

DAFINET WORKSHOP

Pangasius and Tilapia production:

Upgrading Fish Health and Value Chains

University of Copenhagen, Frederiksberg Campus, Denmark

Program and abstracts



Dates: November 8th and 9th, 2016

Time: 10:00 to 17:00

Venue: Grand Lecture Theatre

Auditorium A1-1.01

Bülowsvej 17, DK-1870 Frederiksberg C, Denmark

Proceedings edited by Kurt Buchmann

Photo and cover illustration by Kurt Buchmann

The workshop has been organized in a collaboration between Department of Veterinary Disease Biology, Department of Plant and Environmental Sciences, and Department of Food and Resource Economics, University of Copenhagen, Denmark and is affiliated with Danida, Denmark, the Horizon 2020 project ParaFishControl and the FP7 project Targetfish.

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November 1st, 2016



Program Day 1

November 8th, 2016

10:00

Welcome address by DAFINET leader Kurt Buchmann, University of Copenhagen, Denmark

10:15

Alexandra Adams, University of Stirling, Scotland

Striped Catfish *Pangasianodon hypophthalmus* Immunity

11:00 Coffee break

11:30

Hetron Mweemba Munang'andu and Øystein Evensen, Faculty of Veterinary Medicine and Biosciences, Norwegian University of Life Sciences, Oslo, Norway

An overview of the innate and adaptive immune systems of Nile tilapia (*Oreochromis niloticus*)

12:00 Lunch

13:30

Dinh Thi Thuy, RIAII, Ho Chi Minh City, Vietnam

The current state of catfish (*P. hypophthalmus*) production in the Mekong Delta and strategies to improve survival rate and quality from fry to juvenile stage

14:00 Coffee Break

14:30

Seikh Razibul Islam, Patuakhali Science and Technology University, Bangladesh

Commercial Aquaculture in Bangladesh: Present Status, Constraints and Potentials

15:00

Afjal Hossain, Department of Food and Resource Economics, Faculty of Science, University of Copenhagen, Denmark and Department of Economics and Sociology, Faculty of Business Administration and Management, Patuakhali Science and Technology University, Bangladesh

Identifying Drivers of International Trade in Different Qualities using the Gravity Model: The Case

of Pangasius Export of Vietnam

15:30

Takibur Rahman Takib and Sandip Mitra, Department of Food and Resource Economics , Faculty of Science, University of Copenhagen, Denmark

Data collection of farm level data of Pangas and Tilapia farms in Bangladesh

16:00

Raju Podduturi, Department of Plant and Environmental Sciences, University of Copenhagen, Denmark

Environmental impact on quality of pangas and tilapia from fish farms in southern Bangladesh

16:30

Md. Emranul Ahsan, Patuakhali Science and Technology University, Bangladesh

Pangas and Tilapia farming in Bangladesh: Better management practice for optimum production

17:00 Wrap up by DAFINET leader Kurt Buchmann

18:00 Dinner at Stigbøjlen 7, Frederiksberg Campus

Program Day 2

November 9th, 2016

10:00

Hetron Mweemba Munang'andu, Joydeb Paul and Øystein Evensen

Faculty of Veterinary Medicine and Biosciences, Norwegian University of Life Sciences, Norway

A review of the vaccination strategies currently used for *Streptococcus agalactiae* in Nile tilapia (*Oreochromis niloticus*)

10:30

Csaba Szekely and Kalman Molnar, MTA, Budapest, Hungary

Myxozoan infections in sutchi Catfish *Pangasianodon hypophthalmus* In freshwater cage cultures in Malaysia

11:00 Coffee break

11:30

Joydeb Paul, Øystein Evensen and Hetron Mweemba Munang'andu, Faculty of Veterinary Medicine and Biosciences, Norwegian University of Life Sciences, Norway

Comparison of virulence and antigenic proteins of *Streptococcus agalactiae* biotypes I and II

12:00 Lunch

13:30

Chalumba K. Simukoko, Kaampwe Muzandu, Stephen Mutoloki, Øystein Evensen and Jan L. Lyche, University of Zambia and Norwegian University of Life Sciences, Norway

Occurrence and levels of chemical contaminants and their effect on disease susceptibility and reproductive performance on Tilapia species from Lake Kariba in Zambia.

14:00

Kizito K. Mugimba, Stephen Mutoloki, Øystein Evensen, Denis Byarugaba & Hetron M. Munang'andu, Makerere University, Faculty of Veterinary, Uganda and Norwegian University of Life Sciences, Norway

The use of metagenomics analysis for the search of pathogens in aquaculture

14:30

Saurabh Dubey, Stephen Mutoloki, Øystein Evensen and Hetron M. Munang'andu, Faculty of Veterinary Medicine and Biosciences, Norwegian University of Life Sciences, Norway

The role of bacterial outer membrane proteins as vaccine candidates for aquatic organisms

15:00

Kizito K. Mugimba, Stephen Mutoloki, Øystein Evensen, Denis Byarugaba & Hetron M. Munang'andu Makerere University, Faculty of Veterinary, Uganda and Norwegian University of Life Sciences, Norway

Overview of Tilapia farming in Uganda and potential implication in disease management

15:30

DAFINET leader Kurt Buchmann, University of Copenhagen, Denmark

Wrap up and conclusions

List of participants

| <i>Surname</i> | <i>First name</i> | <i>e-mail</i> | <i>Affiliation</i> |
|--------------------|--------------------------|--|--|
| Adams | Alexandra | Alexandra.adams@stir.ac.uk | Institute of Aquaculture University of Stirling, Scotland |
| Ahsan | Md. Emranul | meahsan@bsmrau.edu.bd | Department of Aquaculture, Patuakhali Science and Technology University, Bangladesh |
| Al-Jubury | Azmi | azmi@sund.ku.dk | University of Copenhagen, Denmark |
| Allahghadry | Toloe | tooloo1981@yahoo.com | University of Copenhagen, Denmark |
| Barlaup | Lotte | Lotte_barlaup@hotmail.com | University of Copenhagen, Denmark |
| Borsting | Ejner | ejner@borsting.dk | Troutex ApS, Denmark |
| Buchmann | Kurt | kub@sund.ku.dk | University of Copenhagen, Denmark |
| Christensen | Nanna D. | nannadaugbjerg@gmail.com | University of Copenhagen, Denmark |
| Dalsgaard | Inger | inda@vet.dtu.dk | Technical University of Denmark, Denmark |
| Saurabh | Dubey | | Norwegian University of Life Sciences, Oslo, Norway |
| Hossain | Afjal | Aho@ifro.ku.dk | Department of Economics and Sociology Faculty of Business Administration and Management, Patuakhali Science and Technology University, Bangladesh |
| Hukom | Venticia | vh@ifro.ku.dk | Department of Food and Resource Economics Section for Environment and Natural Resources University of Copenhagen, Denmark |
| Islam | Razibul Seikh | islamsr@yahoo.com | Department of Aquaculture, Patuakhali Science and Technology University, Bangladesh |
| Jaafar | Rezgar M. | rezgarhadad@sund.ku.dk | University of Copenhagen, Denmark |
| Jaglarz | Anita | Anita.Jaglarz@moredun.ac.uk | Moredun Research Institute Aquaculture Research Group Pentlands Science Park Bush Loan, Penicuik, Scotland |

| | | | |
|--------------------|-----------------------------|---------------------------------------|---|
| Jeberg | Sandra | Wcm651@alumni.ku.dk | University of Copenhagen, Denmark |
| Jørgensen | Louise von Gersdorff | lvkj@sund.ku.dk | University of Copenhagen,Denmark |
| Kahoza | Mugimba Kizito | kahoza@gmail.com | Makerere University College of Veterinary Medicine Animal Resources and Biosecurity Kampala |
| Kania | Per | pwk@sund.ku.dk | University of Copenhagen, Denmark |
| Karami | Asma | asma.m.karami@gmail.com | Guilan University, Rasht, Iran |
| Komar | Cedric | Cedric.komar@ictyopharma.com | Ictyopharma, La Villate, Deneuille- Les-Mines, France |
| Korbut | Rozalia | Rozalia.korbut@sund.ku.dk | University of Copenhagen, Denmark |
| Labrie | Lauke | Cedric.komar@ictyopharma.com | Ictyopharma, La Villate, Deneuille- Les-Mines, France |
| Lilledrange | Åsne | mcz@480.alumni.ku.dk | University of Copenhagen, Denmark |
| Lorenzen | Niels | Niels.lorenzen@anis.au.dk | University of Aarhus, Denmark |
| Lu | Cao | lucyer@gmail.com | University of Copenhagen University of Sichuan, China |
| Marana | Moonika H. | mmarana@sund.ku.dk | University of Copenhagen, Denmark |
| Mitra | Sandip | s.mitra_yahoo.com | University of Copenhagen, Denmark and and Patuakhali Science and Technology University, Bangladesh |
| Madsen | Lone | loma@vet.dtu.dk | Technical University of Denmark |
| Mazaheri | Sanaz | shma@sund.ku.dk | University of Copenhagen |
| Munang'andu | Hetroney Mweemba | <hetroney.mweemba.munangandu@nmbu.no> | Norwegian University of Life Sciences, Oslo, Norway |
| Nielsen | Max | max@ifro.ku.dk | University of Copenhagen, Denmark |
| Nielsen | Rasmus | rn@ifro.ku.dk | University of Copenhagen, Denmark |
| Olesen | Niels Jørgen | njol@vet.dtu.dk | Technical University of Denmark, Denmark |

| | | | |
|---------------------------|--|--|---|
| Otani | Maki | maki@sund.ku.dk | University of Copenhagen, Denmark |
| Paul | Joydeb | | Norwegian University of Life Sciences, Oslo, Norway |
| Podduturi | Raju | podduturi@plen.ku.dk | University of Copenhagen, Denmark |
| Simukoko | Chalumba | | Norwegian University of Life Sciences, Oslo, Norway |
| Skov | Jakob | jask@sund.ku.dk | University of Copenhagen, Denmark |
| Takibur Rahman | Md. | Takib@pstu.ac.bd | University of Copenhagen and Patuakhali Science and Technology University, Bangladesh |
| Skall | Helle Frank | Hellef.skall@anis.au.dk | University of Aarhus, Denmark |
| Thompson | Kim D | kim.thompson@moredun.ac.uk | Aquaculture Research Group Moredun Research Institute Pentlands Science Park Bush Loan, Penicuik Midlothian, Scotland |
| Vendramin | Niccolo | niven@vet.dtu.dk | Technical University of Denmark, Denmark |
| Veselý | Tomáš | vesely@vri.cz | Veterinary Research Institute Brno, Czech Republic |
| Viaplana | Maria Esperança Castellón | acv@aquabt.com | AquaBioTech Group, Malta |
| Villumsen | Kasper R. | krv@sund.ku.dk | University of Copenhagen, Denmark |
| Zuo | Shaozhi | chao@sund.ku.dk | University of Copenhagen, Denmark |

Practical information:

Registration by binding e-mail to:

Kurt Buchmann at kub@sund.ku.dk

Dinner on November 8th, 2016 at 18:00 and coffee and tea at coffee/tea breaks are free of charge if participants are registered before October 21st, 2016

Lunch can be taken at own expenses at the cafeteria GIMLE (Dyrlægevej 11) located only 4 minutes from the lecture theatre

Hotels

Hotel Sct. Thomas

Frederiksberg Alle 7

DK-1621 Copenhagen V

www.hotelsctthomas.dk

Radisson Blu Falconer Hotel

Falkoner Allé 9

DK-2000 Frederiksberg

www.radissonblu.com/da/falconerhotel-koebenhavn?csref=ppc_g_cr_sk_dk_ho_cphzr_brand&facilitator=BIGMOUTHMEDIAREZIDOR&gclid=Cj0KEQjwipi4BRD7t6zGl6m75IgBEiQAn7CfF5YcSpPvaEzFstm7mIDbbOzCjcdHdtBEunVWW15nI6MaAhMP8P8HAQ&

Cabinn Danasvej

Danasvej 32

DK-1910 Frederiksberg C

www.cabinn.com

express@cabinn.com

Cabinn Vodroffsvej

Vodroffsvej 55

DK-1900 Frederiksberg C

www.cabinn.com

sca@cabinn.com

Following hotels on this page can all be booked on www.brochner-hotels.dk

Avenue Hotel

Aboulevarde 29

Copenhagen Frederiksberg

Hotel SP34

Sankt Peder Stræde 34

DK-1453 Copenhagen K

Hotel Danmark

Vester voldgade 89

DK-1552 Copenhagen V

Grand Hotel

Vesterbrogade 9

DK-1620 Copenhagen V

Hotel Astoria

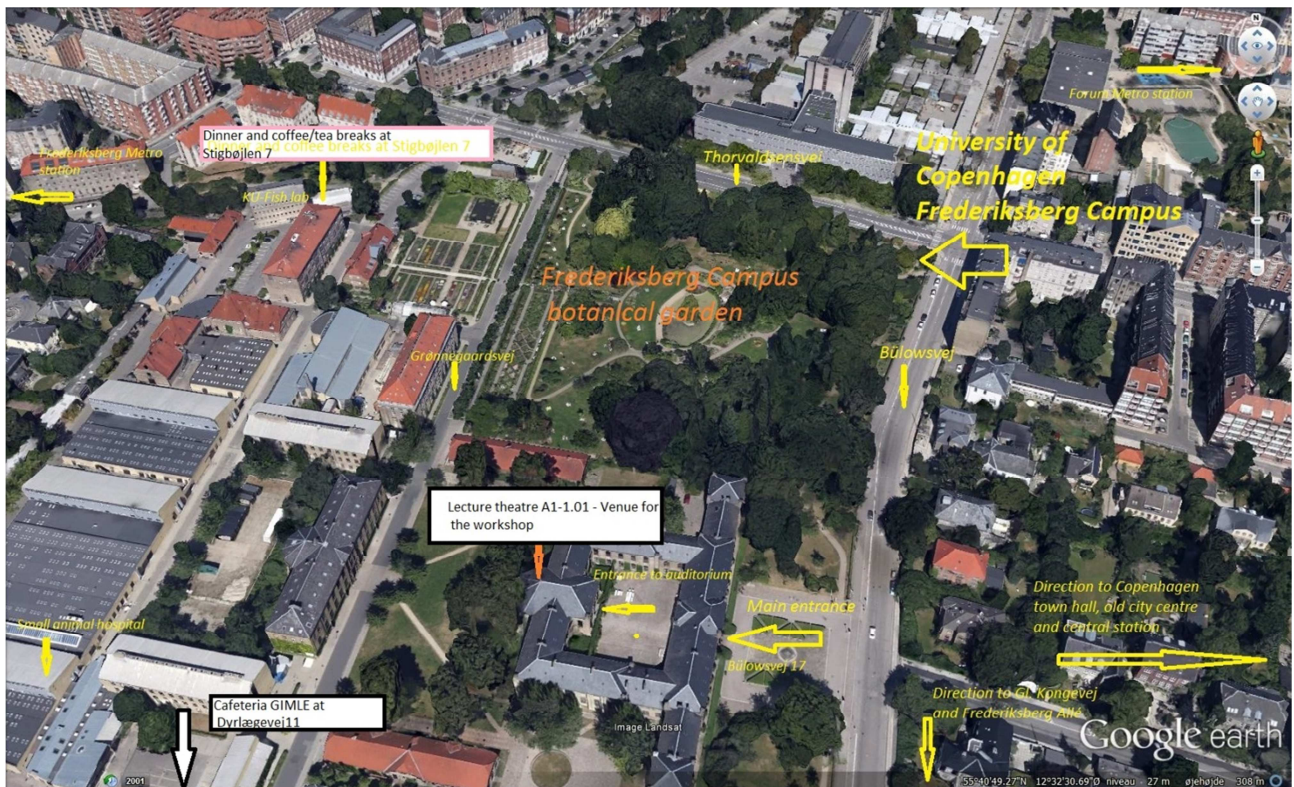
Banegaardspladsen 4

DK-1570 Copenhagen V

How to get there?

The workshop venue is located 5-7 min walking from the Frederiksberg Metro station which can be reached from the Copenhagen airport by a direct line (11 stops and approximately 25 min).

Please find the workshop location on the map below.



Abstracts

Striped Catfish *Pangasianodon hypophthalmus* Immunity

Alexandra Adams

Institute of Aquaculture, Faculty of Natural Sciences,

University of Stirling, Stirling, Scotland, UK

In Southeast Asia, family Pangasiidae is important for commercial fisheries and aquaculture and *Pangasianodon hypophthalmus* (the striped catfish) is the most economically important species. Intensive aquaculture can lead to problems and there have been major outbreaks of disease with *Edwardsiella ictaluri* and *Aeromonas hydrophila* representing two important bacterial pathogens in *P. hypophthalmus* aquaculture. As *P. hypophthalmus* is a relatively new aquaculture species, there have so far been few reports on immunity or evaluating its immune response to pathogens. Understanding the immune response is very important in order to evaluate the health status of the fish and assist in control of disease (including prevention) so that production levels by the aquaculture industry can be sustained. This presentation will give an overview of the *Pangasianodon hypophthalmus* immunity including information on functional assays and how these have been standardised to evaluate both innate and adaptive immune responses of this species and then used to compare immune response following stimulation with live and killed *A. hydrophila*. Immunostimulants have proven to be a very useful food additive for the aquaculture industry, since they can be easily fed to fish to enhance their immune response at times of stress and to improve resistance to disease. The effect of the β -glucan on the immune response and disease resistance of *P. hypophthalmus* will also be described as well as an immune gene response. Overall, a variety of functional immune assays and gene expression methods for *P. hypophthalmus* have been developed and standardised and these provide useful tools and basic information on the immune response in striped catfish that can be applied for the health control of this species.

**An overview of the innate and adaptive immune systems
of Nile tilapia (*Oreochromis niloticus*)**

Hetron M. Munang'andu and Øystein Evensen

*Norwegian University of Life Sciences, Faculty of Veterinary Medicine and Biosciences,
Oslo, Norway*

The Nile tilapia (*Oreochromis niloticus*) has emerged to be one of the important fish species used for human consumption. Its rapid increase in production calls for a better understanding of its immune system in order to pave way into producing protective vaccines against infectious diseases. Hence, the objective of this study is to provide an update of our current understanding of the Nile tilapia immune system based on studies carried out this far of which growing evidence shows that tilapia possess a functional immune system comparable to other fish species. Its innate immune system is endowed with antigen presenting cells (APCs) such as monocytes and macrophages that possess pattern recognition receptors (PRRs) that include toll like receptors (TLRs), RIG-I like receptors (RLR), NOD-like receptors (NLRs), mannose binding receptors (MBR) and C-lectin receptors. In addition, the innate immune system of tilapia is also endowed with MHC I and II molecules that play a pivotal role in antigen presentation to cells of the adaptive immune systems. Like all vertebrates, the tilapia adaptive immune system is divided into cellular and humoral immune components of which some of the transcription factors and cytokines that regulate the functional activities of T-lymphocytes have been characterized. As for humoral immunity, only IgM and IgD have been characterized of which IgM has been shown to correlate with vaccine protection while the functional role of IgD is yet to be elucidated. However, it is vital to point out that there still remains a vast array of transcription factors, cytokines, ligands, host receptors and several other genes yet to be characterized. A comparative analysis of the tilapia immune system with other teleosts fish species is herein discussed.

The current state of catfish (*P. hypophthalmus*) production in the Mekong Delta and strategies to improve survival rate and quality from fry to juvenile stage

Dinh Thi Thuy, Nguyen Diem, Kurt Buchmann

Research Institute II, Ho Chi Minh City, Vietnam

Department of Veterinary Disease Biology, University of Copenhagen, Denmark

Production of Tra Catfish (*Pangasianodon hypophthalmus*) has a long history in the Mekong Delta and in recent years it has achieved the status as the main target species. In the year 2015, fish production of the Mekong Delta was estimated at 1,123 thousand tons, distributed in various areas such as 375,277 tonnes in Dong Thap, 248,064 tonnes in An Giang and 153,140 tonnes in Can Tho (vasep.com.vn). The Mekong Delta hosts about 230 catfish hatcheries that included 4,000 households located on a total area of more than 2,250 hectares with a production of more than 2 billion fry specimens of Tra catfish in 2014. We have identified a number of challenges connected to the production. We point to shortcomings associated with hatchery technology, nurseries and grow-out systems. According to a survey by Nguyen Van Sang *et al.* (2010) who focused on the period from hatching via fry to the juvenile stage the over-all survival rate could be as low as 12.6%. Many factors may explain the low survival rate and we point to egg quality, fry quality, feed quality, water quality environment and fish diseases as the main obstacles. We report parasites such as *Trichodina* sp., bacterial infections caused by bacteria *Aeromonas hydrophila* (eliciting skin haemorrhages) and *Edwardsiella ictaluri* associated with fish liver disease.

We have developed new techniques for improvement of fish production and we suggest that fish survival rates can be improved by:

(1) Introducing new breeding techniques for zooplankton (*Moina* sp.) which is a suitable and favorite feed for Tra catfish at the early developmental stage (the first 12 days after stocking);

- (2) Aeration of system water to raise oxygen levels by using circular aeration disks, powered by electrical or backup diesel blowers. The distance between aeration disks were calculated and adjusted to ensure maximum efficiency and optimal levels of dissolved oxygen, especially for the early morning period from 4 am to 7 am;
- (3) Improving hygienic standard of water by the use of chlorine (content of at least 70% of Calcium Hypochlorite to a water concentration of 15ppm) in the water treatment process before stocking;
- (4) Supplying industrial feed of the correct size and nutritional content according to the size of the fish;
- (5) Introducing disease prevention by using probiotic products comprising fermented poly-beta-hydroxybutyrate, microorganisms including *Bacillus subtilis*, *Lactobacillus acidophilus*, cereal and glucose. These products can be mixed with the industrial feed following the ratio 2.5/100.
- 6) Controlling the bottom of the pond and pond water environment by useful microorganism including *Bacillus subtilis*, *Nitrosomonas* sp., *Nitrobacter* sp. and *Thiobacillusparus* (50kg/10000 m² and each time for 20 days);
- (6) Desinfection of ponds with Polyvidone Iodine and subsequent restoration of the useful microflora by adding probiotic product made from *Bacillus subtilis*, *Lactobacillus acidophilus*, *Aspergillus oryzae*, *Saccharomyces cerevisiae* and some Amylaza, Xellulaza, Proteaza enzymes. The studies have shown that these measurements can elevate productivity by improving water quality which will increase fish growth, particularly in the supplemental aeration fish ponds. The disease prevalence in fish can be markedly reduced which is fundamental for establishing stable juvenile nursing procedures, high survival rates and high quality of juvenile fish.

Commercial Aquaculture in Bangladesh: Present Status, Constraints and Potentials

Seikh Razibul Islam

Department of Aquaculture, Patuakhali Science and Technology University, Bangladesh

Bangladesh is one of the world's leading fish producing countries with a total production of 3.68 million MT, where aquaculture production contributes about 56 percent of the total production. It is fortunate in having an extensive water resource in the form of ponds, natural depressions, lakes, canals, rivers and estuaries. Fisheries sector is contributing significantly in food security through providing safe and quality animal protein, almost 60 percent animal protein comes from fish. It contributes 3.69 percent to our national GDP and around one-fourth (23.12 percent) to the agricultural GDP. This sector has high potential for the perspective of economic development of the country. Over the last decade, dramatic increases in the production of a variety of species from commercial aquaculture systems and sharp increases in per capita fish consumption have occurred in Bangladesh. This transition has been made possible by widespread adoption of semi-intensive and intensive production practices. Pangas (*Pangasianodon hypophthalmus*) and tilapia (*Oreochromis niloticus*) are two commercially important fish species in Bangladesh. With the expansion of commercial aquaculture of these two species environmental degradation, outbreak of disease and production of quality fish have become the major issues. Low water quality in terms of pollution, lack of oxygen, toxic algae's, toxic substances and transfer of diseases etc. have numerous negative effects on production. The negative effects are identified as higher mortality, non-optimal growth rates, diseases and low quality of fish. Furthermore, low quality effects farm income through the price received, either locally or internationally, and is a barrier to export, because developing countries are facing progressively stricter food safety requirements, especially to the major markets in EU, USA or Japan. In addition to risk of diseases and accumulation of contaminants, the quality of the fish is challenged by off-flavor compounds in the pond water. All

together several environmental and man-impacted conditions threaten a future success for production of demandable freshwater fish in Bangladesh for both local and international markets.

Identifying Drivers of International Trade in Different Qualities using the Gravity Model: The Case of Pangasius Export of Vietnam

Afjal Hossain

Department of Food and Resource Economics

Faculty of Science, University of Copenhagen, Denmark and

Department of Economics and Sociology, Faculty of Business Administration and Management

Patuakhali Science and Technology University, Bangladesh

The gravity model is used to identify the drivers of international trade in different quality markets. The level of exports between Vietnam and different global quality markets is analyzed for identifying the specific driver(s) which influences the exports. We established the model for high, medium and low quality separately to find out the specific quality market to which the trade will be conducted and provides greater profits for the exporting country. Quality, an unobserved product characteristic, is difficult to measure but in this article we consider the high quality market to be 15% more than the average price per kg. of pangasius a year and 15% less for the low quality market. The middle quality market is in between. This paper compares the different quality markets in relation to the different drivers so that the exporter country and the single exporter company can detect the specific type of quality market for its followings trade giving emphasis on the particular driver(s) of international trade.

Environmental impact on quality of pangas and tilapia from fish farms in southern Bangladesh

Raju Podduturi and Niels O. G. Jørgensen

Department of Plant and Environmental Sciences, University of Copenhagen, Denmark

In Bangladesh, production of fish in small, earthen ponds in village communities constitutes an important asset to the local economy. To ensure an acceptable market price of the fish, it is important to maintain a high water quality in the ponds. In a recent study of fish ponds in southern Bangladesh, we analyzed the effect of water treatment on abundance of potentially toxic cyanobacteria (blue-green algae) in the water, and examined taste and metal content of the produced pangas (*Pangasianodon hypophthalmus*) and tilapia (*Oreochromis niloticus*). Water treatment by sand filtration proved efficient in reducing the content of cyanobacteria in the ponds, while addition of probiotic and assumed beneficial bacteria had a minor effect on the phytoplankton community. Analysis of known off-flavour compounds in fish from freshwater production (geosmin and 2-methylisoborneol) by a chemical approach demonstrated a low content of these compounds in both water and fish. A sensory panel (local fish farmers) observed a mild off-flavour in some fish but depuration of the fish for 24 to 48 hours in ground water removed these off-flavours. The content of arsenic and lead and 10 other potentially toxic elements (Ba, Ce, Cr, Cu, Fe, Mg, Mn, Se, Sr and Zn) was determined in flesh from selected tilapia and pangas. Tilapia had a slightly higher content of some metals than pangas, possibly caused by different feeding habits of the two fish. Content of arsenic and lead was low in the fish and it was calculated that for As, consumption of 100 g fresh fish per day corresponded to 1.3% (pangas) and 5% (tilapia) of the maximum tolerable daily intake according to FAO recommendations. Our study indicates that fish produced in the local ponds generally had a high quality and that rather simple measures, such as sand filtration of the water, can improve the water quality when needed. Regarding expansion of the fish production, e.g. for

export, breeding of pangas with a whiter flesh colour as in Vietnam (pangas produced in Bangladesh have typically a yellowish flesh) might be considered.

Pangas and Tilapia farming in Bangladesh: Better management practices

Md. Emranul Ahsan

Department of Aquaculture,

Patuakhali Science and Technology University, Bangladesh

The purpose of this presentation is to provide better management practices (BMPs) to producers of Bangladesh to aid in efforts to optimize the production of pangas and tilapia according to some standard. These standards are global standards set by Pangasius Aquaculture Dialogue (PAD) that will help minimize the key negative environmental and social impacts associated with both pangas and tilapia aquaculture. There are seven basic principles with different criteria need to be fulfilled by the producers. The main principles are: location and operation of farms according to national legal framework; minimize negative impacts on other users; minimize the negative impacts on water and land resources; minimize the impact on genetic integrity of local pangas; ensure that feed and feeding particles are sustainable; minimize ecosystem and human health impacts, while maximizing fish health, welfare and ensuring food safety; and develop and operate farms in a socially responsible manner that contributes effectively to community development and poverty alleviation. To achieve these goals different better management practices (BMPs) are recommended to the producers to increase production and to minimize negative impacts on environment.

A review of the vaccination strategies currently used for *Streptococcus agalactiae* in Nile tilapia (*Oreochromis niloticus*)

Hetron M. Munang'andu, Joydeb Paul and Øystein Evensen

Norwegian University of Life Sciences,

Faculty of Veterinary Medicine and Biosciences, Oslo, Norway

Streptococcus agalactiae is a highly pathogenic disease that infects different fish species including Nile tilapia (*Niloticus oreochromis*). In order to reduce its devastating impact, different vaccine development strategies are being sought for use in aquaculture. The purpose of this review is to provide an overview of the current vaccination strategies and antigen delivery systems currently used for *S. agalactiae* vaccines in tilapia. Based on data presented herein, current vaccine designs include the use of replicative antigen delivery systems such as attenuated virulent strains, heterologous vectors and DNA vaccines while non-replicative vaccines include the inactivated whole cell (IWC) and subunit vaccines encoding different *S. agalactiae* immunogenic proteins. The most widely used vaccination strategy is intraperitoneal vaccination, although immersion, spray and oral immunization strategies are being explored. The most common challenge method used is by intraperitoneal injection of virulent strains of *S. agalactiae* in fish in order to evaluate the relative percent survival (RPS) of vaccinated fish as a measure of vaccine efficacy. The major drawback with this approach is that it does not mimic natural infection thereby making it difficult to determine the mechanisms of vaccine protection at the portals of bacteria entry in mucosal organs. However, studies carried out thus far show that the correlates of vaccine protection can be established based on antibody responses and antigen dose although these parameters require optimization before they can become an integral part of vaccine production for commercial purposes. Despite so, this study shows that different vaccine design strategies can be used to produce protective vaccines against *S. agalactiae* in tilapia.

**Myxozoan infections of the sutchi catfish *Pangasianodon hypophthalmus* in
freshwater cage cultures in Malaysia**

Kalman Molnár and Csaba Székely

Veterinary Medical Research Institute, Hungarian Academy of Sciences, PO Box 18, 1581

Budapest, Hungary

Cage-cultured sutchi catfish *Pangasianodon hypophthalmus* (Sauvage, 1878), a favourite food fish in Southeast Asia, proved to be infected by 6 myxozoan species. Three species belonged to the genus *Hennegoides* (*H. berlandi*, *H. malayensis*, and *H. pangasii*), 1 to *Henneguya* (*H. shariffi*) and 2 to *Myxobolus* (*M. baskai*, and *M. pangasii*). Five myxozoans infected the gills and 1 was found on the spleen. Myxozoans infecting the gills were characterised by a specific site selection. *H. shariffi* sp. n. and *H. berlandi* sp. n. formed plasmodia in the multi-layered epithelium of the gill filaments. Of the 2 vascular species *H. pangasii* sp. n. developed in the gill arteries, while *M. baskai* sp. n. infected the capillary network of the gill lamellae. Plasmodia of *H. malayensis* sp. n. were found inside the cartilaginous gill rays of the filaments. Large plasmodia of *M. pangasii* sp. n. were located in a groove of the spleen but they affected only the serosa layer covering the spleen.

Comparison of virulence and antigenic proteins of

***Streptococcus agalactiae* biotypes I and II**

Joydeb Paul, Hetron M. Munang'andu, and Øystein Evensen

Norwegian University of Life Sciences, Faculty of Veterinary Medicine and Biosciences,

Oslo, Norway

Streptococcus agalactiae, also known as group B streptococcus (GBS), is one of the important pathogens of fish, humans, animals, reptiles and other terrestrial and aquatic organisms. Group B Streptococci (GBS) are Gram-positive bacteria that are common asymptomatic colonizers in many host species. However, this opportunistic organism can overcome host defenses to cause severe tissue damage leading into disease outbreaks. As a result, different virulence factors responsible for tissue damage in GBS infections have been identified in mammals and other vertebrates. In aquaculture, two *S. agalactiae* strains commonly referred to as biotypes I and II that are phenotypically, biochemically and geographically distinct have been shown to cause disease in different fish species. To date, little is known about the virulence mechanisms and antigenic properties of GBS in fish. It is not clear as to whether *S. agalactiae* biotype I expresses the same virulence and antigenic proteins as biotype II. Moreover, it is also not clear as to whether the mechanisms used by both biotypes to cause disease in fish are comparable to mechanisms seen in higher vertebrates. Hence, this study shows a phylogenetic comparison of virulence factors and antigenic proteins expressed by *S. agalactiae* biotypes I and II obtained from Nile tilapia (*Oreochromis niloticus*). It also compares sequence alignments of these genes with those obtained from other vertebrate species. As a comparative analysis of the antigenic properties of different *S. agalactiae* strains in fish, the study also compares the cross reactivity of antibodies generated from Nile tilapia vaccinated using biotype I and II inactivated whole cell bacterial vaccines. Hence,

comparative analysis of biotype differences and the impact of variations between host species of GBS are discussed herein.

Occurrence and levels of chemical contaminants and their effect on disease susceptibility and reproductive performance on Tilapia species from Lake Kariba in Zambia.

Chalumba K Simukoko^{1,2}, Kaampwe Muzandu², Stephen Mutoloki¹,

Øystein Evensen¹ and Jan L. Lynche¹

¹Norwegian University of Life Sciences, Oslo, Norway

²University of Zambia, Lusaka, Zambia

The objective of this study is to measure chemical contaminants (persistent organic pollutants and heavy metals) in farmed and free living Tilapia (*Oreochromis niloticus*) and potential effects on reproductive function. Lake Kariba is located in the southern part of Zambia in central southern African. The study covered four locations (strata) of the lake. Strata I and II are located near a coal mine, considerable fishing and farming activities and has a sizable human population. Stratum III has very little human activity, while stratum IV has a high human population, fishing activity and several commercial fish farms. An average of 30 fish was sampled from each stratum. Parameters including sex, weight and length were recorded, and tissues (organs and blood) and water samples were collected for toxicology analysis. Persistent chemical pollutants (POPs) and pharmaceuticals, and heavy metals will be measured using GC-MS, LC-MS and AAS in liver tissue and water respectively. Gross examination showed sex ratios in Strata I, II and III were almost equal (slightly skewed towards female in I and III), while in stratum IV it was skewed towards males. Examination of water samples showed that levels of Heavy metals (As, Cd, Cr, Co, Fe, Pb, Mn, Hg, Ni and Zn),

were below detectable levels in all sites. Water quality analysis showed Magnesium levels (strata I to IV respectively; 4.32-14.4, 5.76-34.08, 5.76-34.08 and 6.24-16.32 mg/l) above the WHO guidelines (1.5 mg/l). Magnesium seems not to have any adverse effects on human or fish health according to the available literature. Analysis of POPs is underway and once completed will provide important information of their presence and potential to affect fish health in the lake. Endpoints such as histological examination and hormone analysis will be used to assess immune and reproductive effects of contamination.

The use of metagenomics analysis for the search of pathogens in aquaculture

Mugimba Kahoza Kizito, Stephen Mutoloki, Øystein Evensen and Hetron M Munang'andu

Norwegian University of Life Sciences, Faculty of Veterinary Medicine and Biosciences,

Oslo, Norway

Studies on infectious pathogens have for a long time centered on isolation, culture, characterization and identification of the infectious agents followed by fulfilling the Koch's postulates. However, growing evidence shows that a large proportion of infectious microorganisms found in natural environments are unculturable, which makes their study an uphill task. With the recent advent of metagenomic analysis, strides have been made in the identification of novel pathogens causing disease in different terrestrial and aquatic organisms as well pathogens found in freshwater and marine environments. Metagenomics involves sequence independent determination of all the genomes present in a sample. It can be applied on environmental samples and tissues collected from infected hosts for pathogen identification, microbiome determination and host pathogen interaction studies. Herein, we highlight the procedures involved, the advantages over other approaches, the opportunities it presents and challenges. Application of this novel technique will help in accurate

and timely fish pathogen identification and guide timely interventions. It is anticipated that metagenomics analysis will greatly influence the future of pathogen discovery and open new dimensions in the study of pathogens infecting different aquatic organisms.

The role of bacterial outer membrane proteins as vaccine candidates for aquatic organisms

Saurabh Dubey, Stephen Mutoloki, Øystein Evensen and Hetron M Munang'andu

Norwegian University of Life Sciences, Faculty of Veterinary Medicine and Biosciences,

Oslo, Norway

Bacterial outer membrane proteins (OMPs) are made of β -barrel structural proteins that project outwardly on the bacterial outer surface membranes. They are involved in nutrient uptake, bacteria adhesion on host cells, export of waste products and virulence. In addition, they contribute to bacteria resistance to host immune molecules such as lysozyme, P-lysine and various leukocyte proteins. In addition, they are highly conserved and are immunogenic because they encode epitopes that project outwardly on bacterial outer surface membranes that easily bind to neutralizing antibodies. Because of their immunogenic properties, they have proved to be reliable vaccine candidates able to confer protective immunity against different bacterial infections in mammals and fish. In this study, the OmpW of *Aeromonas hydrophila* and OmpA of *Edwardsiella tarda* were cloned and expressed in *Escherichia coli*. The purified recombinant OmpW and OmpA were encapsulated in PLGA and chitosan nanoparticles, respectively, and were used to vaccinate the Indian carp (*Labeo rohita*) administered as oral vaccines. Our findings show that the rOmpW of *A. hydrophila* encapsulated in PLGA nanoparticles produced a dose dependent protective immunity in which fish vaccinated with a high antigen (HiAg) dose had higher protection than fish vaccinated with a low antigen (LoAg) dose vaccines. On the other hand, the rOmpA of *E. tarda* encapsulated

in chitosan nanoparticles produced superior protection over the inactivated whole cell (IWC) vaccine administered as oral vaccines. Overall, data presented herein shows that bacterial OMPs can be used as vaccines against different fish diseases and that the level of protection induced by these proteins can be optimized to correlate with antigen dose.

Overview of Tilapia farming in Uganda:

Challenges in the control of Nile tilapia diseases

Mugimba Kahoza Kizito^{1,2}, Stephen Mutoloki¹, Øystein Evensen¹

and Hetron M Munang'andu¹

¹-Norwegian University of Life Science, Faculty of Veterinary Medicine and Biosciences, Oslo,

Norway, ²-Makere University, Faculty of Veterinary Medicine, Kampala, Uganda

World aquaculture production has been increasing over the years to keep up with the demand. This is augmented by that fact that capture fisheries, both from freshwater and marine environments, has increased tremendously in recent decades rendering some of the over-harvested aquatic organisms to be endangered of extinction. In Uganda, aquaculture was introduced in the 1940s but has remained largely under developed despite 20% of the country surface area being covered by freshwater ecosystems. Nevertheless, fish export is the country's second largest foreign exchange earner although export volumes have declined considerably in recent years. Fish farming in Uganda can be broadly categorized into subsistence and commercial farming with tilapia as the most farmed species. Subsistence farming is mainly restricted to ponds, is characterized by low investment and low output while commercial farmers grow their fish in cages on Lake Victoria, invest heavily and have a high output. Challenges include inadequate or poor sources of fingerlings and feed, vagaries of weather and poor aquaculture management and these will be discussed in light of predisposing factors to infectious diseases in Ugandan aquaculture.

Pangasianodon hypophthalmus

