by month and lake's area and on spatial distribution.

2) Length/weight relationships.

3) Specific growth parameters according to the von Bertalanffy growth model.

4) Mortality rates and preliminary indices of the exploitation and the turnover rates.

5) Condition factor and its evolution during the year.

6) Reproductive strategy and recruitment patterns.

7) CPUE estimates from the selected sampled gear as possible index of the relative stock abundance and occurrence during the year.

8) Selectivity and efficiency of the various gear used in the dagaa fisheries.

9) Fishing patterns and preliminary identification of the coastal fishing grounds.

10) Specific fresh/dried weight conversion relationship.

11) Indication of the species composition and magnitude of the by-catches of the Rastrineobola fishery.

Moreover, the results of this study could be complementary if combined with the findings of the envisaged lakewide acoustic surveys of the EEC funded regional project. For example, population parameters could be completed by the acoustic biomass assessments to provide an estimate of the productivity (i.e., production/biomass ratio) of the Rastrineobola stock. Once the information on the occurrence and abundance of the species in the offshore waters are available, all the data will constitute the basis to approach the management and planning of a truly pelagic fishery, switching the effort from the heavily fished coastal waters.

DATA RECORDING FORMS <u>Form A</u>

FAO–IFIP Project/UFFRO/KMFRI/TAFIRI *Rastrineobola* Research Programme

Date: Fishing hrs: Dist. coast: By-catch (% weight):

Place: No. hauls: No. lamps: W. sample: W. catch:

SL mm			43		Tot.
15		Tot.	44		
16			45		
17			46		
18			47		
19			48		
20			49		
21			50		
22			51		
23			52		
24			53		
25			54		
26			55		
27			56		
28			57		
29			58		
30			59		
31			60		
32			61		
33			62		
34			63		
35			64		
36			65		
37			66		
38			67		
39			68		
40			69		
41			70		
42					

Grand Total

Other observations:

Form B

FAO–IFIP Project/UFFRO/KMFRI/TAFIRI **Rastrineobola Research Programme**

Date: Fishing hrs: Dist. coast:
Place: Other:

Length (SL)	**Weight**	**Sex**	**Mat. stage**	FL	TL

Total:

Observations:

Form C (sub-stratification by 1 mm length class to be used in Form B)

FAO–IFIP Project/UFFRO/KMFRI/TAFIRI *Rastrineobola* **Research Programme**

Date: Place: Dist. coast:

SL mm			43		Tot.
15		Tot.	44		
16			45		
17			46		
18			47		
19			48		
20			49		
21			50		
22			51		
23			52		
24			53		
25			54		
26			55		
27			56		
28			57		
29			58		
30			59		
31			60		
32			61		
33			62		
34			63		
35			64		
36			65		
37			66		
38			67		
39			68		
40			69		
41			70		
42					

Grand Total

Observations:

Form D

FAO–IFIP Project/UFFRO/KMFRI/TAFIRI **_Rastrineobola_ Research Programme**

Gear type: **Mesh size:**

Date: Fishing hrs: Dist. coast: By-catch :

Place: No. hauls: No. lamps: W. sample: W. catch:

SL mm			43		Tot.
15		Tot.	44		
16			45		
17			46		
18			47		
19			48		
20			49		
21			50		
22			51		
23			52		
24			53		
25			54		
26			55		
27			56		
28			57		
29			58		
30			59		
31			60		
32			61		
33			62		
34			63		
35			64		
36			65		
37			66		
38			67		
39			68		
40			69		
41			70		
42					

Grand Total:

Other observations:

Form E

FAO–IFIP Project/UFFRO/KMFRI/TAFIRI Rastrineobola **Research Programme**

Date: Place:

Length	Wet weight	Dry weight	Length	Wet weight	Dry weight	Length	Wet weight	Dry weight

Total:

Observations:

APPENDIX 4: PAPERS PRESENTED

4.1 THE DAGAA (Rastrineobola argentea PELLEGRIN) FISHERY IN THE KENYAN WATERS OF LAKE VICTORIA : A NATIONAL REVIEW AND PROPOSAL FOR FUTURE RESEARCH

By

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ABSTRACT

Changes in annual catch of Rastrineobola argentea in the Kenyan sector of Lake Victoria from 1968 to 1990 is presented. The catch rate rose from 8.2 m.t. Km^{-2} yr^{-1} in 1987 to 24.3 m.t. km^{-2} yr^{-1} in 1989. Distribution of dagaa landings from different parts of the Kenyan waters showed significant differences between the Winam Gulf and open waters. Fecundity of dagaa was estimated at 1350 eggs for specimens of 60mm total length (TL) and 170 eggs for specimens of 41mm TL. Annual total mortality rate (Z) is estimated at 3.1 yr^{-1} for 1990-91 while there is an apparent differential sex ratio of 2.5 females to one male. A proposal for future research on dagaa is made based on available data.

INTRODUCTION

The pelagic cyprinoids endemic to some East and Central African lakes were previously placed in one genus, Engraulicypris, until a revision by Howes (1980). This group of fishes is represented by Rastrineobola argentea in Lake Kyoga, Nabugabo and Victoria and Chelaethiops minutes in Lake Tanganyika which is of no economic value (Okedi, 1981a; Wanink, 1989). R. argentea is locally known as "omena" in Kenya, "mukene" in Uganda and "nsalali" in Tanzania (Graham, 1929; Greenwood, 1966). The name dagaa became popular in the early 1970s when a light fishery of this species reached commercial significance. The fishermen of Lake Victoria adopted this name from the clupeids of Lake Tanganyika which were also caught by light attraction (Okedi, 1981a, 1981b; Wanink, 1989). Present knowledge of dagaa in Lake Victoria is mainly based on the works of Okedi (1973, 1981a, 1981b), Ogari (1985), Chitamwebwa (1988) and Wanink (1989).

Dagaa fishing methods may or may not utilize pressure lamps to concentrate the fish. If so, the lamps are anchored with a sinker and after some time, they are moved slowly towards the beach, bringing the fish within the reach of a beach/mosquito seine. Beach seines (up to 100m) are made of nylon (ply 4 or 6) having a stretched mesh size of 4 - 12mm. Before 1970, a beach seine used to be a mosquito net of 30 - 60m long. In the 1980s, mosquito seines of stretched mesh sizes 5mm and 10mm became common in the Winam Gulf of Lake Victoria.

Catches of dagaa have undergone explosive changes in the last 15-20 years in Lake Victoria. In the Kenyan portion of the lake Rastrineobola landings increased to 30 % of the total fish landings by weight in 1985 as compared to 4.5% in 1969 (CIFA, 1988). Recent figures (Asila *et al.*, 1990) indicate an increase from 30 % in 1986 to 38.5 % in 1989 for R. argentea; with a decline in Nile perch (Lates niloticus) from 62.3 % to 54.3 % and Nile tilapia (Oreochromis niloticus) from 2.4 % to 1.7 % during the same period. These three species currently forms the main stay of Lake Victoria fishery (CIFA, 1988; Rabuor, 1988; Getabu, 1988; IFIP. 1990), contributing about 95% of the total landings by weight in Kenya and other riparian states.

The decline of Haplochromis (Ogari and Dadzie, 1988) and other insectivores has possibly benefitted Rastrineobola which is generally abundant and booming in Lake Victoria (Ssentongo, 1989). Despite a booming dagaa fishery in Lake Victoria, very little is known of its biology, distribution, standing biomass or exploitation pattern (Ligtvoet and Mdus, 1990). The dagaa boom has promoted a milling industry in Kenya for transformation of dagaa into fishmeal. The product is incorporated into livestock and poultry feed industries (Achieng, 1990) which consumes about 50 % of the landings. Marketing of dagaa and dagaa products in Kenya is not well documented and long term guidelines for the management and research on dagaa in Kenya is still lacking.

Lake Victoria (Kenyan sector)

The major portion of Kenyan waters of Lake Victoria (Fig. 1) is a narrow gulf, known to various authors by several names. The Victoria Nyanza (Graham, 1926), Kavirondo Gulf (Copley, 1953; Muller and Benda, 1981), Nyanza Gulf (Rinne and Wanjala, 1982; Ogari and Dadzie, 1989) and the Winam Gulf (Okach, 1982) all refer to the same place.

The Winam Gulf has an area of approximately 1920 km^2 with a length of about 60 km and width varying between 6 to 30 km. A short description of Winam Gulf has been given by Rinne and Wanjala (1982), Ogari and Dadzie (1988), while a detailed description can be found in Ogari (1984). The Winam Gulf lies between 34°13' and 34°52' East of latitude 0°4' and 0°32' South of the equator. The gulf has a mean depth of 6 m and a maximum depth of 43 m while its surface is at an elevation of 1136 m above sea level. Its irregular shoreline is about 300 km, with several large bays.

The major affluent rivers include the Kibos and Nyando to the coast, Kuja, Sondu, Awach, Mogus and Lambwe to the South and Yala, Nzoia to the north. Water exchange with the rest of the lake takes place through the Mbitu channel while the major outflow from the lake is the river Nile.

The geological, hydrographical physical and chemical characteristics of the lake Victoria basin can be found in Kendall (1969) while recent hydrologic and morphometric characteristics for the Winam Gulf are given in Ochumba (1990). The Gulf lies within equatorial region. The water temperature and solar radiation are relatively constant through the year.

Trends in Lake Victoria fishery research

Recent studies on the fish and fishery of Lake Victoria have concentrated on the ecology of Nile perch in association with the decline of some commercially important fish species (Okemwa *et al.*, 1982; Okemwa, 1983; Ogutu-Ohwayo, 1984; Ogari and Dadzie, 1988). The ecology of the haplochromine cichlids has been studied in the Mwanza Gulf of Lake Victoria (Oijen *et al.*, 1982; Goudswaard and Ligtvoet, 1987).

Fish stock assessment has been carried out in the Winam Gulf of Lake Victoria using bottom trawls (Marten *et al.*, 1976; Benda, 1981; Muller and Benda,1981) and catch assessment survey on artisanal fishery has also been conducted (Rabuor, 1988). The stock has been found to be changing from year to year with marked decline in some endemic cichlids, especially Haplochromis spp. This has been attributed to predation by the Nile perch, the use of wrong fishing gear (Fryer, 1973; Wanjala and Marten, 1974; Marten, 1978) and probably pollution (Kibaara, 1981).

After the disappearance of the haplochromine cichlids from the Winam Gulf, the Nile perch has shifted its diet to Caridina niloticus, L. niloticus and R. argentea, the latter being perhaps the third most important prey and contributing some 10 - 20 % of the diet (Ogari and Dadzie, 1988). R. argentea is the second most important diet of the adult siluroid catfish (Bagrus docmac) in the Winam Gulf of Lake Victoria with a frequency of occurrence of 70 % (Okach and Dadzie, 1988; Dadzie and Okach-Ochieng, 1989). The effect of other large predators, namely Clarias gariepinus and Protopterus aethiopicus on R. argentea is still uninvestigated in the Winam Gulf.

Available data on dagaa (Kenyan sector)

Data on the total catch (m.t.) and percentage contribution of dagaa in the Kenyan sector are available for several years (Table 1). KMFRI fishery statistics department has estimated the total catch (m.t.), percentage composition and catch (m.t.) km^{-2} yr^{-1}, as well as ha^{-1} yr^{-1}, from 1987 to 1990 (Table 2). Distribution of dagaa landings from 22 beaches in the Kenyan sector of Lake Victoria are shown in table 3 while catch per unit effort for various effort measurements are shown in Table 4 for 1989 and 1990. Monthly landings from the same 22 beaches are available for dagaa for the year 1989 and 1990. Growth constant (K), asymptotic length (L_∞), total mortality coefficient (Z), natural mortality coefficient (M), fishing mortality coefficient (F), exploitation rate (E) and yield indices are known for the Kenyan portion of Lake Victoria.

MATERIALS AND METHODS

Monthly catches from 7 different landing beaches were tested for significant differences using one way analysis of variance (ANOVA). There were significant differences between landing beaches and these were analyzed using Student Newsman-Keuls (SNK) test. Additional data was collected from Rakwaro beach (Fig. 1) to study the fecundity of dagaa by total egg count, sex ratio and proportion of breeding individuals in the population. Egg bearing, non egg bearing and egg remnants were noted from the gonads of all females in the samples on a fortnight basis from August to November 1991. Monthly length frequency distribution were summed and used to derive the total mortality coefficient (Z) by length-converted catch curve[1]

RESULTS

There were significant differences between monthly landings from different beaches ($P < 0.05$). Landings from Port Victoria on the northern zone of Kenyan open water were similar to all landings from the gulf, while landings from Misori and Uhanya (northern open waters) were different from all landings in the gulf. Landings from Sori (southern open waters) were different from other two beaches in the northern region but closer to the gulf beaches (Table 5).

The fecundity of dagaa is shown graphically in figure 2. The regression equation derived from log transformed data were then compared to that of Wanink (1989) (Fig. 3). The percentage of egg bearing females reached a maximum of 94%. The rest were accounted for by individuals with either partially shed eggs or egg remnants (Fig. 4). At no time were all females found to be bearing.

The length-converted catch curve estimated a total mortality coefficient of 3.12 per annum (Fig. 5). The sex ratio indicated that females were significantly more than males ($0.025 < P < 0.05$) and quite different from the expected 1:1 ratio (Table 6).

DISCUSSION

From available records from the Kenyan sector of Lake Victoria, much of the information is on annual catches, catches from different beaches and catch-effort data. This information is quite important for economic assessment of the fishery but is lacking in biological principles. It is not possible to predict, for example, maximum sustainable yield (MSY) or optimum exploitation rate.

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[1] Editor's note: growth parameters used were $L_\infty = 68$ mm, $K = 0.56\ yr^{-1}$.

Differences in landings from different beaches are attributed to the following external and internal factors:

(i) number of boats operating from these beaches which reduces the catch per unit effort if the fishing ground is the same;

(ii) the use of light for attracting the fish thus efficiency of fishing units;

(iii) distribution of dagaa in the lake and hence stock abundance;

(iv) edaphic factors connected with depth, currents, temperature profiles and other physico-chemical parameters;

(v) predation pressure from piscivorous species;

However, it should be noted that if the catch per unit effort is relatively constant over the Kenyan waters of Lake Victoria, then differences in total landing at different beaches could only be accounted for by the number of boats operating from the beach and the distribution of dagaa in the lake.

There is an indication that fecundity of dagaa is higher in the Winam Gulf compared to Mwanza Gulf for larger specimens (above 57mm TL). Several biological and physico-chemical parameters could be possible explanations for this observation. Gonadal status of females tends to suggest a protracted breeding period lasting 3-4 weeks in the population but still needs verification from data collected over a longer period of time. Total mortality rate is within the range from other studies in the Kenyan sector.

RECOMMENDATIONS FOR FUTURE RESEARCH

Since it is evident that very little information is available on dagaa though it now forms a considerable portion of total landings in Lake Victoria, it is appropriate to carry out very comprehensive research on various aspects of this species. The study areas that need urgent attention are:

(a) population dynamics on continued basis;

(b) breeding biology;

(c) egg and larval survey;

(d) catch and catch-effort statistics; and

(e) spatial/temporal distribution and biomass estimates.

Population dynamics

Length-frequency methods should be adopted for the three riparian states. Besides being less expensive, the methods yield important results within a comparatively less time than other methods. Attempts should be made to acquire data for production models in this respect.

Breeding characteristics

Breeding seasons, fecundity, sex ratio, recruitment rate, maturity stages and histochemical observations should be carried out on this species.

Egg and larval surveys

Since no information is available on these aspects, immediate investigations are necessary for the whole lake to know the breeding habitat, nursery grounds and survival rates in the early life stages.

Catch and catch per effort data

The existing catch assessment survey (CAS) methods should be strengthened and specific objectives incorporated in the exercise. Apart from this, the fishing grounds of all fleets should be mapped out.

Distribution and biomass estimates

Distribution of dagaa in Lake Victoria should be studied using trawl surveys and acoustic methods whereas biomass estimates should be done to facilitate estimation of maximum sustainable and economic yields in surplus production models. From those investigations, it could be possible to formulate sound management policies for rational exploitation, management and development of this fishery.

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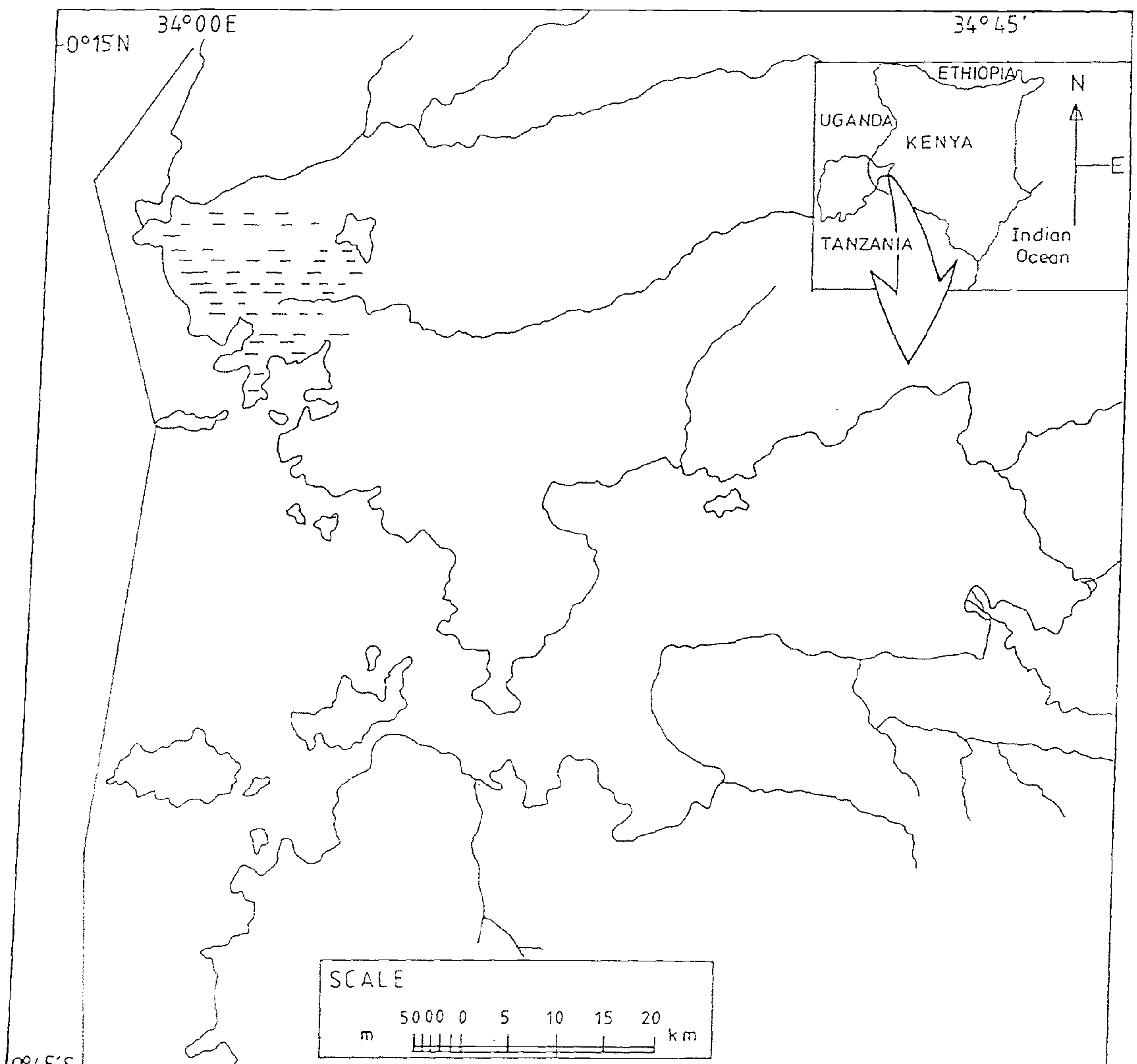

Figure 1: Map showing the Kenyan portion of Lake Victoria

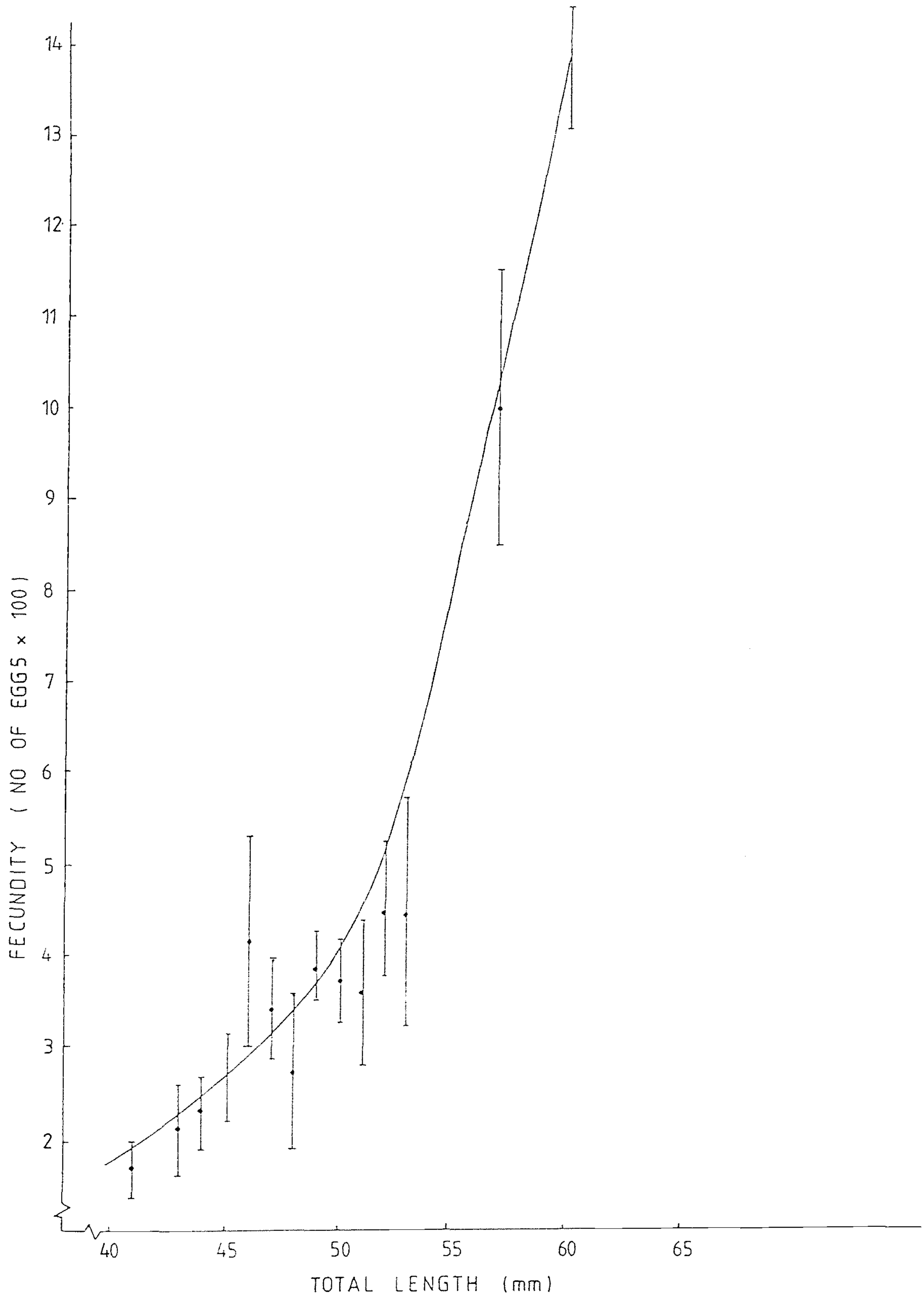

Fig. 2 : The variation of fecundity of dagaa with total body length
Vertical bars show 2 SD

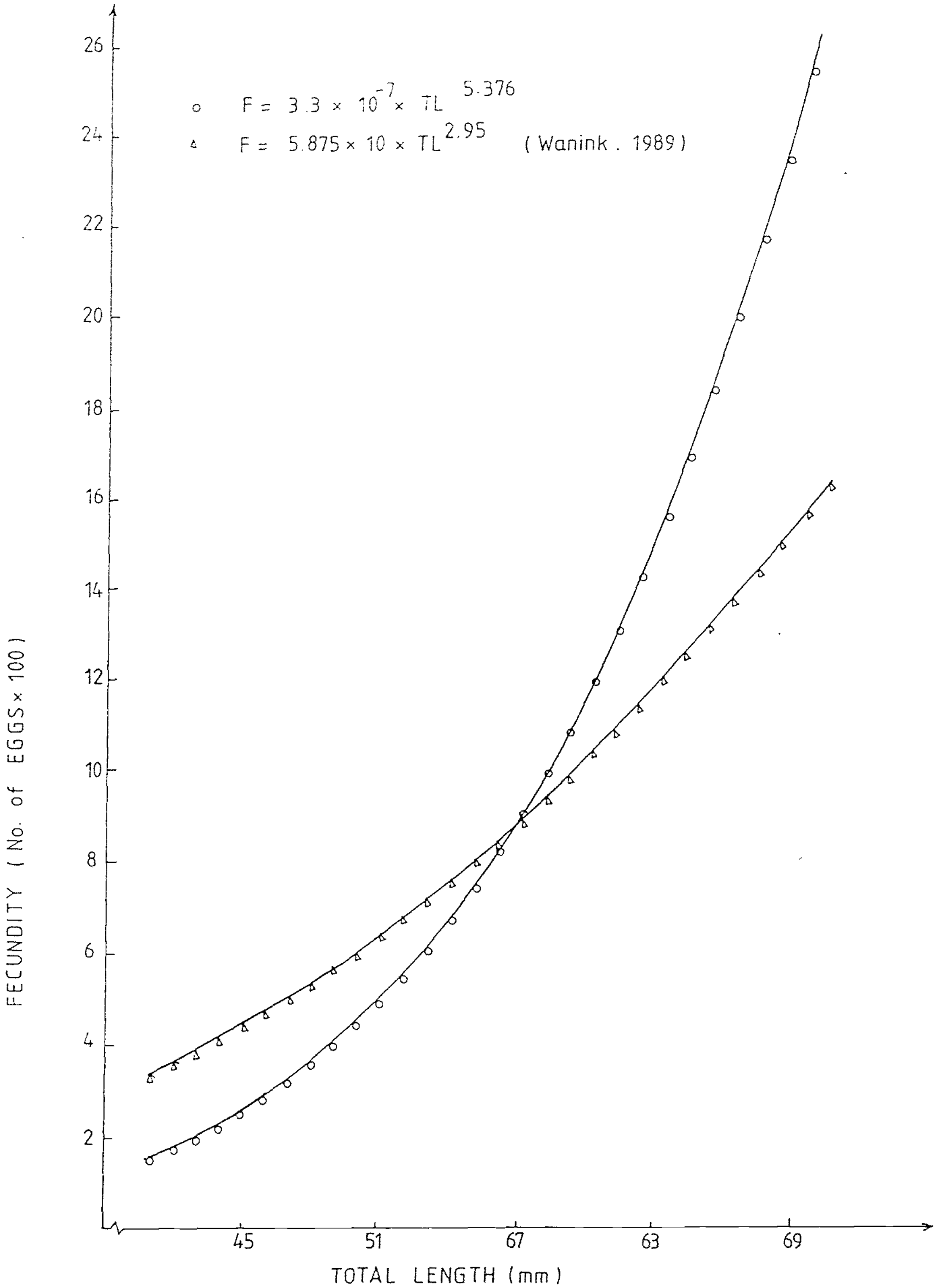

Figure 3 : Fecundity of dagaa from this study (o) compared to Wanink (1989) (Δ)

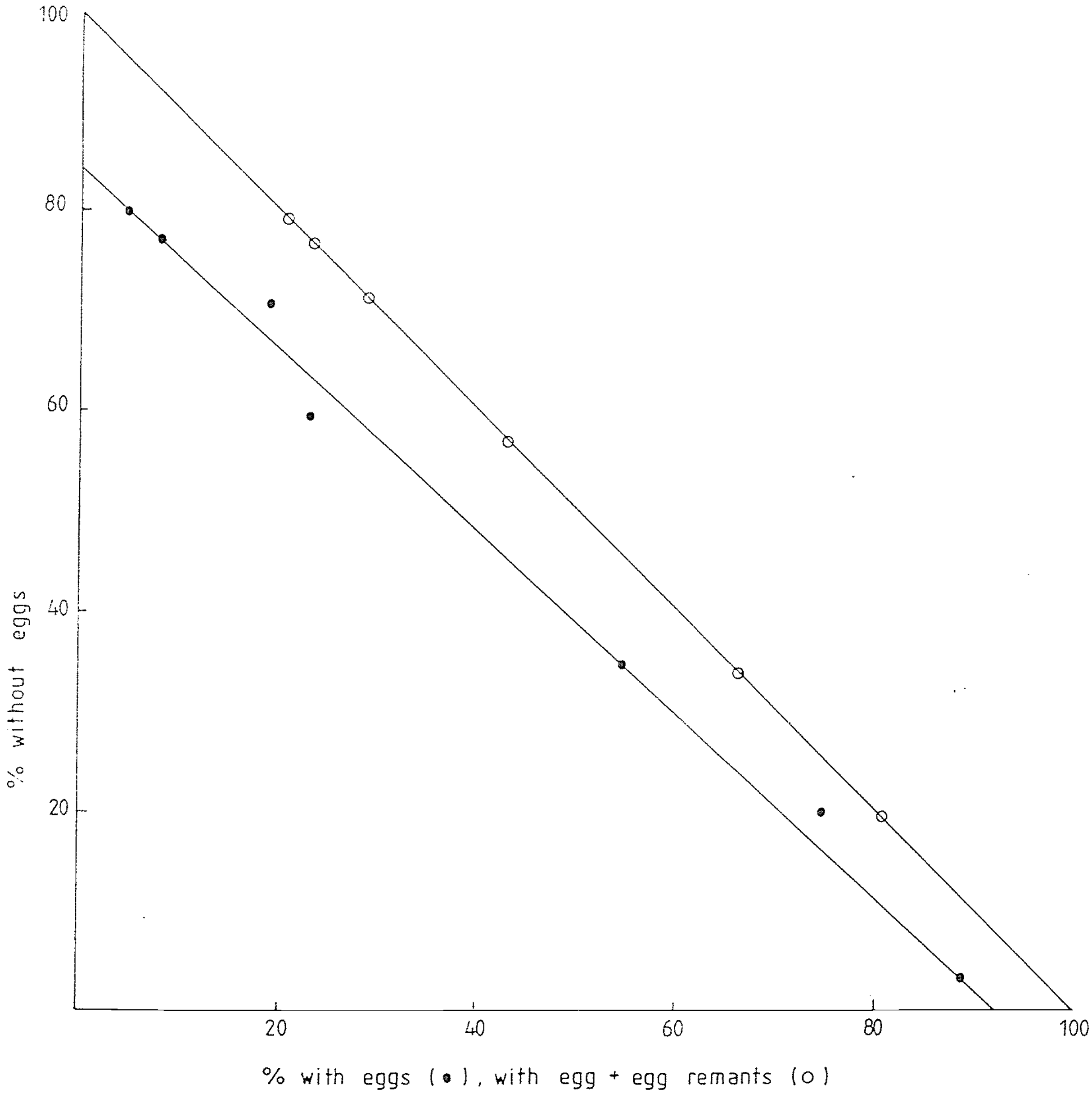

Figure 4 : The in egg bearing population of dagaa from the Winam Gulf of Lake Victoria.

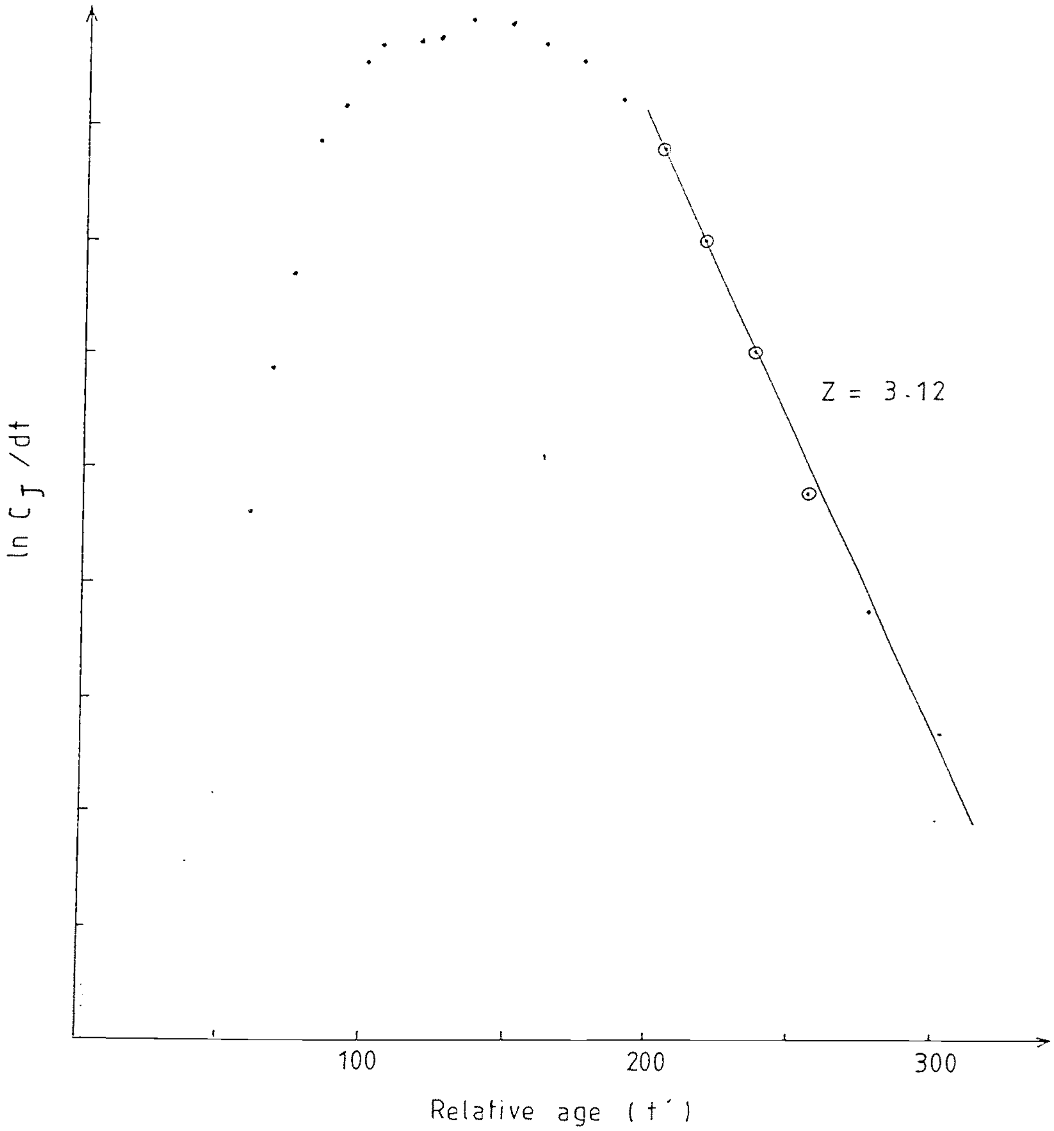

Figure 5: The total mortality coefficient of dagaa estimated from the length-converted catch-curve for 1990/91 (L_{∞} = 68 TL , K = 0,56 year).

Table 1. Annual landings and percentage contribution of dagaa from the Kenyan sector of Lake Victoria from 1968 to 1985.

Year	Annual catch (m.t)	% Contribution
1968	16357	4.5
1969	17442	2.9
1970	16400	3.2
1971	14918	5.1
1972	15989	7.8
1973	16797	10.5
1974	17175	21.8
1975	16581	27.4
1976	18680	30.3
1977	19335	34.5
1978	23856	36.5
1979	30592	30.5
1980	26914	35.1
1981	45667	20.0
1982	60958	17.1
1983	71854	21.3
1984	78420	27.1
1985	89589	29.2
1986	31084	30.4

Table 2. Annual catches from 1987 to 1990, percentage contribution and catch estimates per unit area.

Year	Annual catch (m.t)	% comp.	m.t km^{-2} yr^{-1}	kg ha^{-1} yr^{-1}
1987	30778	24.5	8.2	82
1988	50512	36.5	13.5	135
1989	91422	40.7	24.3	243
1990	75290	39.6	20.0	200

Table 3. Distribution of "dagaa" landings from 22 beaches in the Kenyan sector of Lake Victoria in 1989 and 1990.

Beaches	Catch (m.t) 1989	Catch (m.t) 1990
A. Gulf beaches		
Dunga	65.786	130.315
Usoma	173.398	186.304
Kaloka	180.195	80.942
Asembo Bay	92.537	100.612
Kusa	175.487	176.189
Sango Rota	6.344	15.403
Rakwaro	268.563	248.651
Kendu Bay	-	-
Ngegu	77.342	106.285
Homa Lime	145.787	304.009
Homa Bay	9.248	-
B. Open water beaches		
Luanda Kotieno	87.598	-
Misori	1255.098	2103.499
Wichlum	59.789	161.090
Usenge	230.542	339.962
Uhanya	2488.574	2620.016
Port Victoria	94.997	405.337
Sio Port	-	-
Mbita	-	20.283
Sindo	-	-
Sori Karungu	361.601	573.708
Luanda Konyango	10.993	12.213

Table 4. Effort and catch per unit effort (CPUE) of dagaa in the Kenyan portion of Lake Victoria in 1989 and 1990, in kg.

Effort	1989	1990
Boat days	1170	31500
Net days	7052	178792
Hours worked	12932	358676
Crew days	5155	131360
Average catch/ boat day	191.1	240.8
Average catch/ net day	31.7	42.4
Average catch/ boat hour	17.3	21.2
Average catch/ crew day	43.4	57.7
Average catch/ haul day	6.4	23.0

Table 5. Similarities and differences between monthly landing from : Ngegu (1), Usoma (2), Dunga (3), Port Victoria (4), Sori (5), Misori (6) and Uhanya (7) in 1990. * = similar, + = different and @ = closer to 1, 2 and 3.

	1	2	3	4	5	6	7
1		*	*	*	@	+	+
2			*	*	@	+	+
3				*	@	+	+
4					*	+	+
5						+	+
6							+

Table 6. The sex ratio of dagaa females : males from August to October 1991. Females were significantly more than males.

Date	Sex ratio (females : males)
06 - 08 - 91	1.72
20 - 08 - 91	1.40
03 - 09 - 91	1.39
17 - 09 - 91	1.59
03 - 10 - 91	5.13
17 - 10 - 91	4.10
n	6
Mean	2.555
SD	1.633
	0.025 < P <0.05

4.2 A STUDY OF Rastrineobola argentea IN THE UGANDAN LAKES

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ABSTRACT

Increased stocks of mukene Rastrineobola argentea and the subsequent interest in its fishery on Lake Victoria has been attributed to the poor performance of the endemic fishery as a result of introductions into this lake of foreign fish species Lates niloticus and Oreochromis niloticus. R. argentea now remains the only endemic fish species of economic importance ranking second to the Nile perch in this lake. Despite this importance, biological information on the species and knowledge of its fishery is scanty. Preliminary observations on the species in the Ugandan waters indicate that R. argentea feeds mainly on zooplankton (copepods) during daylight hours. Small quantities of aquatic insect larvae/pupae (chironomids and chaoborids) are also eaten mainly at night. These fishes breed just after the rainy seasons and the young eventually mature at between 43-44mm standard length (SL). Growth and population parameters show a rate of growth (K) of 0.92 yr^{-1} with L_∞ of 64.5mm SL. Natural mortality (M) is given at 2.37 yr^{-1} and total mortality (Z) of 3.59 yr^{-1}. Two mesh size nets 10 and 5mm are in use in the lake. The smaller mesh size which is more preferred by the artisanal fishermen however tends to capture many immature fishes. There is therefore need for a unified lakewide data collection on the species and its fishery in order to obtain more reliable biological information necessary for proper management of this fast developing fishery.

INTRODUCTION

Rastrineobola argentea locally known as mukene (in Uganda), dagaa (in Tanzania) and omena (in Kenya), is a small pelagic cyprinid, which occurs in Lakes Victoria, Kyoga and Nabugabo (Greenwood, 1966). Prior to the 1960's this species was of little economic importance, forming an insignificant proportion of fish landed from those lakes. As a result of the decline in catches of the original commercially important species in Lakes Victoria and Kyoga, fishermen on Lake Victoria have shifted to exploiting this species in commercial quantities. R. argentea now ranks among the top three species landed from Lake Victoria, others being the Nile perch Lates niloticus and the Nile tilapia Oreochromis niloticus. Commercial exploitation of the species on Lakes Kyoga and Nabugabo has however not yet developed although the potential of this fishery on the two lakes and especially on Lake Kyoga exists (Proude, 1963).

The fishery of R. argentea is currently based in the inshore areas and around the numerous islands of lake Victoria where "light fishing" is possible. On moonless nights, kerosene pressure lamps are used to attract the fish which is then either scooped by lift nets, lampara nets or towed to the beach by a mosquito seine net. The catch is sun-dried for both direct human consumption and preparation of animal feeds.

Other than its importance as a cheap source of protein to both humans and in the animal feeds manufacturing industries R. argentea plays an important role in these lakes' ecosystem dynamics. The species in absence of the once abundant haplochromine cichlids is the major food of the Nile perch which in turn accounts for over 50% of the total catches from these lakes. It therefore serves a bridging role in the transfer of energy from the lower (invertebrates) to higher (fish) trophic levels.

Despite its commercial and ecological importance, very little bio-ecological information on R. argentea has been available. Graham (1929) reported that R. argentea spawns in Lake Victoria producing planktonic eggs while Corbet (1961) notes that R. argentea feeds mainly on zooplankton. Preliminary studies by Okedi (1973) revealed that the species breeds in the months of June, July and August and that its fecundity increased with size. In the report of HEST (1988) it was indicated that adult R. argentea stay near the bottom of the lake during daytime and move to the surface at night while the juveniles and parasitized adults stay at the surface throughout. Okedi (1982) suggested that R. argentea could be the most abundant species in waters less than 10 meters deep in the Tanzanian waters of Lake Victoria.

This paper gives a summary of results so far obtained on the biology of R. argentea. It outlines the food, feeding and breeding patterns of the species. The paper also examines the catch characteristics of the gear in common use by the artisanal fishermen on the Ugandan waters of the Lake and tries to assess the impact of these gear on the stocks of R. argentea.

MATERIALS AND METHODS

Sampling sites (Fig. 1).

(a) Napoleon Gulf.

This is the main experimental sampling ground. It is an inshore shallow ground less than 15m deep and close to Jinja. Three main sampling sites were chosen comprising of a sandy beach at Tongolo, the deepwater mid channel and a shallower open bay opposite Masese fish landing. Beach seines were operated at Tongolo while the other two sites were sampled by a trawler M.V. Mputa.

(b) Pilkington Bay

The main fishing ground for artisanal fishermen. It is a small shallow bay (maximum depth of 10m) and covers an area of about 30 km^2. From this fishing ground fishermen's catch were sampled.

Offshore station

Due to lack of facilities into the open deep waters of the lake, it was not possible to sample these waters. It has however been planned to sample open waters deeper than 40m for comparison with shallower bays. There is still hope that when the research vessel "Ibis" which is undergoing repairs is ready these waters will be sampled.

Sampling gears and methods

A mosquito seine net 10mm stretched mesh, measuring 14m long and 2m deep was operated on sandy beaches around Tongolo. A 19mm codend mesh trawl net operated from a research trawler "MV Mputa" was used in waters within the gulf and Masese bay. At Lingira, the fishermen operating in Pilkington Bay have changed their fishing methods at least twice in the last decade. Prior to 1989, these fishermen were operating 10mm stretched mesh beach seines measuring 15m long and 2m deep. These were operated from ropes 20m on either sides. A pair of lighted kerosene lamps was slowly towed towards the beach after one hour's exposure into the open bay. At the beginning of 1989 this method was abandoned for an off-beach 5mm stretched mesh lampara net. This net measuring 24m long and 10.5m deep was cast around a lamp and the catch hauled directly onto a canoe without having to tow the lamp ashore.

On hauling the fish ashore or on the boat from the beach seine or trawl net respectively, samples of R. argentea were sorted out and immediately fixed in 4% formaldehyde solution for laboratory examination.

From the fishermen catch a random sample of about 300 specimens was taken and also fixed as above. Sampling has been done at various times of the day covering the four main seasons.

In the laboratory the fishes were sorted out, and standard length (SL) and weight recorded. Each fish was cut open to determine sexual maturity stages following Kesteven as modified in Bagenal (1978). The gut was dissected out and food examined. Eggs from ripe ovaries stages 5 and 6 were counted. From Lingira fishing villages, the number of fishing units i.e. nets, boats and lamps were recorded. Records of catches from these fishing units were monitored from Masese fish landing where the bulk of the processed catch from this village was landed for sale.

RESULTS AND DISCUSSION

Food and feeding

Zooplankton mainly copepods form the major diet of R. argentea. Aquatic insect larvae and pupae mainly chaoborids and chironomids are also eaten. Major feeding peaks occurred during daylight hours while least feeding was at night (Figs. 2a and 2b). On nights when the lake flies emerged, the percentage of stomachs with food would be higher and would contain large quantities of these emerging flies and their pupae. An examination of a twenty four hours feeding cycle revealed that during day time zooplankton formed the main food while at night insect larvae and/or pupae were the main food type (Fig. 3). Juveniles of mukene (smaller than 30mm SL) fed almost exclusively on zooplankton (copepods and early instars of chironomid larvae) during the day. No feeding activity was observed among these juveniles at night.

The feeding patterns of R. argentea is closely related to the species distribution over time and space. Adult fishes stay near the bottom of the lake during daylight hours and move to near the surface at night (Wanink, 1988). Zooplankton is also known to undergo similar dial migration. This avails R. argentea with a zooplankton diet during the day. At night however, the species appears to favour the larger insect larvae and pupae prey although zooplankton could also be available in the water column. Juveniles being too small for this type of prey are unable to ingest them. Judging from the clear nature of food items eaten, R. argentea appears to be sight feeder which obtains prey from the water column. This probably would also explain the least feeding of adults at night when visibility is poor.

Maturity and breeding

Fishes showing gonadal development stage I and IIa were considered immature, IIb were considered recycling females while males recycled at stage III. In 1988 size at first maturity, defined as the smallest size at which 50% of the fishes examined are mature (Beverton and Holt, 1957), for females was found at between 43-44mm SL. The males matured at 40-41mm (Fig. 4). All individuals of 47mm and above were mature. It is to be noted that during this period fishing pressure on R. argentea in Pilkington Bay was considerably lower than in the later years beginning with 1989. The situation at present is slightly different and more mature specimens of a smaller size than those quoted above are being encountered.

The species being fast growing and with a high turnover rate is capable of reacting to higher fishing pressures within such a short time. The reduction in size at first maturity may be one of the reactions to this increased fishing mortality. It appears that higher fishing pressure may not be solely responsible for this reduction in size. Fishes from lake Kyoga where no commercial fishery for mukene exists, show even a smaller size at maturity. Specimens as small as 20mm from this lake were found mature. The mean adult size of R. argentea from Lake Kyoga is also smaller. This could be the effect of Nile perch which was introduced and established itself much earlier than in Lake Victoria and has exerted considerable predation pressure on mukene.

R. argentea breeds throughout the year with peaks occurring just after the rain seasons in April-May and August-September. These results differ slightly with Okedi (1973) who notes that R. argentea breeds in the months of June, July and August. These periods after the rain seasons in Lake Victoria are normally associated with the lake's turnover period when the lake completely or partially mixes (Talling, 1966). The subsequent algal blooms and presumably the high densities of zooplankton and insects which follow these blooms provide a lot of food to R. argentea. Availability of enough food resources to the species encourages gamete production.

Population structure and fishery

Prior to 1989 when fishermen on Lingira Island were using 10mm stretched mesh beach seine nets, the size structure of mukene captured showed a larger mean size (Fig. 5a). Figure 5b however shows the size structure of the catch from a 5mm lampara net introduced at the beginning of 1989. While the 10mm net allows the majority of the juveniles to escape, the 5mm lampara net tends to capture even these small immature fishes (Ogutu-Ohwayo *et al.*, 1989; Wandera, 1989). The beach seine net tended to capture many juveniles of non-target species O. niloticus and L. niloticus. The lampara seine net on the other hand catches negligible quantities of these by catch species (Ogutu-Ohwayo *et al.*, 1989).

Continued use of the 5mm net and the increase in effort that followed its introduction (from 2 nets in 1988 to 12 nets in 1990) has led to a reduction in the mean size of R. argentea caught from this Bay. Catch per net per month as monitored from landings at Masese also dropped from 7430 kg to 2912 kg in the same period, as reported in table 1 (Wandera, 1990). The mean adult size of mukene and the percentage contribution of mature fishes caught in this bay has continued to decline (Fig. 6). Because of this general reduction in catch rates fishermen who had originally restricted their operation to Pilkington Bay, are now spreading their fishing grounds and now cover Buvuma Channel and Napoleon Gulf.

Growth

Analysis of mukene data collected in 1988 by the ELEFAN Computer program revealed the following growth parameters: $L\infty = 64.5$mm, $K = 0.92\ yr^{-1}$, $M = 2.37\ yr^{-1}$, $F = 1.22\ yr^{-1}$ and $Z = 3.59\ yr^{-1}$ (Wandera and Wanink, in press). With the increase in fishing pressure and the subsequent reduction in the mean size of fish caught, these parameters are likely to have changed considerably. Over the last two years length frequency data collection has been irregular and thus the inability to work out new growth parameters.

While fecundity studies on Lake Victoria specimens have not been completed preliminary observations indicate that R. argentea produces very few eggs as compared to other species. Fishes from Lake Kyoga showed total count of 118 eggs from the smallest fish 27mm long examined to 1250 from the largest examined measuring 49mm. However as noted by Okedi (1973) fecundity in _R_. _argentea_ increases with length.

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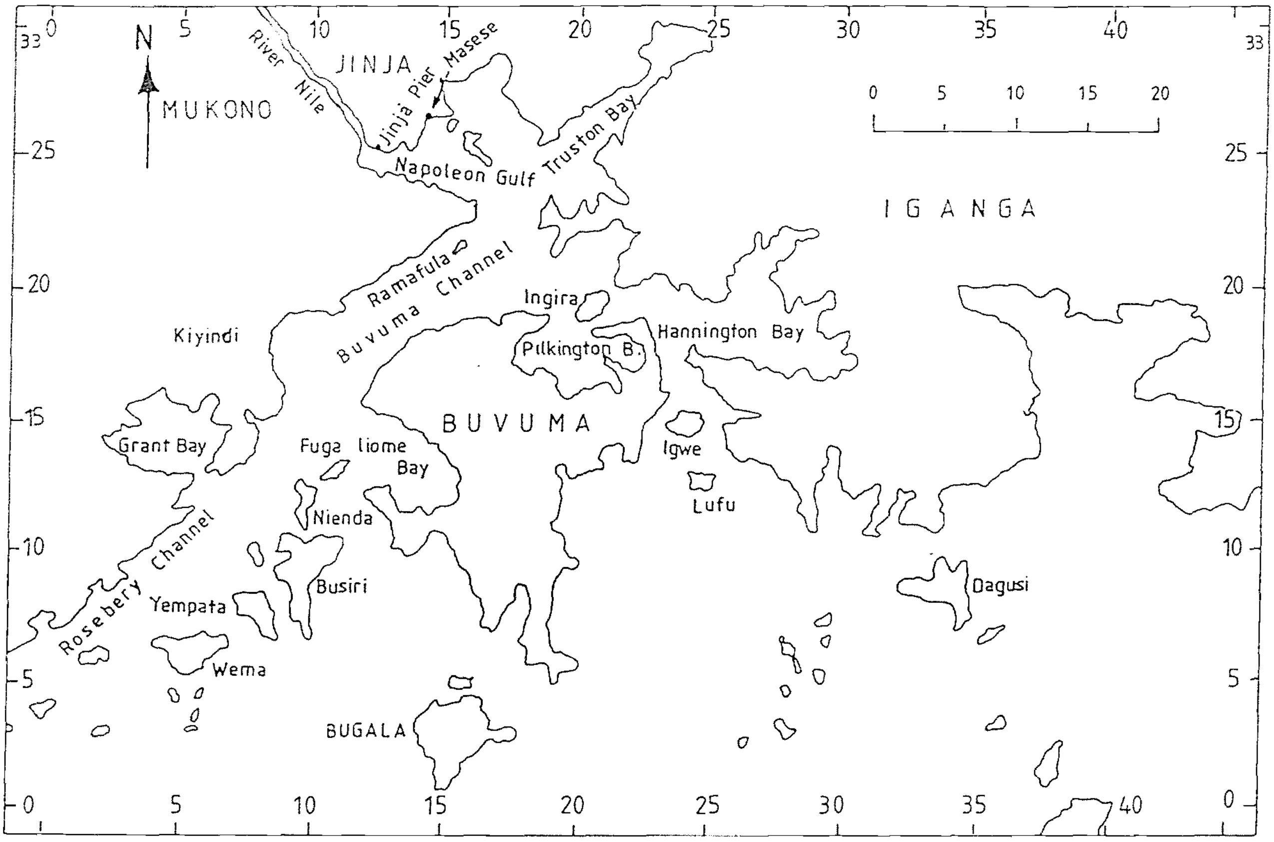

Figure 1 : The Jinja portion of Lake Victoria.

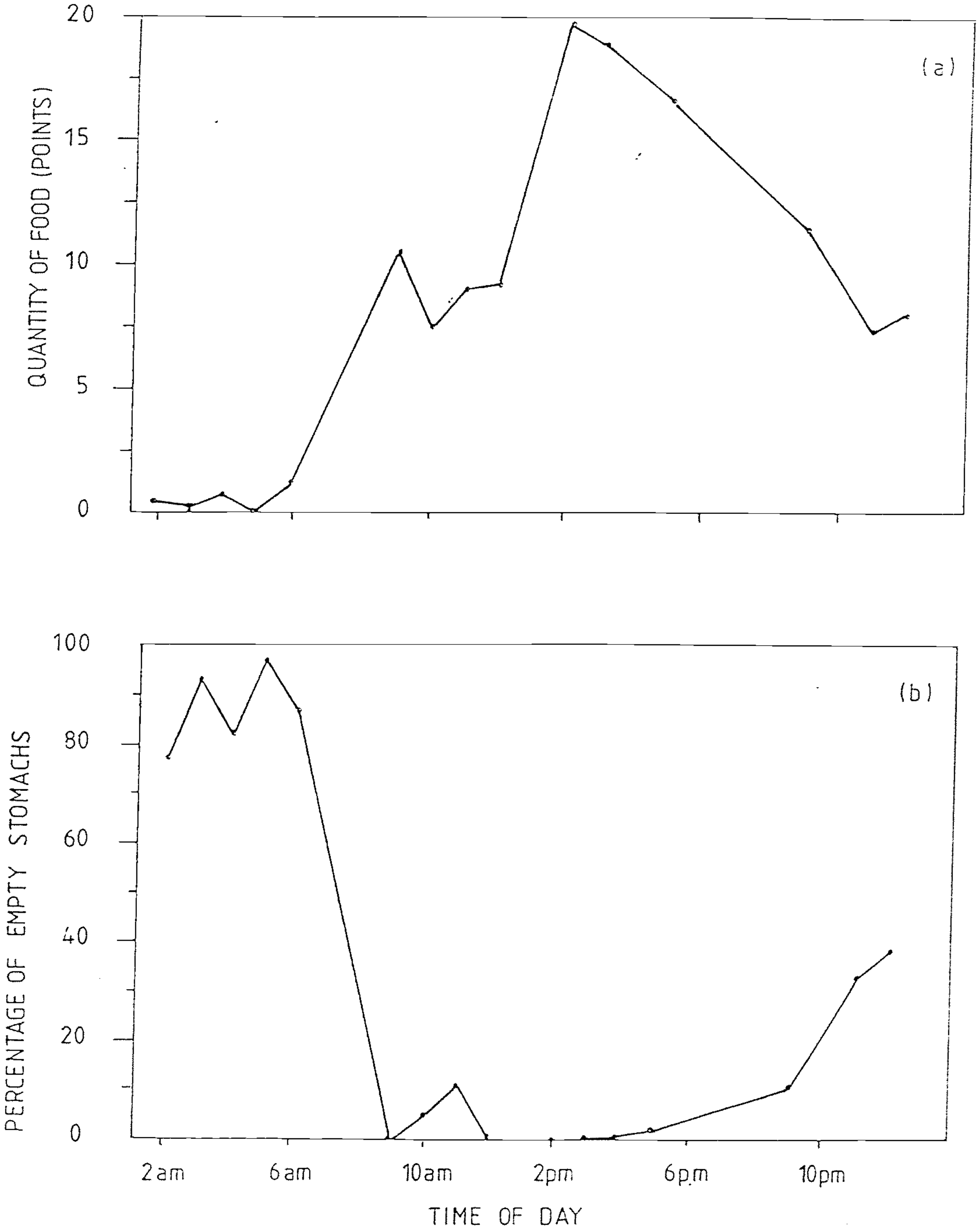

Figure 2: Feeding periodicity of *Rastrineobola argentea*

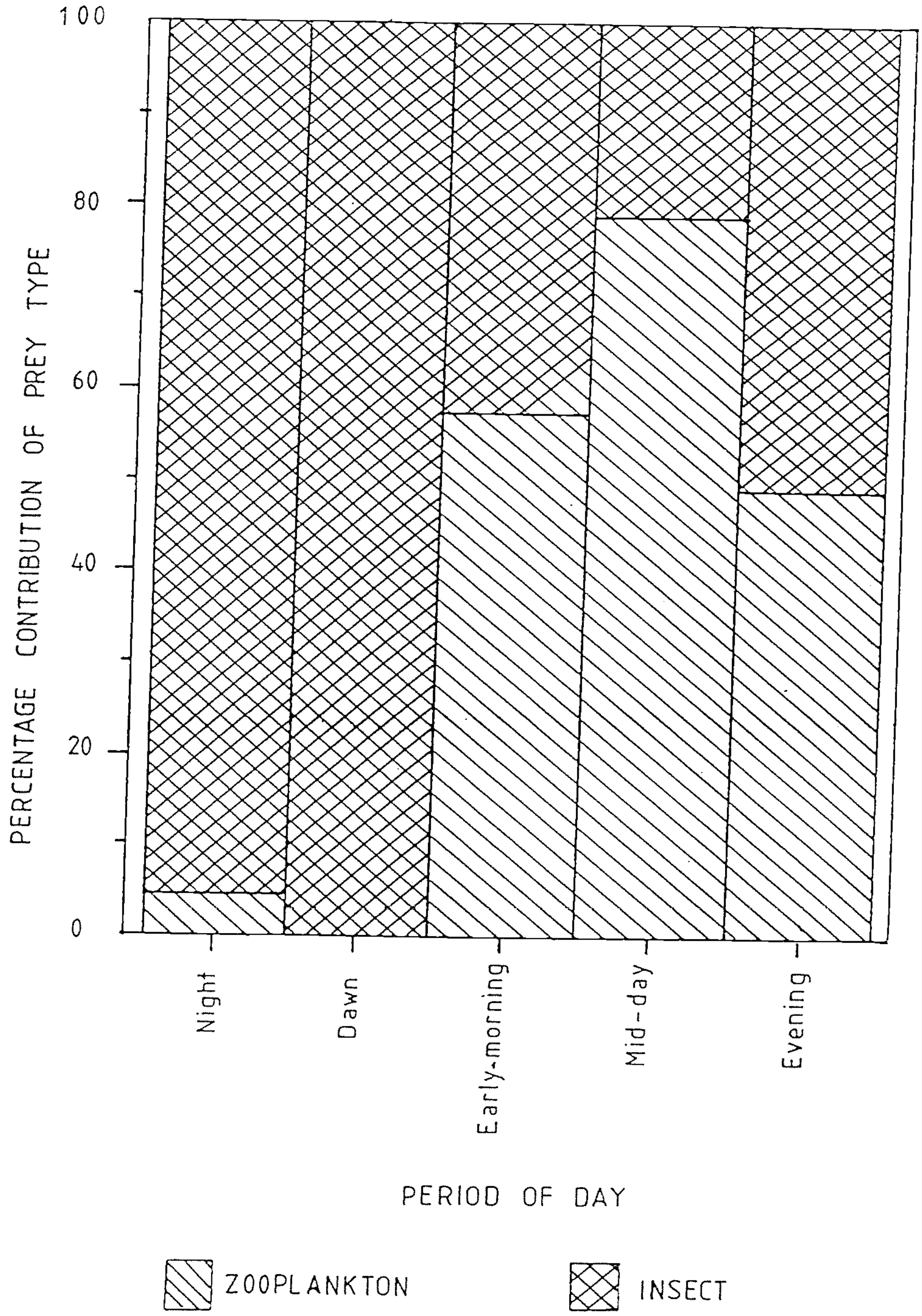

Figure 3: Prey selection by R. argentea

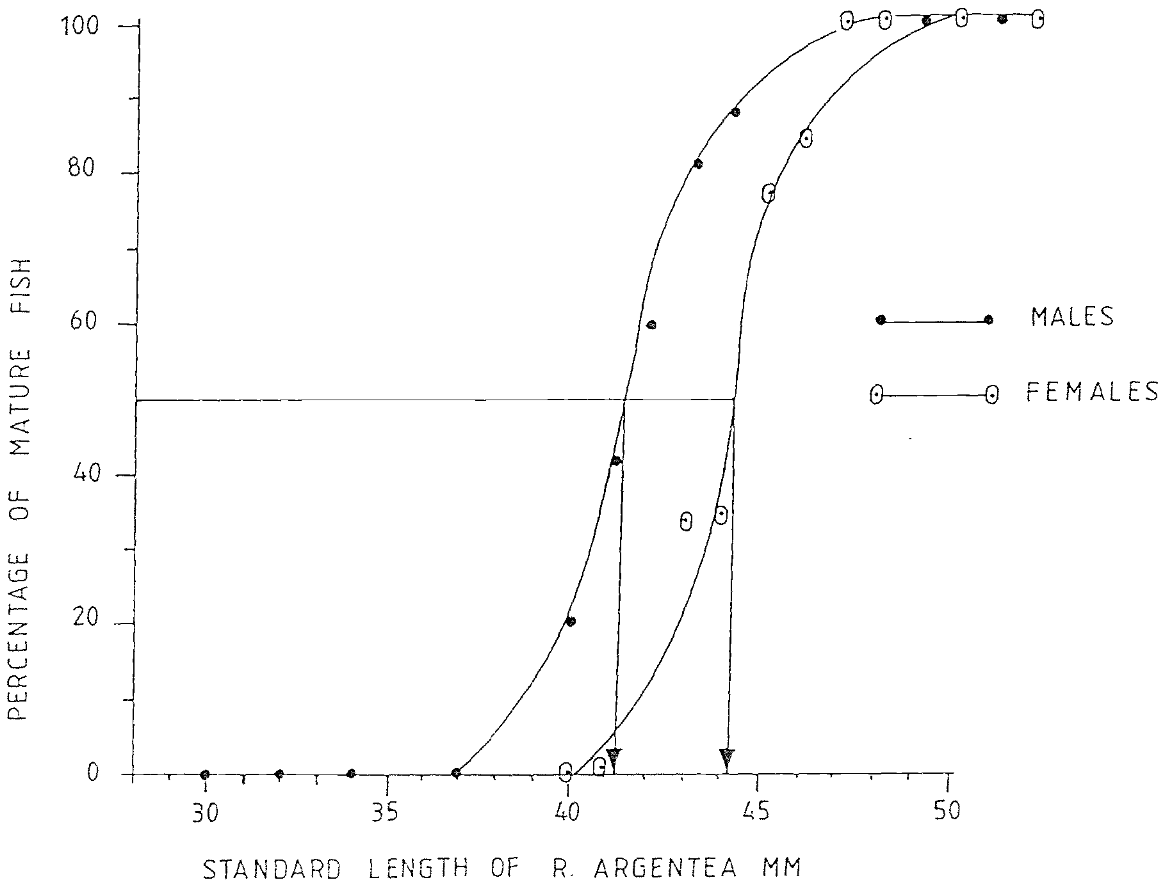

Figure 4 Size at first maturity of R. argentea.

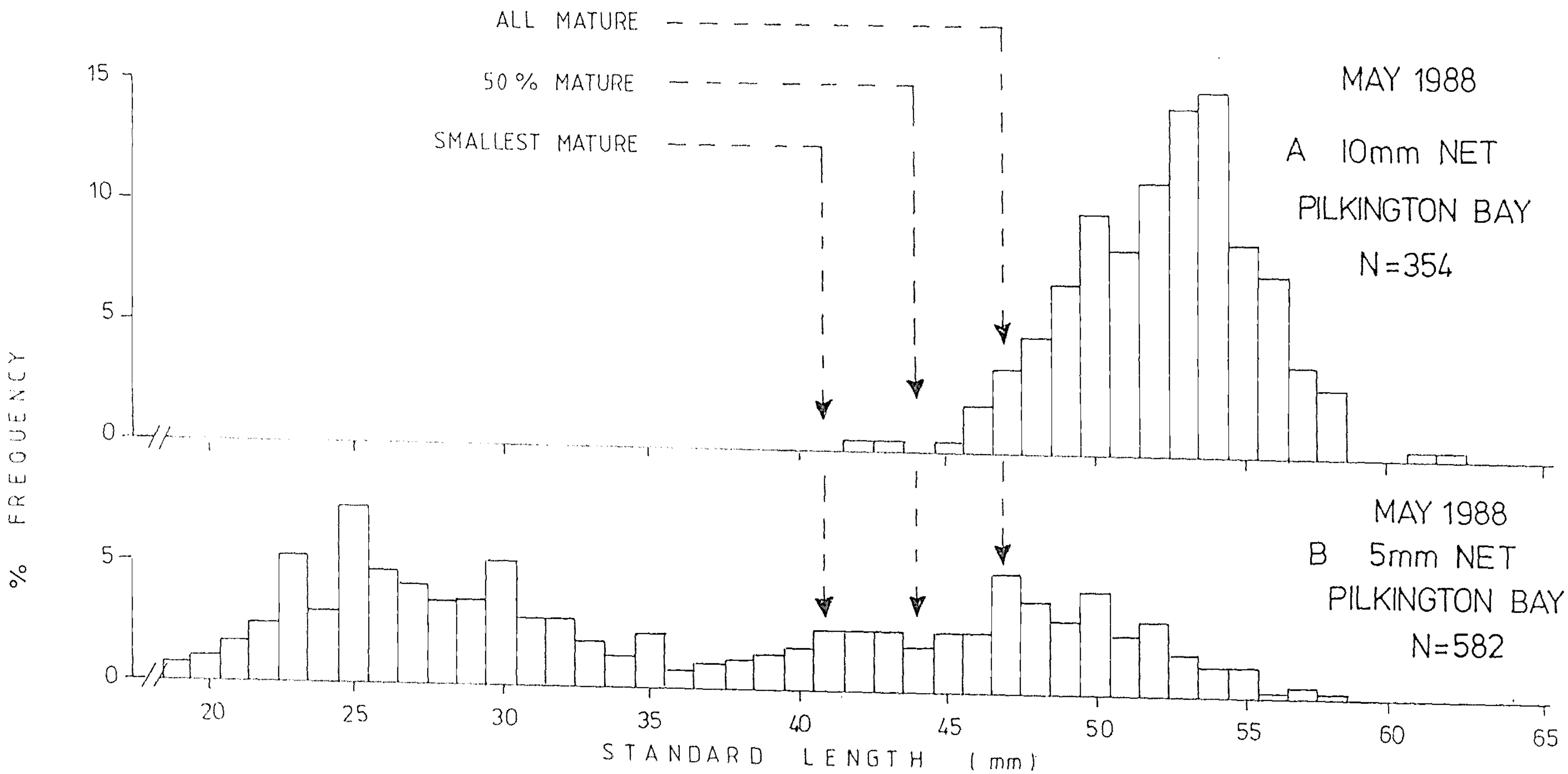

Figure 5. Length frequency distribution of R. argentea caught by A: 10mm beach seine net B. a 5mm Lampara net operated by artisanal fishermen in Pilkington Bay.

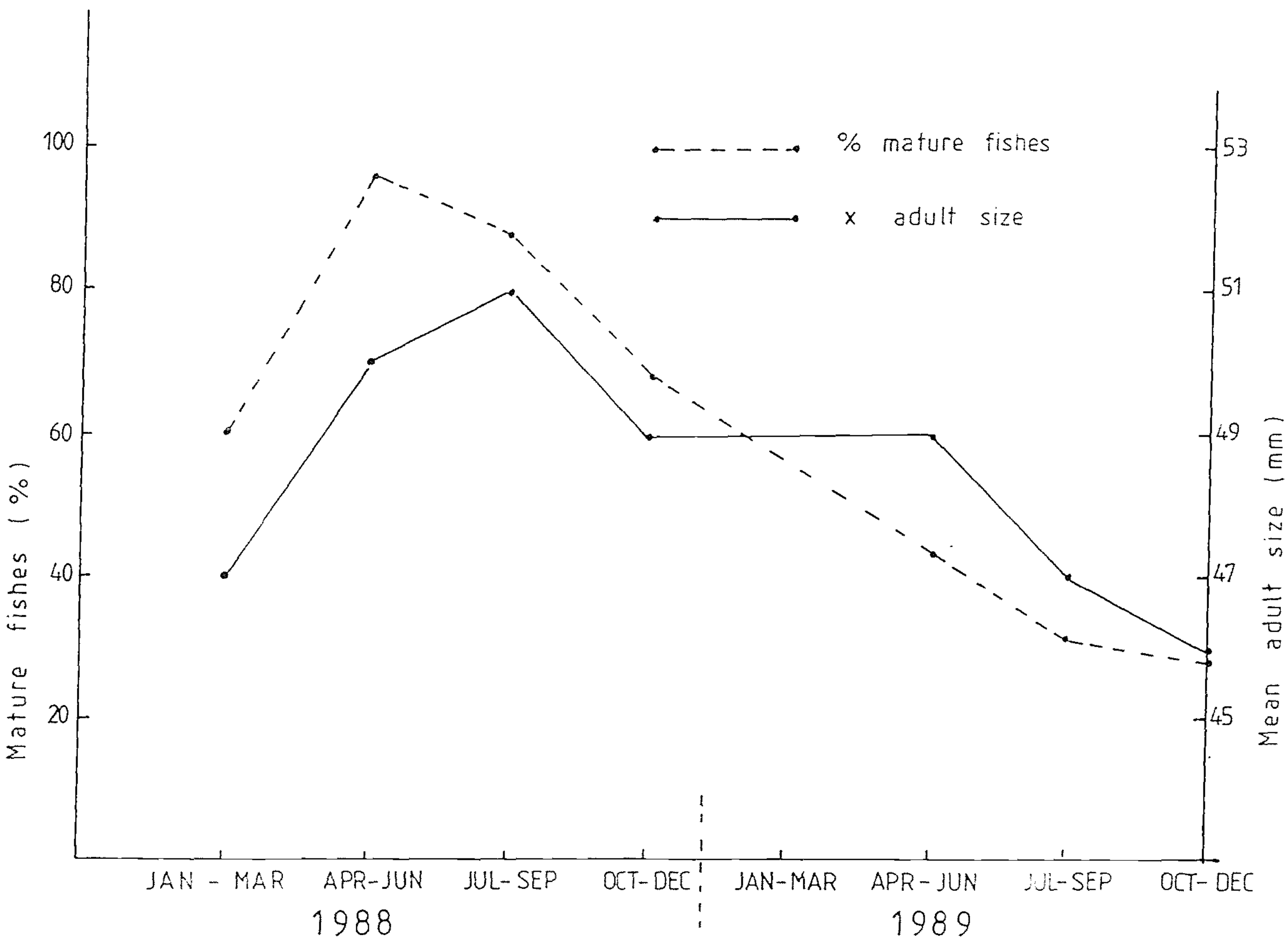

Figure 6 Changes in percentage mature fish and mean adult size of *R. argentea* caught in Pilkington Bay.

	1 JAN-MAR	9 APR-JUN	8 JUL-SEP	8 OCT-DEC	1 JAN-MAR	9 APR-JUN	8 JUL-SEP	9 OCT-DEC	1990 JAN-MAR
No. of nets	2	4	4	7	6	8	9	11	12
Size of nets (mm stretched mesh)	10(BS)	10(BS)	10(BS)	10(BS) 5(LN)	5(LN)	5(LN)	5(LN)	5(LN)	5(LN)
Mean size of fish caught (mm SL)	47	50	51	49	49	48	47	46	39
Catch/net/ month (Kg)			7430	5410	6608	7170	9425	4531	2912
Mature fishes caught	60	96	88	68	NA	44	31	21	21

Table 1. Changes in the mukene fishery of Pilkington Bay, January 1988 to March 1990. BS = Beach seine net, LN = Lampara net.

Sources 1. Landings at Masese - UFFRO records
2. Author's samples from Lingira artisanal fishermen's catches

4.3 BIOLOGICAL AND FISHERY ASPECTS OF *Rastrineobola argentea* IN THE SOUTHERN PART OF LAKE VICTORIA

by

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ABSTRACT

Over the past recent years, small pelagic fisheries have been reported to be increasing in many of the great African Lakes. Prior to this, both the industrial and the artisanal fisheries targeted on the large commercial species often causing their depletion. This has led to the recognition of small pelagics as a potential economic resource. Data collected in the Mwanza Gulf over the past years have depicted a steady decrease in the mean sizes of *Rastrineobola* fishes. Factors considered to be contributing to this phenomenon are discussed. Variable methods exist in the mode of exploitation of the fishery but features common to all these are described. The catch per unit of effort (CPUE) for the fishery is defined with practical problems pertaining to the collection of catch-effort data. The paper summarizes the available information on the biology and fishery aspects with a view to describe the fishery and identify biological facts likely to lead to the formulation of management policies.

INTRODUCTION

In recent years, small pelagic fisheries have been reported to be on the increase in many of the Great African Lakes. In Lake Tanganyika the clupeids *Stolothrissa tanganicae* and *Limnothrissa miodon* contribute greatly the beach landings. Lake Malawi is known to harbour appreciable amounts of *Engraulicypris sardella*. *Neobola bredoi* in Lake Mobutu, and *Neobola moeruensis* in Lake Mweru and Bangweulu also support growing fisheries. *Rastrineobola argentea* is reported to be an important species in Lakes Victoria, Kyoga and Nabugabo.

Over the past years both the artisanal and industrial fisheries targeted on the large preferred species, as a result causing a depletion in catches of these species. This decline gave way to the recognition of the pelagic fishes as an economic potential resource (CIFA, 1984). Further attempts to increase productivity, resulted in the introduction of these fishes into other smaller bodies, e.g. *L. miodon* from Lake Tanganyika has been introduced in Lakes Kivu and Kariba (Frank, 1977; Petr and Kapetsky 1983). Also it is considered that *L. miodon* may have found its way into Cahora Bassa reservoir (Junor and Begg, 1971, in Marshall, 1984).

Initial information on the evolution of *R. argentea* in Lake Victoria was reported by Okedi (1974). R. argentea was first observed in Tanzania and Kenyan markets in the 1960. The significance of the fish never came to notice until a later date. From regular beach sampling programmes, Okedi (1974) established a yield of 3500 metric tons around Ukerewe Island. Ever since, there has not been serious collection of catch effort data on the species, despite tremendous quantities being transported to neighboring countries. Neither has there been biological investigation on the fish except the recent information by Wanink (1989).

The current paper reviews the available information on the biology and fishery aspects with a view to devise a management strategy suitable for optimal harvest. The information is based on the data from Igombe, Izeragara and Mwanza Gulf.

THE BIOLOGY AND ECOLOGY

The Cyprinidae (Pisces, Teleostei, Cypriniformes) are normally riverine although some members occur in lakes. Data from offshore waters is lacking. Large quantities of Rastrineobola come from inshore and coastal waters (Greenwood, 1966). Wanink (1989) reports an increasing biomass (both density and mean size increase) with increase in depth up to a maximum between 10-20m in the Mwanza Gulf. However, the biomass tends to decrease at greater depth. There has not been attempt to estimate the standing stock so far and the figures available are only on estimate.

Vertical migration involve both the adult and juvenile Rastrineobola. The majority of the adult fishes are found at the bottom during daytime, and move to the surface at night, when the juveniles show a reverse pattern (Wanink, 1989). This behavioral pattern has been associated with depth-related biotic and abiotic factors, like dissolved oxygen in the water column, light penetration, food abundance, competition, predation and parasitization.

In addition to their value as food and an economic resource, R. argentea plays an ecological role, in that it forms a link in the food chain between the herbivores and predators higher up in the lake ecosystem. It has been considered as a buffer to the cannibalistic effect of the Nile perch (Katunzi, in prep.).

Earlier studies had indicated R. argentea to coexist with Lates niloticus because of their differences in habitats (Arunga, 1981; Muller and Benda 1981; Okemwa, 1981, 1984). The vertical migration during the day leaves the much smaller fishes on top to be preyed on by the birds. Despite the heavy predation by Lates, R. argentea has survived, and is the only native fish in the lake with appreciable quantities.

There are significant differences in the maximum lengths of Rastrineobola found in different areas. Data collected in the Mwanza Gulf over the past years have revealed a steady decrease in mean sizes of the fishes. This could be a result of a number of reasons. Adaptation to adverse growth conditions could result in size reduction of fish (Fryer and Iles, 1972; Bowen, 1979). It could result from intraspecific competition for food (Mittlebach, 1981). It could also be a result of abrupt change in the environment (Noakes and Balon, 1982).

In the current situation, the intense predation pressure caused by the Nile perch is considered the main cause of environmental stress on the stock. This is further enhanced by the heavy fishing pressure developed in the southern part of the lake, particularly in areas around Ukerewe and Igombe. In consequence, there is stimulation of the reproductive output in order to sustain survival. This tends towards attaining reproductive maturity at a smaller adult body size (Law, 1979; Begon, 1985). Shorter life span, smaller eggs and faster growth rates which are also associated with these changes (Noakes and Balon, 1982) have not been observed in the Mwanza Gulf (Wanink, 1989).

THE FISHERY

A survey over the fishing ground has revealed the main basic types of artisanal fisheries based on R. argentea. These are beach seine, scoop net and lift net fisheries. Considerable variability exists in the mode of fishing for each of these methods. A number of features are however common to all of them and these are as follows:

(I) all gear types depend on light attraction of the fish by an artificial light source. The lantern of an average fuel consumption of 0.1 l/hr^{-1} is in common use (Mous *et al.,* 1990).

(II) during a period of full moon fishing stops because of interference with light concentration;

(III) processing by sun drying is done by fishermen on the beaches. Only about 20% of the catch is sold fresh;

(IV) a tin of about 20 kg is taken as a unit of measurement for marketing at retail level; and the dried fish is sold in gunny bags of 35-40 kg at wholesale level;

(V) fishermen are known to operate in groups. They are normally employed or hired, and arrangements on the mode of payment are negotiated between the fishermen and boat owners or traders.

(VI) fishermen migrate to other sites when the catches get low.

Beach seine which is the most common gear, is better operated on sandy beaches. The lamps are attached on a locally made raft at a distance varying between 10 and 20m. These are left for some time to allow the fish to concentrate. The lamps are then hauled to the beach, and the net is set around the lamp and then hauled to the shore. Beach seines up to 100m are made of nylon (ply 4 or 6) having stretched mesh size of 8 - 10mm. In the scoop net fishery, the lamps are hauled close to the canoe after the fishes have been attracted, so that they are scooped and placed in the canoe. Many scoop nets have mesh sizes

5 - 8mm. The lift net operation is slightly different. The vessel is composed of two boats connected to each other like a catamaran. Lamps are set on planks in the middle of the catamaran. The net is set under the craft. After some time the net is hauled and the fish put into the canoes. The lift net units have been introduced from Kigoma and constitute a truly pelagic and offshore fishery.

For efficient fishery management, statistical data collection is a necessity for prediction of the long term evolution of the fishery in question. This would take the form of gathering catch and effort data from artisanal landings. Mous *et. al.* (1989) proposed a technique for a quick gathering of information taking into consideration the constraints imposed by limited resources. The unit of effort has been identified as lamp burning hours or lamp fuel consumption. The idea is based on the assumption that fish concentration depends on the number of lamps, and the length of time taken for the lamps to burn. The lamp hours measure is however appropriate for both the beach seine and scoop net but inappropriate for the lift net fishery (Mous *et al.*, 1989). This is because the variation in number of lamps per catamaran is very low and thus resulting in a non-linear relationship between catch and effort. Fishing hours were however proved appropriate measure of unit of effort for the lift net fishery.

There are practical problems pertaining to the collection of catch effort data of R. argentea. Planning the catch assessment survey is complicated by the fact that the fishermen process the fish themselves as soon as the catch is landed. Since landings occur throughout the hours of darkness the recorder should stay overnight in order to measure and weigh the fish. As there is no regular landing site for Rastrineobola, it is difficult for a recorder to carry out site visits. Indeed the "dagaa" fishermen are known to shift from one place to another depending on the evolution of catch rates. Catch records from the lift net fishery are more reliable since the fishermen stay overnight and the landing time is predictable. Since this is mainly from offshore waters depending only on information from this fishery may not be decisive. In general, it is difficult to obtain a reliable estimate of total dagaa catch from catch recording at the landing sites.

Kirumba harbour is the best trading centre for dry R. argentea. The fishes are collected by dhows from all the parts of the lake, and landed at Kirumba ready for transport to either other parts of the country or abroad. Over the past years both the fresh and dry weights have been recorded but at different places. Beach recorders at landing sites take fresh weight whereas the sundried dagaa are transported from the Islands to Kirumba mwaloni (Tables 1 and 2).

Table 1. Fresh weight in tons of R. argentea as recorded from landing beaches.

Year	1979	1980	1981	1982	1983	1984	1985	1986
Weight (tons)	2126	1332	3718	1628	541	1219	2895	8217
Year	1987	1988	1989	1990				
Weight (tons)	4239	15863	3076	16017				

Table 2 . Sundried R. argentea in tons as recorded from the major commercial centre (Mwaloni).

Year	1985	1986	1987	1988	1989	1990
Weight (tons)	3372	3333	6404	3143	3531	5334

There are however, no recent information on the total catch. Okedi (1981) estimated a total catch of 3828 metric tons wet fish from Ukerewe Island in 1978. The total catch for Rastrineobola on the Tanzanian sector based on national statistical data set was reported to be 3289 tons during 1978 (Ssentongo, 1985). This covers a period 1978-1984. Eversince, there is no recent data for the Tanzanian part of the lake.

The available information is scanty to estimate a reliable maximum sustainable yield and fishing mortality. Casual observation however indicate an increase in yield, but there is no data to quantify this phenomenon.

The number of beach seines scoop and lift nets getting into the fishery has greatly increased. External market has also been expanded to Zambia, Rwanda, Burundi and Zaire. Such a trend should be monitored in order to assess the possible marketing routes and patterns of exploitation. Second to Nile perch Rastrineobola has contributed greatly to the revenues and welfare of the local communities. The prospects for the fishery are promising, but there is need for continuation of fishery research in order to obtain relevant information on the stock and be in position to devise management strategies.

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4.4 THE FISHERY OF RASTRINEOBOLA ARGENTEA IN SOUTHERN SECTOR OF LAKE VICTORIA

by

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ABSTRACT

In the present situation of Lake Victoria Rastrineobola argentea is both the most important fish prey to Lates niloticus and the second species of commercial importance. Although it is indigenous to the lake, its exploitation started about three decades ago and its yield has been increasing alongside that of L. niloticus an introduced predator. At present it is not easy to predict the future trends of R. argentea fishery as there are no data for the exercise. There is need to gather information and study about this small cyprinid so as to assess its potential yield and ensure the rational management of the fishery.

INTRODUCTION

Rastrineobola argentea - locally known as dagaa - is a small cyprinid, indigenous to Lake Victoria. In the past the fish was almost unknown and its exploitation only started in the mid 1960's. The fishery became important following the collapse of the then important fisheries of Oreochromis esculenta, O. variabilis, Haplochromis spp., Bagrus docmac, Clarias spp., Labeo victorianus, Schilbe mystus and Mormyrus spp. The above species have almost disappeared through overfishing (Beauchamp, 1958) and Nile perch (L. niloticus) predation (Asila and Ogari, 1988). This has resulted in the upsurge of R. argentea biomass through much reduced interspecific food competition (Wanink *et al.*, 1988) as compared with the situation prevailing during the haplochromine era.

Despite the current importance of R. argentea there exist no catch data on the fishery in Tanzania and this brings about uncertainty in assessing its contribution, though it is taken for granted from visual experience that the species is second in commercial importance as is the case elsewhere (Asila and Ogari, 1988).

R. argentea is about 7cm standard length (SL). A few length - frequency measurements carried out at our station have yielded modal lengths ranging from 3.5 to 5.5cm SL. Sample frequencies were mostly unimodal but a few showed bimodality. Sometimes modes of fish taken from the same fishing ground in two consecutive nights differed greatly, indicating that the fish might be moving rapidly in discrete patchy units. However, a lot more of work is still required on this species.

THE FISHERY

Four types of gear are now used in capturing R. argentea. These are the dagaa seine, the scoopnet, the liftnet and the canoe seine. They are usually constructed with netting material of 8-10mm stretched mesh and 4 to 6 ply. Frequently the cheap mosquito net material is used in constructing the canoe seine locally known as "hurry up".

All types of gear use light to attract and concentrate the fish. The commonly used source of light is the pressure lamp of 350 - 500 c.p. Two to ten lamps may be used by one fishing unit during operations. The scoopnet takes the least amount of material to construct, followed by the dagaa seine; the liftnet and the canoe seine involve quite substantial amounts of netting and are therefore expensive. Fishermen are sometimes inclined to use the cheaper mosquito net material in constructing the canoe seine.

Catch rates differ correspondingly among the types of gear. Fishermen measure their catches in terms of the 20 l tin locally known as "debe". On the average the scoopnet fetches about 3 debes per night; the dagaa seine gets about 5 - 10 while the liftnet and the boat seine get around 10 - 15 debes. In extreme cases the scoopnet can fish as much as 20 debes per night, while the last two may get up to more than 50 debes.

In R. argentea fishery not always does the catch comprise purely of the target species, occasionally there are by-catches of other species. In the past the by-catch used to be Haplochromis spp. but as the Nile perch predation intensified the by-catch changed to juvenile perch and occasionally the young of Oreochromis niloticus. To date the by-catch also includes substantial amount of the shrimp Caridina nilotica. An interesting phenomenon was observed in Shirati waters during the October-November 1991.

At the beginning of the fishing season the by-catch of juvenile Nile perch was so high (over 70%) that some fishermen decided to close fishing altogether. Then the by-catch changed to large amounts (about 80%) of Caridina which were not only caught in R. argentea gear but also in large beach seines having net bags with mesh sizes of 19mm. Later the by-catch was smaller and composed of a mixture of the two. During that period (18-23 November 1991) large amounts of Caridina, most of them dead, were seen in shallow waters at our station. Later, they were washed ashore and birds were seen gorging them.

PROCESSING AND MARKETING OF R. argentea

Very little, if any, R. argentea is consumed fresh. Almost all the catch is sundried. The fish is spread on any available space which includes fleet rocks, sandy beaches and dry grass or natural grass lawns. Drying takes two to three days, depending on the nature of the drying surface and weather. The dried product is packed in gunny bags (about 30 kg) for sale. Usually fishermen take their dried fish to buying centres at the end to of the fishing period. Large dagaa buying centres are Mwanza, Musoma, Bukoba and Nkome (Geita). There, dagaa dealers buy the processed product in large quantities. They transport it for sale to inland towns and market centres. Some dealers export to neighbouring countries such as Kenya, Rwanda, Burundi, Zaïre, Zambia and Zimbabwe. Sometimes the fish dealers buy the fish right from the fishing stations.

The dagaa fishery is very much controlled by the present processing and marketing system. Since sundrying is the only practical processing method used in processing R. argentea, the fishery is mostly successful in the dry period when there is enough sunshine to carry out sundrying. During the wet season sundrying is almost hampered as the fish takes longer to dry, resulting in the product becoming rancid and of poor quality. The poor product fetches a lower price and does not keep long without being attacked by insect larvas. On the other hand good catches of dagaa quickly choke the demand thus lowering the price. Prices sometimes reach such a low level that fishing expenses become too high to allow fishermen to operate profitably. This compels fishermen to close fishing temporarily until prices improve again. In general, prices are highest at the beginning of the fishing period and lowest and the end of the fishing season when a lot of the fish is brought in for sale. These two problems will always constrain the dagaa fishery unless other practicable methods of processing are adopted together with more markets to absorb the fish at a faster rate.

Caridina is a highly proteinous resource. Should high catches of the shrimp persist and people learn how to process and utilize it, it could give an added advantage to the dagaa fishery. However, it is just too early to say more about it at this stage.

STOCK ASSESSMENT AND MANAGEMENT

R. argentea, like any other renewable resource, requires sound management steps for maintaining high sustainable yields. Such steps may be adequately taken if the biology of the fish is sufficiently known. In southern Lake Victoria not much attention has yet been focused on studying this species. This deficiency needs to be rectified as soon as possible, given the prominence of the species both as the main prey to Nile perch and as a target of commercial fishing. Its small size and short life span suggest that the fish should have a high turnover rate and be resilient to heavy predation and exploitation (Nikolsky, 1969). So far it seems to be the only indigenous fish species that has succeeded in withstanding heavy predation by the introduced Nile perch predator. Indeed its biomass has increased following the elimination of the other indigenous species (Wanink *et al.*, 1988).

How R. argentea is going to respond to predation and heavy fishing pressure cannot be predicted. As already stated above the by-catches of this fishery are beginning to reveal interesting phenomena: large catches of juvenile Nile perch and Caridina reveal that the fishery is not only competing with adult Nile perch for its food but also affecting it directly by taking away its young.

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4.5 Some characteristics of small pelagic species and possible affinities with the population of Lake Victoria *Rastrineobola argentea*

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ABSTRACT

The small pelagic cyprinid *Rastrineobola argentea* is, at present, the second most important commercial species of Lake Victoria fisheries. Small pelagic species are known to sustain important fisheries in several African lakes and reservoirs. Population dynamics and biology of this species make it very productive and resilient to commercial exploitation. At the same time, the short life-span implies that any decrease in recruitment will be followed quickly by a correspondent decrease in stock size. Some important biological characteristics of small pelagic species, such as growth and mortality are discussed. Preliminary considerations on *R. argentea* based on the available data are carried out, and affinities with other small pelagics of African Great Lakes are evaluated.

INTRODUCTION

Pelagic communities of African inland waters can be defined basically as a system made up of small planktivorous species and predators feeding upon them. The pelagic community of Lake Tanganyika, consisting of two clupeids and four centropomid predatory species, is a well known example.

Recently much interest has been given to small pelagic fish stocks, as readily exploitable resources. This is mainly due to two factors: first, is the increase of human population with higher market demand for fisheries products; itself leading to excessive exploitation and the subsequent decline of many coastal stocks, mainly cichlids, traditionally targeted by commercial fishery. Secondly, some small pelagic species introduced in new environments (e.g. large reservoirs), have been able to sustain quickly the development of profitable fisheries. An overview of the taxonomy and geographical distribution of African freshwater small pelagic fishes is provided in Marshall (1984), Wandera (1990).

The present paper mainly deals with some aspects (growth and mortality) of the population dynamics of some pelagic clupeid and cyprinid fishes which support important fisheries in African inland waters (Lakes Tanganyika, Victoria, Kivu, Kariba and Cahora Bassa). A preliminary consideration needs to be pointed out, especially in view to attempt the stock assessment of Lake Victoria *Rastrineobola argentea*. Most of the available experiences concerning population dynamics and stock assessment of small pelagics are from marine species and generally concerns clupeids. The presumable affinity between clupeids and small pelagic cyprinids, as Rastrineobola, is very uncertain and has to be verified. Furthermore it is generally thought that small pelagic species do not fit well with traditional models and related assumptions used in population dynamics studies; thus making their assessment and management difficult and dubious.

GROWTH

The estimation of growth curve parameters is of fundamental importance in the stock assessment process when analytical methods are used. There are three principal methods to study the fish growth performance: marking and recapture experiments, ageing of specimens by otoliths and scales reading and length frequency analysis.

When dealing with small pelagics it is almost impossible to obtain sets of age and length data for individual fish from which a growth curve could be plotted and parameters estimated. Tagging experiments are not possible for practical reasons because of high handling mortality and low likelihood of recaptures. Scales reading is considered for some species as inappropriate due to the absence of apparent seasonal marks (Chapman and van Well, 1978). Ageing of tropical small pelagics by means of daily rings in otoliths appears to involve too much work, even in short-lived species, to become a routinely applied method. Furthermore, using otolith-based technique at micro structural (daily increments) levels requires a careful preliminary analysis of some otoliths with a scanning electron microscope (SEM) prior to undertaking any study with a light microscope (Morales-Nin, 1988). Consequently, for the lack of a better alternative, it is necessary to use length frequency-based methodologies to infer growth rates and curves.

Several mathematical formulae have been proposed to describe fish growth. The von Bertalanffy Growth Formula - VBGF, (von Bertalanffy, 1938) appears to best fulfill some requirements particularly significant to the field of fishery science. Some aspects are: description of growth in terms of length and weight, incorporation of growth parameters in yield models, inter and intraspecific comparisons of the growth in different stocks and suitability to fit to any set of growth data. An extensive discussion of the von Bertalanffy growth model properties and criticisms given by various authors are provided in Pauly (1981).

The methods used and problems encountered in estimating growth of small pelagics are similar to those for other fish taxa. But a special complication rises because most small pelagics form shoals. These generally tend to be constituted by fish of about the same size, which makes it difficult to have a representative sample of the size composition of the population (Csirke, 1988).

The cohort is usually defined as a group of individuals, belonging to the same stock, born in the same period. While school (or shoal) means a physical gathering of gregarious individuals, which are mutually attracted (Shaw, 1970). Length frequency methods are based on length cohort analysis. Problems in the analysis of length frequency data can be complex when taking into account Freon's observation (Freon, 1984 and 1985) on body length variability in schools and cohorts of two tropical marine pelagic species (Sardinella aurita and S. maderensis). The author noted that within the schools, the standard deviation of frequency distributions tends to increase as the average size increases. While, within the cohorts, because of the extended reproductive period and variability of the individual growth, the standard deviation of frequency distribution tends to increase during the rapid growth phase, to decrease afterward in such a way that it is not comparable to the standard deviation of the schools for the same average size. Therefore, difficulties in the analysis of length frequency data can arise as commercial catch is sampled for scientific purposes with effort being mostly applied to schools. Freon concluded that the schools can be rarely representative of a cohort. If the school is constituted of young individuals, they belong to one or more fractions of cohorts, if it is constituted of large fishes, these will be from more cohorts.

It is easy to identify the main attributes of the growth performance of small pelagic species by displaying the VBGF parameters on a $L\infty/K$ plan, as in figure 1, together with the growth parameters of other African inland water fishes. It appears that common characteristics of small pelagics are high growth rate and short longevity generally not exceeding two years.

Adaptive capability and flexibility of some species to adjust their life cycle to given environmental conditions can be observed through the analysis of growth patterns of Limnothrissa miodon, a clupeid endemic to Lake Tanganyika and successfully introduced in Lakes Kivu, Kariba and Cahora Bassa (Fig. 2).

The growth performance of Limnothrissa in Lake Kivu is similar to the growth pattern displayed in Lake Tanganyika, its native environment, and quite different from that of the artificial Lakes Kariba and Cahora Bassa. The different lacustrine ecosystems affect remarkably the growth pattern. In man-made lakes, as Lake Kariba and Cahora Bassa, the reported maximum length is about half of the maximum length reached in natural environments. The growth rate (K) is also much higher, resulting in a life span of less than one year. L. miodon appears to have a good capacity to adapt to different ecosystems. The system of growth limiting factors is still not well understood. Food availability does not seem to be determinant, nor does predation pressure (Marshall, 1987). In Lake Tanganyika, for example, L. miodon is the main prey, together with Stolothrissa tanganicae of four Lates species (Coulter, 1970 and 1991; Roest, 1988), while in Lake Kariba L. miodon is the prey of Hydrocinus vittatus (Takano and Subraniam, 1988). The opposite situation happens in Lake Kivu where the species lives in a largely enemy-free environment, though there is some cannibalism and very slight predation from Clarias gariepinus (Deceuninck, 1990). Also the lake's aquatic bird population is negligible (pers. obs.).

L. miodon and its success to adapt quickly to unstable environments, as the pelagic zone of man-made lakes, introduce a characteristic of small pelagic species which has important implications also in the field of fishery biology. Small pelagic fishes are believed to be r-selected species within the r-K selection mechanism theory (MacArthur and Wilson, 1967; Pianka, 1970), where r, in the logistic growth equation is the intrinsic rate of increase and K is the maximum abundance (asymptotic population size) that can be supported by the environment, i.e. the carrying capacity. The rate of increase, r, is a composite parameter reflecting the difference between birth rate and death rate. The carrying capacity, K, is the population abundance towards which the population converges whenever equilibrium is disturbed. In the logistic model growth rates of populations at densities well below the carrying capacity are influenced largely by the parameter r, while growth rates of population at densities close to the carrying capacity are greatly influenced by K. Populations kept at, or repeatedly reduced to, low densities by physical or biotic environmental factors will be influenced by a different set of selective pressures (r-selection) from the set influencing more stable populations at high densities (K-selection). A summarization of features of r- and K-selected fish species is reported in table 1.

In the r-K continuum, clupeid fishes are typically r-selected species. L. miodon shows more marked r-characteristics when living in habitat more unstable than others. The relative instability of artificial lakes, as Lakes Kariba and Cahora Bassa, with wide variations of water level, and the stability of Lakes Tanganyika and Kivu are different conditions affecting the growth pattern of these species.

MORTALITY

Estimating mortality of short-lived animals is usually problematic, especially when individual animals are difficult to age. A widely used method to estimate total mortality rate (Z) is the "length converted catch curve" (Ricker, 1975; Pauly, 1983). Briefly, this method is based on length frequency data where lengths are converted to their corresponding relative ages by means of a set of growth parameters (L_∞ and K). The application of catch curve analysis is subject to quite restrictive assumptions: the population is assumed to be in a steady state (i.e. have a stable length composition), the samples must be representative of the population (e.g. samples must not be biased by gear selectivity or by massive emigration from the sampling area), and Z is supposed to be constant over time (i.e. all the cohorts experiences the same mortality). These conditions are probably not fully applicable in the majority of cases.

The estimation of natural mortality (M) is even more problematic than for Z. Actually most of the methods used are essentially qualified guesses. However, it can be stated that an apparent correlation exists among growth rate (K), asymptotic length (L_∞) and time required to reach sexual maturity (for extensive discussion see Beverton and Holt, 1959; Beverton, 1963; Saville, 1977; Peterson and Wroblewski, 1984; Rikhter and Efanov, 1976; Pauly, 1980; Gunderson and Dygert, 1988).

Fishes, as small pelagics, with a high K have a high M, and species with a low K have a low M. This is simply because a slow growing species (low K) cannot have a high natural mortality, if it was so, it would be soon extinct.

At the same time, a species with high natural mortality must have a life cycle with early sexual maturity to compensate the high M starting to reproduce earlier.

Some available estimates of mortality rates for African freshwater small pelagics seem to confirm this demographic characteristic, even if the overestimation of this parameter has been reported in some cases (Mannini, 1991). Methods used and results concerning few species from different lakes are given in table 2.

EXPLOITATION OF SMALL PELAGIC STOCKS

High growth rate, early sexual maturity, short life-span, and high natural mortality leading to rapid succession of generations, are basic features of the population biology of small pelagics. Also, these are the reasons for which these species can tolerate high levels of exploitation (i.e. high fishing mortality) and provide high yields.

The Production*/Biomass ratio (P/B) is assumed to be equivalent to the mortality rate when growth follows the von Bertalanffy model and mortality is of exponential type (Allen, 1971). As previously discussed total mortality rate of small pelagic species is generally quite high and it can assume Z values often ranging between 2 and 4 yr^{-1}. Furthermore, Leveque et al. (1977) observed that another indication of P/B ratio is the relationship between P/B and longevity. When estimates of mean standing stock are available, total annual production is obtained simply by multiplying values for mean biomass and annual P/B ratio (Waters, 1977).

Data from some small pelagic species indicate that annual total production can be much higher than mean biomass, e.g. 3.5 times as higher in case of S. tanganicae (Coulter, 1981).

Coulter (1981) commented that in these situations "standing stock is a poor indicator of potential yield because production and mortality rates are so high and biomass fluctuates seasonally". High total production of small pelagics explains how large standing stocks of long-lived predator species i.e. Lates spp. in Lakes Tanganyika and Victoria are sustained by planktivorous pelagic species with mean biomasses much less than annual production. Coulter (1981) concluded his analysis on the Lake Tanganyika pelagic community suggesting that predator biomass should be correlated with clupeid prey productivity rather than with clupeid biomass. Thus the potential fishery yield from small pelagic stock depends on their high production and on fishing mortality applied to their predators. If natural predation decreases (e.g. increased fishing mortality) then the availability of the prey to fishery exploitation increases.

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* The increase in biomass of a species population over a given period of time (growth of new tissue and production of new offspring).

These apparently positive characteristics of small pelagic stocks, implying a remarkable suitability toward exploitation, are mitigated when considering that these stocks are highly variable resources. Wide fluctuations or sharp decline of population size and total catches of some small pelagic stocks as those of Peruvian anchovy (Engraulis ringens), Pacific bonito (Sarda chiliensis) and Japanese sardine (Sardinopsis melanostictus), are quite indicative signs that pelagic fishing can be a risky activity (Figs. 3 and 4).

Changes in recruitment due to changes in growth and natural mortality rates of early life stages occur in all fish taxa. Because small pelagics are short-lived and fast growing fishes they are more exposed to recruitment fluctuations than demersal species, most of which are usually of longer lived and slower growing fishes. Then, in case of short life-span species any decrease in recruitment will be followed quickly by an equal intensity decrease in stock size (Csirke, 1988).

SOME PRELIMINARY OBSERVATIONS ON *R. argentea*

Available information on R. argentea from scientific literature is scarce to make reliable considerations about the population dynamics and fishery potential of the species. Nowadays Rastrineobola, together with the whole lake's fauna, is exposed to the drastic changes occurring in the ecosystem following the introduction of Lates niloticus.

It is not possible to understand which changes of the biological characteristics of Rastrineobola stock have happened in the last thirty years because of lack of data from the past. At the same time, it is difficult to establish if this population has really expanded during the last decade or if the stock size is almost the same but now subject to more intensive exploitation.

The majority of the available findings from research work are from investigations carried out in small areas and with different sampling methods. However, it might be useful to consider some of these results, even if comparisons and extrapolations are quite hazardous.

Estimates of growth parameters from different parts of the Lake are reported in table 3 and the growth curves are given in figure 5. It should appear that growth performances are different in the 3 study areas. According to these results, the growth of R. argentea would be slower than that of the clupeid population in other African lakes, as well as the cyprinid E. sardella in Lake Malawi (Table 4).

The length at first maturity (L_{50}), expressed as the length at which 50% of the population is mature was established for R. argentea by Wandera (1990; this vol.) at about 44mm SL, corresponding to 53mm TL. According to the above mentioned growth curves this L_{50} is reached not before the second year of life or even later. This seems to be quite different from the "early maturity" pattern displayed by freshwater clupeids which are generally known to reach L_{50} during the first year of growth (Ellis, 1971; Spliethoff *et al.*, 1983).

Natural mortality rates estimated using Pauly's formula (Pauly, 1980) are in agreement with what is expected for small tropical pelagic species. But, when computed by Rikhter and Efanov's formula (Rikhter and Efanov, 1976. Table 5) the results are quite low.

Differences in M estimates are due to the methods used and are directly determined by the growth parameters (and the mean water surface temperature) in case of Pauly's method, or indirectly as in case of Rikhter and Efanov's formula. The remarkably lower M values obtained by the latter formula are explained by the time employed to reach the age of massive maturation (L_{50}).

At this preliminary stage of knowledge, it should seem that Lake Victoria R. argentea has slower growth than other small pelagic species inhabiting African lakes. Moreover, the length at first maturity according the estimated growth parameters, is reached relatively late during the life when compared to similar species. The relatively high M rates, obtained by Pauly's formula, are somehow in contradiction to the above patterns. All this does not fit properly with the widely accepted concept that high M values are associated with early sexual maturity and fast growth performances.

As a final consideration one can state that, at the present time there is a wide area of uncertainty in the definition of demographic parameters of the species. In light of the role of Rastrineobola within the Lake Victoria ecosystem and of its quickly expanding commercial exploitation, there is a strong need to undertake lakewide research work on population biology of R. argentea stock.

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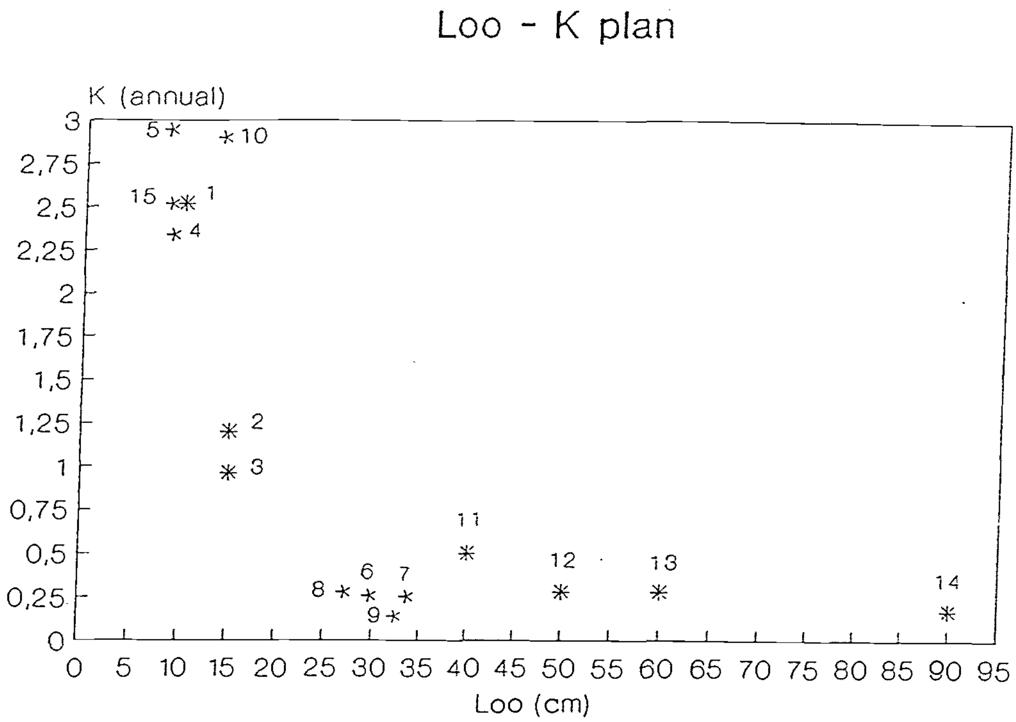

Figure 1. Comparison of growth performances of some African inland waters fish species. 1: S. tanganicae (L. Tanganyika; Chapman and Van Well, 1978), 2: L. miodon (L. Kivu; Spliethoff et al., 1983; Mannini, 1991), 3: L. miodon (L. Tanganyika; Pearce, 1988), 4: L. miodon (L. Tanganyika; Matthes, 1968), 5: L. miodon (L. Kariba; Marshall, 1987), 6: Oreochromis shiranus (L. Malawi; Lowe, 1952), 7: O. squamipinis (L. Malawi; Lowe, 1952), 8: O. variabilis (L. Victoria; Fryer, 1961), 9: Tylochromis bangweulensis (L. Bangweulu; Griffith, 1977), 10: Engraulicypris sardella (L. Malawi; Rufli and van Lissa, 1982), 11: O. niloticus (L. Albert; Ssentongo, 1971), 12: Labeo mesops (L. Malawi; Lowe, 1952), 13: Hydrocinus vittatus (L. Kariba; Balon, 1971), 14: Lates mariae (L. Tanganyika; Coulter, 1976), 15: S. tanganicae (L. Tanganyika; Roest, 1978).

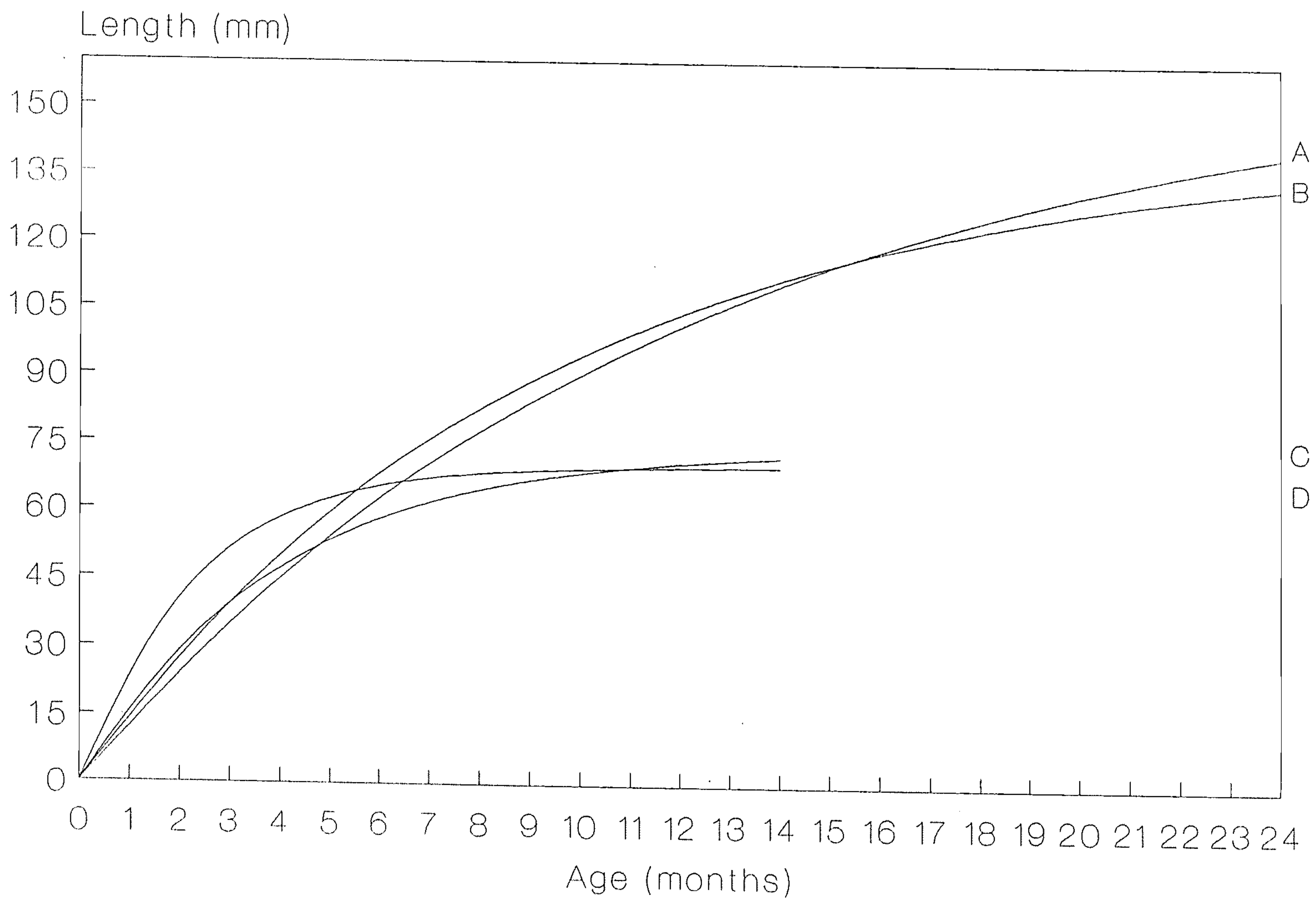

Figure 2 : Growth of L. miodon in Kivu, Tanganyika, C. Bassa, Kariba.

A) Kivu (Spliethoff et al., 1983; Mannini, 1991)
B) Tanganyika (Matthes, 1968)
C) Kariba (Marshall, 1987)
D) Cahora Bassa (Gliwicz in Marshall, 1987)

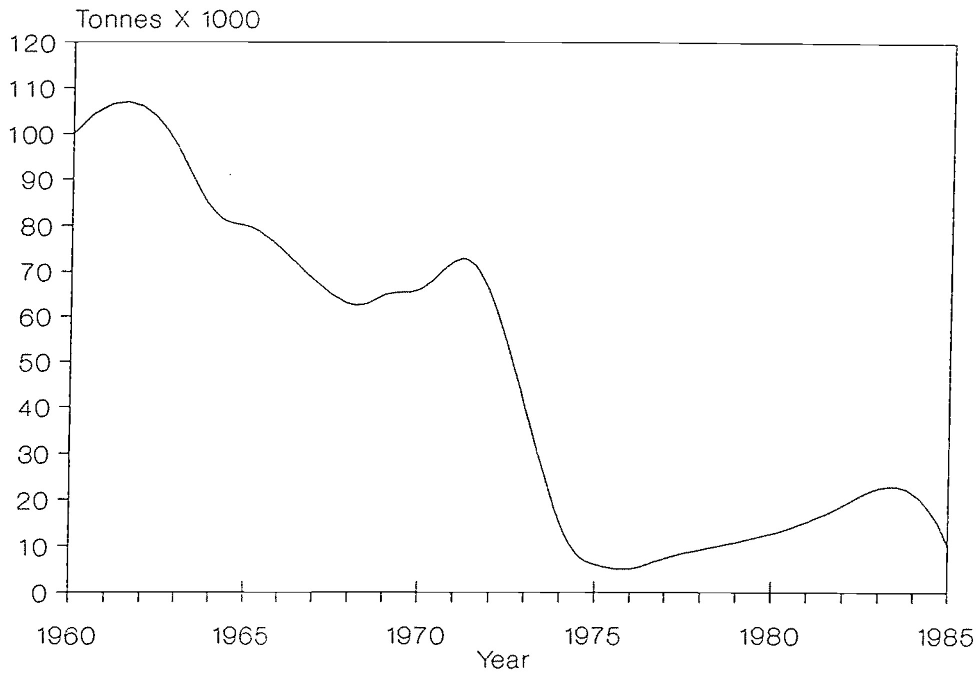

Figure 3 : Nominal catches of <u>Sarda chiliensis</u>, southeast Pacific.
Adapted from Csirke, 1988.

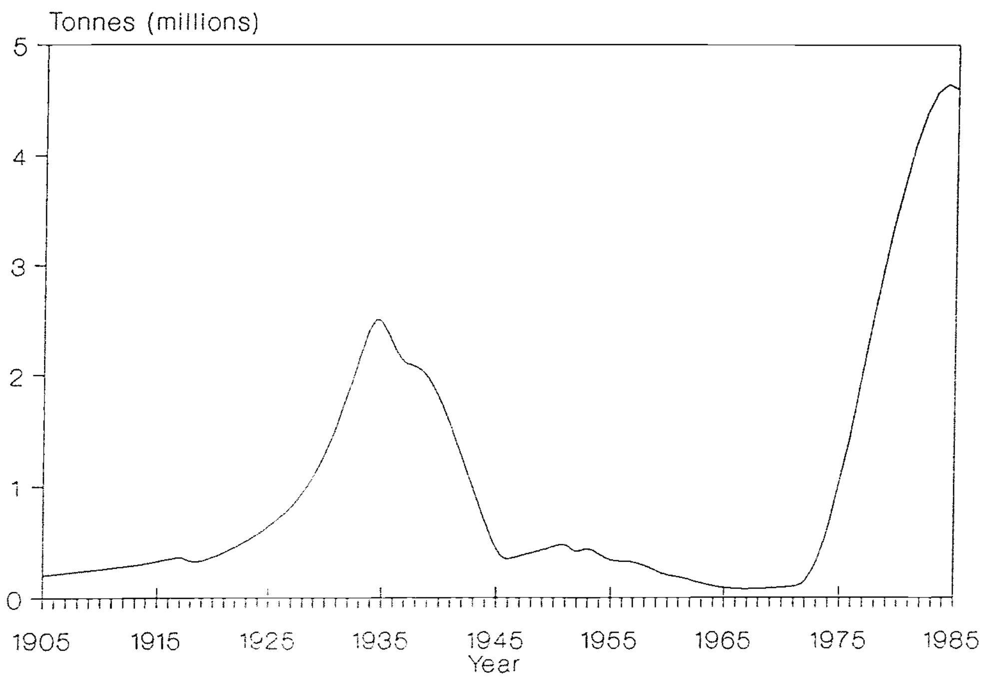

Figure 4 : Catches of <u>Sardinopsis melanostictus</u>, northwest Pacific.
Adapted from Csirke, 1988.

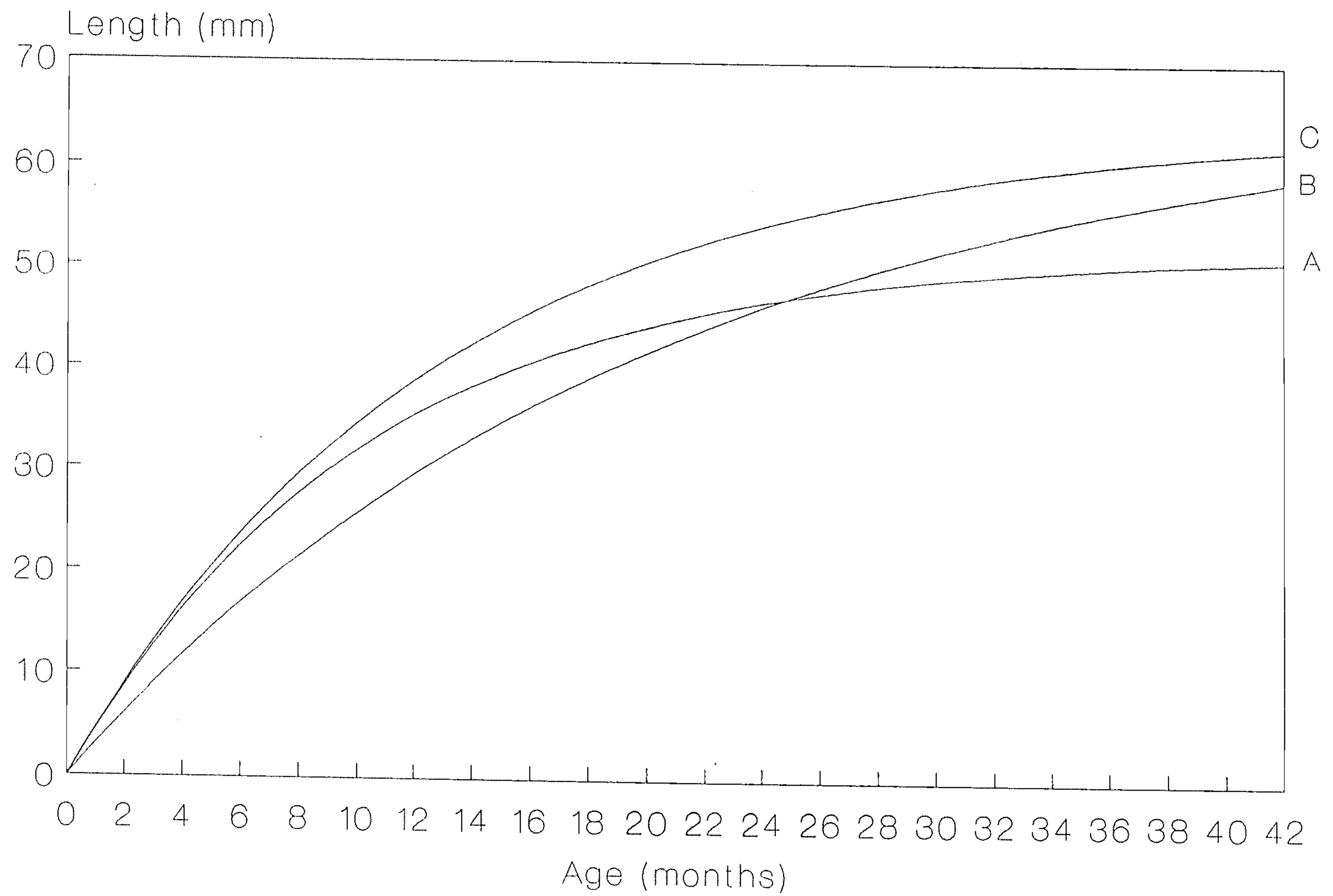

Figure 5 : Growth curve estimates for R. argentea.

A) Wanink, 1988. Loo = 52 mm, K = 1.14
B) Manyala et al., this vol. Loo = 68 mm, K = 0.57
C) Wandera and Wanink, in press. Loo = 64.5 mm, K = 0.92

Table 1. Some of the characteristics of r- and K-selected fish species (adapted from Pianka, 1970, and Ssentongo, 1988).

Characteristics	r-selected	K-selected
Habitat	Upwelling areas,estuaries flood plains, pelgic zone of E. Africa great lakes	Coral reefs, littoral and benthic areas of E. Africa great lakes
Species group	Mostly pelagic marine fishes (Clupeidae, Carangidae), but also Stolothrissa, Poecilothrissa, Limnothrissa, Engraulicypris, etc.	Mostly demersal fishes (Scienidae,Serranidae, catfishes, Cichlidae, etc.)
Environmental stability	Usually variable and/or unpredictable	Fairly constant and/or predictable
von Bertalanffy growth coefficient (K)	Relatively high	Relatively low
Longevity	Short (usually maximum about two years)	Longer
Natural mortality	Often high, sometimes catastrophic, indipendent of population size (density-independent)	Relatively low, dependent on population size (density-dependent)
Population size	Variable in time, occupies ecolological vacuum but rarely reaches the carrying capacity of the environment	Fairly constant in time, at or near carrying capacity of environment
Reproduction mode	High rate of egg production, no parental care, often semelparity	Low rate of egg production, often highly developped parental care, often iteroparity
Interspecific and intraspecific competition	Generally lax	Usually keen
Feeding adaptation	Specialist at low trophic levels	Adaptative feeding types but with some stenophagous specialists
Other characteristics	High P/B ratio Rapid turnover rate Small body size	Low P/B ratio Slow turnover rate Large body size
All above lead to	Productivity	Efficiency

Table 2. Estimates of total mortality (Z) and natural mortality (M) rates for L. miodon and S. tanganicae from Lakes Tanganyika, Kivu, and Kariba (a = data from Bumi estuary, b = data from Sanyati basin).

Species, lake and year	Z yr^{-1}	M yr^{-1}	Sources
L. miodon, Tanganyika, 1980	4.4		Munyandorero (1989)
" " " " 1981	9.8		" " " "
" " " " 1982	6.7		" " " "
" " Kivu 1990	7.4	1.8 - 2.1	Mannini (1991)
" " " " "	2 (Z_m from VPA)		" " " "
" " Kariba (a) 1980	8.6	8.4 (Z vs. f)	Marshall (1987)
" " " " 1981	9.7		" " " "
" " " " 1982	8.4		" " " "
" " " (b) 1978	9.8		" " " "
" " " " 1979	9.8		" " " "
" " " " 1980	12.6		" " " "
" " " " 1981	11.6		" " " "
" " " " 1982	12.3		" " " "
" " " " 1983	13.8		" " " "
S. tanganicae Tang.	5.5		Roest (1978)
" " " "	5.2		Chapman & Van Well (1978)

Table 3. Growth parameter (L_∞ and K) estimates for Lake Victoria R. argentea. Phi prime is a test to compare growth performance estimates of the same species or stock (Munro and Pauly in Sparre *et al.*, 1989).

Source	L_∞ (mm)	K yr^{-1}	phi prime
Wanink (1989)	52 SL	1.14	8.03
Wandera and Wanink (in press)	64.5 SL	0.92	8.25
Manyala *et al.* (pers. comm.)	68 TL	0.57	7.88

Table 4. Growth parameter estimates ($L\infty$ and K) of some small pelagic species occurring in African Great Lakes.

Species	Lake	L_{∞} (mm)	K yr^{-1}	Source
S. tanganicae	Tanganyika	90 FL	2.52	Chapman and van Well (1978)
S. tanganicae	Tanganyika	94 FL	2.52	Roest (1978)
L. miodon	Tanganyika	115 FL	2.16	Matthes (1968)
L. miodon	Tanganyika	164	0.96	Pearce (1988)
L. miodon	Kivu	145 FL	1.20	Spliethoff *et al.*, (1983) Mannini(1991)
L. miodon	Kariba	74 TL	3.05	Marshall (1987)
L. miodon	Cahora Bassa	70	5.40	Gliwicz in Marshall (1987)
E. sardella	Malawi	137.5 FL	2.58	Rufli and van Lissa (1982)

Table 5. Natural mortality rate estimates for R. argentea obtained by Pauly's and Rikhter and Efanov's formulae using available growth parameters.

Methods / Data source	Pauly's formula (T = 25°C)	Pauly's formula (20% reduction)	Rikhter and Efanov formula
Wanink (1989)	2.9	2.3	0.9
Wandera and Wanink (in press)	2.3	1.8	1.1
Manyala *et al.*, (pers. comm.)	1.8	1.4	0.6

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