

Sixth Framework Programme
Specific targeted research project



Drexler S.-S., Waidbacher H. (Eds.)

BOOK OF ABSTRACTS

BOMOSA

**Integrating BOMOSA cage fish farming
system in reservoirs, ponds and
temporary water bodies in Eastern
Africa**

FINAL CONFERENCE

Machakos, Kenya

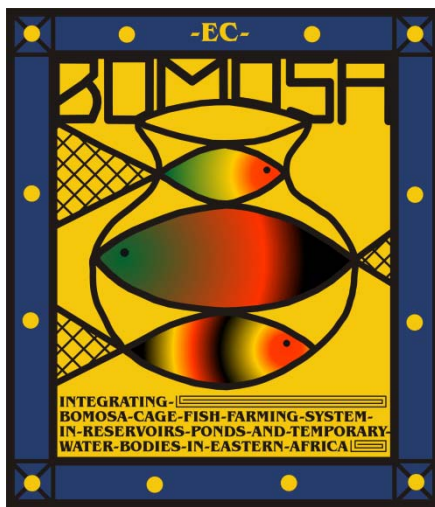
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BOMOSA Book of Abstracts

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PREFACE

Aquaculture is a major contributor to securing food for many countries on our planet earth. It is a much-needed and affordable source of high-quality animal protein, but the farmed species must be produced using low-cost and sustainable farming methods. There are still concerns over potentially negative environmental, social and economic impacts associated with aquaculture. However, mass production generally is concerned with commercial and/or capture-based aquaculture. In contrary, the BOMOSA project is only concerned with small-scale, cage-based aquaculture. The benefits aimed for within the BOMOSA project are targeted at the community level; food security and poverty alleviation as well as creating additional income are the ultimate targets.

Inland aquaculture can generally be described as being under-developed in Eastern Africa, though it should be noted that considerable success has been achieved through farming of Nile Tilapia in Egypt. The under-developed status of aquaculture in Eastern Africa can be explained by four problems – answered by BOMOSA-based solutions:

Knowledge mobility and know-how

- The BOMOSA hub and plot systems are unique in Eastern Africa. The technical know-how exists. The project researches requirements and conditions for economic viability, social acceptance and supporting institutional environment.

Lack of suitable fish species

- BOMOSA will only utilize non-exotic species such as Nile Tilapia and African Catfish, which are deemed for local consumption, not export markets.

Improvement of hatchery development and poor fish seed availability

- BOMOSA “plots” are located within a distance from a fish farm allowing supply and transport of fingerlings.

Lack of markets

- BOMOSA will utilize a participatory approach to assess factors of social acceptance and employ capacity building measures to assist development of local markets, so that fish production will generate benefits at community and regional levels.

Kenya, Uganda and Ethiopia share common problems in sustainable management of sensitive and dynamic ecosystems, as well as facing deficits in high protein food supply and an ongoing battle to alleviate rural poverty. The BOMOSA scheme uses an existing fish farm (“hub”) to supply fingerlings (mainly Nile Tilapia at approx. 25g) for rearing within suitable water bodies such as reservoirs, ponds and naturally occurring temporary water bodies formed during the rainy season. Farmers will be trained to rear the fish in cages in their “plots”, harvest them for fresh consumption, to sell locally or to process for long-keeping i.e. drying, smoking and packaging. The fish will be a high protein dietary supplement and/or an additional source of income for subsistence farmers.

Strong response can be detected by communities, public decision makers and top-ranked politicians up to now. Established “plots” have been already visited by the honorable Kenyan Minister of Fisheries, by a Ugandan Minister on his private visit to Kenya and by a whole group of Members of Parliament from Kenya in August 2008. The EAAWA (East African – Austrian Water Association with 210 members from seven countries) has taken notice and started dissemination of the BOMOSA concept. EAAWA is interlinking various institutions and multiplied synergy effects are expected due to the direct linkage of experts/actors of the higher education, research, implementation and policy sector.

Honoured, and with high respect we can report that the federal president of the Republic of Austria, honorable Dr. Heinz Fischer and his wife Margit, visited the Ethiopian BOMOSA partner-institute NFALRC-Sebeta during the state visit on 21st of February 2008. The BOMOSA system and the “training plot” were presented to Dr. Fischer and the accompanying delegation with sustainable impression.

To sum up, our scientific officer in Bruxelles, Dr. Mario Scalet, reported after the mid term meeting in April 2008 to the European Commission: “.... The strong point of the project is the commitment of African partners

and the real interest of the local stakeholders about the small scale fish farming system of BOMOSA. The mid term meeting was also attended by the Ethiopian stakeholders already involved for using the system and giving the operational support to the work package activities. Honestly it is quite rare to have such direct interaction in international research projects.....”

This book contains a collection of abstracts, which are presented during the final conference of the BOMOSA project and cover the major topics. Depending on the contents of the contributions the book is divided into four sections. The first one is dealing with general aspects, like a summary of the project aims and the basics of a BOMOSA plot construction. Section two presents results about the influence of such farming systems on environmental parameters of water bodies and public health, as well as veterinary findings and the possibilities of using remote sensing for water body detection. The aspects of fish feed production and processing are summarized under section three. And finally, one of the most important topics in the project is represented by section four, namely social aspects, ethical issues and a socio-economic model.

As the coordinator of the project I want to express my gratitude to all authors for their contribution to the preparation of this book. We are an international team with researchers from six different nations and two continents; to all of them my thanks for such a good cooperation during the last three years. Deep gratitude goes to Martin Šíma, who brought such an excellent spirit to the working group when he was teaching, but unfortunately had to pass away much too early last year. Special thanks go also to Ms. Franziska Schmuttermeier and Mr. Martin Seebacher for their assistance during the printing and binding session. And finally, on behalf of the consortium, I would like to express my gratitude to the European Commission for funding this project and for the close collaboration in terms of scientific and financial issues.

Prof. Herwig Waidbacher (Coordinator)

Wien, 20. August 2009

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SECTION I: GENERAL ASPECTS



Integrating BOMOSA cage fish farming system in reservoirs, ponds and temporary water bodies in Eastern Africa

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The project “Integrating BOMOSA cage fish farming system in reservoirs, ponds and temporary water bodies in Eastern Africa” is a specific targeted research project in the sixth framework programme funded by the European Commission (see Table 1).

Table 1: Project details

Contract number	INCO-CT-2006-032103
Project duration	01.10.2006 – 30.09.2009
EC-Contribution	1.499.998,00 €

BOMOSA (an acronym from BOKU University Vienna, Moi University Kenya and Sagana Aquaculture Centre - Fisheries Department Kenya) is the name given to the “hub and plot” cage-based fish farming system that was prototyped in 2003 - 2004 especially for East African conditions. The net-like BOMOSA cages can be folded, easily transported and handled by two persons without mechanical aid. The INCO project technically optimizes this prototype system and the whole BOMOSA fish farming scheme to prove its economic viability and social acceptability, as well as determine requirements for an institutional environment to support broad uptake of the BOMOSA scheme in Eastern Africa. The BOMOSA system forms the basis of a socio-economic model that will contribute to poverty alleviation in Eastern Africa by providing sources of supplementary high protein food and additional income to rural communities in Kenya, Ethiopia and Uganda.

The 36-month project involves four European partners (see Table 2):

- two universities, a science academy and an NGO and
- six African partners: two Kenyan universities and four government-run fisheries research centers from Kenya (2) and one each from Ethiopia and Uganda.

Table 2: Participants

Participant No.	Participant name	Participant short name	Country
1	Universität für Bodenkultur Wien	BOKU	Austria
2	Austrian Academy of Sciences	OEAW	Austria
3	Enki public benefit cooperation	ENKI	Czech Republic
4	University of Bologna	UNIBO	Italy
5	Moi University	MU	Kenya
6	Kenyan Ministry of Livestock and Fisheries Development	DFK	Kenya
7	Kenya Marine and Fisheries Research Institute	KMFRI	Kenya
8	Egerton University	EgU	Kenya
9	Ethiopian Institute of Agricultural Research	EIAR	Ethiopia
10	Department of Fisheries Resources Uganda	DFRU	Uganda

The BOMOSA project offers extensive research with the following scientific and technical objectives:

- Apply a participatory approach to define targets in terms of economic viability and social acceptability at community levels for the new BOMOSA plots.
- Develop and validate an evaluation method using remote sensing to assess and characterize water bodies for use as potential BOMOSA plots.
- Set up fourteen BOMOSA plots and optimize the technology in three types of small (less than 5 ha.) water bodies within four eco-zones across Kenya, Ethiopia and Uganda.

- Evaluate locally available, agricultural by-products and cost-effective processing technologies as a resource for sustainable production of low-protein fish feed.
- Determine requirements and make recommendations for a legal and regulatory framework based on potential veterinary, public health and environmental impacts of BOMOSA.
- Develop capacity building and dissemination material for the local community, relevant authorities and policy makers and the international scientific community.
- Develop a socio-economic model for sustainable introduction and widespread uptake of the BOMOSA scheme in Eastern Africa.

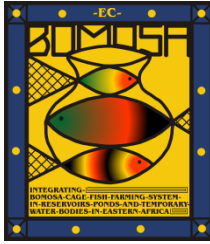
The workload of the 36 month project is divided into 7 work packages. Table 3 shows the details of each work package with the corresponding deliverables.

Table 3: Description of work packages with the appending deliverables

WP 1: Management of the consortium	
D1.1	Periodical activity and management reports (including financial issues) according to the contract
D1.2	Audit Certificates
D1.3	Final reports according to contract with key results and policy recommendations
D1.4	Documentation of workshops and meetings
WP 2: Participatory approaches, capacity building and dissemination	
D2.1	Communication Plan and BOMOSA website
D2.2	Capacity building and dissemination material and documentation (recurring)
D2.3	Conference proceedings
WP 3: Select sites and establish trial BOMOSA plots in target countries	
D3.1	A criteria checklist for BOMOSA plot site selection

D3.2	Plot Design Documents for each BOMOSA plot: Site study, owner and authority approvals and first level designs
D3.3	BOMOSA plots set up and fingerlings delivered
WP 4: Analyze environmental, veterinary and public health aspects for development of aquaculture legal and regulatory frameworks	
D4.1	Synthesis of baseline environmental data from existing BOMOSA plots
D4.2	Short report on first three „priority regions“
D4.3	Basic evaluation method and first findings (report and maps) using RS evaluation
D4.4	First report of vet. and public health aspects (results of surveys and recomms.)
D4.5	List of vet. and public health aspects for the env. monitoring programme
D4.6	Report on existing aquaculture institutional environment in Eastern Africa
D4.7	Final report of vet. and public health aspects (results of surveys and recomms.)
D4.8	Final evaluation method and first findings (report and maps) using RS evaluation
D4.9	Final RS evaluation method documented in a manual
D4.10	Recommendations for aquaculture institutional environment in Eastern Africa
WP 5: Low protein, by-product fish feeds, resource development, feed processing and feed economics	
D5.1	Report on survey of available by-products as feed ingredients for the three countries
D5.2	Report on blends of formulated diets, suitable processing, storage and dispensing systems

D5.3	Optimized prototypes for processing and dispensing the selected feeds
D5.4	Report on quality and economic performance of the selected feeds with respect to community level socio-economic targets defined in WP 7
WP 6: Technical optimization and monitoring of the BOMOSA plots	
D6.1	Chapter of “Post-harvest processing and preservation” for the final BOMOSA manual as a contribution to Task 2.3.
D6.2	Report on minimum BOMOSA production cycles for the various water bodies and eco-zones under economic considerations
D6.3	Chapter of “best management practices” for the final BOMOSA manual as a contribution to Task 2.3.
D6.4	Manuscripts for peer review and MSc works on environmental impacts of BOMOSA from each African partner country.
WP 7: Assess economic viability, social acceptance and ethical issues to develop the BOMOSA socio-economic model	
D7.1	Report on baseline data for existing plots and socio-economic targets for the new plots
D7.2	Market reports with case studies for each plot at community level
D7.3	Reports on social acceptance and ethical issues with case studies at community level
D7.4	Cost-Benefit Analysis of the BOMOSA scheme with case studies at country level
D7.5	TIP for BOMOSA within East Africa with policy recommendations



BOMOSA plot construction

Mbaluka R.K.^a, Thiga B.^a, Waidbacher H.^b, Liti D.^c, Munguti J.^d

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Cage culture, the practice of rearing fish in cages, can be applied in existing bodies of water that cannot be drained or seined and would otherwise not be suitable for aquaculture. These include lakes, large reservoirs, farm ponds, rivers. Cage culture offers several important advantages. The breeding cycle of Nile tilapia (*Oreochromis niloticus*) is disrupted in cages, and therefore mixed-sex populations can be reared in cages without the problems of recruitment and stunting, which are major constraints in pond culture. Other cage advantages include, flexibility of management, ease and low cost of harvesting, close observation of fish feeding response. Some disadvantages associated with cage culture include risk of loss from poaching or damage to cages from predators or storms, less tolerance of fish to poor water quality, dependence on nutritionally-complete diets and greater risk of disease outbreaks.

Idea behind BOMOSA cage culture was to promote the use of small water bodies to grow fish in cages and to research on the economic viability, social acceptance of a relatively simple technology in small scale Cage fish farming in Eastern Africa. The choice of water bodies range from Public dams/reservoirs, rain-fed ponds (including quarries), existing family fishponds, temporary water bodies and floodplain otherwise under-utilized in the region. Dams and water bodies where water is not urgently required for human consumption were targeted (non-drinking water). BOMOSA endeavoured to provide sources of supplementary high protein food and to

generate some additional income to the rural poor communities in the Region.

BOMOSA plot sites are stocked with Nile tilapia and originally had the cages placed on water surface and each anchored on dam bottom to prevent them from drifting by wind. With this the cages continued to drift to deeper areas. Regular operations like stocking, feeding, sampling and cage repairs were very difficult. Cages were placed a few meters from the shore and site attendants used to physically walk into the water thus wetting cloths. Operations were difficult, inconvenient and discouraged day to day activities such as feeding and repairs consequently the fish were not fed or sampled to avoid getting wet. The fish were found to have sand or soil particles within the gills possibly as result of turbid waters as cages could not be suspended from the dam bottom due to shallow dam shore areas. This may have caused severe mortalities of socked fish observed during preliminary period. Bomosa team had to think of a better design on cage placement and therefore the idea of a fixed pier was conceived and implemented.

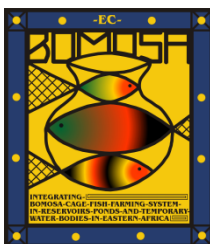
The pier was constructed fixed on dam bottoms and cages fixed on edges. It was very stable and extended to deeper sections of the dams because reservoir levels fluctuate more on shores than deeper areas. Operations were easy and convenient as attendants were able to operate from the pier except during the lowest levels when cages were to be dropped further several meters to reach water level hence operations became difficult from the platform and cages became exposed. During the rainy seasons, water levels could rise to a point of submerging the fixed pier platform and the cages placed around it.

The pier design was to be modified consequently to cope with new challenges. This led to a design of a floating pier that could move with the water levels. A floating pier was designed with 10 (ten) cage placement slots and attendants operate from the platform. A shuttle was also designed to ferry fish, attendants and other goods to the pier platform from the shore. In case the water bodies flood, the floating pier will float together with the cages and during dry season when water levels drop, the pier together with cages drop and hence solving the floating and exposure problems. Floating pier posed some challenges of floatation with the heavy sinker weights to avoid drifting. The system needed to be supported with more robust

floaters and metal drums of 200L were preferred. The system was expensive to construct as a result of the elaborate structure and floatation system.

The design advantages, disadvantages and future improvements are presented in the paper. Complete description of a pier, cage and feeder are discussed below.

Key words: cage culture, cage design and placement, Nile Tilapia, pier (fixed and floating), shuttle.



BOMOSA – Czech TV documentary

Bezouška P.¹, Fiala Z.¹, Pokorný J.², Hesslerová P.²

¹Czech TV, ²ENKI, Public Benefit Corporation, Trebon, Czech Republic.

The BOMOSA team participated in the production of the documentary film funded by EU and made by the Czech TV. Film material was gathered in Ethiopia (20.9. – 6.10.2008), Kenya (6.10. - 22.10.2008) and Uganda (22.10.-30.10.2008). The Czech TV team visited BOMOSA sites and interviewed representatives of local communities due to the project acceptance, functioning, demands and future. The film shows plots from Yemlo, Lukenya, Ngeki, Sagana, Harambee, Sangoro Station, Kasolwe, Ngeki, and the school plot near Kamuli.

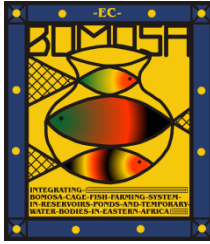
The main mission of the documentary film is to present the BOMOSA project to EU citizens and demonstrate background, basic principles, effectiveness and social acceptance of the BOMOSA project, as well as the cooperation between EU and African partners.

Due to cooperation with African partners the film has not only included information about BOMOSA. Daily life of rural people and hot topics, related to human impacts on environment as deforestation, overgrazing and soil erosion are also shown. The positive effect of wise use of wetlands is demonstrated on example of fishing control in Victoria Lake region. The film has been completed by interviews with representatives of partner's institutions. The meeting with the Minister of Agriculture, Uganda has revealed the support and future perspectives of BOMOSA fish farming system on governmental level.

The 55 minutes film will be projected on the Conference: Promotion of Inland Aquaculture in Eastern Africa.

The film was performed in Czech TV on 28th May 2009 and repeated several times. In addition it is available at web pages of the Czech TV.

**SECTION II: ENVIRONMENTAL, VETERINARY AND
PUBLIC HEALTH PARAMETERS**



Development and application of a Remote Sensing (RS) based evaluation method to assess potential water bodies

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Remote sensing task within BOMOSA project was to develop and apply an evaluation method to assess potential water bodies for regional development of aquaculture. Processing and evaluation of satellite images seems to be a very practical way of detecting small water bodies. This should enable improved site selection and zoning and lead to better engineering of farms. The RS analysis comprised of stepwise evaluation of Landsat TM/ETM+ images, in parallel capacity building of RS competence in the African partner countries (Kenya, Uganda, Ethiopia) and collaborative development of the new evaluation method.

The first stage RS analysis (first 6 months) was used to analyze existing and available Landsat images and other cartographic material (Russian topographic maps, DEM, GIS layers), which has formed the essential data background for method development. This stage has provided the BOMOSA project with more than 40 orthorectified Landsat satellite images found and obtained free of charge. As data were no longer obtained from the Landsat TM satellite for the African region after 2001 and due to deficiencies in the ETM+ sensor on the Landsat 7 satellite, it has been impossible since 2003 to obtain more recent data from the sensor. All images obtained show the structure and state of the land cover at the end of dry season.

The method developed, had to meet criteria of low-cost, simplicity, universality, high accuracy and reliability. To distinguish small water bodies, from size 1 pixel, we have tested several approaches. From all tested, two have provided satisfactory results – Principal Component Analysis (PCA) and Normalized Difference Snow Index (NDSI). Both

complementary variants are based on radiometric enhancement of Landsat data. The principal components method is able to detect water bodies as such and also areas which contain a bigger amount of vegetation (wetland etc.). The method based on the NDVI index can only detect water bodies; however, it is able to detect even straight water streams which are mostly ignored by the first alternative. Therefore, in order to gain as complex information as possible about potential water bodies in the area, it is advisable to add the masks resulting from both alternatives together. The method also includes some other procedures of digital data processing. The supporting interpretation is based on color compositions (which are generally considered as a type of radiometric enhancement) and on interactive techniques providing a spectral enhancement of the visualized image. The final stage of the development of the water bodies' mask is the controlled recoding of the image values into the binary form. The method and all the supporting procedures are designed for an open source software system for digital data processing called MultiSpec (Purdue University, Indiana, USA). Its scheme is universal and can therefore be used in commercial software systems.

In order to develop the remote-sensing based evaluation method to assess potential water bodies, three model areas were selected – two in Central Kenya and one in the Kamuli district, Uganda. In these three cases, the work could be supported with findings from field observations.

The method for detecting small water bodies was designed for Eastern Africa and the BOMOSA project. Its universal use and application to other areas cannot be guaranteed. The main constraints of the method are following: The size of the water bodies that can be potentially detected is dependent on spatial resolution of the satellite data (Landsat 0.08 ha). Cloud shadows, very steep slopes and bottoms of canyon valleys are mistaken for water bodies. Another factor potentially distorting the results is thick vegetation. The multispectral satellite systems scan the land cover only and cannot penetrate below the thick cover of plants. Urban units contain a huge amount of pixels and aerosols in the air which can cause a false detection of water etc.

To verify and test the BOMOSA method, other six model areas have been selected – one in Uganda (Jinja-Kampala), two in Ethiopia (Alagae and Lake Koka region), and three in Kenya (Rift Valley, Bomet and Kisumu region). Different scene size has been chosen with regards to the

localization of BOMOSA plots, potential areas of interest and characteristics of Landsat data.

The BOMOSA method has been originally proposed for Landsat data. During the project the unexpected circumstances came out. The CSIR Satellite Application Centre (SAC) that used to serve as regional African receiving station had discontinued reception of Landsat 5 data by 19th August 2001. This means that there are no later Landsat 5 data available. As a potential source of new and up-to-date data Terra ASTER multispectral satellite data has been investigated to represent the current state of BOMOSA areas. Both approaches of the small water bodies' detection – Principal Component Analysis and image rationing (Normalized Difference Snow Index) were tested on Terra Aster data. Processing of five scenes (Machakos, Thika, Sagana, Mailo, Ndolwa areas) has revealed that the method should be applied mainly on Landsat TM/ETM+. The accuracy of the outputs from Aster data is very changeable and in some cases neither of both approaches brings reliable results. Potential future use¹ of Aster data would require the development of a new method and approach how to detect small water bodies, suitable for BOMOSA project purposes. E.g. thematic recoding of AST 3N band seems promising and was tested on Machakos area.

Special study was paid to Southern Ethiopia. On the example of Awasa region is demonstrated, how the water and wetness characteristics of the landscape are gained from Landsat 7 ETM+ multispectral satellite images (acquired on 2 May 2000). Water bodies' detection was based on thematic recoding of Normalized Difference Snow Index and information about wetness characteristic was derived from the third component of tasseled cap transformation.

Wetlands suitable for BOMOSA upscaling - Uganda

¹ Latest news from NASA: ASTER SWIR detectors are no longer functioning due to anomalously high SWIR detector temperatures. ASTER SWIR data acquired since April 2008 are not useable. This fact unfortunately limits future use of Aster data. There is EO-1 ALI satellite with similar specifics like Landsat has, however the possibilities of its use are matter of further research.

There are wetlands in the Kamuli District overgrown by macrophyte vegetation. Small water bodies are getting shallower due to accumulation of macrophyte biomass. It happens also in the present BOMOSA site Ndolwa, so as in many other places in Kamuli district. In order to get more water bodies for BOMOSA cage fish farming wetland vegetation should be harvested and recent sediment partly removed. Question is where to restore water bodies for cage farming. Remote sensing and archive images offer an objective method how to look back. Comparison of two scenes from 1986 and 2001 enables to detect the extent of free water and wetlands and to make change-over-time analyses. The whole scene 171-069 (Lake Kyoga) has been processed. As a first step free water was detected, by using BOMOSA method (NDSI approach). Information about wetlands was derived by multispectral classification methods. The results show rapid decrease of wetlands between both years. According to satellite images, it seems large areas have been drained to rivers. The discussion with local inquires and GPS measurement of current state would be helpful for the verification of results. In addition satellite maps of wetlands and water bodies may be use for discussion with local and wetland protection authorities on future dissemination of BOMOSA fish farming.

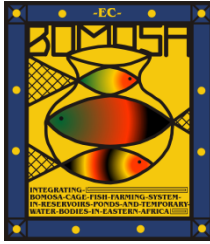
Mau forest

A low number of small water bodies and shortage of water have been found in most of the evaluated scenes (except Uganda Kamuli district and Thika region in Kenya). There are many factors, leading to rapid decrease of water in catchments and landscape drying. Decrease in total area of tropical forests is considered as a significant factor that influences landscape functioning, contributes to climate change and changes in water cycle. Remote sensing data enable to analyze the impact of deforestation of large areas upon thermal-water characteristics of the landscape. Case study of Mau Forest Complex (Central Kenya) shows evident negative effect of deforestation on hydrology of a large catchment. Deforestation resulted in dramatic decline of water in rivers, lakes and wells.

Landsat satellite data of the area enables estimation of land cover and assessment of distribution of radiation temperature and surface wetness. Landsat satellite data are available from 1980's and enable evaluation of changes both in number of small water bodies and of forest area in time. Supervised classification (algorithm Maximum Likelihood) was used to discriminate dense and humid forest, bitemporal colour synthesis of two

forest masks enhanced changes- over -time between 1986 and 2000. The maps of the relative temperatures were gained from the cumulated histogram of band TM6 values using the equal-area method. Five temperature classes were defined (each containing ca 20 % of pixels): coldest – cold – medium-warm – warm – warmest. To assess relative water content within selected area, WETNESS - the third component of the Tasseled Cap Transformation was used. Like in case of temperature, five relative categories of wetness were applied, labeled as wettest – wet – medium – dry – driest surfaces. Cross-classification method was used to assess changes-over time of both indicators.

The results of satellite image processing show a decrease of total area of dense and humid forests between 1986 and 2000 and its negative impact on thermal-water characteristics of the landscape. Radiation temperature markedly increased on deforested areas followed by wetness decrease. To complete the frame of changes in Mau forest region Terra Aster data from 2005 were analyzed. As in case of Landsat data, the information about forest cover, relative radiation temperature and wetness was extracted. The scene displays only the central part of Mau forest, however displays the area of most significant changes. The largest excised area is situated right on the top of Mau escarpment. The increase of temperature, followed by wetness decrement is more apparent.



Survey of bacterial outbreaks in farmed Tilapia (*Oreochromis niloticus*) from Kenyan BOMOSA plots

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Diseases outbreaks can occur and represent serious problems in cage culture, mainly in presence of stressful conditions such as typically the phases of restocking with fingerlings (transportation /introduction /acclimatization). Furthermore crowding, handling, water quality and several environmental factors can create conditions conducive to outbreaks of infectious diseases during the on-growing phases both in cages and open ponds farming activities.

A bacteriological and parasitological survey was carried out in order to investigate: A) the causes of recurrent mortality outbreaks in tilapia (*Oreochromis niloticus*) fingerlings used to restock BOMOSA cages, and B) the etiology of eye diseases frequently observed in F1 tilapia obtained from Lake Victoria breeders and farmed in BOMOSA hubs' open ponds.

A) *Causes of mortality in fingerlings during BOMOSA cages restocking*
A batch of 418 tilapia fingerlings (6.6 cm long) from Sagana hatchery was monitored during the days before departure, for the whole transportation phase and then for one week after their introduction in BOMOSA cages. Parasitological and bacteriological analyses were carried out on 18 fingerlings randomly sampled before departure and on 54 fish dead during transportation and after introduction in the cages. Parasitological exams were carried out by using standard methods. Brain and eye were inoculated on TSA (Tryptic Soy Agar), TCBS (Thiosulfate Citrate Bile Salts Sucrose agar) and skin, gills and brain on CY (Cytophaga agar). All the isolates were identified by both traditional methods and miniaturized systems API

20E and API 20NE. Histology was carried out on some sick fish fixed in 10% buffered formalin. Environmental parameters such as Dissolved Oxygen (DO) and Water Temperature (T) were recorded during all the sampling days.

A total of 10 out of 18 tilapias examined the day before departure were positive for bacteria, identified as *Acinetobacter* spp., *Chryseobacterium* spp. and *Pseudomonas* spp. All the parasites recovered in fingerlings before departure were consistent with the common parasitofauna found in pond fish population. From the 8 fish died during the transport, lasting 6 hours, the same bacteria and parasites isolated before departure were found. At the arrival the fish were acclimatized and then stocked in 4 small pre-stocking cages (100 hundred fish/cage). Every day after the arrival the cages were checked for fish mortality, that increased progressively up to 175 dead fish in a day (at 6th day). At the end of the first week a cumulative mortality of 360 (90%) tilapia fingerlings was recorded. The dead fish showed heavy skin lesions and fin rot. *Acinetobacter* spp., *Chryseobacterium* spp., *Pseudomonas aeruginosa*, *Aeromonas hydrophila* were isolated from brain and eyes and Flavobacteriaceae referable to *Flavobacterium columnare* from skin lesions of the dead fish. Furthermore the presence of filamentous bacteria referable to Flavobacteriaceae was detected in all the fresh smears performed from skin lesions and microscopically examined. The diversity of parasite groups observed in these fish was higher than that found in fingerlings before departure, but always at low intensity, and none of the recovered parasites was related to the mortality outbreak. The histopathological observations allowed to detect gill disease with severe oedema and hyperplasia at the basis of the lamellae and severe necrotic skin lesions associated to the presence of filamentous bacteria. The main water parameters monitored at the BOMOSA site at the arrival and during the observation period were: DO range 7.7-12.4 mg/l, T range 18.7-23.7°C.

B) Causes of eye diseases in tilapia farmed in BOMOSA hubs' open ponds

Parasitological and bacteriological analyses were carried out on 22 tilapia (13.8 cm long) owing to F1 generation obtained from wild breeders caught from Lake Victoria and farmed at Sangoro hubs' open ponds. The same methods described above were applied.

Ten (45.5%) out of 22 tilapia showed ocular lesions and brain congestion. The disease showed a chronic course starting with monolateral exophthalmia and keratitis evolving in blindness. In some case the disease affected both the eyes. No significant mortality was observed in the affected fish and the influence of the disease on the productive parameters is still under evaluation. *Aeromonas hydrophila* and *Pseudomonas aeruginosa* were isolated from brain and eyes of all the ten fish showing ocular lesions. Furthermore, *Aerococcus viridans* and *Vibrio fluvialis* were isolated respectively from a symptomatic and an asymptomatic fish. No parasites were detected on/inside eyes of the diseased fish, except for 1 diplostomatid metacercaria in a single tilapia. The other parasitological findings were protozoan and monogenean ectoparasites, and *Myxobolus* spp. and acanthocephalans endoparasites, always at low infection intensity.

Histology showed the presence of large several bacterial colonies in the vitreous with lens atrophy in the sick eyes and in some case the presence of granulomas behind the retina. In the retina and in the choroidal vessels bacterial colonies were also present. In one case the iris margins showed coalescence with pupil obliteration. Brain congestion and hemorrhages were frequently observed, associated to the presence of bacteria.

Considerations and recommendations: concerning the survey on causes of mortality in fingerlings, during the restocking activities, several stressful conditions were identified, such as a long time of transportation in a too small amount of water, presence of subclinical infections in the hatchery, strong temperature fluctuations in the BOMOSA plots, overcrowding in small pre-stocking cages facilitating the contact between fish causing skin and fin lesions and the transmission and colonization of opportunistic bacteria and parasites with direct life cycle. For these reasons a starvation lasting at least 24 hours should be always performed before the transportation of fingerlings, and some periodical fallowing and disinfection of the hatchery tanks where the fingerlings are stocked during the days before delivery could be effective in reducing the bacterial load and ectoparasites. The plastic bags could be transported within box containing some ice in order to avoid the increase of water temperature during the trip and some salt could be added to the water used to transport the fingerlings for helping the gill functionality and reduce the stress.

Concerning the eye diseases observed in F1 tilapia obtained from Lake Victoria breeders and farmed in open ponds, the eye seem to be the first

site of bacterial colonization with a secondary systemic spread. It is likely that the entrance route for these opportunistic pathogens could be represented by traumatic lesions of the cornea due to handling procedures or not optimal biomass density parameters, together with a high load of opportunistic bacteria in the environment. Good management practices reducing the incidence of these factors may allow to prevent this pathology and improve the productive potential of the tilapia “Lake Victoria” strain for its farming in the BOMOSA systems.



Veterinary and public health aspects linked to BOMOSA farming systems

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Diseases could represent an important constraint to aquaculture production, causing both production losses and public health problems. Therefore, the knowledge of the diseases of major concern in a fish farming system is necessary in order to assess the risk factors influencing their introduction/spreading and define the measures useful to their prophylaxis and control.

Although several scientific papers and books have been published in the past on diseases of wild and farmed fish from Africa (Robert & Sommerville, 1982; Paperna *et al.*, 1984; Van As & Basson, 1984; Michel, 1989; Paperna, 1996), a survey was carried out to evaluate their importance in BOMOSA farming systems, mainly in reference to risk factors influencing disease outbreaks in the farmed fish, their influence on productive parameters and their possible public health implications.

Main aim of the task 4.3 “*Analyze veterinary aspects and public health*” was to assess the diseases of major concern in the BOMOSA fish farming systems, to achieve some practical indications on preventive approaches aimed to improve health and productivity of farmed fish. In order to avoid

risks for the consumers, the zoonotic potential of the pathogens recovered during the veterinary monitoring actions has been also estimated and used for defining the main risk factors.

The activities carried out within this task have been performed collaboratively between EU and African veterinarian experts and have been targeted to investigate the following main topics:

quantitative/qualitative assessment of parasitofauna in farmed and wild tilapia: from March 2007 to October 2008 a total of 982 tilapias *Oreochromis niloticus* - 685 from Kenya, 222 from Uganda and 75 from Ethiopia - were subjected to necroscopical and parasitological analyses by specific diagnostic protocols compiled on the basis of fish pathology manuals. In some cases, infected tissues were fixed in 10% buffered formalin and subjected to histology by standard techniques in order to study the histopathological lesions induced by parasites and evaluate their pathogenic effects on the host. During the survey, fish from different environments (cages of BOMOSA plots, open ponds and water reservoirs) were taken into consideration in order to evaluate the factors which could influence the parasite diffusion and outbreak of diseases. Quantitative data, such as prevalence, intensity, abundance of parasites in the different farming and aquatic systems under study, and qualitative data, such as description of all the recovered parasites, evaluation of their effects on the hosts and study of the main abiotic and biotic factors influencing their diffusion and favoring disease outbreaks, were used in order to evaluate the sanitary risks in caged fish *vs.* wild/open pond farmed fish.

study of the life cycle of fish parasites recovered during the survey: specific researches were carried out to study the life cycle of some parasites showing sanitary and/or public health implications, i.e. Clinostomids and Anisakids. In particular, parasitological analyses of invertebrates and piscivorous birds found dead during the study period were made in order to identify the main intermediate and definitive hosts of the parasites.

investigation on the causes of mortality during/after transportation of fingerlings: in order to understand the causes of mortality frequently observed in fingerlings just after their introduction into BOMOSA cages, and define measures aimed to prevent mortality outbreaks and reduce losses in fingerling batches used to restock BOMOSA plots, a complete

diagnostic survey was performed on fingerlings during all the phases of transportation from hub to plot.

public health aspects: during the survey, all the aetiological agents potentially pathogenic to man were identified and studied in order to evaluate the main risk factors.

A total of 805 (82%) out of 982 tilapias were positive for parasites, among which 589 (86%) out of 685 in Kenya, 178 (80.2%) out of 222 in Uganda and 38 (50.6%) out of 75 tilapia examined in Ethiopia. Parasites owing to >20 different taxa were identified during the survey.

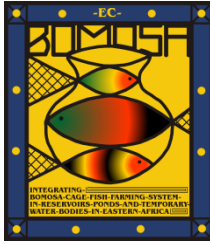
The parasitofauna didn't show remarkable differences between wild and farmed (in cages and earth-based ponds) fish, except for protozoan ectoparasites found mainly and with high infection intensity in farmed tilapias. At this regard, parasitic infections due to protozoan ectoparasites appear to be influenced by poor water parameters (pH, ammonia, low water exchange, high organic load, etc.) and husbandry conditions (overcrowding, etc.), requiring attention to these factors during environmental monitoring programme. Biomass density is an important factor conditioning also the monogenean (dactylogyrids and gyrodactylids) infections. At this regard, the maintenance of good water parameters and low biomass density are important methods of prevention and control of these infections.

Concerning parasitic infections due to heteroxenous parasites, detected in all the sampling sites, biotic factors such as presence of invertebrates and piscivorous birds could represent important risk factors and should be evaluated and estimated during the environmental monitoring programs of the BOMOSA sites. In particular herons, cormorants and pelicans have been found massively infected by Clinostomatids, *Contracaecum* nematodes and Gryporhynchid cestodes during this survey. Biosecurity actions aimed at reducing or avoiding the presence of snails (e.g. introducing a congruous number of siluroid catfish) and fish-eating birds (e.g. protecting by nets the farming area when feasible) could be useful in limiting the colonization and spreading of some parasitic infections.

The causes of mortality observed in fingerlings during/after transportation have been referred to opportunistic bacterial infections commonly associated to integrated farming systems, and Flavobacteriaceae, commonly present in skin and gill mucus of fish, triggered by stressful

conditions preventable with simple technical optimization measures to be applied during the transportation phases. Diseases referable to primary bacterial pathogens frequently reported in farmed tilapias, i.e. *Streptococcus iniae* (which causes high mortality and is potentially zoonotic) have not been individuated in the examined fish.

Concerning public health aspects, among the pathogens found during this survey, only Clinostomatid digeneans and *Contracaecum* nematodes may represent a risk factor for humans when raw or slightly cooked parasitized fish are eaten. At this regard the cooking of the fish easily inactivate the parasite, representing an useful individual control method. At a community level, the knowledge on the diffusion of these parasites in the aquatic systems exploited for tilapia farming may be useful to evaluate the risk level linked to the consumption of farmed fish and set some appropriate actions of sanitary education.



Parasites of *Tilapia (Oreochromis niloticus)* in Chepkoilel-Fish farm of Moi University, Eldoret, Kenya

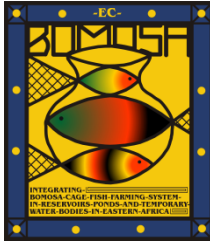
Matolla G.K.

Department of Fisheries and Aquatic Sciences, Moi University, Kenya.

Tilapia have been successfully farmed under a wide range of environmental conditions and are an important group of cultured fish species in many parts of the world, particularly in developing countries. They are considered to be hardy, rapid in growth and generally resistant to many diseases. Intensification of their culture has however resulted to deterioration of the environment have been associated with an increase in parasitic and infectious diseases.

A study was conducted to establish the presence of internal and external parasites of *Oreochromis niloticus* at Chepkoilel fish farm of Moi University in Eldora, Kenya. Water temperature during the study ranged from 17- 22°C. A total of 44 *Oreochromis niloticus* fish were sampled for parasites. Both internal and external parasites were observed. External parasites included Digenean metacercarial cysts, Trophonts of the protozoan *Ichthyophthirius* sp., crustacean parasite, fungi, the protozoan *Trichodina*, and the monogene *Dactylogyrus*. Internally, Acanthocephalans were found in the intestine while diplostomatid metacercariae were found in the vitreous region of the eye and in the muscles.

The most prevalent parasites were acanthocephalans and Diplostomatids. *Ichthyophthirius* sp. and Diplostomatid parasites had the highest mean intensity. Although parasite prevalence and intensity levels are considered as acceptable to the fish, there is need for continuous monitoring for to establish critical parasite levels for so as to develop control measures to prevent mortalities and economic losses. Furthermore, some of the parasites found may be have public health concerns and need further investigation.



Cause of fingerling mortality in Kwa-Ngeki's reservoir, Machakos district, Kenya

Otachi E.O.¹, Wathuta E.M.¹, Magana A.E.M.¹, Fioravanti M.L.², Florio D.², Gustinelli A.², Konecny R.³

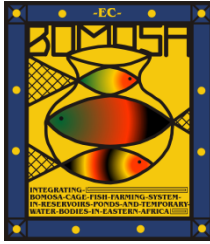
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The culture of freshwater fish is rapidly gaining currency in Kenya. This is evident in the growing number of people rearing fish in their farms (individual), institutional and communal farms and in the introduction of new fish farming model systems such as the “BOMOSA cage fish farming systems” in Central, Eastern, Rift valley and Nyanza provinces in Kenya as well as other sites in Uganda and Ethiopia within the 6th framework of European Union funded BOMOSA project. However, there are often massive fingerling mortalities of *Oreochromis niloticus*, L. and this presents a major challenge to this practice in these water bodies. The precise causes of these mortalities remain largely unknown and are often attributed to transportation and environmental stress. Therefore, to try and establish the real causes of these mortalities a research was designed to follow through the clinical and sub-clinical health conditions of pre-transport, transport and post-transport fingerlings processes such as acclimatization and stocking. The techniques employed included bacteriological, necroscopy and parasitological analyses. In addition, post-stocking mortalities were recorded, sampled and bacteriological, necroscopic and parasitological analysis performed on freshly dead specimen. The pre-transport bacteriological results indicated presence of facultative opportunistic bacteria of Flavobacteriaceae/Myxobacteria such as *Pseudomonas* sp., *Chryseobacteria* sp. and *Acinetobacter* sp. Parasitological studies revealed presence of ectoparasites such as Monogenetic trematodes. Results on post-stocking fingerlings showed characteristic deaths with severe necrotic fins, ulcerative skin and gill

oedema indicative that the mortalities could have been caused by the opportunistic bacteria.

Key words: Fingerlings, Mortalities, Bacteria, *Oreochromis niloticus*



Occurrence of Protozoan, Acanthocephalan and Helminth Parasites in Nile Tilapia (*Oreochromis niloticus* L.) ponds in Eastern and Central provinces of Kenya

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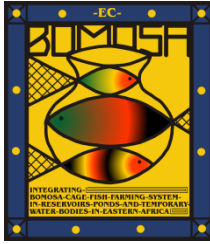
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Aquaculture is an important food contributor to the global and local economy. Diseases and parasitic infections have been recognized as one of the detrimental and limiting factors in the development of aquaculture. No research has been carried out to study the occurrence of protozoan, helminth and acanthocephalan parasites in *Oreochromis niloticus* cultured in pioneer integrated cage fish culture in shallow and temporary water bodies (BOMOSA cages) in Kenya, Uganda and Ethiopia within the 6th framework European Union funded BOMOSA project. Therefore, the aim of this study was to find out the occurrence of protozoan, helminth and acanthocephalan parasites in caged and open pond *O. niloticus* fish. Major objectives were to identify parasites, determine their prevalence rates, mean intensities, abundance and distribution, and relate occurrence of these parasites to seasonality and biotic factors such as presence of intermediate hosts. Using routine necroscopy and parasitological examination procedure a total of 383 *O. niloticus* fish comprising of 70 caged and 313 open pond fish were examined for the presence of these parasites. A total of 4 protozoan, 1 acanthocephalan and 13 helminth parasites were identified. There was no significant variation in parasitic infections in caged and open pond fish (sign test, $x=4$, critical value for a two-tailed test=4, $n=19$, $p>0.05$). In terms of distribution, some parasites seemed more abundant in caged than in open pond fish and vice versa. A few parasites such as the eye fluke, *Tylodelphys* sp. seemed to occur at high intensities during the dry season when the water level in the reservoir was low but a majority of the parasites did not show any relationship with seasons. Even though there

were no losses and mortalities recorded due to parasitic disease and infections, some parasites occurred in prevalence and intensities that are of major concern for a healthy productive system.

Key words: Cage fish culture, *Oreochromis niloticus*, parasites, prevalence, mean intensity, abundance, distribution.



The prevalence of internal and external parasites of *Oreochromis niloticus* L. and *Clarias gariepinus* B. collected from lakes and ponds in Ethiopia

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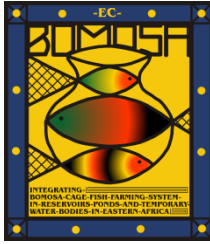
¹National Fisheries and Aquatic Life Research Center, Ethiopia.

Two consecutive surveys were made in 2007/2008 to study major parasites of *Oreochromis niloticus* collected from Lakes Hora, Babogaya, Ziway, as well as from Wonji and Yemilo ponds. A total of 132 *Oreochromis niloticus* and 40 *Clarias gariepinus* specimen were collected from the studied water bodies using gill nets of different mesh size (60-100 mm stretched mesh). Both external and internal parasites were reported during the sampling period. All collected fish specimens were first examined in temporary field laboratories. Further laboratory studies were conducted at Sebeta National Fisheries and Aquatic Lifer Research center. Laboratory results indicated that parasites belonging to protozoans, monogean, digenean nematodes and crustaceans were important parasites of the fish. Among protozoan the genus *Trichedinela* (16.6%) was reported only from Lake Hora where as the genus *Trichodina* (23.21-26.78%) was recorded from Wonji and Yemilo ponds. The genus *Garyodactylus* (8.3%) and Dactylogyridae (3.57-58.3%) were common among monogean parasites. Moreover, the genera *Clinostomum* (16.07-50%), *Eulinostomum* (33.3%), *Diplostomum* (40%) and *Tylodelphis* (3.57%) were also common. Larval nematode (10-50%) of the genus *Contracecum* (16.7-23.2%) was recorded. The genus *Argulus* (1.8%) was the only Crustacean external parasite recorded during the survey. *C. gariepinus* were also infected with different monogean, digenean and crustacean parasites. Among the digeneans, the genera *Diplostomum* (100%), *Centrocestus* (100%) and *Clinostomum*, (15%) were common parasites. The monogemeans of the genera *Garyodactylus* (15-31.6%) and *Dactylogyrus* (100%); larval nematodes (100%) the *Contracecum* nematodes (75-89.5%), and the crustacean

Dalops ranarum were also common parasite of *C. gariepinus* in the study areas.

Earlier reports suggested that *Clinistomum* infection could be zoonotic to humans. We have also found this parasite in the present study. We therefore suggest detailed studies on this parasite which could be important both from the human health aspect and the fishery point of view.

Key words: Fish parasites, *O. niloticus*, *C. gariepinus*, Ethiopian water bodies, Yemlo, Wonji



Prevalence and abundance of fish parasites in BOMOSA cage system and Lakes Babogaya and Awassa, Ethiopia

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Despite the expanding of aquaculture, little is known about the status of fish parasites in Ethiopia. This study was undertaken from October, 2008 to January, 2009 at two ponds (Wonji and Yemilo) and two natural Lakes (Awassa and Babogaya) in Ethiopia to identify the most abundant Metazoan and Protozoans parasites of two fish species; Nile tilapia, *Oreochromis niloticus* and African cat fish, *Clarias gariepinus*. Four sites, two each from cultured fisheries and natural lakes, were reasonably selected for comparison and their importance in public health aspects. Total of 185 *O. niloticus* and 39 *C. gariepinus* were examined and the major endo parasites identified during the investigation include Larvae of *Contracaecum* spp. (Nematoda) from pericardial cavity of *O. niloticus* and Mesentery of *C. gariepinus*, Metacercariae of *Clinistomum* spp. (Digenea) from the pharyngeal cavity. Plerocercoid of *Amirthingamia macracantha* (Cestoda) from the liver of *O. niloticus* and Metacercariae of *Diplostomum* spp. (Digenea) from the cranial cavity of *C. gariepinus*. The protozoan *Trichodina* spp. and Crustacean *Dolops ranarum* were found to be the most ecto parasites from cultured *O. niloticus* and wild *C. gariepinus* respectively. Adult nematodes of the genus *Contracaecum* were recovered from the investigation of Cormorant, one white Egret and Pelican. In spite of the general poor parasite diversity of the four water bodies during the investigation period, Lake Babogaya was relatively more diverse in parasite fauna of both species than the other three water bodies. Among parasites recorded in the present study, eating raw or smoked fish.

Key words: Fish parasites, prevalence, aquaculture, fish cage system, *O. niloticus* and *C. gariepinus*



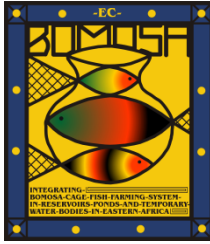
Risk evaluation of parasite transmission to caged fish in Uganda

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Fish cage technology has been recognised in improving growth performance of prolific spawners like tilapia as well as its simplicity and easy to manage. The technology is also expanding tremendously in bid to cope with increasing demand for animal protein. Several studies from regions with well-established cage culture systems have revealed epizootic outbreaks associated with parasites and other environmental degradation. In Uganda, the technology was introduced in 2003; however, no pathogen risk assessment was conducted. In 2006, under the BOMOSA project exploiting small permanent and temporary water bodies provided an opportunity to explore the possible risk of parasite invasion present in the water system. To; parasitological examination was conducted on pond-raised, wild and caged fish and differences in infestation parameters: prevalence, mean intensity and abundance of parasites were used to estimate the risk of parasite invasion. The result revealed that monoxenous parasites especially Cichlidogyrus sp and trichodinids occurred on fish from all sites. Heteroxenous parasites: digenetic trematodes cestodes, acanthocephala and nematodes were not readily transmissible to caged fish. The low risk of heteroxenous parasite invasion into caged fish could be attributed to low proximity of intermediate hosts and little exposure time to infested intermediate hosts. The study suggests that location of the cages and the fish-growing period significantly influences the transmission of

heteroxenous parasites to caged fish while the source of fry for cages and interaction with wild fish favours transmission and exacerbation of monoxenous parasites invasion.



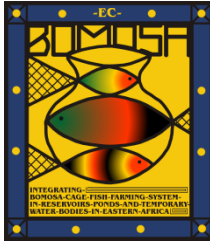
Effect of blue background light on Cortisol stress response, hematology and plasma biochemistry of three strains of Nile Tilapia (*Oreochromis niloticus*) fingerlings

Warugu H.W.¹, Liti D.¹, Wathuta E.M.²

¹Department of Biological Sciences, Moi University, Kenya; ²Biological Sciences Department, Egerton University, Kenya.

The effect of blue background light on acute stress response, hematology and plasma biochemistry of three strains (Sagana, Turkana, Victoria) of Nile tilapia, *Oreochromis niloticus* (L.) was evaluated. 80 fingerlings of each strain were placed into 8 20l glass aquaria, distributed in two isolated compartments in the same experimental room. After the acclimation period, 20 fish of each strain were anaesthetised with benzocaine to reduce the stress caused by capture and blood samples collected from the caudal vein using heparinised syringes. Blood samples collected in the heparinized bottles were used for the determination of hematocrit (PVC) haemoglobin (Hb), RBC and WBC counts. Other samples were centrifuged at 3000rpm for 10 minutes, plasma collected and used to determine the basal cortisol levels; protein, albumin and globulin content. White and blue light was then imposed over the two isolated compartments. After 10 days, an acute stressor was imposed in two aquaria of each colour compartment. The rest were used as control groups. 8 fish from each aquarium were sampled and blood collected for assessment. Basal cortisol levels were similar for each group, thus, plasma levels were analysed in terms of variation from their respective basal level. Blue light significantly inhibited an increase of cortisol in all groups. Lowest cortisol levels after stress were recorded in the Victoria strain. Turkana and Sagana strain had similar cortisol levels. There was marked decrease in erythrocyte and hematocrit values and an increase in Hb values for stressed fish under white light. Blue light significantly inhibited these changes, the values being similar to the control groups. These results indicate that blue light reduces stress in tilapia and the Victoria strain is less susceptible to stress than the Turkana and Sagana strains.

Key words: Acute stress, cortisol, haematology, Nile tilapia



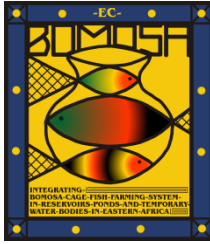
Sex reversal of Nile Tilapia (*Oreochromis niloticus*) L. at single, double and triple immersion in male androgen

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The production of single sex populations offers several advantages in tilapia aquaculture, including enhanced growth and prevention of unwanted reproduction. To achieve an all male tilapia population hormones are usually administered to fish through the diet. However this method is prone to inefficiencies such as uneven exposure to the steroid due to the establishment of feeding hierarchies or the availability of supplemental feed from pond primary productivity. Immersion of tilapia fry in steroid solutions may be one way to achieve masculinization and avoid these inefficiencies. An experiment was conducted to investigate the efficacy of single (SI), double (DI) or triple (TI) immersion in Dimethyltestosterone (DMT) on the sex ratio of Nile tilapia *Oreochromis niloticus*. Post hatch fry were exposed to 30g/L of DMT for 4 hours in SI, DI or TI. In the SI 14 days post hatch (DPH) fry were immersed once. In DI the fry were immersed on the 9DPH and 14DPH. In TI the fry were immersed on the 9DPH, 10DPH and 14DPH. Each treatment group consisted of two replicates. A control was set where the fry were not immersed in the hormone. At 60DPH the fish were dissected to validate sex reversal by macroscopic examination. Change in proportion was analyzed by the chi-square test. Best response was observed in TI where the immersion significantly increased the proportion of males (Males 87% Females 13%) as compared to DI (Males 84 Females 16%) and SI (Males 78 Females 22%). The study recommends the use of the triple immersion in order to achieve the highest number of males in culture of the *O. niloticus*.

Keywords: Nile tilapia, *Oreochromis niloticus*, sex reversal, male androgen



Impact of water quality variables on Nile Tilapia (*Oreochromis niloticus*) in cages installed in small tropical reservoirs

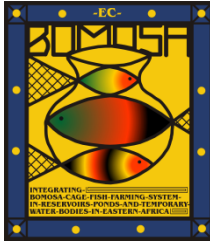
Liti D.M.¹, Kaggwa M.N.², Lukuyu R.K.¹, Schagerl M.³, Mbaluka R.⁴, Winkler G.⁵, Waidbacher H.⁶

¹Moi University, Department of Biological Sciences, Kenya; ²Kyambogo University, Department of Chemistry, Uganda; ³University of Vienna, Department of Marine Biology, Austria; ⁴Sagana Aquaculture Centre, Sagana, Kenya; ⁵Austrian Academy of Sciences Institute for Limnology, Austria; ⁶Department of Water, Atmosphere & Environment, BOKU- University of Natural Resources and Applied Life Sciences, Austria.

A study was conducted to evaluate the environmental parameters that determine growth of Nile tilapia (*Oreochromis niloticus*) in nine small and shallow reservoirs with surface area less than 2ha and depths between 3-5m located in three different eco-zones (low semi-arid, highland and lake region) in Kenya. Several water quality parameters were used in the evaluation. These parameters included temperature, chlorophyll *a*, DO, altitude and relative depth. All the reservoirs developed superficial stratification during sunny days in the early afternoon due to surface heating of the water. This was followed by nocturnal cooling and subsequent mixing of the water column towards morning, which occurred frequently at 06.00 hr when air and water temperatures were lowest. The stability of the thermal structure was depended on exposure of the reservoir to wind and their relative depths. Some of the water bodies however displayed prolonged stratification with mixing only occurring in the upper 1m of water during rainy and cold windy periods. Dissolved oxygen was highly influenced by the temperature regime and was also reduced to very low values during periods of persistent superficial thermal stratification. This led to overall oxygen reduction in the entire water column when mixing occurred. Multiple regression and cluster analyses predicted several environmental factors which significantly influenced fish growth. These included in order of their relative magnitudes minimum temperature,

chlorophyll *a*, pH, DO. However, Altitude and relative depth were not directly related to fish growth and were poor predictors of fish growth. Three types of production patterns were recognized among the water bodies; those water bodies with higher average minimum temperatures at low altitude (1150-1250m, Above Sea Level (ASL) – e.g. Sagana and Harambee dams, had highest production followed by those with moderate minimum temperature at altitude between 1600-1750m ASL – Ngeki, Lukenya and Ruthagati and Kapkesosio. The reservoirs at high altitudes >1800m such as Mailo, Damside had lowest production due to low average minimum water temperature. However specific differences of reservoirs within the same location occurred due to the degree of exposure and the magnitudes of their relative depths.

Key words: Temperature regime, mixing, water quality, pH, Nile tilapia, small reservoirs.



Diurnal thermal patterns in tropical water reservoirs: their impact on water quality and implications for cage culture of Nile Tilapia (*Oreochromis niloticus*)

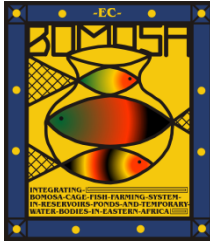
Lukuyu R.K.¹, Kagwa M.N.², Liti D.M.¹ and Waidbacher H.³

¹Department of Biological Sciences Moi University, Kenya; ²Kyambogo University, Uganda; ³Department of Water, Atmosphere & Environment, BOKU-University of Natural Resources & Applied Life Sciences, Vienna, Austria.

A study was conducted to analyze temporal and spatial distribution of physico-chemical parameters on nine small and shallow ($SA \leq 3\text{ha}$, z_m : 1.5-4.5m) reservoirs located in three different eco-zones in Kenya. The aim was to investigate the thermal patterns of the water bodies and the key driving forces controlling these patterns together with their impact on the key water quality parameters. All the reservoirs developed stratification during early afternoon due to surface heating. This was followed by nocturnal cooling and subsequent mixing of the water column towards morning, especially at 06.00hr when temperatures were lowest. The thermal structure was mainly dependant on climatic conditions which were largely determined by altitude, exposure to wind and relative depth of the reservoirs. In those water bodies with high relative depth and reduced exposure to wind influence there was prolonged stratification with mixing occurring only in the upper 1m of water during rainy and cold seasons this was evident in Damside, Mailo and Ngei. Dissolved oxygen was highly influenced by the temperature regime and was also stratified during thermal stratification. There was overall oxygen reduction in the entire water column towards morning as mixing of the entire water column occurred. The reservoirs varied markedly in terms of temperature, conductivity, salinity and pH values. Cluster analysis reveals close association between conductivity and salinity in one cluster, DO and temperature in a second cluster with pH forming its own cluster. Categorization of the reservoirs for suitability for aquaculture could group the reservoirs into three broad categories. Water bodies with optimum water quality dynamics for tilapia growth, the low altitude reservoirs of Sagana and Harambee (Altitude

1150-1250m ASL); Water bodies with moderate water quality dynamics, the intermediate altitude reservoirs of Ngeki, Lukenya and Ruthagati (1600-1800m ASL); and finally water bodies with adverse water quality dynamics, the highland water bodies of Damside and Kapkesosio (Alt>1800m ASL). Ngei and Mailo would form a unique group because they are sheltered from excessive wind exposure and have a high relative depth leading to poor mixing within the water column.

Key words: Temperature regime, thermal structure, stratification, mixing, dissolved oxygen, conductivity.



A preliminary evaluation of suitability of small tropical reservoirs for integrated cage culture of Nile Tilapia (*Oreochromis niloticus*) using water quality parameters

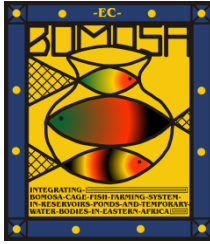
Kaggwa M.N.¹, Schagerl M.³, Mbaluka R.⁴, Winkler G.⁵, Lukuyu R.K.², Straif M.⁶, Waidbacher H.⁶, Liti D.M.²

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Cage culture is presently less developed in Sub-Saharan Africa despite the region's high potential and vast resources in water reservoirs. Cage culture has commonly been undertaken in large water bodies, which are relatively stable environments and suitable for fish culture. However, cage culture in small water bodies poses a major challenge because these water bodies are highly unstable water quality. Therefore there is need for thorough evaluation of the dynamics of water quality variables before integration of cage culture into the reservoirs. A pilot study was conducted to evaluate water quality parameters that affect cage fish production. The parameters included physical (temperature, dissolved oxygen, Secchi transparency) chemical (conductivity, total hardness) and nutrients (nitrogen and phosphorous compounds) as well as biological (chlorophyll-*a* and algae). Sampling was done bi-weekly in three reservoirs (Ngeki, Ngei and Kavovi) located in a semi-arid area of Machakos District, with surface areas of 2 ha or less and maximum depths between 3-5 m. The evaluation involved both spatial and temporal variations. Results from this study indicated that only one reservoir (Ngeki) had suitable water quality parameters for integrating cage culture into the reservoir. Temperature was suitable for fish growth in specific periods, such as between March and May. This observation was supported by positive increments in fish

growth., However, negative occurred growth between June and August, which is a period characterised by low temperatures. The present findings also indicated marked differences in the variability of water quality parameters among reservoirs in spite of being sited in the same locality. The morphological structure of the reservoirs played a key role in dynamics of the water chemistry. The distribution of oxygen, for example, a key parameter in growth was controlled by hydrographical structure, which in turn was dependent on the morphology of the basin. These findings highlights the importance of undertaking an independent assessment of the suitability of each water body before integrating cage culture in to the water body. Furthermore the activities carried out in the catchment areas had marked effect on the water quality parameters and in particular the phosphorus levels. These findings highlight the heterogeneous nature of reservoirs even within the same locality and the need to undertake prior evaluation before integration of cage culture.

Key words: Temperature regime, mixing, dissolved oxygen, conductivity, salinity, pH, fish performance



Potential influence of fish cage farming on water quality & plankton in fish ponds: a case study in the Rift Valley & North Shoa reservoirs, Ethiopia

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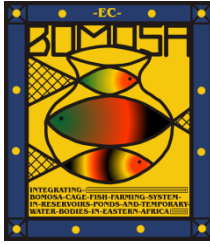
The potential impact of Tilapia, *Oreochromis niloticus* cage culture on water quality parameters and subsequent primary production and/or biotic composition of small water bodies (Alagea and Yemlo reservoirs) in Ethiopia were investigated between October 2007 and February 2008. Core objective of this study was to assess the difference between the cages and open water in relation to water quality parameters which may be attributed to intensive inputs of fish waste and left over fish feed.

It was observed that all physico-chemical water quality parameters including inorganic nutrients varied temporally over the study period coupled with dry and wet periods. The reservoir's trophic state ranged from eutrophic to hypereutrophic with strong correlation between chlorophyll-*a* and total phosphorus. High solar radiation and elevated nutrient levels from terrestrial runoffs probably have bigger impacts on the eutrophic state than fish caging in the reservoirs.

Dissolved inorganic nutrient concentrations and other physical parameters showed no significant differences between the cages and open water except for dissolved oxygen and ammonium nitrogen, which were lower and higher in the cages respectively. The mean values observed were 10 μgL^{-1} and 13 μgL^{-1} for SRP; 105 μgL^{-1} and 98 μgL^{-1} for total phosphorus; 3 mgL^{-1} and 3.2 mgL^{-1} for nitrate-N; ammonium-N concentration was 17 μgL^{-1} and 6 μgL^{-1} while nitrite-N concentration was 36.2 μgL^{-1} and 38.7 μgL^{-1} in the cages and open water respectively.

The phytoplankton community was dominated by cyanobacteria (84% of the total phytoplankton abundance) in particular by *Anabaenopsis sp.* in Alagea reservoir whilst Chlorophyta (70%) with *Pediastrum simplex* as dominant genus prevailed in Yemlo reservoir. The zooplankton species composition of both reservoirs was simple and is highly dominated by rotifers which contributed 43 and 70% to the total zooplankton in Alagea and Yemlo reservoirs respectively.

Key words: Fish cage farming, water quality, nutrient, plankton composition, pond, reservoir



Environmental monitoring of phytoplankton possibly influencing fish culturing in fish cages located at the BOMOSA sites

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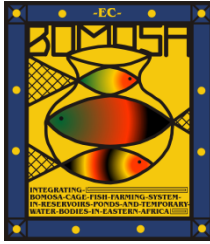
As it is well known that fish feed on phytoplankton, its composition was monitored at the nine project sites from May 2007 – June 2008. In addition nutrient concentrations essential to phytoplankton growth were determined. To investigate horizontal gradients in primary production due to fish caging concentrations of Chlorophyll a were determined inside the cages and in the middle of the lake. Particular emphasis was on cyanobacteria as these have been shown to produce the hepatotoxic peptides (microcystins) that threaten livestock and humans via the foodchain. Microcystins (MCs) were quantified by means of HPLC (High performance liquid chromatography) from aqueous methanolic extracts obtained from phytoplankton harvested from both depth integrated and plankton net samples.

According to total phosphorous concentrations five sites were classified as eutrophic and four as hypertrophic. The phytoplankton was dominated by green algae (most importantly the genera *Pediastrum*, *Scenedesmus*, *Botryococcus*) at four sites, by Dinophytes (genera *Peridinium*, *Ceratium*) at two sites, by Euglenophytes (*Phacus*, *Euglena*, *Trachelomonas*) at one site, by cyanobacteria and diatoms at one site each. Cyanobacteria were composed mainly of *Microcystis*, *Planktolyngbia*, *Anabaenopsis*. Although cyanobacteria were mostly subdominant, microcystins, mostly MC-LR (containing leucine and arginine in the variable positions two and four of the microcystin molecule) were more frequently detected in extracts from plankton net samples at the following sites: Ruthagati, Lukenya, Mailo Dam. No microcystins were detected in depth integrated water samples

(Filter volume ranges from 25 to 300 ml) by means of HPLC. However more sensitive methods such as ELISA (Enzyme linked immunosorbent assay) still could demonstrate the presence of microcystins in those three sites.

In order to find out which cyanobacteria are microcystin-producing a larger number of *Microcystis* was isolated and purified to obtain clonal cultures. Those cultures were again analyzed for microcystin and in total eleven out of 31 strains were found to produce microcystin. The following MC structural variants were observed: MC-LR (100% of the strains), MC-YR (36% of the strains). On average the cells of the microcystin-producing strains contained 3 ± 5 fg MC per cell.

The results of this study imply that limitation of phytoplankton growth by phosphate or nitrate is unlikely and other growth limiting factors such as light availability or flushing are more important. As no trend in Chlorophyll a concentrations on a horizontal scale could be found we exclude a direct effect on phytoplankton primary production by fish caging. The occurrence of *Microcystis* in water samples can be used as a proxy to infer microcystin production. As fish gill raker feeding cichlids have been shown to feed on *Microcystis* most efficiently. It can be recommended that in general ponds free of *Microcystis* should be chosen for the cage farming.



Overview of the legal and regulatory framework for inland aquaculture up scaling in Eastern Africa

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Legal documents were collected and reviewed in order to examine the legal and regulatory frameworks and institutional arrangements for aquaculture in Kenya, Ethiopia and Uganda. This document is a follow up to Deliverable 4.6 to provide recommendations for aquaculture institutional environment in Eastern Africa. The documents examined from Ethiopia include broad and remotely related documents to fishery and aquaculture. However, from these documents it was possible to collect fundamental data on ownership of land and water resources. Land and water resources are common properties of the people and state. It cannot be privately owned but can be leased to the private sector on contractual basis. In contrast to this situation, land and small water bodies can be privately owned in Kenya and Ethiopia. Most documents reviewed from Kenya were directly targeted to the fisheries and aquaculture. From Uganda relevant documents of general nature as well as those relevant to the fisheries and aquaculture were reviewed.

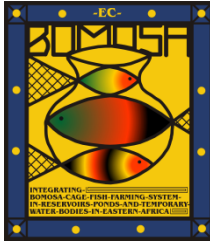
The Ministry of Agriculture was found to be the legal institution in charge of fisheries and aquaculture development in all three countries, although recently (2008) in Kenya the Ministry of Fisheries has been created, with the institution of the Department of Aquaculture in progress. However, the structural organization and level of the fishery and aquaculture sector varied considerably between the countries. In Ethiopia, the fishery sector has shrunk from the department level few years ago to team and then to desk level today. In Kenya the Fisheries has been given high priorities and

has been structured at the Ministry level along with livestock, and now at an autonomous level as already described. In Uganda, the Minister of states for fisheries is in charge for the aquaculture sub-sector. The aquaculture sector has been organized at department level indicating the importance of fishery in the country. Governmental institutions such as the Environmental Protection Authority (EPA) in Ethiopia and National Environment Management Authority (NEMA) are regulatory authorities mandated with the responsibility of coordinating, monitoring and supervision of environmental protection interventions.

BOMOSA cage fish farming system targets primarily in providing cheap fish protein for consumption or source of income for the rural farmers. The water bodies targeted for implementation of the project are mostly seasonal and small water bodies that are primarily constructed for the purpose of irrigation or animal watering. Integration of BOMOSA with agricultural activities should be congruent with proclamations and legislations in place in each country. In this regard up scaling of the project should abide to the articles and provisions that are pertinent with ownership of land and water resources, environmental protection and pollution, impact assessment of BOMOSA on the environment, transfer of fingerlings, aspects of veterinary and disease etc.

We believe that the policies, laws and regulations included in this study can provide basic information to establish and scale up the BOMOSA cage farming systems in Ethiopia, Kenya and Uganda.

SECTION III: ASPECTS OF FEED PROCESSING



Nutritional value of selected potential feedstuffs for sustainable aquaculture of Nile Tilapia (*Oreochromis niloticus* L.)

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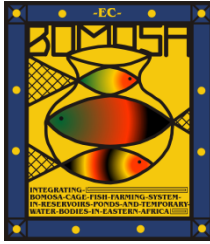
The limited availability and high costs of feedstuffs which possess a high nutritional quality frequently constitutes a major obstacle to the development of sustainable aquaculture systems in developing countries. Especially fish meal and other (by)products of animal origin are scarce sources of high-quality protein and energy and previous research has focussed on potential ways of substituting these feed ingredients. In the light of limited availability and questionable sustainability of fishmeal and similar ingredients, the omnivorous character of Nile tilapia makes it an even more relevant fish species for utilization in aquaculture systems relying on local resources.

Nevertheless, only little information is available on the nutritional value of locally available and inexpensive feed components of plant origin for low-input, sustainable fish production. A starting point for any study of the nutritional value of feedstuffs is the chemical analysis of the nutrient content of potential feed materials. In Eastern Africa, a wide variety of plant materials is basically available which may be used for fish feeding. Therefore proximate analysis was conducted on representative samples of leaves (banana, papaya, cassava, leucena, arrowroot, sweet potato, water fern, water hyacinth, mexican sunflower, sesbania, tree lucerne and gallant soldier), meals or cakes from seeds (cotton, sunflower, mango, papaya),

several by-products from agriculture or food processing (brans from maize, wheat, rice, various seed husks, vegetable residues, tea leaves residues, brewery waste) and animal products (fish meal, fresh water shrimp meal and poultry feathers).

The majority of leaves contained relatively high protein contents of 25 to 35 % (on dry matter basis), but their contents of ether extracts was only in the range of 10 %, which is likely to mainly consist of non-lipids and will therefore limit their energy content. Among the seed cakes, cotton and sunflower seed cakes contain high amounts of protein and relevant levels of lipids (39 and 26 % of protein and 11 and 5 % of ether extracts, respectively) and are already used in fish diets. As expected, animal by-products (freshwater shrimp meal, fish meal and feather meal) are the highest in protein, reaching values between 55 and 80 %.

Based on the results from proximate analysis, on their availability and the feasibility of removing anti-nutritional factors, leaves from sweet potato, cassava and mexican sunflower and brewery waste were identified as most promising alternative feed components for inclusion into diets of Nile tilapia. Aspects such as potential conservation in order to overcome seasonal shortage, variability of the nutritional value throughout the supply chain, the acceptability by fish and the resulting performance in vivo will be dealt with in other papers presented during this conference.



Nutrient content of selected potential feed ingredients for inclusion in fish feeds in Eastern Africa region

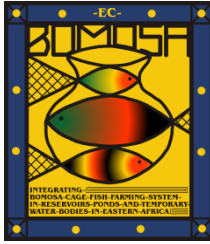
Munguti J.¹, Liti D.², Asaminew K.³, Mwanja W.⁴, Mwanja M.⁴, Waidbacher H.⁵, Drexler S.-S.⁵, Straif M.⁵, Heimberger B.⁵, Hammerl K.⁵, Nalwanga R.⁵, Zollitsch W.⁶

¹Kenya Marine & Fisheries Research Institute, Kenya; ²Moi University, Department of Biological Sciences, Kenya; ³Ethiopian Institute of Agricultural Research, National fisheries and other aquatic life research center, Ethiopia; ⁴DFRU- Department of Fisheries Research Uganda; ⁵BOKU- University of Natural Resources and Applied Life Sciences Vienna, Department of Water, Atmosphere and Environment, Austria; ⁶BOKU- University of Natural Resources and Applied Life Sciences Vienna, Department of Sustainable Agricultural Systems, Austria.

Aquaculture in Eastern Africa like many other sub-Saharan countries is under developed and contributes less than 1% to global aquaculture production. The cost of fish feeds among other factors has been identified as one of the key factors limiting factors. In an effort to contribute towards solving the problem of feed cost Bomosa European Union project funded the collection processing and analysis of 86 different locally available feed ingredients to evaluate their suitability for inclusion in fish feeds. The collections were contacted in three Eastern African countries (Kenya, Uganda and Ethiopia) and analyzed at Sagana Aquaculture Center which lies at latitude 0° 39'S, longitude 37° 12'E, and at an altitude of 1230 m above mean sea level. The farm is located 105 km Northeast of Nairobi and has coverage of 50 ha of which 20 ha are under fishponds. Proximate analysis of the feeds was carried out as described in AOAC (1990) in triplicates. The analyses involved the following nutrients: crude protein (CP), ether extract (EE), ash, nitrogen free extracts (NFE) and crude fiber (CF). Crude protein was estimated from Kjeldahl nitrogen. Crude lipid was quantified as the loss in weight after extraction of the sample with petroleum ether (40-60 °C). Ash was determined by burning dry samples in a muffle furnace at 550 °C for 4 hours. Crude fibre was quantified by

alkaline/acid digestion followed by ashing the dry residue at 550 °C in a muffle furnace for 4 hours. NFE was determined by the difference method (DM-CP-EE-CF-Ash).

The proximate analysis resulted indicated that 67 feedstuffs were suitable for inclusion as fish feeds. This conclusion is based on actual nutrient content (proximate analysis), local availability and potential competition with other uses and feasibility of removing anti-nutritional factors (ANFs). The authors recommend that further analysis to determine amino acid profiles of the feedstuffs, and growth experiments be conducted to evaluate biological availability of the feedstuffs and their performance of on fish growth.



Potential of Pawpaw (*Carrica papaya*) leaf meal to replace freshwater shrimps (*Caridenea niloticus* R) from diets for Nile tilapia *Oreochromis niloticus* (L).

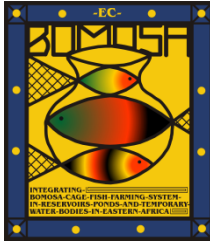
Obwanga B.O.¹, Liti D.², Wathuta E.M.¹, Magana A.M.¹, and Waidbacher H.³, Mbaluka R.⁴, Njoroge R.W.¹

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Feed is the primary expense for intensive tilapia production and protein is the most expensive protein ingredient necessitating substitution of expensive ingredients like freshwater shrimps, with cheaper ingredients such as pawpaw (*Carrica papaya*) leaf meal. Available information indicates that pawpaw leaves could be a good source of protein because of its good amino acid profile. To determine the effect of substituting freshwater shrimp meal with pawpaw leaf meal *O. niloticus* fingerlings were assigned to 60litre aquaria and 1m³ hapas in fertilized ponds and fed diets on diets formulated using pawpaw leaf meal for 60 days. Four isonitrogenous (300g/kg) practical diets were formulated to contain 0%, 25%, 50% or 100% pawpaw leaf meal (PLM). The 0% PLM (Sagana diet) was used as the control and the performance of fish fed on the other diets was compared to it. Sex reversed *O. niloticus* male fingerlings with initial mean weights and lengths respectively in aquaria (7.69±0.55g fish⁻¹; 8.30±0.32cm fish⁻¹) and in hapas (8.94g±0.51 fish⁻¹; 8.66±0.26cm fish⁻¹) was fed the test diets at 10% of their body weights in triplicates. Effects of the substitution were determined by assessing the fish growth performance. Growth performance in Hapas set up in an earthen pond was similar among the formulated diet (P>0.05). There was no significant difference (P>0.05) in all the parameters (SGR, % PGR, and FBW). PLM successfully replaced FSM from the control diet up to 100% replacement. The formulated diets had similar (P>0.05) effects on growth performance of *O. niloticus* to 0%PLM for the fish cultured in the glass aquaria. The study concludes that

PLM can successfully substitute FSM from diets used to culture *O. niloticus* in fertilized ponds and in indoor culture systems like concrete tanks.

Keywords: Nile tilapia *Oreochromis niloticus*, pawpaw leaf meal, growth performance whole body composition and Hepatosomatic index



Review on locally available fish feedstuffs for aquaculture development in Ethiopia

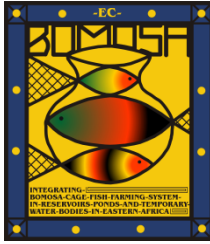
Asaminew K.¹, Waidbacher H.², Munguti J.³, Zollitsch W.⁴

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Locally available feedstuffs which could have a potential in aquaculture feed formulation was assessed for further development of aquaculture in Ethiopia. In this review the results of proximate analysis from International Livestock Research institute (ILRI) laboratory, Seyoum *et. al.*, 2007 and Adugna Tolera 2007 were used to compare the nutritive value of the available feedstuffs. The categories of feedstuffs were different in different literature. However, the categories used in ILRI are used in this review. The feedstuffs were categorized in to 9 major groups; that was crop residues, agro-industrial by-product, herbaceous forage, fodder trees and shrubs, cereals and legumes, mineral supplements, other food crops, less common feed, and roots and tubers food crops. According to the proximate analysis result there are several feedstuffs which could have a potential for fish feed in aquaculture development as supplement or as ingredient for feed formulation. The feed categories which have several alternatives for this purpose were included; agro-industrial by-product, herbaceous forages, cereals and legumes and fodder trees and shrubs. On the basis of proximate analysis results the other feedstuff categories were found to be less important for aquaculture feed development. Ethiopia is an agricultural country, which is dominated by crop farming; therefore crop residues are the most available feedstuffs for livestock and aquaculture. However, according to the proximate analysis result the nutrient content of this category were very low especially the crude protein content hardly exceeds

10% so emphasis has to be given to assess possibilities of improving nutritional value of crop residues.

Keywords: Aquaculture, Ethiopia, proximate analysis, fish, feed development



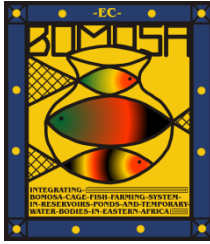
Analyses of Potential Fish Feed Ingredients and Formulation Low Cost High Nutritional Value Feed for Low Volume High Density BOMOSA cage Culture of Nile tilapia based in ponds, reservoirs and temporary water bodies for rural fish production, Uganda

Mwanja M.T.¹, Mwanja W.W.², Munguti J.M.³ and Bende A.⁴

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Different plant parts, agricultural by-products animal wastes and food cut-offs that are not of human food value or farm waste were identified and evaluated as potential fish feed ingredients depending on their local availability in three regions of Uganda. The potential ingredients were analysed for availability in terms of quantities and accessibility, quality and components of basic ingredients including crude protein, lipids, ash, fibre and Nitrogen free extracts using proximate analysis method. The ingredients were also analysed for anti nutritional factors mainly through literature review and comparative data analyses. The potential fish feed ingredients were analyzed for Nile tilapia feed. Based on their availability, potential competition with other uses, content of protein and fibre and the feasibility of removal of anti-nutritional factors, the identified potential feed ingredients were listed along with their nutrition values. Based on the results of the proximate analysis two fish feeds formulations were made and tested on Nile tilapia grown in the BOMOSA cages. The two formulations were found to be similar in performance of the fish attaining an average weight of 530g and 550g after 8 months of cage culture.

Key words: Tilapia, fish cage farming, potential ingredients, feed formulations



The efficacy of boiled tea leaves residues in diets for *Oreochromis niloticus* (L) and its effect on the liver and whole body composition

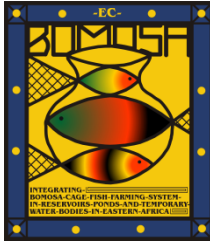
Obwanga B.O.¹, Liti D.², Wathuta E.M.¹, Magana A.M.¹, Waidbacher H.³, Mbaluka R.⁴, Njoroge R.W.¹

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Challenges facing production of Nile tilapia *Oreochromis niloticus* in Kenya today lie in identification of cost-effective feeds. Proximate analysis on boiled tea leaf residues normally considered as kitchen wastes showed a potential of using them in diets used for culture of *O. niloticus*. An 8-week feeding trial was conducted to determine the effect of substituting freshwater shrimp meal as a protein source with boiled tea leaves residues from diets used to culture Nile tilapia, *Oreochromis niloticus* in aquaria (initial mean weight 12.36 ± 1.1 g fish⁻¹; mean length 8.43 ± 0.27 cm fish⁻¹) and in hapas (initial mean weight 10.98 ± 0.75 g fish⁻¹. and mean length 8.77 ± 0.3 cm fish⁻¹). The effects of the substitution were determined by assessing the fish growth performance, resulting whole body composition and effect on the Hepatosomatic index (HSI). Four isonitrogenous (300g/kg) practical diets were formulated to contain 0%, 25%, 50% or 100% boiled tea leaves residues meal (BTLR). 0% BTLR (Sagana diet) was used as the control. Diets were fed to fish in glass aquaria and in hapas in a pond. All fish were fed 10% of their body weight in triplicates. Results showed no significant difference ($P > 0.05$) between the diets and the control up to 50% BTLR in hapas. However for fish cultured in the aquaria there was a significant ($P < 0.05$) difference between the control diet and increasing inclusion in BTLR in the diet. The diet had the same effect ($P > 0.05$) on the whole body chemistry (moisture, total ash and crude protein) in the fish raised in hapas. In glass aquaria total body ash increased ($P < 0.05$) significantly with increase in BTLR inclusion. Crude protein

decreased significantly at 100% BTLR. The HSI was significantly ($P>0.05$) high at 100% BTLR in hapas, while in the aquaria there was a significant increase in hepatosomatic index with increase in BTLR inclusion. The study concludes that boiled tea leaves residues can successfully substitute freshwater shrimps up to 100% in fertilized ponds without an adverse effect on the whole body moisture, crude protein and total ash. However in recirculating systems BTLR cannot substitute freshwater shrimps from diets used for culture of Nile tilapia *Oreochromis niloticus*. The study recommends the use of boiled tea leaf residues in formulated diets for culture of *Oreochromis niloticus* in fertilized ponds by small scale farmers to reduce on the cost of fish culture.

Keywords: Nile tilapia, *Oreochromis niloticus*, boiled tea leaves residues, growth performance whole body composition, Hepatosomatic index



Performance, whole body composition and hepatosomatic indices of Nile tilapia (*Oreochromis niloticus*) L fed on diets formulated using cassava (*Mannihot esculenta*) leaf meal

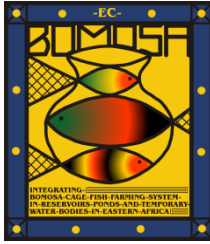
Obwanga B.O.¹, Liti D.², Wathuta E.M.¹, Magana A.M.¹, Waidbacher H.³, Mbaluka R.⁴, Njoroge R.W.¹

¹Department of Biological Sciences Egerton University, Kenya; ²Department of Biological Sciences Moi University, Kenya; ³Department of Water, Atmosphere & Environment, BOKU- University of Natural Resources and Applied Life Sciences, Austria; ⁴Sagana Aquaculture Centre, Kenya.

Increased culture of tilapia has stimulated expansion of tilapia feed production and a search for ideal plant protein sources to replace animal proteins from tilapia diets. Cassava is locally grown in Kenya and leaves from the cassava plant are a promising alternative to use of freshwater shrimps in diets for *Oreochromis niloticus*. A study was carried out to evaluate the effects of substituting the protein from freshwater shrimp meal with Cassava (*Mannihot esculenta*) leaf meal (CLM) from diets used to culture Nile tilapia, *Oreochromis niloticus* in aquaria (initial mean weight 10.90 ± 0.64 g fish⁻¹; mean length 6.20 ± 0.25 cm fish⁻¹) and in hapas set up in fertilized earthen ponds (initial mean weight 10.55 g fish⁻¹ mean length 8.17 ± 0.23 cm fish⁻¹). Effects of the substitution were determined by assessing the fish growth performance, the resulting whole body composition and effect on the hepatosomatic index (HSI). Four isonitrogenous (320g/kg) practical diets were formulated to contain 0%, 25%, 50% or 100% CLM. The 0% CLM (Sagana diet) was used as the control and the performance of fish fed on the other diets were compared to it. Test diets were fed to fish in glass aquaria and in hapas in a pond at 10% of their body weight in triplicate. It was possible to replace up to 50% of freshwater shrimps from diets used to culture *O. niloticus* hapas. 100% CLM caused significant ($P < 0.05$) decrease in final average weights in hapas. In glass aquaria substitutions beyond 25%CLM caused significant ($P < 0.05$) decrease in final average weights. Carcass chemical composition showed similar effect of diets on body moisture content at 25%CLM and

100%CLM in hapas. At 50%CLM the diets caused a significant ($P<0.05$) increase in the whole body moisture level. Substitution up to 50% CLM showed similar effect on body moisture in fish cultured in aquaria. 100%CLM substitution significantly ($P<0.05$) increased whole body moisture, significantly ($P<0.05$) decreased whole body crude protein and significantly ($P<0.05$) decreased HSI of fish grown in aquaria . HSI was similar at 0%CLM, 50% CLM and 100% CLM but increased significantly ($P<0.05$) in hapas. The study concludes that cassava leaf meal can successfully be included up to 50% in diets used to culture *O. niloticus* in fertilized ponds but can only be included up to 25% in diets used in indoor systems.

Keywords: Nile tilapia, *Oreochromis niloticus*, cassava leaf meal, growth performance whole body composition, Hepatosomatic index



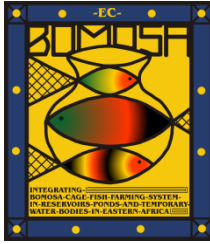
Effects of pure and crude papain on the utilization and digestibility of diets containing hydrolysed feather meal by *Oreochromis niloticus* – The Bomosa cage culture experience

Munguti J.¹, Liti D.², Charo-Karisa H.¹, Waidbacher H.³, Straif M.³, Zollitsch W.⁴

¹Kenya Marine & Fisheries Research Institute, Kenya; ²Moi University, Department of Biological Sciences, Kenya; ³Department of Water, Atmosphere & Environment, BOKU- University of Natural Resources & Applied Life Sciences Vienna, Austria; ⁴Department of Sustainable Agricultural Systems, BOKU- University of Natural Resources & Applied Life Sciences Vienna, Austria.

A study was conducted to evaluate the effects of pure and crude papain on the digestibility and utilization of diets containing hydrolysed feather meal (HFM) by Nile tilapia (*Oreochromis niloticus* L.) under indoor and outdoor conditions. *O. niloticus* fingerlings with a mean weight of 22 and 30g were stocked in aquaria and cages, respectively. Recirculating water was used in the aquaria while cages were installed in 800-m² earthen pond. The pond was fertilized at 20kg/N/week/ha and 8kg/P/week/ha. Five isonitrogenous (250g CP kg⁻¹) and isocaloric (2,940 kcal kg⁻¹) diets designated as 1, 2 3, 4 and 5 were formulated using papaya leaf meal (PLM), cotton seed cake (CSC), freshwater shrimps (FSM) and wheat bran (WB). Diet 1 contained 6 % freshwater shrimp meal (FSM) and 4.5 % HFM and served as control, Two other diets were formulated by adding pure papain (Diet 2) and 4.5 % PLM (crude papain) (Diet 3). The other two diets were formulated by completely replacing FSM with HFM plus pure papain (Diet 4) and crude papain (Diet 5). All fish were fed at 10% body weight day⁻¹ in three replicates for 58 days. Results indicated that dietary levels of HFM and PLM above 4.5% each led to significant (P<0.05) growth reductions in aquaria. However, complete replacement of FSM with HFM did not significantly (P>0.05) affect growth of fish in the cages. In both experiments, survival was similar among treatments, but protein digestibility decreased with increasing levels of HFM in the diet. In conclusion, substitution of FSM with HFM at levels above 50% in a

intensive culture system leads to decline in *O. niloticus* growth performance while 100% substitution is possible in a fertilized earthen pond culture system where fish can access extra nutrients from the natural environment.

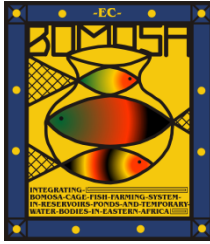


Effects of substitution of *Caridina nilotica* with hydrolyzed feather meal on growth performance and apparent digestibility in *Oreochromis niloticus* under different culture conditions

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The effects of substituting hydrolysed feather meal (HFM) for freshwater shrimp meal (FSM; *Caridina nilotica*, Roux) on growth, digestibility and survival in Nile tilapia (*Oreochromis niloticus* L.) were evaluated under laboratory and practical culture conditions. Fingerlings with mean ranges of 26.0-26.5 and 35.4-37.0 g were held indoor in aquaria with recirculating water, and in cages that were installed in 800 m² fertilized pond, respectively. Five isocaloric (12.3 kJ g⁻¹) diets, containing between 28.5 and 31.0 % of crude protein, were prepared by gradually substituting HFM for FSM at rates of 0, 25, 50, 75 and 100% and fed to fish in aquaria; tilapia in cages were fed diets at substitution levels 0, 50 and 100%. All fish were fed at 10 % of body weight day⁻¹ in three replicates for 84 days. Results indicated that substitution of HFM for FSM at levels above 50% led to significant (P<0.05) growth reductions in aquaria. However, even 100% substitution rate did not significantly (P>0.05) affect growth of fish in the cages. In both experiments, survival was similar among treatments, but apparent protein digestibility decreased with increasing levels of HFM in the diet. In conclusion, 100% substitution of HFM for FSM may be possible in semi-intensive culture of *O. niloticus*, where natural food is available.



Effects of feeding rate and frequency on the growth performance of Nile tilapia (*Oreochromis niloticus*) in cages installed in a small reservoir

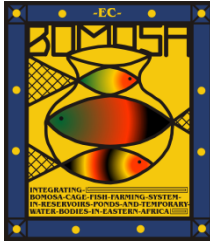
Liti D.M.¹, Lukuyu R.K.¹, Mbaluka R.K.², Munguti J.M.³, Waidbacher H.⁴, Zollitsch W.⁵

¹Moi University, Department of Biological Sciences, Kenya; ²Sagana Aquaculture Centre, Kenya; ³Kenya Marine and Fisheries Research Institute, Kenya; ⁴Department of Water, Atmosphere & Environment, BOKU- University of Natural Resources and Applied Life Sciences, Austria; ⁵Department of Sustainable Agricultural Systems, BOKU- University of Natural Resources and Applied Life Sciences, Austria.

A study was conducted to evaluate the optimum feeding rate at two feeding frequency levels in semi-intensive culture of Nile tilapia (*Oreochromis niloticus*) in cages of 1m³, which were installed in a 2.4 ha reservoir. The experiment involved a two-way ANOVA model design with the feeding rate factor set at three levels (3, 6, and 10% body weight) and the feeding frequency factor at two levels (twice a day- at 10.00 and 16.00hr, and continuous feeding-between 10.00 and 16.00hr). Each combination of levels of the main factors was replicated three times and each cage stocked with fingerlings with average weight of 38.0g. A total of 18 cages were used in the experiment which took 190 days. Fish samples were taken monthly to monitor growth and make feed adjustments. At the conclusion of the experiment, growth performance, feed conversion ratio, monetary values were determined and used as indices of performance. Feed was dispensed through an automatic device, which was fabricated from local materials and calibrated to deliver feed at the desired times. The diet was formulated to contain 915 g kg⁻¹ dry matter, 247 g kg⁻¹ crude protein, 69.0 g kg⁻¹ ether extract, 130 g kg⁻¹ crude fibre, 86 g kg⁻¹ ash and 465 g kg⁻¹ Nitrogen Free Extract. Water quality was monitored monthly throughout the experimental period. Temperature ranged between 24 and 29°C throughout the experimental period and was within the suitable range for tilapia growth. Growth performance (mean weight, net and gross yield) was significantly (P<0.05) influenced by feeding rate but not feeding frequency

($P > 0.05$). Fish growth was higher at the 6% feeding rate than 3 and 10%. Feeding fish at 3% led to growth performance, which was similar to those fed at 10%. Interaction was significant suggesting some form of synergy or interference between the levels of the main factors. Feeding fish at 3% on a continuous basis improved growth performance compared to those fed twice a day at the same feeding rate. However, feeding at 6 and 10% did not demonstrate any significant interaction. Feed Conversion Ratio was significantly different at all the three feeding rates and increased from 3 through 6% and increased with the increase in feeding rate. However, interaction was not significant suggesting that unlike growth; it was not dependent on feeding frequency. Although growth was optimal at 6%, highest economic performance occurred at 3%, which also had the best feed utilization. It is concluded that under the present conditions, the growth performance of fish fed in semi-intensive cages is optimized at 6% body weight but economic optimization occurred at 3% feeding. A feeding rate of 3% is therefore recommended for semi-intensive culture of *O. niloticus* in cages.

Key words: cage culture, feeding rate, feeding frequency, economic performance, Nile tilapia



Testing of acceptance of formulated fodder for Nile Tilapia (*Oreochromis niloticus*) made of locally available agriculture by-products with behavioural analysis in observation tanks

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¹Department of Water, Atmosphere & Environment, BOKU- University of Natural Resources and Applied Life Sciences, Austria; ²Moi University, Department of Biological Sciences, Kenya; ³Sagana Fish Farm, Kenya; ⁴ Department of Sustainable Agricultural Systems, BOKU- University of Natural Resources and Applied Life Sciences, Austria.

According to the procedure of testing different agricultural by-products as fish food for small-scale cage aquaculture it can be mentioned that the method of feeding directly into cages for a period of three months is a very time-consuming operation for getting clear results. In the actual BOMOSA project a major focus was set on direct behavioural studies to decrease the time-consuming procedure. The studies have been performed in a special built observation room at Sagana Fisheries Research Center, Kenya. Two tanks with a circulation system have been available for observation; the volume of each water body was 1,6 m³. The glass screen for watching the fish from inside of the dark room had a dimension of 60 x 40 cm. The behaviour of respectively 5 individuals of *Oreochromis niloticus* has been recorded with a video camera at each single feeding event. The measured parameters for evaluating the reactions of the fish after dropping different food particles and mixtures on the surface have been as follows: time between food presentation and first reaction of the fish; uptake of the food from surface, water column or bottom of the tank; handling of the food particle and different handling types; handling time; colour and texture preference and sinking behaviour of the food particles.

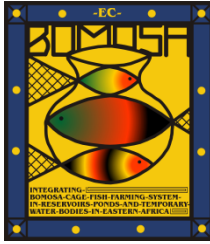
Eight potential diets and created mixtures made of leaves from Sweet potato (*Ipomoea batatas*), Mexican sunflower (*Tithonia rotundifolia*) and Gallant soldier (*Galinsoga parviflora*) as well as brewery waste have been

tested. On the one hand, feeds were fed as flakes where the leaves have just been chopped and dried; on the other hand, the diets were fed as pellets where the chopped leaves have been pelletized respectively ensilaged and pelletized in an additional step. As a reference diet served the locally produced “Sagana diet formulation”.

The results clearly showed that pellets made of brewery waste with gelatine respectively without gelatine have had the highest acceptance as a diet by all of the fish. Interesting is, that a silage made out of this product was mainly ignored. Feeds made of Gallant soldier and the silage of Sweet potato leaves have been accepted by the fish with a low value, Mexican sunflower leaves were not accepted at all. In “mixed diet” experiments (Sweet potato leaves, Cassava leaves and Mexican Sunflower particles, each mixed with breweries waste) the results pointed out clearly that the feeds have an increasing acceptance the more breweries waste is involved in the texture. This statement does not work with Mexican sunflower, if this plant is involved at any percentage in the formulation *O. niloticus* does not accept the pellet as a food at all.

Light-coloured pellets with an intermediate hard texture have been preferred by the fish as well as optimum sized pellets performed better as food particles than small-sized flakes. The sinking speed of diet-particles is different for the tested feed types and has to be taken into account in future optimisation of cages in small-scale aquaculture.

**SECTION IV: SOCIAL ASPECTS AND ETHICAL ISSUES,
SOCIO-ECONOMIC MODEL**



Social issues relating to BOMOSA fish project in Central and Eastern Kenya

Ngari E.W., Muhia, R.N.

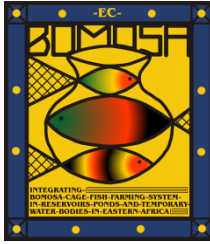
Department of Sociology, Economics and Anthropology, Egerton University, Kenya.

The BOMOSA project involves producing fish in floating cages where they are fed using developed feeds. This is a relatively new technology in Kenya and there is no study done on social issues relating to the project. A study was therefore carried out in central (Ruthagati and Mairo) areas and eastern region (Ngeki) to determine social acceptability of BOMOSA fish project in the areas. The objective was to understand the ethical, ownership and community-related issues in order to identify and solve any potential conflicts at an early stage. Data was collected by semi structured questionnaire and checklist methods. A total of 108 respondents chosen by systematic random sampling responded to the questionnaire. Key informants were drawn from fish sub-sector stakeholders in the community.

Results indicated that fish is not consumed regularly, men consume fish more often than women and they have consumed fish for a longer period. Tilapia was noted to be the most eaten fish type in both central and eastern regions. Catfish was the preferred species in Ruthagati and Mairo area. 250 grams and above fish were preferred for their flesh and bigger bones hence easier to eat. Fish is considered to be a superior protein source and are mainly prepared by deep frying and stewing. Men were more conversant with fish preparation methods than women. Some people do not consume fish due to unpleasant smell, bones and few people are allergic to fish or are strict vegetarian.

From the study, only few people of old generation who strongly believe that fish is food for lake regions, snake-like shape and scales hinders fish uptake. No religious belief was noted to hinder fish uptake. The project has been ethically accepted in the regions but non-project members need to be

enlightened on feeds composition and drug use on fish in water bodies. Out- reach programme and cage expansion need to be implemented involving community members to benefit from cage fish farming.



Social, cultural and ethical issues relating to fish farming in Kenya: Lessons from BOMOSA project sites in Machakos and Nyeri districts

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The BOMOSA project was undertaken in three countries of Kenya, Ethiopia and Uganda, with aim of promoting cage fish farming in reservoirs, dams and temporary water bodies. The fish are produced in hubs near each project site and fed using feeds developed from readily available raw materials in each site. This is a relatively new technology in Kenya and there is no study yet done to explore the social-cultural and ethical issues relating to the project.

This paper presents a comparative exploration of some socio-cultural and ethical issues around the BOMOSA project sites in Machakos and Nyeri districts, Kenya. The study was carried out in Ruthagati and Mairo sites, Lukenya school and Ngeki sites, all not traditionally fish eating/farming communities. The objectives were to determine social acceptability of BOMOSA fish farming and explore the ethical, ownership and community-related issues in order to identify and solve any potential conflicts likely to affect the project in the two areas at an early stage.

Primary data was collected from a randomly selected sample of communities within the radius of each water body (identified by GIS mapping) using semi structured questionnaire and key informant interviews. A total of 108 respondents were interviewed. Key informants were drawn from fish sub- sector stakeholders in the neighbouring and immediate community.

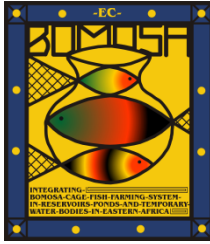
Results indicated that though fish is not consumed regularly, men consume fish more often than women and they have consumed fish for a significantly longer period than women. Tilapia was noted to be the most

generally preferred fish type in both regions although Catfish was the preferred species in Ruthagati and Mairo areas specifically. These two areas have had active fish farming activities for a longer period than the other two sites. Contrary to popular belief that people will not like “small size fish”, size 220 grams and above fish were preferred as they are considered easier to eat even for children. Fish is considered to be a superior protein source preferred for use consumption for the elderly, children and the more affluent, and are mainly prepared by deep frying and stewing.

Men were more conversant with fish preparation methods than women. This finding sharply contrasts the practice and experiences documented in other traditionally fishing communities like those around Lake region and even those in Lake Baringo, where most of the work concerning fish preparation and processing is done almost exclusively by women, except when commercialized.

There are no religious beliefs that were noted to hinder fish uptake, only cultural prejudices and preferences.

The project is ethically accepted in all the regions but potential ethical concerns are concern the use of public water resource for “private” (group) benefit: non-project members need to be enlightened on environmental effects of fish farming on dams and temporary water bodies in water bodies. BOMOSA were not found to contradict any of the legislation regarding use of public water bodies in Kenya. - To enhance benefit by the larger community, an outreach programme and cage extension strategy need to be implemented by multi-sectoral stakeholders.



Baseline survey on economic viability and social acceptance of the BOMOSA cage farming system

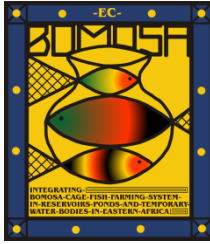
Alemu S.

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The main objectives of this study was to collect baseline information on economic viability, social acceptance and ethical issues related to BOMOSA cage fish farming system in the two BOMOSA sites, Yemlo and Wonji. A total of 68 farmers were interviewed using the prepared structural questioners. The questioner was used to collect house hold information on the situation of the agricultural system, fishery innovation process, access and utilizations of water bodies states ownership etc. Data were analyzed using SPSS computer soft ware and descriptive statistics. It was learnt that fish are not major sources of protein in the study areas and this is because of limited supply of fish. Most respondents (64.7%) are aware of fish farming and they obtain the information from farming government institutions. Most of the family members have no idea how to fish from water bodies and they attribute this problem to lack of awareness and absence of tools for fishing. The survey also revealed that, about 57% of the house holds lack knowledge about the different types of fish species. Fish extension services related to fish farming such as training and field demonstrations are given only once in a year at Yemlo. There is also shortage of water all year round and this is because the community uses the water for irrigation purpose as well.

In conclusion, introduction of appropriate fishery technologies such as pond culture and cage culture systems are needed to increase fish production in the regions. It is also recommended to organize trainings, seminar and farmer demonstration so as to create awareness of the community about integration of aquaculture with agriculture in both BOMOSA areas.

Key words: BOMOSA, Yemlo, Wonji, fish, fish farming, fishing tools



Cultural influences on fish eating as barriers to the adoption of appropriate technologies for farmed fish production in a pastoral corridor in Uganda: the case of BOMOSA cage fish farming project introduction in Nakasongola district

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With other factors in consideration, there are two traditional production and cultural aspects that could hinder the development of cage fish farming in the Uganda cattle corridor as established during the attempt to introduce BOMOSA cage fish farming system in traditionally non fish eating pastoral communities in Uganda. These aspects include the presence of a majority non-fish eating communities and high value attached to water sources as cattle survival sheds. Findings indicated that Nakasongola communities that were comprised majorly of pastoralists were largely traditionally non-fish eating, and strongly objected to introduction of BOMOSA cage fish farming system in the communal water reservoirs as it was considered taboo for a cattle keeper to farm fish. Majority of water reservoirs that had been targeted for the BOMOSA Cage fish farming plots were purposed to water their large herds of cattle; and were guarded as such and were not open to any other use. Using data from the BOMOSA household based survey in 2006 fish consumption patterns as well as willingness to adopt the BOMOSA cage fish farming project were assessed in Nakasongola district with the following general indications. 20 community leaders were interviewed as respondents in the baseline survey as part of preliminary activities for introduction of BOMOSA Cage Fish Farming systems. 85% of the respondents were non fish eaters due to traditional and cultural inhibitions and 90% of the respondents strongly opposed the introduction and participation in the cage fish farming systems on the 4 communal water reservoirs. Among the reasons given were that fish would ‘infest and affect’ the performance of their cattle and contaminate the domestic water supply from the reservoirs; secondly that they were primarily beef eaters,

and cattle keeper cannot be seen or heard to have eaten fish. A cultural change programme needs to be incorporated in the BOMOSA concept for successful introduction and adoption of BOMOSA Cage Fish Farming systems in such pastoral communities with no tradition of fish eating.

Key words: culture, fish eating, BOMOSA cage fish farming, pastoral communities



Community mobilization for promotion and adoption of BOMOSA cage fish farming systems: achieving acceptability, ownership and adoption of BOMOSA cage fish farming at Ndolwa and Busoga High community dams in Kamuli district

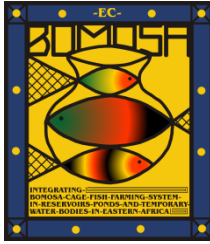
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Two communities selected to participate in the piloting of BOMOSA cage fish farming system in Uganda were mobilized towards participation, acceptance, adoption and owning of the BOMOSA cage fish farming system in two communities in Kamuli, Uganda. The two communities comprised of a rural community around Ndolwa communal water reservoir and another of comprised of teachers, staff and students of Busoga High both of Kamuli district. Two approaches including the Rapid Rural Appraisal and Participatory Rural Appraisal methods re-designed after the 'own efforts' concept of RISE community mobilization were used. The RISE concept stipulates that external support can only make meaningful development if the beneficiaries make significant contributions towards the development goal. The two communities were successfully mobilized to accept, participate in and own the BOMOSA plots during the piloting of the BOMOSA technologies. Based on the concept that acceptability and ownership foster project sustainability, preliminary evaluation results show that both Ndolwa and Busoga High communities made significant steps towards the project sustainability by the end of the implementation period. Research findings indicate that 60% and 90% of respondents from Ndolwa and Kamuli High respectively always participated in the project field activities alongside meetings and launch events. A combined 67% of the respondents participated in the project activities because of earlier participative mobilization efforts and foreseen project benefits. The remaining 35% for Ndolwa and 5% for Kamuli High participated in the events most times while only 5% and 5% for Ndolwa and Kamuli High respectively rarely participated in the project activities. On examining the

level of knowledge of the BOMOSA cage fish farming project held by the respondents, the survey revealed that 95% and 70% of respondents at Ndolwa and Kamuli High respectively had good knowledge of the project while only 5% and 15% did not know about the project in Ndolwa and Kamuli High respectively. The findings points to the relevance and value of participative mobilization methods in promoting of BOMOSA cage fish farming systems for rural fish production.

Key Words: BOMOSA fish farming system, participative mobilization, acceptability, adoption, ownership



Analysis of demand for fish in Kenya: the almost ideal demand system approach

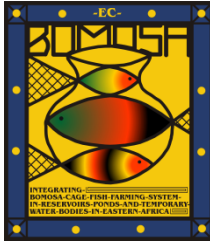
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Consumer behavior theory can be used to explain the level of demand of a commodity given a structure of relative prices faced, real household income, and a set of individual household characteristics such as age, gender, education level and geographical location. The study was driven by the need for understanding on how consumers respond to fish price changes and how their consumption behavior can be influenced by changes in real household incomes. The understanding of these parameters would inform production and marketing decisions for the BOMOSA scheme. The study used the Almost Ideal Demand System (AIDS) model to estimate direct and cross price and income elasticity of demand for fish in selected markets in Kenya. Cross-sectional primary data was collected through surveys on 120 fish consumers drawn randomly from 15 shopping centers spread over three regions in Kenya.

Preliminary results confirm a supplementary relationship between fish and beef among the sampled households. Beef had a lower income elasticity of demand compared to fish, but higher price elasticity. Education level, gender, household size and location were found to significantly influence the average share of household income allocated to fish per month. The study draws implications that can be direct policy towards improving poor household nutrition status through improved protein intake.

Key words: direct elasticity, household livelihoods, AIDS



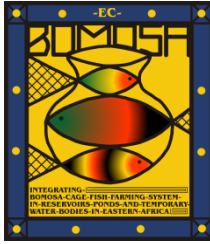
Analysis of fish marketing channels in Kenya: a transaction costs approach

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The Institutions Analysis and Development (IAD) Framework was used in this study to analyze fish marketing channels in Kenya. First, the study identified the actors and activities involved in small scale fish distribution, in selected BOMOSA regions in Kenya. Secondly, the attributes of the commodity (fish), the actors and the activities were analyzed with view of how they influence two vital outcomes: transaction costs and profitability. Primary data for the study was collected through a survey among 90 small scale fish traders drawn from 15 shopping centers in Kenya, and augmented with secondary data from various sources. Results indicate that in all channels identified, transaction costs in fish trade exist and were found to arise due to a number of reasons. Traders incur transaction costs while searching and screening for reliable suppliers and customers, transporting the product, obtaining transfer permits and trade licenses and monitoring the transactions. Further, the type of transaction costs incurred within each marketing channel highly depends on the level of information asymmetry between actors, the actors' attributes and existing institutional arrangements that are necessary to maintain transactions and counter opportunistic behavior. The nature of activities and actors within each channel was also found to influence the transaction costs. The study draws imperative policy implications that can be used to reduce the transaction costs incurred in fish trade, hence make the fish marketing channels more efficient. Some suggested policy options include: improving traders' asset base to facilitating storage, improved infrastructure, and better mechanisms for market information transmission.

Key words: BOMOSA, transaction costs, fish markets, pricing



Assessing the relevance of marketing skills in community development and household progress in rural poor communities: a case study of Kasolwe and Ndolwa rural communities in Kamuli district, eastern Uganda, 2008

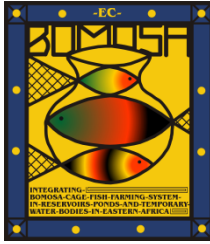
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As Uganda adapts to the globalization and market economy there is danger that the smallholder rural farmers without adequate marketing skills and strategies may be economically suffocated failing their prospects of breaking out of poverty. This study reports on interventions made to enhance the orientation of rural poor farmers to a market economy. Like many rural smallholder farmers in Uganda, the rural fish farmers and fishing communities studied face two major problems that hinder their full orientation to a market economy: remoteness in technology and distance from major and bigger fish markets; and the low marketing knowledge and skills, a combination that leads to relatively higher postharvest losses. Assessment was made to establish the level of marketing knowledge and skills, and marketing experience of those involved in fish trading. A strategy was also designed to enhance marketing skills and bring the markets nearly to the communities. A survey of 88 fish producers and marketing stakeholders in Kasolwe and Ndolwa communities of Kamuli district, Eastern Uganda depicts that of the 14 local fish markets within 45km radius only two fish markets (Balawori and Kamuli) attract major buyers. The other 12 markets have insufficient demand to uptake the produced fish. 83% of the stakeholders interviewed had never received training or sensitization on marketing skills and appropriate marketing behavior. 17% only employed their retail shops experience to trade fish. In bid to improve marketability of the produced fish a committee was set up at each of the two sites to develop appropriate market strategies for their produce, organize means by which to access bigger markets and attract better buyers. As a result outsider buyers were enticed into venturing into

these two communities in search of fish. There was also an increase in household fish production with new demand. This study confirms that with targeted practical knowledge and skills rural farmers can be brought into the market economy, and availing marketing skills for the rural smallholder producer communities can work to improve attitudes and creativity in accessing market and trigger higher productivity with multiplicity of community benefits that lead to community and household progress.

Key words: rural communities, fish producers, market economy, community and household progress



Assessments and analysis of fish marketing around the BOMOSA sites & the Rift valley lakes in Ethiopia

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The study was conducted at the two BOMOSA sites and the Rift Valley fishery areas in order to assess the market condition and total fish harvest and give recommendations to the major challenges of the fishery sector. A total of 71 farmers and fishermen were interviewed using structural questionnaire. Data were analyzed using SPSS and descriptive statistics. The key focus of the questionnaire include accessibility of marketing, availability of cold room facility, marketing constraint, value of fish, post harvest lose due to absence of refrigerator, value total fish harvest, market out let, market channel, the way of price determination, availability of tools and overall constraints of the fishery. It was identified that there was a regular fish market in the area. The majority of the house holds sell their fish products in markets less than 0.5km from production site. The survey also revealed that, most of the house holds (87.3%) did not have cold room or refrigerator and this situation force them to sell in areas close to the production area. Fish boats are critical for fishing purpose, and 78% of the households own boats for transport and fishing. The total value fish harvested in the area accounted from 20,001-27,000 Birr last year. When considering fishery marketing situation of the area, 60.6% of the harvest is sold to whole seller and the rest to local collector and hotels. The price of fish is mostly determined by fish harvesters. The majority of the respondents (95.8%) reported that the price of fishing tools is expensive & unaffordable to buy. Overexploitation of lake fishery, lack of suitable marketing system, poor fish harvest and handing system & in put delivery systems were found to be major constraints of the fishery sector in general.

In conclusion, there is a good potential for market oriented fishery development in the study area. However, there is a strong need for creating awareness about proper utilization of the fish resource, organizing fishermen in a formal cooperatives, develop good linkage of producers with major markets, enhance in put supply systems and training to upgrade the skill of fishermen and farmers in fishery production, processing & marketing systems.

Key Words: fish, fishery, fishery marketing, BOMOSA, fishery production constraints

BOKU (AUSTRIA) / OEAW (AUSTRIA) / ENKI (CZECH REPUBLIC) / UNIBO (ITALY)

MOI (KENYA) / DFK (KENYA) / KMFRI (KENYA) / EGU (KENYA)

EIAR (ETHIOPIA) / DFRU (UGANDA)

BOMOSA is pioneering small scale fish farming in Eastern Africa by establishing rural aquaculture networks (coordinated in a “hub and plot” system) to economically integrate aquaculture with agriculture. The BOMOSA system will form the basis of a socio-economic model that will contribute to poverty alleviation in Eastern Africa by providing sources of supplementary high protein food and additional income to rural communities in Kenya, Ethiopia and Uganda. BOMOSA is funded by the 6th Framework Programme of the European Commission and is performed from October 2006 to September 2009. This book provides an overview on the main outcomes of the three-year period presented during the final conference.