

Title:	Harnessing the High Protein and Nutrient Sequestration Potential of Bivalves for Value Addition for Enhanced Profitability of Smallholder Aquaculture in Uganda
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Purpose	To harness the nutritional composition of bivalves to provide high protein feed manufacture and exploit their nutrient sequestration to treat culture effluent to enhance and sustain aquaculture production in Uganda as well as building capacity of undergraduate and graduate students.
Project Summary	<p>In Uganda’s aquaculture sub-sector, feeds constitute about 40-60% of the total production costs, hence an outstanding impediment to its development. The main source of proteins for the manufacture of fish feeds is the silver cyprinid/silver fish (<i>Rastreneobola argentea</i>), commonly called Mukene, which is however highly competed for human consumption and as ingredients for making livestock feeds. The high demand has pushed prices high; making mukene unprofitable for fish feed manufacture. This project innovates the integration of bivalve culture with aquaculture to obtain: a) cheap protein for aquafeed formulation and b) effective nutrient removal from aquaculture effluent. Bivalves are less demanded for human food in Uganda and propagated easily to offer cheap and high quality protein for aquafeeds and environmental protection.</p> <p>This research proposal will contribute towards the Government of Uganda’s efforts aimed at continuously promoting investments into the aquaculture sector through initiatives like aquaculture parks and cage culture as alternative practices to capture fisheries meant to attain the annual target of 300,000 tons of fish by 2016. Indeed Uganda’s Vision 2040 recognizes that the abundant freshwater resources, covering about a third of Uganda’s surface area, have a great potential for aquaculture development. However, this potential has not been realized mainly due to: (1) The high cost of fish feeds that discourage smallholder farmers. In as much as there some commercial feed manufacturers in Uganda, including Ugachick Poultry Breeders Ltd and the Chinese supported feed mill project, aquafeed cost remains high. Mukene, the main fishmeal in aquafeeds is the most expensive single ingredient that puts the cost of aquafeeds high and limits backyard feed production in Uganda. As such, farmers often import feed supplements from as far as Israel, Mauritius and South Africa in a bid to reduce the production costs. Feed importation has not necessarily cut aquaculture production costs low, and this continues to make the enterprise non-profitable. (2) Limited research/search for less demanded alternative protein ingredients. Fish require more protein in their diet than terrestrial animals and protein is the most expensive component of the feed. However, the price of</p>



Mukene, the main protein source is prohibitive due to the growing demand for direct human consumption and use in other livestock feeds. Consequently, it is imperative to search for alternative protein sources that are locally available and with little or no demand for human consumption in the value chain to replace Mukene fishmeal in aquafeeds. This less competed for option is cheap and would reduce the cost of production; hence increase the profit margin for farmers. We propose the culture and use of bivalves (species of *Mutera*, *Corbicula* and *Sphearium*) in fish feed manufacture since unlike Mukene, they are not directly part of the human food. Bivalve flesh contains about 65% proteins, 8% fats and high proportions of essential amino acids, critical for fish growth (Lindahl 2013). This feed is ideal for fish feeds. (3) Limited eco-cycle oriented and more resource efficient production systems. Sustainable fish farming can only be achieved in a healthy aquatic environment. However, current aquaculture production systems are environmentally unfriendly because the effluents are nutrient-laden and can significantly pollute the receiving environments (Shpigel, 2005). Therefore, there is need to develop systems with improved circularity of energy and resource recycling as well as adopt methods that decrease pollution from food production systems. Apart from obtaining cheap and high quality proteins, this project innovates the utilization of bivalves in reducing pollution associated with aquaculture effluents. Bivalves will be cultured in fish pond effluent to ensure filtration of nutrients before final discharge to the receiving environment. Indeed, this model minimizes resources input and maximizes resource recycling. Since bivalves are prolific breeders and can build large biomass that can offer effective bio-filtration. This will in turn produce adequate protein for commercial fish feeds production. The culture of bivalves using effluent from fish ponds is sustainable since they feed on excess nutrients, detritus and algae in the effluent and therefore do not require extra feeds (Shpigel, 2005). It is also profitable since bivalves are rich in essential amino acids required for proper fish growth (Lindahl, 2013). This study will generate baseline information to be used in underscoring the economic profitability and sustainability. By knowing nutrient compositions, we shall be able to utilize adequate quantities in feeds, understand the cost per unit protein, protein retention by fish, protein efficiency ratio, Food Conversion Ratio (FCR), digestibility, and hence profitability of bivalve based diets. Moreover sustainability will require the social dimension that cannot be assessed without the present study.



	<p>This project will generate information that directly contributes to commercializing the use of bivalve-based meal for manufacture of fish feed and environmental protection. This will lead to achieving profitable, clean and environmentally sustainable aquaculture in Uganda as underscored in Uganda’s National Developmental Programmes and Vision 2040 for socio-economic transformation.</p> <p>The proposal is in line with RUFORUM’s goal of strengthening capacities of Universities to enhance innovations responsive to the demands of farmers through training of high quality researchers. Similarly, the proposal fosters the objective of IGAD (Uganda is a member State) to enhance food security through aquaculture development. The project fits into pillars 3 and 4 of Africa’s Comprehensive Africa Agriculture Development Programme (CAADP) of integrating agricultural practices and supporting aquaculture development. The project will also contribute to initiatives of ASARECA to build public-private sector partnership to enhance the productivity and competitiveness of aquaculture in the East and Central African region. The undergraduate and graduate programmes in the Department of Biological Sciences together with its affiliates have the national mandate to train fisheries and aquaculture practitioners. The Department, however, faces a challenge of provision of real-life field-based teaching and research approach. This project will provide the opportunity for 2 MSc and 4 undergraduates to have hands-on training so that they are fit-for-purpose to improve fish production.</p>
Country and Specific Location(s)	Uganda: Tende Innovations Farm, Wakiso District; and Aquaculture Research and Development Centre (ARDC) - Kajjansi, both off Entebbe Road.
Participating Institutions	<ul style="list-style-type: none"> • Department of Biological Sciences (Zoology Unit), College of Natural Sciences, Makerere University • Tende Innovations Farm, Wakiso District • Aquaculture Research and Development Centre (ARDC) – Kajjansi.
Start Date	1 st July, 2015
End Date	31 st July, 2017
Budget	USD 59,963



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Dr. Odong is a zoology specialist with special research interest in the use of benthic macro-invertebrates as: (i) bio-indicators of the quality of lakes and rivers; and, (ii) removing excess nutrients from aquaculture ponds as well as polluted water and wastewater. Invertebrates of the taxa Diptera, Gastropoda, Bivalvia, Ephemeroptera, Trichoptera and Annelida are of special interest to Robinson. Bivalves particularly feed on algae through filter feeding mechanism, and therefore useful in removing excess nutrients from aquaculture ponds. He has vast experience in Limnology, a subject which he undertook during his MSc studies and that he teaches in the Department of Biological Sciences, Makerere University. Dr. Odong holds a PhD in Environmental Biotechnology of Makerere University, Uganda, obtained in January 2015. For his PhD, he used integrated bio-processes including anaerobic and aerobic sequencing batch reactors, and constructed wetland systems to efficiently treat abattoir wastewater at the City Abattoir, Kampala. Through the treatment process, biogas and slurry are generated as by-products of digestion. Biogas is a renewable source of energy, in contrast to fossil fuels. The conversion of wastes to energy contributes to climate change mitigation, since it is a carbon neutral source of energy. Slurry, which is the residual liquid from biogas digesters provide a suitable source of bio-fertiliser for use in gardens and landscaping. Currently, Dr. Odong is the Main Activity Manager of the Project titled, “Integrated process for sustainable agro-process waste treatment and climate change mitigation in Eastern Africa”, sub-component based at the City Abattoir in Kampala, Uganda. Together with the Principal Investigator, Dr. Joseph Kyambadde, Dr. Odong innovatively developed biogas digesters generating biogas from abattoir wastewater at the City Abattoir. This research was supported by the Swedish International Development Corporation (Sida) through Bio-Innovate Africa Project (<http://bioinnovate-africa.org/>). The outputs of the City Abattoir Project has been widely profiled and disseminated both locally and internationally, for example by the New Vision Newspaper; NTV, BBC (English and Swahili); CCTV; Thomson Reuters Foundation and the Inderscience Publishers).

Publications



- Odong, R., Kansiime, F., Omara, J., Kyambadde, J. (2015). Tertiary treatment of abattoir wastewater in a horizontal subsurface flow constructed wetland under tropical conditions. *International Journal of Environment and Waste Management* 15 (3): 257-270. DOI: 10.1504/IJEWM.2015.069160.
- Odong, R.**, Kansiime, F., Omara, J., Kyambadde, J. (2013). The potential of four tropical wetland plants for the treatment of abattoir effluent. *International Journal of Environmental Technology and Management* 16 (3): 203-222.
- Steigen, A., Nylund, A., Karlsbakk, E., Akoll, P., Fiksdal, I.U., Nylund, S., Odong, R., Plarre, H., Semyalo, S., Skår, C., Watanabe, K. (2013). *Cand. Actinochlamydia clariae gen. nov., sp. nov.*, a Unique Intracellular Bacterium Causing Epitheliocystis in Catfish (*Clarias gariepinus*) in Uganda. *Plos One*, doi: 10.1371/journal.pone.0066840
- Odong, R.**, Kansiime, F., Omara, J. and Kyambadde, J. (2012). Performance evaluation of anaerobic and aerobic/anoxic sequencing batch reactors receiving abattoir effluent. The 18th International Society of Commodity Science and Technology Symposium Proceedings: 24-28 September 2012, Rome, Italy.
- Muyodi, F. J., Hecky, R.E., Kitamirike, J.M., **Odong, R.** (2009). Trends in health risks from water-related diseases and cyanotoxins in Ugandan portion of Lake Victoria basin. *Lakes & Reservoirs: Research and Management* 14: 247–257.
- Larsson, P., Kizito, Y.S., Miyingo-Kezimbira, A., Luyiga, S., Haande, S., Semyalo, R.P., Asio, S.M.R. **Odong, R.**, Lyche-Solheim, A., Brettum, P. (2009). Development in Murchison Bay. In *Sharing Water – Problems, conflicts and possible solutions, the case of Kampala*. Larsson, P., Kirumira, E.K., Steigen, A.L. and Miyingo-Kezimbira, A. (Eds.). Universitetsforlaget, Oslo, Norway. ISBN : 987-82-15-01444-9.
- Muyodi, F.J. and **Odong, R.** (2005). *Hydrobiology*. Department of Distance Education, Institute of Adult and Continuing Education, Makerere University. ISBN: 9970 423 168.

Research Grants & Contracts that I have been engaged in

- **2015-2017:** Strengthening regional capacity in research and training in fisheries and aquaculture for improved food security and livelihoods in Eastern Africa”. Funded by the Austrian Partnership Programme in Higher Education and Research for Development (APPEAR). EURO 389,982. **Collaborator**
- **2010-2014:** Integrated Process for Sustainable Agro-process Waste Treatment and Climate Change Mitigation in Eastern Africa. Bio-Innovate Africa Project. Funded by Sida. USD 498,000. **Activity Manager**
- **2014:** Synthesis and Interpretation of Lake Victoria Environmental Management Project (LVEMP) I Data. Funded by the World Bank and the Government of Uganda through the Ministry of Water & Environment. USD 105,000.



- **2013-2015:** Short Course Training on Mukene value addition & marketing for fishers and Processors in the Lake Victoria Basin. Funded by the World Bank and the Government of Uganda through the Ministry of Water & Environment, under the Lake Victoria Environmental Management Project - LVEMP. **Task Leader**
- 2012: The Uganda Climate Resilience Status Preparation. The Global Water Partnership for Eastern Africa. USD 8,000. **Collaborator**
- 2005: Lake Victoria Environmental Applied Research Programme Contract, Department of Zoology. Funded by World Bank and the Government of Uganda through the Ministry of Water & Environment. USD 125,000. **Special Assistant.**

