FITFISH ANNUAL CONFERENCE

20th April 2018

Fundação Cupertino de Miranda

Porto, Portugal

U.PORTO

INDEX

Dear Colleagues,

We would like to welcome you to the final Annual conference of COST Action FA1304 "Swimming of fish and implications for migration and aquaculture (FITFISH)". Three main topics connected to the goals of the FITFISH Action will be presented at the Annual Conference: *Functional mechanisms behind the beneficial effects of swimming*, *Fish Migration* and *Exercise in aquaculture*. The Annual Conference will provide a synthesis of the progress made in gaining knowledge about exercise effects on the growth and welfare of fish, as well as the implementation of this knowledge in aquaculture, and in tracking fish, biological solutions to optimise migration and modelling of effects on populations.

We hope that the conference will provide a stimulating environment for many interesting discussions.

Leonardo J. Magnoni (Local organiser)
Luisa Valente (Local organiser)
Josep Planas (FITFISH Action Vice Chair)
Arjan Palstra (FITFISH Action Chair)

Annual Conference will be held at the:

Dr. António Cupertino de Miranda Foundation

Fundação Dr António Cupertino de Miranda

Address: Av. da Boavista # 4245

4100–140 Porto

Telephone: +351 226 101 189

Fax: +351 226 103 412

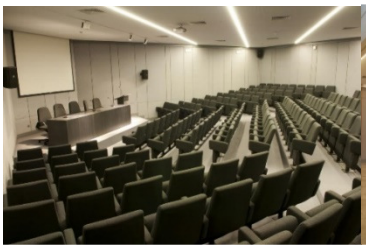
E-mail: geral@facm.pt

Website: www.facm.pt/facm/facm/en/Congress-and-Exhibition-Center

How to get there:

- By bus # 502 (bus stop: Parque da Cidade).
- Other public transportation (taxi, UBER and Cabify).
- By car. Private park with capacity for 120 vehicles.
  GPS coordinates: 41° 9' 54" N 8° 40' 19" W

The Cupertino de Miranda Foundation is a private, not-for-profit institution whose aim is to provide educational and cultural activities that promote the knowledge society and contribute to social inclusion. The Conference Centre at the Foundation has vast functional spaces including Auditoriums, meetings rooms and a restaurant.



FRIDAY, APRIL 20th, 2018
Auditorium I, ground floor at Cupertino de Miranda Foundation.

8.30 Registration

8.45 Welcome
Arjan Palstra (Action chair, Wageningen UR, Wageningen, The Netherlands)
Leonardo Magnoni (Local organizer, CIIMAR, Porto, Portugal)
Luisa Valente (Local organizer, CIIMAR, ICBAS-UP, Porto, Portugal)

ORAL PRESENTATIONS

Chair: Leonardo Magnoni

9.00 Muscle metabolic remodeling with environmental and energetic stress in fishes.
Grant B. McClelland (McMaster University, Hamilton, Canada)

9.30 Exercise and postprandial cardiovascular physiology in fish.
Erika Eliason (University of California, Santa Barbara, USA)

10.00 Benefits of sustained swimming exercise on heart, health and growth performance in farmed Atlantic salmon.
Ian Mayer (Norwegian University of Life Sciences, Oslo, Norway)

10.30 Coffee-break

Chair: Grant McClelland

11.00 Swimming performance in reared fish. Teratogenic effects and developmental plasticity.
George Koumoundouros (University of Crete, Heraklion, Greece)

11.30 A robotic system interacting in a closed-loop with groups of zebrafish *Danio rerio*.
Frank Bonnet (Ecole Polytechnique Fédérale de Lausanne, Lausanne Switzerland)

12.00 Preliminary thoughts on establishing swimming exercises for fish in farms.
Carlos Andrade (CMC, *Oceanic Observatory of Madeira,* CIIMAR, Madeira, Portugal)

12.30 Lunch

Chair: Marie Laure Begout

14.00 Cardiovascular capacity is compromised at elevated temperatures in upstream migrating anadromous Arctic char and brown trout compared with lacustrine conspecifics.
Katja Anttila (University of Turku, Turku, Finland)

14.30 The swimming behaviour and activity patterns of the Argentine sand perch *Pseudopercis semifasciata*, and bioenergetics implications.
Paolo Domenici (IAMC CNR, Torregrande, Italy)

15.00 Effects of swimming exercise on brain plasticity, cognition and foraging behaviour in Atlantic salmon.
Daan Mes (Norwegian University of Life Sciences, Oslo, Norway)

15.30 Coffee-break

Chair: Erika Eliason

16.00 Gaining insights into the initiation of vitellogenesis by comparing the European eel (*Anguilla anguilla*) and the shortfin eel (*A. australis*).
Pauline Jéhannet (Wageningen UR, Wageningen, The Netherlands)

16.30 Critical swimming speed and oxygen consumption on Atlantic cod (*Gadus morhua*) internally tagged with an accelerometer sensor.
Inge van der Knaap (Gent University, Ghent, Belgium)

17.00 A potential link between swimming activity and oxidative stress in the European sea bass (*Dicentrarchus labrax*).
Božidar Rašković (University of Belgrade, Belgrade, Serbia)

17.30 Poster presentations

19.30 Conference dinner

FRIDAY, APRIL 20th, 2018

Foyer I at the ground floor of the Cupertino de Miranda Foundation.

POSTER PRESENTATIONS

P1 **Effects of size on optimal swimming speed and cost of transport in rainbow trout (*Oncorhynchus mykiss*).**
Pedro Cunha, Peter Skov

P2 **Swimming performance and oxygen consumption rate of *perca spp.* in relation to salinity and habitat origin.**
Emil A. F. Christensen, J. Stieglitz, M. Grosell, J. F. Steffensen

P3 **Rearing juvenile brown and rainbow trout in earthen ponds with and without flow.**
Stefan Reiser, Niko Sähn, Dominique Marie Pohlmann, Marc Willenberg, Ulfert Focken.

P4 **Comparison of swimming capacity of *Acipenser gueldenstaedtii, Acipenser ruthenus* and hybrid sturgeon (*Acipenser gueldenstaedtii* x *Acipenser ruthenus*).**
Lorena Dediu, Raluca Cristina Andrei (Guriencu), Victor Cristea, Mogodan Alina, Angelica Docan, Iulia Grecu

P5 **Modelling oxygen availability within aquaculture sea-cages-theoretical vs. real-time measurements.**
Heidrikur Bergsson

P6 **Fish farmer´s perception of the need for fish exercise in aquaculture-case study in Croatia and FYR Macedonia.**
Ana Gavrilović, Aleksandar Cvetkovikj, Damir Kapetanović

P7 **Ex situ conservation of endemic soft mouthed trout *Salmo obstusirostris oxyrhinchus* (Heckel, 1851) with the view of restocking the population in the Buna River- Implications for aquaculture.**
Sanel Riđanović, Lejla Riđanović, Denisa Žujo Zekić, Pavle Spasojević, Emina Ademović

P8 **Mortality of silver eels in hydropower turbines and migration patterns in lowland rivers and lagoons in the north-eastern region of their distribution**
Saulius Stakėnas, Justas Dainys

P9 **Movements of the giant catfish in the Danube River determined by acoustic telemetry.**
Mirjana Lenhardt, Stefan Hont, Sladana Spasiç, Radu Suciu, Miroslav Nikčević, Marija Smederevac-Lalić

P10 **Migration problems of the Black Sea roach (*Rutilus frisii*).**
Özcan Gaygusuz, Devrim Memiş, Gökhan Tunçelli, Meriç Albay

ABSTRACTS:
ORAL PRESENTATIONS

MUSCLE METABOLIC REMODELING WITH ENVIRONMENTAL AND ENERGETIC STRESS IN FISHES

GRANT B. McCLELLAND
Department of Biology, McMaster University, Hamilton, Ontario, Canada

Unlike other tissues, muscles routinely sustain extreme changes in metabolic rate that requires equivalent increases in oxygen and substrate delivery. Muscles are also capable of significant phenotypic plasticity, allowing animals to match physiological traits involved in metabolism with changes in local conditions. However, the mechanisms responsible for muscle remodeling in fishes are still unclear, as are explanations for stressor-specific and species-specific responses. We have found in zebrafish that significant metabolic remodel resulting from both chronic contraction (exercise training) and cold occurs through distinct molecular mechanisms. While induction of some transcription factors (e.g. nuclear respiratory factor, NRF-1) suggests a common mechanism to increase muscle aerobic phenotype, other responses (e.g. peroxisome proliferator receptor, PPAR) were unique to either exercise or cold stimulation. Although exercise is known to be a potent stimulant of muscle remodeling, including muscle growth, the degree of phenotypic plasticity may depend on the relative intensity of swimming. There was also a disconnect, depending on the stressor, between muscle remodeling and changes in whole-animal exercise performance. Furthermore, genome duplication events have led to increased variation in possible regulatory responses (e.g. multiple isoforms for PPAR) and functional outcomes (e.g. multiple isoforms of carnitine palmitoyl-transferase, CPT1) that may help fine-tune acclimatization. We have observed that in salmonids fasting, exercise, and migration all lead to different changes in PPAR isoform expression and of the multiple forms of its putative target, CPT1. Pollution may alter these responses and we have found that water-borne copper reduces exercise induced maximum metabolic rate and impedes recovery. I will discuss how muscle metabolic remodeling aids in adaptive responses to changing environments and possibly maladaptive plasticity to given stimuli.

Key words: temperature, exercise, migration, pollution, mitochondria

EXERCISE AND POSTPRANDIAL CARDIOVASCULAR PHYSIOLOGY IN FISH

ERIKA J. ELIASON[1], ANTHONY P. FARRELL[2]
[1]Department of Ecology, Evolution & Marine Biology, *University of California, Santa Barbara*, Santa Barbara, CA, 93106, USA,
[2]Department of Zoology, *University of British Columbia*, Vancouver, BC, Canada, V6T 1Z4

The cardiorespiratory system plays the essential role of delivering sufficient oxygen to support the metabolic demands required for daily activities in fishes: such as foraging for food, digesting a meal, competing for mates, developing gonads, escaping predators, and migrating to new areas. Over the last decade, my research program has examined how the cardiorespiratory system supports exercise, digestion, and reproduction in fishes, with a particular emphasis on Pacific salmon. Pacific salmon are fascinating because they return to their natal streams with strong fidelity resulting in reproductively isolated populations. Exercise performance and thermal tolerance appear to be locally adapted to the specific environmental conditions encountered by each population. Specifically, populations with more challenging upriver spawning migrations have enhanced cardiorespiratory performance across numerous levels of biological organization (whole animal, organ, cell). On an individual level, fish must simultaneously perform numerous activities (e.g. swim, digest a meal, develop gonads & secondary sexual characteristics) and given that all capillary beds cannot be simultaneously & maximally perfused, oxygen delivery to competing tissues must be partitioned according to the capacity of the heart to deliver blood. Trade-offs exist between swimming performance, digestion, and sexual maturation, which may be modulated by environmental stressors such as temperature and hypoxia. For example, maximum swim performance may be reduced in fish that are simultaneously swimming and digesting. As another example, fish that are able to reduce energy requirements during upriver migration will have more energy remaining on the spawning grounds to compete for mates. Finally, several recent studies have found that adult female salmon suffer higher mortality compared to males when fish are exposed to capture and handling stressors. Mechanistically, these differences in survival may be attributed to differences in recovery from exercise and stress.

Keywords: salmon, cardiovascular, local adaptation, metabolism, temperature

BENEFITS OF SUSTAINED SWIMMING EXERCISE ON HEART HEALTH AND GROWTH PERFORMANCE IN FARMED ATLANTIC SALMON

IAN MAYER[1], INGRID OLESEN[2], HARALD TAKLE[2], BJARNE GJERDE[2]

[1]Department of Production Animal Clinical Sciences, Norwegian University of Life Sciences, NO-0454 Oslo, Norway
[2]Nofima Marin, PO Box 5010, NO-1432 Ås, Norway

Domestication results in increased levels of production-related diseases in farmed fish, including heart deformities. A variety of heart deformities have now been reported in farmed Atlantic salmon including pronounced heart hypertrophy, increased levels of fat deposition, and arteriosclerosis. Evidence indicates that these heart deformities result in impaired cardio-vascular performance and increased stress responsiveness, making farmed fish more vulnerable to the ill-effects of production-related procedures. The objective of this study was to determine whether subjecting farmed salmon to increased swimming exercise at different stages of the production cycle would result in improved heart health, as well as important production traits such as growth, fillet quality and survival.

In the autumn of 2012, 5000 Atlantic salmon parr (from 100 SalmoBreed families) were first individually PIT-tagged, and then divided between 4 indoor tanks and subjected to 80 days of either natural flow rate (0.5 body lengths/sec) or accelerated flow rate (1.5-2.0 body lengths/sec). In spring 2013, following smoltification, all fish were transferred first to a common sea cage, and then on two occasions (June-Nov 2013 and June-Aug 2014) the salmon were transferred to four smaller sea cages and again subjected to either natural water flow (0-3 cm/sec) or accelerated water flow (20-30 cm/sec). At six time points over the production cycle, all fish were weighed and measured, and additionally a select number were dissected to evaluate heart indices (heart weight, fat content and pathologies). At the final sampling at slaughter size, a number of important production traits (fillet colour and fat content) were also determined from all remaining fish (n=1901).

In addition to describing the potential benefits of sustained swimming exercise on heart health and growth performance in farmed Atlantic salmon this talk will also discuss whether there is a hereditary

component to good heart health, and if so make the case for selecting this trait in future salmon breeding programs.

Key words: swimming exercise, Atlantic salmon, heart disease, growth, flesh quality

SWIMMING PERFORMANCE IN REARED FISH. TERATOGENIC EFFECTS AND DEVELOPMENTAL PLASTICITY

GEORGE KOUMOUNDOUROS
University of Crete, Biology Department, Vasilika Vouton, 70013, Heraklion, Greece, gkoumound@uoc.gr

During the different production phases, reared fish are subjected to variable swimming -water current- conditions, which are related with the used aquaculture structures (e.g. different tank types) or practices (e.g. tank self-cleaning), as well as with performance goals (e.g. increase of growth rate). Moreover, scientific results of the last two decades demonstrate that the control of water-current conditions is a prerequisite for the normal development of fish skeleton. In various fish species (*Dicentrarchus labrax*, *Sparus aurata*, *Pagrus major*, *Gadus morhua*, etc), intense swimming has been correlated with the development of lordosis (V shaped curvature of the vertebral column) at frequencies reaching up to 70%. Existing literature suggests that swimming-induced lordosis is the outcome of muscle/bone interactions and/or imbalanced development. Nutrition, genetic background and water temperature have been suggested to control the effects of swimming on fish vertebral column, by directly affecting muscle and bone development. Indirectly, water temperature during the embryonic and larval period has been suggested to control the swimming-induced lordosis, through the plastic responses of features which are known to affect fish swimming performance (e.g. body shape, muscle structure and anatomy). This presentation will focus on the relationship between swimming and the development of vertebral abnormalities in fish, as well as on the related thermally-induced plasticity of swimming performance.

Key words: aquaculture, fish ontogeny, skeletal abnormalities, phenotypic plasticity

A ROBOTIC SYSTEM INTERACTING IN A CLOSED-LOOP WITH GROUPS OF ZEBRAFISH *DANIO RERIO*

FRANK BONNET
EPFL STI IMT LSRO, ME B3 30 (Bâtiment ME), station 9, CH-1015 Lausanne, Switzerland
Ecole Polytechnique Fédérale de Lausanne

Robotic animals are nowadays developed for various types of research, such as bio-inspired robotics or animal behavior studies. More specifically, in the case of collective animal behavior research, the robotic device has to interact with animals by generating and exploiting signals relevant for social behavior. Once perceived by the animal society as conspecific, these robots can become powerful tools to study the animal behaviors, as they can at the same time monitor the changes in behavior and influence the collective choices of the animal society.

In this presentation, I will present the robotized tools that we developed to integrate shoals of fish in order to study their collective behaviors. This robotic platform is composed of two subsystems: a miniature wheeled mobile robot that can achieve dynamic movements and multi-robot long-duration experiments, and a robotic fish lure that is able to beat its tail to generate fish-like body movements. The two subsystems are coupled with magnets which allows the wheeled mobile robot to steer the robotic fish lure so that it reaches very high speeds and accelerations while achieving shoaling. An experimental setup to conduct studies on mixed societies of artificial and living fish was designed to facilitate the experiments for biologists. A software framework was also implemented to control the robots in a closed-loop using data extracted from visual tracking that retrieved the position of the robots and the fish.

We selected the zebrafish *Danio rerio* as a model to perform experiments to qualify our system. An experiment involving a mixed society of fish and robots qualified the robotic system to be integrated among a zebrafish shoal and to be able to influence the collective decisions of the fish. These results are very promising for the field of fish-robot interaction studies, as we showed the effect of the robots in long-duration experiments and repetitively, with the same order of response from the animals.

Key words: Animal-robot interaction, Multi-agent systems, Collective behavior, zebrafish, Mixed societies

PRELIMINARY THOUGHTS ON ESTABLISHING SWIMMING EXERCISES FOR FISH IN FARMS

CARLOS ANDRADE
Centro de Maricultura da Calheta, Avenida D. Manuel I nº7, 9370-133 Calheta, Madeira-Portugal
CMC - Calheta Mariculture Centre
OOM - Oceanic Observatory of Madeira
CIIMAR - Interdisciplinary Centre of Marine and Environmental Research

Aquaculture takes into account the several aspects of development of fish during their ontogeny, in order to create the best environmental conditions to support their growth, the good health of the population and lower the mortality rate. Aquaculture ventures tend to maximize these parameters at the lower possible financial cost.
In this presentation, we assumed that fish swimming exercises of aquaculture species are beneficial for growth performance. The introduction of swimming exercises in fish farms would need to consider the development of fish species, the present rearing systems and facilities.
In hatcheries, the fish larvae and post-larvae need no disturbance and the rearing systems favour low water exchange and/or tank design and/or devices to avoid significant high currents in the culture tanks. Labour intensive work keeps tanks clean and guarantee good water quality. In opposition, the fingerlings and juveniles are more capable to swim and can withstand water disturbance at a lower risk of spinal deformities.
Most land based facilities for the pre-growing and on-growing of fish increase the water exchange, at a cost, favouring the self-cleaning of rearing tanks and providing the adequate water quality.
Cage fish farming is a passive production system regarding the control over the water physical characteristics and weather conditions. The fish is exercised depending on the water currents, waves, and production operations (stocking, sampling and harvesting). Most regular and vigorous swimming occurs at feeding. Occasionally, submerged water pumps and air/oxygen blowers have been used to increase dissolved oxygen at critical levels, thus inducing water currents in cages.
From a technical and arguably economic perspective, a programme to implement regular fish swimming exercises seems easily

achievable in present land based facilities. Considerable synergies with cage fish farming could exist to increase fish exercise – e.g. the current trend to extend fish growing periods on land previous to cage transfer. For cage fish farming systems we suggest the introduction of water currents criteria in site selection at planning stage as the most appropriate and economically sustainable choice to suit the introduction of fish swimming exercises.

Key words: aquaculture fish, fish swimming exercises, land based fish farm, cage fish farm, hatchery, on-growing facilities

CARDIOVASCULAR CAPACITY IS COMPROMISED AT ELEVATED TEMPERATURES IN UPSTREAM MIGRATING ANADROMOUS ARCTIC CHAR AND BROWN TROUT COMPARED WITH LACUSTRINE CONSPECIFICS

KATJA ANTTILA[1], GIOVANNA MOTTOLA[1], TORSTEIN KRISTENSEN[2]
[1]Department of Biology, *University of Turku*, 20014, Turku, Finland
[2]Faculty of Biosciences and Aquaculture, *Nord University*, 8026 Bodø, Norway

Anthropogenic activities are clearly changing the earth's climate and because water temperatures have progressively increased for much of the past 50 years, the concern over the future fate of fish is growing. The cardiac function has been suggested to play a significant role in the ability of fish to encounter high temperatures. Since the upstream spawning migration of salmonids occurs at the warmest time of the year, climate change might have especially detrimental effects on migrating fish that are already using their maximum cardiac capacities for completing the migration. Therefore, we investigated the maximum cardiovascular capacities and upper thermal tolerance of Arctic char (*Salvelinus alpinus*) and brown trout (*Salmo trutta*) that were migrating upstream to spawning areas and compared their capacities to residents that were staying in the lake the whole season (or life) in Northern Norway (67.1°N). The results of the measurements were quite devastating. The river temperature during the migration was between 12.1-12.4°C. Both species during river-part of the migration got cardiac arrhythmias around 14-16°C. For the major part of the fish this was only 2°C higher than current river temperature. Interestingly the thermal tolerance of resident fish was significantly higher: 19-26°C. Both of the species had also significantly lower maximum heart rates during the migration as compared to resident fish ($F=33.2$, $p<0.001$) and char had significantly lower heart rates than trout ($F=13.6$, $p<0.001$). The results from the upstream migration show that the fish have limited capacities to handle high temperatures when they need efficiently working heart most (to pass through rapids etc.). The increase of the environmental temperature could, thus, be extremely detrimental for these fish and significant conservation efforts should be directed to secure/build cool refuge areas for fish during the upstream migration. The molecular

mechanism behind the reduced cardiac function in migrating fish are currently under investigations and we are also evaluating the differences in swimming muscles and how those relate to swimming activity. This publication is supported by COST Action FA1304 "Swimming of fish and implications for migration and aquaculture (FITFISH).

Key words: arrhythmias, climate change, conservation, heart, spawning migration

THE SWIMMING BEHAVIOUR AND ACTIVITY PATTERNS OF THE ARGENTINE SANDPERCH *PSEUDOPERCIS SEMIFASCIATA*, AND BIOENERGETIC IMPLICATIONS

PAOLO DOMENICI[1], LUCAS BELTRAMINO[2], LEONARDO VENERUS[2], STEFANO MARRAS[1], JAVIER E. CIANCIO[2]

[1] IAMC CNR, Località Sa Mardini, Torregrande (Oristano) 09170 Italy
[2] CESIMAR-CONICET, Blvd. Brown 2915, Puerto Madryn, Chubut, Argentina

Accelerometry is a novel, fundamental tool for evaluating the behaviour and energetics of swimming fish in the field and in various environmental conditions. It allows to evaluate the individual movement pattern of fish in the field with relatively high resolution (e.g. 25 Hz), including their energetics and also to assess their behavioural patterns by determining specific acceleration signatures that correspond to given motor behaviour. The aim of this project is to investigate the swimming behaviour of a key reef species from the coastal areas of Argentina, using a combination of video and accelerometry observations. These methods will be used to characterize the individual patterns of activity and to test the effect of various factors (time of the day, light level, lunar phase) on the swimming behaviour of the argentine sandperch *Pseudopercis semifasciata,* a species of high ecological importance. The project will have relevance for the ecology and management of this species since swimming behaviour deeply affects bioenergetics. This research will be carried out at the CONICET centre in Puerto Madryn (Argentina) and has direct implications with FITFISH WG1 and WG2 in particular, since it is largely based on monitoring fish swimming behaviour and activity in real-life situations, using high-tech methodology such as tri-axial accelerometry.

Key words: Accelerometry, swimming, behaviour, fish, field work

EFFECTS OF SWIMMING EXERCISE ON BRAIN PLASTICITY, COGNITION AND FORAGING BEHAVIOUR IN ATLANTIC SALMON

DAAN MES[1], ARJAN P. PALSTRA[2], CHRISTIAAN V. HENKEL[3], MARCO A. VINDAS[4,5], IAN MAYER[1]
[1]*Department of Production Animal Clinical Sciences, Norwegian University of Life Sciences, Oslo, Norway*
[2]*Wageningen University & Research, Animal Breeding and Genomics, Wageningen Livestock Research, Wageningen, the Netherlands*
[3]*Department of Basic Sciences and Aquatic Medicine, Norwegian University of Life Sciences, Oslo, Norway*
[4]*Institute for Neuroscience and Physiology, Gothenburg University, Gothenburg, Sweden*
[5]*Uni Environment, Uni Research As, Bergen, Norway*

Current stocking programs introduce millions of hatchery-reared juvenile Atlantic salmon into rivers in Northern Europe every year. Unfortunately, hatchery-reared fish often have lower survival rates compared to their wild conspecifics. After release into the natural environment, hatchery-reared fish display reduced behavioural plasticity, most likely because their neuronal capacity is not optimally developed in the stimulus-poor hatchery environment. A promising tool to improve neuronal development and cognitive performance of hatchery-reared fish is implementation of swimming exercise. Exercise in mammals can enhance brain plasticity and boost cognition: exercised rats can solve a maze more quickly than non-exercised animals. The aim of this STSM, conducted at Wageningen University and Research, was to determine if an 8-week swimming exercise regime can enhance brain plasticity, cognition (as measured by a maze test) and foraging behaviour in Atlantic salmon parr. To determine cognitive capacity, exercised and non-exercised fish were subjected to a four-arm maze test for seven consecutive days. While both groups solved the maze more quickly over time, indicating a learning process, no significant difference was observed between exercised and non-exercised fish in the time taken to solve the maze. To study foraging behaviour, twenty exercised and twenty non-exercised fish were isolated in individual aquaria and presented with a novel prey (a live cricket) twice per day for five consecutive days. No differences in time to consumption and number of consumed prey

were found between treatments. Exercised fish did show significantly higher growth rates after eight weeks and resumed feeding more quickly after being handled than non-exercised fish. Brain plasticity was assessed through mapping the transcriptome of the telencephalon: the brain area specifically involved with learning, memory and decision making in teleosts. Preliminary results show upregulation of several markers for neuronal excitability, neuronal signalling, cell proliferation and neurite outgrowth in exercised fish. In conclusion, exercise did not have an apparent effect on the cognitive capacity of the fish in a spatial orientation test and a novel prey test but it did lead to increased body growth and upregulated gene expression of brain plasticity markers in the salmon telencephalon.

Key words: telencephalon, maze test, transcriptome, RNAseq

This publication is financially supported by:

- COST Action FA1304 "Swimming of fish and implications for migration and aquaculture (FITFISH)".
- the European Union's Horizon 2020 research and innovation programme under the Marie Sklodowska-Curie grant agreement No 642893 "Improved production strategies for endangered freshwater species (IMPRESS)" and under grant agreement No 652831 (AQUAEXCEL^{2020})
- The Research Council of Norway under the HAVBRUK programme, project number 268075/E40

GAINING INSIGHTS INTO THE INITIATION OF VITELLOGENESIS BY COMPARING THE EUROPEAN EEL (*ANGUILLA ANGUILLA*) AND THE SHORTFIN EEL (*A. AUSTRALIS*)

JEHANNET, P.[1], KRUIJT, L.[1], DAMSTEEGT, E.L.[2], SWINKELS, W.[3], HEINSBROEK, L.T.N.[1,4], LOKMAN, P.M.[2], PALSTRA, A.P.[1]

[1]*Wageningen University & Research Animal Breeding and Genomics*, *Wageningen Livestock Research*, PO Box 338, 6700 AH Wageningen, The Netherlands.

[2]*Department of Zoology, University of Otago*, 340 Great King Street, PO Box 56, Dunedin 9054, New Zealand.

[3]*DUPAN Foundation*, Bronland 12-D, 6700 AE Wageningen, The Netherlands.

[4]*Wageningen Eel Reproduction Experts B.V.*, Mennonietenweg 13, 6702 AB Wageningen, The Netherlands.

A negative correlation exists between the maturation stage at the start of the oceanic reproductive migration and the migration distance to the spawning grounds for the various eel species. The European eel migrates up to 6,000 km and leaves in a previtellogenic state. The shortfin eel migrates 2-4,000 km and leaves in an early vitellogenic state. In this study, we compared previtellogenic European silver eels with immature yellow eels, and early vitellogenic silver shortfin eels with yellow eels, to gain insights into the initiation of vitellogenesis. Immediately after being caught and at the catch site, measurements were performed and eels (N=6 yellow and N=6 silver for each species) were sampled for blood and tissues. Eye index (EI), gonadosomatic index (GSI) and hepatosomatic index (HSI) were calculated. Plasma 11-ketotestosterone (11KT) and 17β-estradiol (E2) levels were measured by specific radio-immunoassay (RIA). Pituitary, liver and ovaries were dissected for quantitative real time PCR analyses (pituitary dopamine D2 receptor *d2br*, gonadotropin-releasing hormone receptors 1 and 2 *gnrhr1* and *2*, growth hormone *gh* and follicle-stimulating-hormone-β *fshβ*; liver estrogen receptor 1 *esr1*; gonad follicle-stimulating hormone receptor *fshr*, androgen receptors α and β *ara* and *b*, vitellogenin receptor *vtgr* and P450 aromatase *cyp19*). For each species, fold-change expression was determined of silver *vs*. yellow eels and these were compared.

GSI values of 3.0 ± 0.2% in silver shortfin eels reflected a vitellogenic maturation state while GSI values of 1.4 ± 0.1% indicated previtellogenesis in European silver eels. Plasma 11KT levels were much higher in shortfin than in European silver eels (82.3 ± 11.3 vs. 1.2 ± 0.3 ng mL^{-1}), whereas plasma E2 levels were higher in European silver eels (3.1 ± 0.5 vs. 1.5 ± 0.1 ng mL^{-1}). Expression of *esr1* in European eels was low while *esr1* expression was up-regulated over 100-fold in silver shortfin eels.
Comparison between the silvering European and shortfin eels suggests that pituitary dopaminergic signaling (*d2br*) is increased, whereas the brain-pituitary-gonad reproductive axis (*gnrhr1* and *2*, *fshβ*, *esr1*, *fshr*, and *ara* and *b*) is stimulated during the initiation of vitellogenesis.

Key words: artificial reproduction, brain-pituitary-gonad axis, puberty, gene expression

Acknowledgements: This publication is supported by COST Action FA1304 "Swimming of fish and implications for migration and aquaculture (FITFISH)."; the DUPAN foundation; The Dutch Ministry of Economic Affairs and the European Union, European Maritime and Fisheries Fund; a Department of Zoology Research Enhancement Grant (PBRF63), and by the partners of the international EELRIC consortium (www.eelric.eu).

CRITICAL SWIMMING SPEED AND OXYGEN CONSUMPTION OF ATLANTIC COD (*GADUS MORHUA*) INTERNALLY TAGGED WITH AN ACCELEROMETER SENSOR

INGE VAN DER KNAAP[1], GUDRUN DE BOECK[2], CHRISTIAN TUDORACHE[3]

[1]*Gent University, Krijgslaan 281-S8, 9000 Ghent Belgium*
[2]*Antwerp University, Groenenborgerlaan 171, 2020 Antwerpen, Belgium*
[3]*Leiden University, Sylviusweg 72, 2333 BE Leiden, The Netherlands*

Electronic tagging has become a central and widespread tool in fish ecology and fisheries management; data logging devices are rapidly increasing our understanding of the movement, behaviour and physiology of fish in their natural environment. Today, electronic tags can include a range of different sensors that, among other things, can detect pressure, temperature, salinity and acceleration. Loggers that incorporate an accelerometer sensor track the tilt of the animal over three axes (x, y and z) which can provide us with inside information on the energetic costs of different activities. However, monitoring activity and measuring energy expenditure in free ranging fish in the field is problematic. To link field accelerometer data to certain activity patterns or energetic costs an understanding of the animals movement and energy expenditure related to acceleration is needed. In this project, supported by COST Action FA1304 "Swimming of fish and implications for migration and aquaculture (FITFISH)", we linked acceleration to critical swim speeds (U_{crit}) as well as oxygen consumption rate (MO_2) of Atlantic cod (*Gadus morhua*). We furthermore investigated the effects of internal tagging on both variables. We used a total of 16 wild caught Atlantic cod and measured there swimming activity in Brett (Steffensen) type flow-tunnels. Measurements were taken repeatedly starting with non-tagged control and subsequent internally tagged individuals. Preliminary results indicate no effect of the tagging procedure on swimming capacity. Further analysis will enable us to link accelerometer data to actual swimming speeds and energy use and by that measure energy consumption in the field.

Key words: Critical swim speed, oxygen consumption, flow-tunnel, acceleration

A POTENTIAL LINK BETWEEN SWIMMING ACTIVITY AND OXIDATIVE STRESS IN THE EUROPEAN SEA BASS (*DICENTRARCHUS LABRAX*)

BOŽIDAR RAŠKOVIĆ[1], FRANCISCA SILVA-BRITO[2], LUIS PEREIRA[2], RODRIGO OZORIO[2], LEONARDO J. MAGNONI[2]
[1] *Institute of Animal Sciences, Faculty of Agriculture, University of Belgrade*
Nemanjina 6, Zemun, 11080 Belgrade, Serbia
[2] *Interdisciplinary Centre of Marine and Environmental Research (CIIMAR) - University of Porto, 4450-208 Matosinhos, Portugal*

Exercise at optimal speed appears to enhance muscle growth and flesh quality, improving the immune response and welfare of teleost fish. Swimming affects fish physiology through adaptive mechanisms, but further research efforts should weigh the potential benefits and/or drawbacks of different swimming regimes, which are key applicable issues in the aquaculture sector. Locomotion in fish, from sustained to burst swimming activity, is associated with increased oxygen use, involving the recruitment of a variable proportion of red and white muscle fibers. In addition, swimming activity, utilizing red and/or white muscle contractions, is fueled by a number of metabolic pathways (aerobic and anaerobic energy production) which depend on the exercise conditions, oxygen, and the energy available in the organism itself. In mammals at least, an increase in metabolic demand during exercise has been linked to elevated reactive oxygen species (ROS) formation in muscle mitochondria, which may result in oxidative stress. This burst in ROS results in free radical production, highly reactive molecules that may damage lipids, proteins, DNA and RNA, resulting in subsequent oxidative stress in animal tissues. As a consequence, protective mechanisms at cellular/tissue levels may be displayed to decrease potential oxidative damage that might be produced by an excess of ROS formation in animals. These kinds of mechanisms may include increasing levels of antioxidant enzyme activities (e.g. catalase, superoxide dismutase and glutathione peroxidase). The aim of the study will be to test if swimming speeds above the U_{opt} (and below the U_{crit}) induce oxidative stress in European sea bass (*Dicentrarchus labrax*) tissues. Brett-type tunnel will be set at: i) a low speed water current (control), ii) swimming continously to a speed above U_{opt} or iii) an interval swimming protocol to a speed above U_{opt}. The effect

of different swimming conditions will be investigated in fish analyzing changes in stress/metabolic markers in plasma (cortisol, glucose, lactate) and activity levels of key enzymes involved in protective mechanisms against oxidative stress in skeletal muscle, liver and heart.

Key words: sea bass, oxidative stress, swimming activity, ROS

Acknowledgements: This publication is supported by COST Action FA1304 "Swimming of fish and implications for migration and aquaculture (FITFISH).

NOTES

ABSTRACTS:
POSTER PRESENTATIONS

EFFECTS OF SIZE ON OPTIMAL SWIMMING SPEED AND COST OF TRANSPORT IN RAINBOW TROUT (*ONCORHYNCHUS MYKISS*)

PEDRO CUNHA, PETER SKOV
Section for Aquaculture, The North Sea Research Centre, DTU Aqua, Technical University of Denmark, Hirtshals, Denmark

As aquaculture quickly grows, there is increased focus on using aerobic endurance training as a tool to improve growth and welfare of farmed fish. Optimal swimming speed is considered to be the swimming speed at which fish expend the least amount of energy per unit distance travelled, and is generally coincided to be the swimming speed that is most beneficial in terms of improved growth. Any changes in optimal swimming speed (Uopt) in relation to body length of the fish appears to be less clear, possibly because this is considered accounted for by expressing swimming speed in body length units. In rainbow trout, Uopt is generally accepted to be 1 bls^{-1}. The effects of fish size on Uopt and cost of transport (COT) were investigated in rainbow trout (*Oncorhynchus mykiss*). Fish were housed in circular polyethylene tanks with a water volume around 600L supplied by a RAS system. Trout were randomly selected for a swim trial in a swimming respirometer by increasing the water flow in increments of 0.5 body lengths per second ($BL.s^{-1}$) until fatigue. All differences in variance between groups were evaluated using *F*-tests, and single linear regression analysis by using the "least squares" method was used to compare optimal swimming speed (Uopt) and critical swimming speed (Ucrit), with body mass (BM), standard length (SL), blocking index, stride length, tailbeat frequency (TBF), hepatosomatic index (HSI), viscerosomatic index (VSI), tailbeat amplitude (TBA) and red muscle index (RM). Both Uopt and Ucrit showed similar interactions with the variables in question. These were found to be negatively correlated with BM, SL, and Blocking index, and positively correlated with stride length and TBF. No correlation was found between speed and HSI, VSI, TBA and RM. The results show that smaller rainbow trout can achieve higher critical swimming speeds and have a proportionally higher optimal swimming speed. The main reason for this appears to be the ability to reach higher tail beat frequencies in combination with a greater stride length, which in turn results from less hydrodynamic drag. Therefore, we hypothesize that the rainbow trout might not be the

odd one out when it comes to benefiting from exercise training, and it could just be that size differences unaccounted for justify the suboptimal SGR and overall poorer growth seen in previous studies.

Keywords: *Rainbow trout, swimming, size, cost of transport, respirometry*

SWIMMING PERFORMANCE AND OXYGEN CONSUMPTION RATE OF *PERCA* SPP IN RELATION TO SALINITY AND HABITAT ORIGIN

CHRISTENSEN, EAF[1], STIEGLITZ J[2], GROSELL M[2], STEFFENSEN JF[1]

[1]*Marinbiological Section, Department of Biology, University of Copenhagen, Strandpromenaden 5, 3000 Helsingør, Denmark.*
[2]*Department of Marine Biology and Ecology, Rosenstiel School of Marine and Atmospheric Science, University of Miami, 4600 Rickenbacker Causeway, Miami, FL 33149, USA.*

Swimming performance and metabolism are important traits for fish fitness, and are affected by abiotic factors in the environment. In the present study, oxygen consumption rate and critical swimming speed were measured at salinities of 0 and 10 on European perch (*Perca fluviatilis*) and yellow perch (*Perca flavescens*) originating from fresh water and European perch originating from brackish water (salinity of 10). Standard metabolic rate, active metabolic rate, and maximum metabolic rate were unaffected by salinity. The critical swimming speed and optimal swimming speed were higher in fresh water for the freshwater yellow perch and European perch, whereas it was unaffected by salinity for the brackish water European perch. The results show that the cost of osmoregulation is negligible on metabolism in *Perca* species, and that the effects of salinity on swimming performance and the cost of transport depend on the habitat origin of the fish, rather that species, within the *Perca* genus.

Key words: active metabolic rate, critical swimming speed, brackish water, maximum metabolic rate, optimal swimming speed, standard metabolic rate

REARING JUVENILE BROWN AND RAINBOW TROUT IN EARTHEN PONDS WITH AND WITHOUT FLOW

STEFAN REISER[1], NIKO SÄHN[2], DOMINIQUE MARIE POHLMANN[2], MARC WILLENBERG[1], ULFERT FOCKEN[2]
[1]*Thünen Institute of Fisheries Ecology, Palmaille 9, 22676 Hamburg, Germany*
[2]*Thünen Institute of Fisheries Ecology, Wulfsdorfer Weg 204, 22926 Ahrensburg, Germany*

Despite recirculating aquaculture systems (RAS) and semi-RAS are becoming more and more popular throughout Europe, the use of earthen ponds for salmonid farming is still very common in German aquaculture. This is particularly true for small-scale trout farms. Though some flow is present inside earthen ponds, flow conditions are rarely optimized in order to stimulate a moderate and sustained aerobic exercise promoting swimming enhanced growth. Salmonid farmers, however, commonly use technical devices for water oxygenation and degassing, e.g. paddle wheel aerators, which might also be used to establish a continuous flow inside the ponds. In collaboration with a local trout farmer, we provided two earthen ponds with two paddle wheel aerators each. We aligned the aerators in order to establish a circular and continuous flow inside the ponds. After flow patterns were measured with a magnetic flow meter, one pond was stocked with juvenile brown trout while the other one was stocked with rainbow trout, respectively. We stocked two additional and similar earthen ponds without flow as control. Fish were fed to apparent satiation and length and weight were determined in regular intervals. Following 111 (rainbow trout) and 169 (brown trout) days, random samples from each of the ponds with and without flow were collected to analyze whole body composition of the fish. The paddle wheel aerators were found to generate a heterogeneous flow field inside the ponds, providing the fish with flow conditions that have been previously shown to enhance growth in salmonids. However, there was no significant difference in growth of brown and rainbow trout reared with and without flow. Indeed, proximate body composition differed between flow conditions and brown trout reared with flow had higher crude protein content but lower crude lipid content in dry matter when compared to brown trout reared without flow. In rainbow trout, specimens reared with flow had higher crude

ash and lower energy density. Alongside oxygenation and degassing, paddle wheel aerators can also be used to induce flow inside earthen ponds at no extra cost. Power and output of the aerators, however, must be adjusted to match flow speeds to body size of the reared fish.

Keywords: aquaculture; swimming enhanced growth; salmonids

COMPARISON OF SWIMMING CAPACITY OF *ACIPENSER GUELDENSTAEDTII*, *ACIPENSER RUTHENUS* AND HYBRID STURGEON (*ACIPENSER GUELDENSTAEDTII* × *ACIPENSER RUTHENUS*)

LORENA DEDIU, RALUCA CRISTINA ANDREI (GURIENCU), VICTOR CRISTEA, MOGODAN ALINA, ANGELICA DOCAN, IULIA GRECU

Dunărea de Jos University of Galați, Faculty of Food Science and Engineering, Department of Food Science, Food Engineering, Biotechnology and Aquaculture, Domneasca street, 47, Galati, Romania

The sturgeons represent an extremely valuable natural heritage of the Danube River Basin from biodiversity, scientific perspective and socio-economical points of view (Parachiv er al, 2016). Nowadays, only four out of six native sturgeon species can be found in Danube River Basin: beluga sturgeon (*Huso huso*), stellate sturgeon (*Acipenser stellatus*), Russian sturgeon (*Acipenser gueldenstaedtii*) and sterlet (*Acipenser ruthenus*). Because sturgeon populations are near extinction, the International Union for Conservation of Nature (IUCN) listed all sturgeons as an endangered species group, highlighting the need of special conservation programs (Boscari et al., 2016). Currently, knowledge about sturgeon swimming behavior and respiratory physiology is still limited, certain aspects being still unknown. Better understanding of swimming capacity of different sturgeon species will bring an important contribution to understanding their migratory behavior.

The aim of the present study was to evaluate the swimming capacity of *Acipenser gueldenstaedtii, Acipenser ruthenus* and hybrid sturgeon (*Acipenser gueldenstaedtii* × *Acipenser ruthenus*). The trials were performed in swimming respirometer, in lab, at 22□. Swimming behavior was video-recorded before, during and after the swimming experiments.

Thus, critical swimming speed (U_{crit}), optimal swimming speed (U_{opt}), mass specific oxygen consumtion rate (MO_2), standard metabolic rate (SMR), routine metabolic rate (RMR), active metabolic rate at U_{crit} (AMR_{crit}) and at U_{opt} (AMR_{opt}), the minimum cost of transport at U_{opt} (COT_{min}) and the scope of activity were determined and compared among species. The U_{crit} was found to be

2.07 ± 0.03 body lengths (bl) s^{-1} for *A. gueldenstaedtii*, 2.77 ± 0,15 bl s^{-1} for *A. ruthenus* and 1,68 ± 0.17 bl s^{-1} for the hybrid. The standard metabolic rate registered 145,61 ± 47,41 mg O_2 kg^{-1} h^{-1} for hybrid, 147,47 ±44,69 mg O_2 kg^{-1} h^{-1} for Russian sturgeon and 213,48 ±61,39 mg O_2 kg^{-1} h^{-1} for sterlet. The lowest maximum metabolic rate (410, 83 ±65,01 mg O_2 kg^{-1} h^{-1}) resulting in a low metabolic scope (265,22 ±35,26 mg O_2 kg^{-1} h^{-1}) was found in hybrid sturgeon. Whit a similar body mass (450g), sterlet showed approximately 25% higher values for U_{crit} compared with Russian sturgeon and hybrid sturgeon.

Key words: respirometry, sturgeon, swimming behavior.

MODELLING OXYGEN AVAILABILITY WITHIN AQUACULTURE SEA-CAGES – THEORETICAL VS. REAL-TIME MEASUREMENTS

HEIDRIKUR BERGSSON
Marine biological section, University of Copenhagen,
Strandpromenaden 5, 3000 Elsinore, Denmark.

Oxygen availability is a key parameter in ensuring food intake and optimal growth of cultured fish. The current study modelled the oxygen availability for rainbow trout (*Oncorhynchus mykiss*) within a sea-cage, using the physical dimensions, density of fish and growth throughout the year of a typical aquaculture pen used in Denmark. A simple model was based on data obtained from measuring oxygen consumption (MO_2) in rainbow trout at different water velocities using a swimming respirometer as well as historical literature data. This simple model indicates that hypoxia can occur in the cage, especially during late summer with warm and slow moving water. If this is the case, the fish will not be able to digest the administered feed, and reduce their growth rates. Using this hypothesis, an advanced model will be constructed using data from an automated CTD profiling buoy, with additional measurements of oxygen and current velocities throughout the water column several times a day. By continuously receiving data from the profiling buoy, the advanced model will be able to indicate when and which quantities of feed should be administered by the aquaculture farmers at any given time.

Key words: Aquaculture, Computer modelling, Rainbow trout, oxygen availability, real-time measurements

FISH FARMER'S PERCEPTION OF THE NEED FOR FISH EXERCISE IN AQUACULTURE – CASE STUDY IN CROATIA AND FYR MACEDONIA

ANA GAVRILOVIĆ[1], ALEKSANDAR CVETKOVIKJ[2], DAMIR KAPETANOVIĆ[3]

[1]*Juraj Dobrila University of Pula, Department of Natural and Health Sciences, Zagrebačka 30, 52100 Pula, Croatia,*
[2]*Faculty of Veterinary Medicine, Lazar Pop-Trajkov 5-7, 1000 Skopje, Fyr Macedonia*
[3]*Ruder Boskovic Institute, Bijenicka cesta 54, 10000 Zagreb, Croatia*

Recent scientific results indicate that sustained fish exercise at optimal speeds enhances muscle growth, has a positive effect on meat quality, fish reproduction and survival and stimulates the immune system of fish. A reduction in aggressive behavior was also reported.
The aim of this study was to evaluate the perception of fish farmers of fish on exercise. A survey was performed at 19 fish farms in Croatia and Macedonia that included ten trout farms and a nine sea bass and sea bream farms. Ten farms utilized flow through technology, eight used cage technology and one was RAS facility. A questionnaire was prepared following the instructions given by Working Group 3 - Exercise in aquaculture, during the Annual FITFISH conference in April 2017.
The results showed that 57,89 % of the total number of respondents were aware of the impact of exercise on fish in aquaculture, while 78,95 % assumed that it could be beneficial for their farm. 70% of freshwater fish farmers considered that they have adequate capacity to regulate exercise in fish, although only 30% of them can regulate the flow rate. Among marine fish farmers, only 37,5% responded positively to the question referring to their capacity to regulate fish exercise. The rest of them considered that exercise is not applicable in cage technology, because flow rate is regulated by water current and by proper net changing ie. proper hygiene.
None of the respondent knew the optimal water velocity for their species, even 42,1 % of them agreed that water velocity is considered an important factor for the fish condition. Most of them considered that it depends on the size and fish species.
47,37% of the surveyed farms would like to participate in a project on fish exercise, while 84,21% could see an advantage in increasing

production volume or shortening production time. 63,16% of the total respondents would like to have project results shared with them. Presented results suggest that more intense dissemination of results of the projects on fish exercise would be beneficial for fish farmers in the investigated areas.

Key words: fish exercise, aquaculture, fish farmer's perception

EX SITU CONSERVATION OF ENDEMIC SOFT MOUTHED TROUT *SALMO OBTUSIROSTRIS OXYRHINCUS* (HECKEL, 1851) WITH THE VIEW OF RESTOCKING THE POPULATION IN THE BUNA RIVER – IMPLICATIONS FOR AQUACULTURE

SANEL RIĐANOVIĆ[1], LEJLA RIĐANOVIĆ[1], DENISA ŽUJO ZEKIĆ[1], PAVLE SPASOJEVIĆ[1], EMINA ADEMOVIĆ[1]
[1]*Department of Biology, Dzemal Bijedic University Mostar*
Univerzitetski kampus bb, Mostar 88000, Bosnia and Herzegovina

The Buna River is the most significant tributary of the longest river in the Dinaric Alps, the Neretva River. It is a natural spawning site for majority of endemic fish species from lower catchments of the Neretva River. This site was recognised as a conservation zone and a single possible site for survival of a range of endemic species, according to which the entire area was declared a Protected Area of Nature. The nucleus of a thriving part of soft mouthed trout population is located in part of the Neretva River downstream from the Mostar hydropower plant, and in the Buna River. It has however, become critically endangered (CR) in Bosnia and Herzegovina, due to overharvesting, habitat degradation and introgression with brown trout. The efforts are underway to conserve this species through *ex situ* breeding program and restocking. We have successfully produced a thriving soft mouthed trout fry population, under controlled conditions at a fish farm. The key objective was maintenance of genetic diversity. The selection of parental lines was based on condition index, body mass index and peak body form. The results show that mortality of breeding individuals was 18.88% at spawning, the percentage of unfertilised roe was 15.19%, the loss of fertilised roe was 15.16%, while the total loss of roe was 28.50%. The fry hatched 30 days after spawning, and started feeding nine days later. Total mortality at this stage was 8.59%. Fingerlings aged six months, 6.5-7.5 cm in length, were selected for restocking. From the start of feeding to restocking, mortality was 31.88%. The highest mortality was in June and July, while the lowest was in September. Fingerlings aged 6-12 months were either used for restocking or selected as breeding stock. The total mortality was 22.85%, with the highest rate observed during December and January. Restocking with selected population was successfully implemented. The Buna River environment offers ideal conditions for survival of fingerling.

Restocking of *Salmonid* species is usually done once a year in late summer. Future studies should be conducted *in situ* to determine the rate of survival and attainment of sexual maturity of restocked fish.

Key words: conservation, aquaculture, soft mouthed trout, IUCN Red List, endangered species

MORTALITY OF SILVER EELS IN HYDROPOWER TURBINES AND MIGRATION PATTERNS IN LOWLAND RIVERS AND LAGOONS IN THE NORTH- EASTERN REGION OF THEIR DISTRIBUTION RANGE

SAULIUS STAKĖNAS[1], JUSTAS DAINYS[2]
[1]*Nature Research Centre, Laboratory of Ecology and Physiology of Hydrobionts*, Akademijos str. 2, 08412, Vilnius, Lithuania
[2]*Nature Research Centre, Laboratory of Marine Ecology*, Akademijos str. 2, 08412, Vilnius, Lithuania

Silver eel mortality was estimated for 4 different HPPs in Lithuania. Mortality was estimated using RFID (Radio Frequency Identification, passive integrated transponders) tags and acoustic telemetry in a large HPP (>100 MW) with Kaplan turbines, a small HPP (<1 MW) with a Kaplan turbine and a fish passage, and for the first time in two small HPPs (<1 MW) with CINK turbines. The results supported a hypothesis that the mortality rate of migrating eels depends mainly on the type and size of the turbine. HPP induced mortality varied from 100% in a small CINK turbine down to 25% in the large HPP with Kaplan turbines. The importance of simple mitigation measures was highlighted by 34% of all tagged eels bypassing one of the HPP via an adjacent fish passage constructed for upstream migration of salmonids. The observed differences in mortality provide essential information for long term strategies designed to restore depleted eel populations in Lithuania and other European countries. Escapement success and migration patterns of silver eels *Anguilla anguilla* (L.) was studied by acoustic telemetry in three natural free- flowing and one dammed river and in Curonian Lagoon in Lithuania. Mean downstream migration speed and escapement success were almost the same in the shorter 210 km dammed river (52%, 13.6 km/day) and the considerably longer 300–480 km free- flowing rivers (53%, 10.7 km/day). Despite the similarity between migration speed in the Curonian Lagoon (14.6 km/day) to that in rivers, migration success was significantly higher (71%) in the Lagoon. Although a majority of silver eels in Lithuania start migrating downstream in spring, the peak of eel migration into the Baltic Sea was observed during late fall. Overall migration success in the rivers and the Lagoon was 35%. Relatively low escapement may have negative consequences on the success on eel stock restoration and must be addressed when strategically planning for the production of spawners.

Anguilla anguilla, CINK turbine, eel migration, hydropower, Kaplan turbine

MOVEMENTS OF THE GIANT CATFISH IN THE DANUBE RIVER DETERMINED BY ACOUSTIC TELEMETRY

MIRJANA LENHARDT[1], STEFAN HONT[2], SLAĐANA SPASIĆ[1], RADU SUCIU[2], MIROSLAV NIKČEVIĆ[1], MARIJA SMEDEREVAC-LALIĆ[1]

[1]*Institute for Multidisciplinary Research, Kneza Višeslava 1, 11000 Belgarde, Serbia*

[2]*Danube Delta Institute for Research and Development, 165 Babadag Street, 820112 Tulcea, Romania*

A giant catfish (*Silurus glanis*) was caught downstream of Djerdap II dam (Danube River, 863 rkm) and tagged with an ultrasonic transmitter (Vemco Ltd, V16PT) equipped with depth and temperature sensors. Records of the transmitter were obtained from nine autonomous receivers (Vemco Ltd., VR 2W) installed in 2015 downstream of Djerdap II Dam along Serbian and Romanian banks, as well as in the vicinity of Romanian shiplock and upstream Romanian turbines. The first signals were recorded on April 28, 2015 and the last on February 13, 2017. Altogether 59,250 and 59,120 measurements were recorded of depth of the catfish and the surrounding water temperature, respectively. The greatest numbers of signals were recorded by the two receivers, which were closest to the location where the catfish was caught (72.3% and 27.1% of signals, respectively) while only 0.6% of signals recorded on other receivers. The mean catfish depth was 8.4 m while minimum and maximum recorded depths were 1.2 m and 16.2 m, respectively. The catfish made a spawning migration from 9 to 29 May 2016, triggered by decrease in water level and water temperature of 16.0 ^{o}C. During that period, the catfish left the area downstream of the dam and migrated along the Gogos branch to the Romanian shiplock, and then continued moving to the hydropower plants some 3 and 12 kilometers upstream, respectively. These most upstream obstacle blocked further migration of catfish. Temperatures recorded from the sensors on the catfish overlapped the measurements water temperature obtained from hydrologic station at Gruia (851 rkm) except for two periods, one from 10 to 27 June 2015 when temperature were from 1^{o}C to 2.8 ^{o}C higher than water temperature, and another from 18 to 28 July 2016 when the telemetered temperatures were from 2^{o}C to 2.7^{o}C lower than water temperature. Diel changes in depth were also determined for the catfish during different months of the year. During

winter the catfish stayed at the same depth during all day, while during summer more changes in depth were recorded during the night. During the spring and autumn changes in depth were recorded in the start of the day from 00:00 to 04:00. Results obtained using transmitters and automated monitors showed that this catfish exhibited high site fidelity, changes in depth at certain times possibly related to its searching for prey, and an upstream spring migration for spawning.

Key words: Vemco V16 TP acoustic tag, temperature and depth sensors, circadian rhythm, dam

MIGRATION PROBLEMS OF THE BLACK SEA ROACH (*Rutilus frisii*)

ÖZCAN GAYGUSUZ, DEVRİM MEMİŞ, GÖKHAN TUNÇELLİ, MERİÇ ALBAY
İstanbul University Faculty of Aquatic Sciences, Ordu Street No 8, Laleli-İstanbul

Rutilus frisii-Black Sea Roach which is located in lakes, rivers and brackish water in Black Sea and Caspian Sea region is a potamodrome species. This species evaluate in The IUCN Red List of Threatened Species as least concern (LC). Black Sea Roach lives in Iznik and Terkos Lake in the Marmara Region in Turkey, and the second most captured natural fish species after the invasive fish species *Atherina boyeri*-Big Scale Sand Smelt in Iznik Lake. Black Sea Roach, which people living in the vicinity of Lake Iznik, consume fondly, is the most capture during the breeding season. Black Sea Roach migrate to Sölöz Stream and Çakırca Stream and other small rivers that flow into the İznik Lake in April-May when temperature reaches 8°C, peaking at 13-15°C. It prefers to water source region with stony-pebbly grounds for breeding. The breeding of the species occurs in the III.-V. age groups (>40 cm). Larvae and early juveniles feed on zooplankton, algae and insect larvae. Adults feed mainly on molluscs and crustaceans, supplemented by other benthic invertebrates. Stops feeding while migrating, spawning and overwintering. In addition, *R. rutilus*, *Squalius cii* and *Vimba vimba* species are also migrating to the İznik Lake. Causes such as bridge legs built on rivers, overfishing, flood retarding dam, sediment losing (e.g. sand quarry), pollution and using of stream water in agricultural irrigation affect the reproductive migration negatively. In this study, the conditions that negatively affect the breeding of Black Sea Roach in İznik Lake Basin have been evaluated and the key of the situation have been discussed.

***Key words**: Rutilus frisii, Black Sea Roach, İznik Lake, migration, obstacles*

NOTES

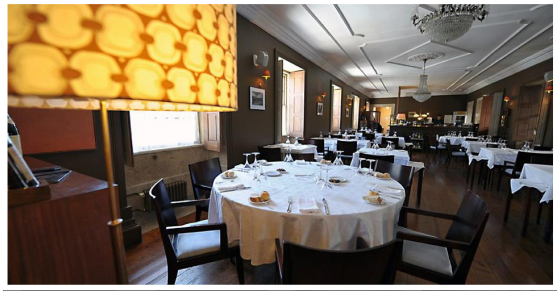
On the 20th April 2018, the conference dinner will be held at the:

Casa Agrícola Restaurant

Address: Shopping Cidade do Porto, Rua do Bom Sucesso # 241
4150-150 Porto
Telephone: +351 226 053 350
Email: geral@casa-agricola.com
Website: www.casa-agricola.com/

How to get there:

- 200 mts from HF Fenix and HF Tuela Hotels.
- Metro (Casa de Musica stop), 400 mts
- Other public transportation (several lines buses, taxi, UBER and Cabify).
- By car. Shopping Cidade do Porto parking.



Contact of local organizer:

Leonardo Magnoni (CIIMAR)

Phone: (+351) 22 340 18 32

E-mail: lmagnoni@ciimar.up.pt