The Promise of Air-Breathing Fishes for Developing Sustainable Aquaculture in a Climate Changing Future

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Introduction

While most fish rely on dissolved oxygen in the water to survive, air-breathing fishes are capable of surviving on oxygen from the air. This characteristic allows them to cope with a variety of environmental conditions, making them more resilient to environmental change. As aquatic habitats become degraded and climate change shifts global temperatures, the value of these fish will become apparent owing to their ability to survive poor water quality conditions and in some cases even extended drought. Whether for human consumption, the aquarium trade, or biodiversity enhancement, the culture of species resilient to climate change may be pivotal for diversifying sustainable solutions in aquaculture. This varied group of fishes has not been well studied and there are many challenges culturing them, include changes in local climates, threats to critical habitats, and dealing with the high protein diet required by some of the target species.

Air breathers fall under two main categories; obligate air breathers that must breathe air and facultative air breathers that can rely on their gills for oxygen until it becomes necessary to breathe air. This is a diverse group of fishes from a range of different environments with a variety of mechanisms for breathing air. This work focuses on seven groups, aiming to characterize each species and natural habitat: gar (*Lepisosteus* sp.), pirarucu (*Arapaima gigas*), lungfish (*Protopterus* sp.), gouramis (*Trichogaster pectoralis, T. trichopterus,* and *Osphronemus goramy*), Pacific fat sleeper or chame (*Dormitator latrifons*), snakehead (*Channa striata*), and goby (*Oxyleotris marmorata*). The seven investigations featured below came about as a result of an Air Breathing Fishes Symposium held by the AquaFish CRSP in April 2011, addressing several different objectives from responding to environmental changes to the marginalization of women. This poster highlights this anticipatory work that was started in the summer of 2011, looking to explore possibilities for culture systems for air breathers.

Research Highlights

Snakehead

- The overall objective of this work is to develop a domesticated broodstock for snakehead seed for a sustainable snakehead aquaculture industry in Cambodia.
- This project identified at least 35 populations of striped snakehead (*Channa striata*) from Tonle Sap (Great Lake) in Cambodia. Researchers collected 703 live breeders and took caudal fin clippings from the 35 populations for genetic characterization.
- Future work will identify favorable traits including growth rate, survival rate, disease resistance, and high tolerance to low water quality. It is also suggested that samples in inland waters of other regions of Cambodia should be taken in order to characterize the populations on a broader scale.

African Lungfish

- The African lungfish is an advantageous fish for culture in Uganda because it is an indigenous air breather and can act as a bio-control against schistosome vector snails. This work is exploring the prospects for developing a broader range of lungfish cultivation in Uganda.
- To date, this study has revealed that indigenous knowledge of lungfish culture can be a starting point for formulating a strategy for more widespread lungfish production in Uganda. Women are the main harvesters of wild lungfish in Uganda.
- Farmers had inadvertently been farming lungfish that had entered their ponds during flood periods and now this fish has become a delicacy among some groups in Northern, Eastern, and Western Uganda. Yet little is known about the growth cycle and the nutritional requirements of farm-reared lungfish.

Pacific fat sleeper (Chame)

- While a popular food fish along the Pacific coast of Latin America, chame or Pacific fat sleeper is locally scarce due to overfishing and habitat loss. Chame culture remains at a bottleneck due to poor growth and survival during hatchery production of eggs and larvae.
- This work aims to develop more reliable hatchery methods, and it has succeeded so far in capturing the full embryonic development on video from an out-of-season spawn. Work continues on looking at the ontogeny of the digestive tract during development and developing nutritionally enriched live food for cultured larval chame.

Gars

- Gars are popular food fish in various regions of Mexico and Cuba and are gaining popularity in the Southern US. They are becoming increasingly popular in the ornamental fish trade as well, due to their unique appearance and predatory nature.
- This work investigates ways to more successfully culture gars for food as well as for replenishing wild populations, which have suffered from overfishing and habitat loss.
- Tests run on two populations of spotted gar-- one from the Great Lakes region and one from the Mississippi River basin-- revealed that gar from the Great Lakes region exhibited a significantly higher growth rate, indicating important genetic and physiological differences.
- Work on ideal stocking density for Cuban gar has revealed the best growth at the lowest density (25 fish/m^3) starting with gars weight on average 13.00 g and 15.66 cm in length

Gouramis

- The culture of gouramis can be a way to take advantage of the vast swampy areas and diversify the aquaculture industry for the benefit of people in the Philippines.
- Three samples of snakeskin gouramis were collected in both Luzon and Mindanao for genetic characterization. Although the samples were of the same species, initial results reveal that intra-specific differences indicate two major clades, representative of the two collection areas.

Marble Goby

- In order to enhance nursing conditions, researchers are working to identify ideal conditions to alleviate stress on hatchery-reared marble goby.
- This research suggests that when nursing the marble goby, farmers need to prevent prolonged exposure to low temperatures (22°C) and not exceed a salinity of 3ppt to alleviate stress.

Pirarucu and Bowfin

- The overall objective of this work was to distinguish between several components of the fishes' response to changes in oxygen concentration in order to increase our understanding of what characteristics constitute a phenotypic adaptation.
- Current research has revealed a distinction between several components of the response such as basic morphological changes, behavioral adjustments, and in some cases, growth.

AquaFish CRSP Air Breathing Fishes Projects

Prospects and Potential of the African Lungfish (*Protopterus* Spp): An Alternative Source of Fishing and Fish Farming Livelihoods in Uganda
Auburn University and the Aquaculture Research and Development Center of the National Fisheries Resources Research Institute (Uganda)

Effects of Environmental Conditions on Gills and Gas Bladder Development in Bimodal-Breathers, Gar (*Lepisosteus* Sp.), Pirarucu (*Arapaima Gigas*) and Bowfin (*Amia Calva*)
University of Hawaii, Ohio State University, Sao Paulo State University (Brazil), and Jagiellonian University, Krakow (Poland)

Sustainable Feed and Improved Stocking Densities for Gar (*Atractosteus* Spp.) Culture
University of Michigan and Universidad Juarez Autonoma de Tabasco (Mexico)

Effect of Different Temperature and Salinity Levels on Stress Response of Marble Goby (*Oxeleotris Marmorata*) Fingerlings
Nong Lam University (Vietnam)

Development of Improved Culture Techniques on Gouramis (*Trichogaster pectoralis, T. trichopterus*, and *Osphronemus goramy*) for Small-scale Rural Freshwater Aquaculture, Aquarium Industry, and Stock Enhancement in the Philippines
Freshwater Aquaculture Center-College of Fisheries Central Luzon State University (Philippines) and Mindanao State University (Philippines)

Sustainable Snakehead (*Channa striata*) Aquaculture Development in Cambodia
Inland Fisheries Research and Development Institute (Cambodia) and Freshwater Aquaculture Research and Development Center (Cambodia)

Improvements in Spawning Control, Larval Growth, and Survival of Pacific Fat Sleeper (*Dormitator latifrons*)
University of Hawaii, Universidad Autonoma de Sinaloa (Mexico), Sao Paulo State University (Brazil), and Ohio State University

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