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Research Application Summary

Fisheries and aquaculture adaptation and conservation strategies in Uganda's changing climate

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Abstract

Climate change has modified the distribution and productivity of many organisms including freshwater species. It has also affected biological processes with eventual alterations in the food webs. Fishers and fish farmers will bear the full force of these impacts through less stable livelihoods, changes in the availability and quality of fish for food, and rising risks to their health and livelihoods. In this project we will investigate potential adaptation and mitigation pathways for communities dependent on fisheries, aquaculture and aquatic ecosystems. The study has two complementary components: a sociological and technical component. The sociological component will focus on assessing climate change vulnerability and understanding current community coping mechanisms and adaptation responses among fish dependant communities in the Albertine and Victoria drainage basins. The technical component will investigate the geospatial patterns of genetic variation in selected cyprinids in the Albertine and Victoria drainage basins. This will elucidate the landscape genomic population structure and aquaculture potential of selected cyprinids in Uganda. The scientific knowledge generated will form the basis for assessing the potential of aquaculture as an innovative response to declining capture fisheries, so as to select the best available strain for genetic gain in aquaculture. It is anticipated that this research will generate knowledge that will directly contribute to a better understanding of factors that build resilience among fish dependant communities and lead to development of a tool that can aid planned adaptation.

Key words: Aquaculture, climate change, cyprinids, Lake Victoria basin, landscape population genetics

Résumé

Le changement climatique a modifié la distribution et la productivité de beaucoup d'organismes comprenant les espèces d'eau douce. Il a également affecté des processus biologiques

avec des éventuels changements dans la toile alimentaire. Les pêcheurs et les éleveurs de poissons supporteront la grande force de ces impacts à travers des gagne-pains moins stables, de changements dans la disponibilité et la qualité des poissons à manger et de risques croissants pour leur santé et vies. Dans ce projet, nous étudierons des voies potentielles d'adaptation et d'atténuation pour les communautés dépendant de la pêche, de l'aquiculture et des écosystèmes aquatiques. L'étude a deux composants complémentaires : un composant sociologique et un composant technique. Le composant sociologique se concentrera sur l'évaluation de la vulnérabilité de changement climatique et la compréhension des mécanismes de la communauté courante et les réponses d'adaptation parmi les communautés dépendant de poissons des bassins dans les bassins de drainage Albertin et de Victoria. Le composant technique étudiera les modèles géospatiaux de la variation génétique des cyprinidés choisis des bassins de drainage Albertin et de Victoria. Ceci élucidera la structure de la population de paysage génomique et le potentiel d'aquiculture des cyprinidés choisis en Ouganda. La connaissance scientifique produite formera la base pour évaluer le potentiel de l'aquiculture comme une réponse innovatrice à la pêche en baisse de capture, afin de choisir la meilleure contrainte disponible pour le gain génétique en aquiculture. On prévoit que cette recherche produira de la connaissance qui contribuera directement à une meilleure compréhension des facteurs qui établissent la résilience parmi les communautés dépendant de poissons et mène au développement d'un outil qui peut faciliter l'adaptation prévue.

Mots clés: Aquiculture, changement climatique, cyprinidés, bassin du Lac Victoria, génétique de population de paysage

Background

Uganda is Africa's leading fish producer (FAO, 2008), with millions of people deriving their livelihoods from mostly capture fisheries and related activities. Climate change affects productivity of many aquatic ecosystems (Brander, 2010; Drinkwater *et al.*, 2010), and threatens the livelihoods of millions of people dependant on fisheries. This threat can only be reduced through knowledge-based adaptation and mitigation pathways including enhancement of aquaculture. Knowledge on climate change and adaptation and mitigation pathways for communities dependent on capture fisheries and aquatic ecosystems in Uganda are at best limited. Even the response of fish stocks to climate change is not well understood although evidence from elsewhere in the world suggests declines in catches (Brander,

2007; Mieszkowska *et al.*, 2009; Marcos-Lopez *et al.*, 2010). This study therefore, will focus on assessing i) climate change vulnerability and understanding current community coping mechanisms and adaptation responses among fish dependant communities, and ii) the potential of aquaculture as an innovative response to declining capture fisheries as well as characterising genetic variation in available fish strains. This study will generate information that will directly contribute to a better understanding of factors that could build resilience among fish dependant communities and lead to development of tools that can aid planned adaptation among the vulnerable fish dependant communities in Uganda. This study is consistent with Uganda's National Development Strategy which in part, seeks to improve household incomes through knowledge-based strategies (MFPED-Uganda, 2009). The study targets communities in the Victoria and Albertine basins which are transboundary resources. It is therefore anticipated that results from this study will have wider application in the great lakes Africa region. The project also addresses one of RUFORUM's strategic goals of training a critical mass of master students who are responsive to stakeholder needs and national and regional development goals.

Literature Summary

Climate change has influenced the productivity of many aquatic resources (Prowse *et al.*, 2009). Yet aquatic resources provide livelihoods for about 500 million people worldwide with 45 million in Africa (Allison *et al.*, 2009). Africa has two thirds of the countries in the world that are most vulnerable to the effects of climate change (IPCC, 2007). Uganda which has once been the leading fish producer on the continent, is now among the most vulnerable (FAO, 2008; Allison *et al.*, 2009). Studies on the effects of climate change on the distribution and production of individual fisheries in Africa are limited making it difficult to estimate or predict the broader or aggregate effects of climate change, adaptation and mitigation strategies at national and regional scales (Brander, 2007). Knowledge of the breadth of these challenges is important to be able to plan and incorporate mitigation pathways for communities most affected so as to reduce climate change impacts. This knowledge can be enhanced if there is information about how the economically important fish species will/or are responding to climate change and variability.

Fortunately, there have been climatic fluctuations in the history of aquatic species that can be reconstructed using genetic

markers and used as a proxy indicator to predict changes. The inherent genetic variation in threatened populations underpins local adaptation (Crandall *et al.*, 2000). Recent advances in molecular genetics and sequencing technology (Shendure and Ji 2008) have introduced new methods to assay adaptive variation in a number of species' genomes (e.g. Luikart *et al.*, 2003), enabling development of prioritization protocols to use unique adaptive variants. These advances present many genetic markers with widespread utility in fisheries and aquaculture (see Karsi *et al.*, 2002). These markers can be used in the detection of essential adaptive loci in the genome to give the possibility of understanding what proportion of a genome or which genes are being shaped by natural selection (Joost *et al.*, 2007). This study will attempt to detect signatures of natural selection using the Bayesian outlier locus approach to estimate posterior probabilities. It will in addition use an approach that estimates the association between genetic data and environmental variables using logistic regressions as implemented in the Spatial Analysis Method (Joost *et al.*, 2007).

Study Description

The study's global objective is to contribute to skilled human resources development and generation of knowledge useful for the implementation of knowledge-based strategies in fisheries and aquaculture responsive to a changing climate. Two M.Sc students will be recruited, one male and another female as part of the project team. One will focus on the sociologic component and the other on technical part. The sociological component will focus on assessing climate change vulnerability and understanding current community coping mechanisms and adaptation responses among fish dependant communities in the Albertine and Victoria drainage basins. The technical component will investigate the geospatial patterns of genetic variation in selected cyprinids in the Albertine and Victoria drainage basins. This will elucidate the landscape genomic population structure and aquaculture potential of selected cyprinids (e.g. the Genus Barbus) in Uganda. Fish samples will be collected from water bodies across the grid in the ecological zones and will be preserved for genetic analyses (Amos and Hoelzel, 1991). Total genomic DNA will be extracted using the DNeasyTM tissue kits (QIAGEN) according the manufacturer's instructions. Polymerase chain reaction amplifications (Mullis and Faloona, 1987) will target nuclear and extra-nuclear markers using appropriate oligonucleotides and reaction profiles. Genetic diversity, structuring, phylogenetics and genome analysis will

be done using genome association and population-based linkage bioinformatics tools (Shendure and Ji, 2008).

Research Application

The study is expected to generate information that will directly contribute to a better understanding of factors that build resilience among fish dependent communities and lead to development of a tool that can aid planned adaptation to effects of climate change. The genetics results will be especially useful in formulation of guidelines in selection of candidate fish strains for aquaculture enterprises. The two M.Sc students trained will gain knowledge and skills for designing and implementing mitigation and adaptation strategies for vulnerable communities to manage the effects of climate change.

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