FITFISH ANNUAL CONFERENCE

22nd April 2016
Hotel Palace
Belgrade, Serbia

INDEX

Drage kolege,
ovim putem Vas pozdravljamo i želimo dobrodošlicu na godišnju konferenciju "Plivanje riba i implikacije za migraciju i akvakulturu (FITFISH)" u okviru COST Akcije FA1304. Tri glavne teme koje su povezane sa ciljevima FITFISH Akcije i koje će biti predstavljene na godišnjoj konferenciji su: funkcionalni mehanizmi odgovorni za korisne efekte plivanja, migracije riba i vežbe u akvakulturi. Godišnja konferencija će dati sintezu napretka postignutog u saznanjima iz oblasti efekata vežbi na rast i dobro stanje riba, kao i implementaciju tog znanja u akvakulturi, za praćenje riba, za biološka rešenja u optimizaciji migracije riba i modeliranju efekata na populacije.

Nadamo se da će konferencija obezbediti stimulativnu sredinu za mnoge interesantne diskusije.

Mirjana Lenhardt (Lokalni organizator)
Josep Planas (Potpredsednik FITFISH Akcije)
Arjan Palstra (Predsednik FITFISH Akcije)

Dear Colleagues,
We would like to welcome you to the 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.

Mirjana Lenhardt (Local organiser)
Josep Planas (FITFISH Action Vice Chair)
Arjan Palstra (FITFISH Action Chair)

Annual conference of FITFISH project will be held at the Palace Hotel

The Palace Hotel Beograd is located in the very heart of Belgrade, in close vicinity to the main pedestrian zone of Knez Mihailova Street and conveniently located in a quiet part of town near the historical and cultural attractions, city and state institutions, museums, theatres, cinemas, numerous shopping centres and Skadarlija – the old Bohemian quarter.

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Web site
http://www.palacehotel.co.rs/en/

FRIDAY, APRIL 22, 2016
Room: The conference room on the top floor of the *Palace* hotel

ORAL PRESENTATIONS

8.30 **Registration of attendance**

9.00 **Stress axis regulation and its role in exercise-enhanced growth**
Marcel Schaaf (Institute of Biology, Leiden University, the Netherlands)

9.30 **Orientation and navigation of the European eel using the Earth's magnetic field**
Caroline Durif (Institute of Marine Research, Norway)

10.00 **Optimal fins and flows underpin reef fish swimming efficiency**
Chris Fulton (The Australian National University, Canberra, Australia)

10.30 **Coffee-break**

11.00 **Exercising Atlantic salmon in fluctuating water current: Consequences for performance in aquaculture production**
Øyvind Øverli (Faculty of Veterinary Medicine and Biosciences, Oslo, Norway)

11.30 **Electronic tracking advances reveal migratory movements of sturgeon in Sacramento/San Joaquin watershad**
Pete Klimley (University of California, USA)

12.00 **Lunch break**

13.30 **COST Action FA1304 FITFISH, WG1 - Functional mechanisms behind the beneficial effects of swimming**
Paolo Domenici (CNR-IAMC, Italy)

13.50 **COST Action FA1304 FITFISH, WG 2 - Fish migration: Status and progress**
Leo Nagelkerke (Wageningen University, The Netherlands)

14.10 **COST Action FA1304 FITFISH, WG3 - Exercise in Aquaculture**
Helgi Thorarensen (Holar University College, Iceland)

14.30 **COST Action FA1304 FITFISH, WG4 - Transfer of knowledge to end users**
Simon MacKenzie (University of Stirling, United Kingdom)

14.50 **COST Action FA1304 FITFISH, WG5 - Training of early stage researchers: Status and progress**
Mirjana Lenhardt (Institute for Multidisciplinary Research, University of Belgrade, Serbia)

15.10 **Coffee-break**

15.45 **Effect of short-term regulated temperature variations on the swimming economy of Atlantic salmon**
Carlos Manuel Alexandre (Universidade de Évora, Portugal)

16.00 **Assessing the influence of individual variation in coping styles on swimming performance in zebrafish (*Danio rerio*)**
Sonia Rey Planellas (University of Stirling, United Kingdom)

16.15 **DIDSON training course**
Beata Schmidt (National Marine Fisheries Research Institute, Gdynia, Poland)

16.30 **Application of high tech sonar techniques for the monitoring of fish migrations in the Danube River (Serbia)**
Marija Smederevac-Lalić (Institute for Multidisciplinary Research, University of Belgrade, Serbia)

16.45 **Swimming exercise to control early maturation in male sea bass (*Dicentrarchus labrax*)**
Marco Graziano (University of Barcelona, Spain)

17.00 **Posters and drinks**

FRIDAY, APRIL 22, 2016
Room: The conference room on the top floor of the *Palace* hotel

POSTERS

P1 **Movements and home ranges of *Capoeta angorae* in River Ceyhan, Turkey**
Ahmet Alp (Department of Fisheries, Faculty of Agriculture, University of Kahramanmaraş, Turkey)

P2 **Simulated migration of feminised eels to stimulate and predict the sexual maturation response**
Thijs Bohm (Animal Breeding and Genomics Centre, Wageningen, the Netherlands)

P3 **Restoration of fish migration on the Danube focusing on the main migration barrier - the Iron Gates hydropower dams between Romania and Serbia**
Mirjana Lenhardt (Institute for Multidisciplinary Research, University of Belgrade, Serbia)

P4 **Danube sterlet morphometrics and genetic - guidelines for restocking programs**
Gorčin Cvijanović (Institute for Multidisciplinary Research, University of Belgrade, Serbia)

P5 **Swimming at low ammonia levels: improved growth and performance?**
Gudrun De Boeck (Department of Biology, University of Antwerp, Belgium)

P6 **Application of an underwater positioning system for long-term observation of fish behaviour and habitat use**
Riha Milan (Biology Centre, Institute of Hydrobiology, Ceske Budejovice, Czech Republic)

P7 **The marine migration and swimming depth of sea trout (*Salmo trutta* L.) in South-Icelandic coastal waters**
Johannes Sturlaugsson (Laxfiskar, Fornubudir, Hafnarfjordur,Iceland)

P8 **The story of Eurasian shads (*Alosa* sp.): genomics, morphometrics, life history and adaptation**
Katarina Tošić (Faculty of Biology, University of Belgrade, Serbia)

ABSTRACTS:
ORAL PRESENTATIONS

STRESS AXIS REGULATION AND ITS ROLE IN EXERCISE-ENHANCED GROWTH

MARCEL J.M. SCHAAF, CHRISTIAN TUDORACHE, HANS SLABBEKOORN, ARJAN P. PALSTRA
Institute of Biology, Leiden University, The Netherlands

Upon stress, the steroid hormone cortisol is secreted form the adrenal gland, and this secretion is tightly controlled by the stress axis or hypothalamus-pituitary-adrenal (HPA) axis. Individual variation in the secretion of cortisol and feedback control of the HPA axis exists, and we use the zebrafish and its equivalent hypothalamus-pituitary-interrrenal (HPI) axis to identify determinants of this variation. First, we have performed a forward-genetic screen in which the pituitary mRNA expression of *pomc* was used as readout. As a result of this screen three zebrafish mutants have been identified that are resistant to GC suppression of the HPI axis, which were previously not known to be involved in HPA axis regulation. Second, we have separated two groups of zebrafish in a behavioral assay, in which they were placed in one compartment and allowed to emergence into a second compartment. The group of first emergers showed a significantly different cortisol response to stress than the group of late emergers. Using transcriptome profiling by RNA sequencing on the brains of these fish, we are currently investigating which factors underly these differences. Finally, we have studied the effect of HPI axis activity on exercise-enhanced growth. We showed that cortisol levels are increased in adult zebrafish that are subjected to an exercise regime. Subsequently, we used a zebrafish line with a point mutantion in the gene encoding the glucocorticoid receptor (responsible for mediating the effects of cortisol), creating a functional knockout. In these mutants, exercise resulted in a larger growth enhancement compared to wild type fish. Apparently, cortisol inhibits exercise-enhanced growth in wild type fish. In order to study the molecular mechanism behind this effect of cortisol, muscle tissue was taken from the fish, RNA was extracted and a transcriptome analysis was perfromed using RNA sequencing.

NOTES

ORIENTATION AND NAVIGATION OF THE EUROPEAN EEL USING THE EARTH'S MAGNETIC FIELD

CAROLINE DURIF
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The European eel migrates long distances between its spawning grounds in the Sargasso Sea and its growth area, which spreads, all over Europe, from northern Norway and far into the Mediterranean. Eels constitute one single population and thus have unique spawning grounds where all sexually mature eels gather at the end of their lifecycle. Therefore, eels need robust orientation cues to guide their short- and long-distance migrations. The Earth's magnetic field can provide directional and positional information to an individual that possesses magnetosensitivity. The geomagnetic field is characterized by intensity and direction; both vary more or less along a latitudinal gradient. Different species may respond to both or to different parameters of the geomagnetic field (declination, inclination, and intensity). Specific behavioral responses can be tested using electrical coil systems which can subtly modify earth-strength magnetic fields. Such a facility has been used to study the orientation mechanisms of juvenile and adult European eels, namely glass eels, yellow and silver eels. Our experiments involved shifting the direction of magnetic north to all four cardinal points and observing the swimming and escape behavior of individual eels. For juvenile glass eels, trials were also carried *in situ* using a drifting circular arena in a Norwegian fjord. All eel stages showed significant compass orientation. Nearly all glass eels tested exhibited a tidal-dependent directional orientation *in situ*, and 72% of the same eels showed the same orientation during the ebb tide when tested in the laboratory under a manipulated simulated magnetic field and in the absence of any other cue. These results demonstrate that glass eels possess a magnetic compass that they use to orient and that is linked to their endogenous circatidal clock.

Yellow and silver eels also oriented significantly in a manner that was related to ambient temperature and to a transitory displacement immediately before the test. Taken together, these results show that eels probably derive positional information from the Earth's magnetic field during their transatlantic migration to navigate to their distant spawning grounds. This would involve imprinting the location of the spawning grounds by larvae as they approach the continental shelf. We simulated this possibility with regards to secular variation and the physical properties of the geomagnetic field over the course of their hypothetical migratory route. Understanding the eel's orientation and navigation mechanisms is crucial to evaluating the potential effectiveness of current management measures which typically involve translocating juvenile eels 100s to 1000s of km from their recruitment location.

NOTES

OPTIMAL FINS AND FLOWS UNDERPIN REEF FISH SWIMMING EFFICIENCY

CHRISTOPHER J. FULTON[1], JOHN F. STEFFENSEN[2], JACOB L. JOHANSEN[3]
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[2]*Marine Biological Section, University of Copenhagen, Helsingør, Denmark*
[3]*Marine Science Institute, University of Texas, Austin, USA*

Fish utilize a range of locomotor structures and forces during propulsion, which can deliver vastly different levels of speed performance and efficiency. For example, oscillating locomotor structures can be optimised for either lift or drag-based propulsion that delivers peak thrust at high or low speeds. As a result, the flow environment in which a fish may thrive may be linked to their particular suite of locomotor traits. Using a collection of case studies on coral reef fishes, we discuss the implications of locomotor form and function for the swimming speed performance and energetic efficiency of reef fishes occupying vastly different habitat flow environments. We examine the hypothesis that different fin morphologies, optimised for either drag or lift-based propulsion, provide a cost of transport minima at markedly different speeds. We then explore whether two different gaits (labriform, carangiform) deliver different levels of swimming speed efficiency within two closely related species. In doing so, we demonstrate how coral reef fishes display locomotor traits, speed performances, and energetic efficiencies that are strongly adapted to their occupation of low or high flow environments. Our findings suggest that fish raised in captivity should be provided with flow speeds matching the level of speed performance suited to their locomotor traits, so that individuals can maintain a minimum cost of transport and dedicate more energy to somatic growth.

NOTES

EXERCISING ATLANTIC SALMON IN FLUCTUATING WATER CURRENT: CONSEQUENCES FOR PERFORMANCE IN AQUACULTURE PRODUCTION

ØYVIND ØVERLI[1], TOM HANSEN[2], TORE S. KRISTIANSEN[2], OLE FOLKEDAL[2]
[1] Norwegian University of Life Sciences, Faculty of Veterinary Medicine and Biosciences, P.O. Box 8146 Dep, 0033 Oslo, Norway
[2] Institute of Marine Research, P.O. Box 1870 Nordnes, 5817 Bergen, Norway

This experiment was carried out at the Matre research station of the Institute of Marine Research. Atlantic salmon parr were distributed in 12 square indoor tanks (0.5 m^3) on the 29th of June 2015. The fish were second-generation double haploid (clones), representing two lines provided in even numbers for each tank (40 fish per line per tank). Bulk weighing of fish (n=40) at transfer showed an average weight of 3.48 and 3.43 g for line 1 and 2 respectively. The fish were kept at a stable fresh water temperature of 12 C and under continuous light, except for a 12:12 light regime employed from October 12. to December 15. to induce smoltification. Control groups (triplicate tanks) were kept at a stable water flow at 10 L/min initially, in exercise groups the water flow was periodically doubled (12 h periods, 3x weekly) and tripled (2h periods, 6x weekly). An additional experimental group were on a daily basis exposed to stress by draining tanks to a water level of 4 cm for 5 minutes. Upon vaccination prior to seawater transfer (December 2015) samples were obtained from each group, revealing that fluctuating increases incurred a significant weight advantage, while fish exposed to long-term intermittent stress had grown less than controls. The plasma cortisol response to handling and vaccination was somewhat increased in control fish compared to both other treatments, however this trend did not reach statistical significance. Future studies will asess the effect of fluctuating water current and exercise on other aspects of stress coping, robustness, and immunocompetence of salmon in aquaculture.

NOTES

ELECTRONIC TRACKING ADVANCES REVEAL MIGRATORY MOVEMENTS OF STURGEON IN SACRAMENTO/SAN JOAQUIN WATERSHED

PETER A. KLIMLEY
Department of Wildlife, Fish, and Conservation Biology, Director, Biotelemetry Laboratory, University of California, Davis, One Shields Avenue, Davis, CA 95616

Green (*Acipenser medirostris*) and white sturgeon (*Acipenser transmontanus*), two distinct species with disparate life histories, reside in the Sacramento/San Joaquin Watershed and pose different challenges related to conservation and management. Green sturgeon, a more marine species, migrate in spring to spawn in the headwaters of the Sacramento River before returning to the estuary during the fall. After their eggs hatch, the larvae are transported downstream with juveniles rearing within the Delta and San Francisco Bay. Adults migrate out the Golden Gate and travel northward along the continental shelf to the waters off Washington and Canada. By contrast, the white sturgeon appear to spawn exclusively in the lower Sacramento River watershed and remain within the San Francisco Estuary throughout their lifespan. The migratory movements of these species have been intensively studied by members of the Biotelemetry Laboratory during the past ten years. Coded ultrasonic beacons have been placed within the body cavity of individuals of both species, and their movements described with an array of 266 autonomous tag detecting monitors deployed throughout the watershed and at the mouth of rivers and bays along the western coast of North America. Recently, modem-equipped monitors have been deployed at critical sites near water diversions and stranding sites to provide resource managers with real-time information on Environet (https//ienvironet.com) about the whereabouts of migrating salmon and sturgeon. Results from these studies have been multi-faceted, including (1) descriptions of the migratory movements of juveniles and adults of both species (1) demonstration that the Red Bluff Diversion Dam blocked the upriver spawning migration of green sturgeon in the Sacramento River that resulted in the removal of the obstacle to their movements, (3) monitoring the ingress and egress of stranded green sturgeon rescued from a floodplain bypassing the city of Sacramento and showing with population viability analysis that in the absence of rescue efforts that the population would diminish in size by 33% over time, and (4) providing weekly alerts during spring 2015 that the river level did not exceed the flood state, at which the bypass was flooded, and voiding the need to rescue green sturgeon. Our recent studies of the movement ecology of both species in the watershed will be described in this symposium. For a review of the studies to be described see Klimley *et al.* (2015) at the following web link: http://escholarship.org/uc/item/7892b2wp.

NOTES

COST ACTION FA1304 FITFISH, WG1 - FUNCTIONAL MECHANISMS BEHIND THE BENEFICIAL EFFECTS OF SWIMMING

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The current knowledge on the functional mechanisms underlying beneficial effects of exercise in aquaculture will be briefly reviewed, along with past work and ideas for future studies. Potential beneficial effects that have been recognised can be categorised into three main areas : production, mitigation and selection. In particular, effects on growth, immunity, stress and agonistic behaviour, and reproduction will be discussed. Methodological aspects as well as issues that need to be improved will be presented. Future potential work should focus on understanding the bases for species-specific effects, disentangling the effects on behaviour from those on physiology, identifying the role of swimming pattern, and exploring the possibility that swimming performance could be used as a selection tool.

NOTES

COST ACTION FA1304 FITFISH, WG2 - FISH MIGRATION: STATUS AND PROGRESS

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The main objective of the FITFISH COST action is to develop a research network in which fish swimming in the wild and in aquaculture is studied for the first time under a multidisciplinary perspective. More explicitly, WG2, Fish migration aims at the exchange and integration of knowledge among scientists and experts involved in the field and to develop a research agenda aimed at generating new knowledge in the fields of 1) monitoring fish behaviour in real-life situations, using a range of well-known and high-tech techniques, 2) experimental approaches in which the effect of disturbing cues on behaviour and physiology of individual fishes is investigated, and 3) modelling the effects of mitigating measures on population dynamics. The activities of WG2 should result in: 1) An international network of fish migration experts that has international scientific, but also societal impact; 2) A research agenda aimed at generating new scientific and applied knowledge on fish migration; 3) A toolbox for the design and evaluation of effective and efficient mitigation measures for fish migration; 4) A comprehensive framework on what drives fish migration, reported in a review paper written by the partners in the project and presented at international scientific symposiums. In this presentation the achievements of WG2 during the course of the FITFISH action will be presented and evaluated.

NOTES

COST ACTION FA1304 FITFISH, WG 3 - EXERCISE IN AQUACULTURE

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Swimming is intimately linked the ability of fish to develop, survive, grow and reproduce successfully. However, current farming conditions often do not allow fish to fully display their normal swimming behaviour. Exercise can be employed as a tool in aquaculture to improve growth, health, welfare and filet quality and, at optimum levels of intensity, may be beneficial not only for athletic fish but also for species that are less known for their swimming abilities in their natural habitat. Exercise protocols that vary in duration and intensity may be developed to suit different species. In WG 3, we unite science and industry in an attempt to solve current bottlenecks in production using exercise. Furthermore, we will examine how different exercise regimes can be implemented under current conditions and in future designs of aquaculture facilities. The beneficial effects of optimal exercise may include:

- Effects on production characteristics such as improved feeding efficiency, better growth rates, and changes in muscle composition leading to higher flesh quality.
- Increased survival through increased robustness or fitness
- Increased welfare of fish and reduced stress
- Improved immune capacity
- Control of maturation.

Working group 3 organized a workshop at Aquaculture 2015 in Rotterdam where members of the scientific community and fish farmers discussed different aspects of exercise and how it can be implemented in aquaculture operations. Furthermore, the WG has produced a flyer with information on the effects of exercise on fish.

NOTES

COST ACTION FA1304 FITFISH, WG4 - TRANSFER OF KNOWLEDGE TO END USERS

SIMON MACKENZIE
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This WG aims to organise bilateral meetings between COST participants, industry and policymakers. In addition, the development of technical manuals including swimming in migratory fish and applications of exercise in aquaculture are being delivered. Furthermore, this WG has a major objective to facilitate the transfer of knowledge to end users and monitor its use. Thus far, achievements include the establishment of an information channel for stakeholders, technical manual development and in-depth discussions with end users at several International events including the 'Exercise in aquaculture' session at the past EAS in Rotterdam. A critical but supportive stance was obtained from industrial representatives serving to create a forum for further discussion in this direction. In this talk, we report upon previous activity and propose a framework for advancing discussion and activity in this WG.

NOTES

COST ACTION FA1304 FITFISH, WG5 - TRAINING OF EARLY STAGE RESEARCHERS: STATUS AND PROGRESS

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Within the frame of the FITFISH COST action, WG5 is specifically aimed at the training of Early Stage Researchers (ESRs). A survey was conducted among ESRs to collect information about their current level of expertise, skills and interests. Based on this information, theoretical and practical training schools were designed and implemented. The course "Fish Swimming: Physiology and Behaviour in Aquaculture and During Migration", from June 15-19, 2015 was organised in the Netherlands and 14 ESRs participated in the course work. The next course "Methods and practical approaches for measuring oxygen consumption in resting and swimming fish" will be organised from May 9-20 in Denmark and will provide a new opportunity for ESRs to learn more about 1) swimming performance of fish, 2) locomotor strategies, and 3) metabolic aspects of swimming and resting fish. Moreover, five Short-Term Scientific Missions (STSMs) have been supported by the Action, three of which were conducted in the field of fish swimming performance and physiology and two were related to the use of high tech sonar techniques for the monitoring of fish and their migrations. All STSM ESRs fellows will present their work orally at the Annual FITFISH conference “Swimming of fish and implications for migration and aquaculture (FITFISH)” in Belgrade on April 22, 2016. All of the above has, and will, enhance ESRs mobility, enable them to work in different scientific environments, and create and strengthen collaborations.

NOTES

EFFECT OF SHORT-TERM REGULATED TEMPERATURE VARIATIONS ON THE SWIMMING ECONOMY OF ATLANTIC SALMON

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The main objective of this study was to evaluate the changes in the swimming economy of a salmonid species, the Atlantic salmon (*Salmo salar* L.), as caused by the abrupt variation of temperature that usually occurs with hydroeletrical dams operation. The Intermittent flow respirometry technique was used to compare the metabolic rates of oxygen consumption before, during and after abrupt temperature variation. A set of control (no temperature variation) and experimental treatments (temperature variation of approximately 4◦C) were conducted in order to: i) quantify the metabolic change associated with abrupt temperature decrease, and (ii) assess if and how much time the tested fish take to resume previous physiological condition. Main results reveal that this particular species shows a strong response to sudden temperature variation, significantly reducing the oxygen consumption rate. Atlantic salmons also show a high resilience to treatment as they quickly return to initial swimming costs after reestablishment of temperature values. This Short Term Scientific Mission (STSM) successfully reached the main objectives initially defined, allowing to apply respirometry in future complementary studies on this theme and, at the same time, providing swimming performance data that can be compared with the same type of data for other freshwater fish species.

Acknowledgements: This study was performed during a Short-Term Scientific Mission supported by the COST Action FA1304 "Swimming of fish and implications for migration and aquaculture (FITFISH)."

NOTES

ASSESSING THE INFLUENCE OF INDIVIDUAL VARIATION IN COPING STYLES ON SWIMMING PERFORMANCE IN ZEBRAFISH (*DANIO RERIO*)

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The main aim of this study was to investigate the influence of coping styles on swimming performance in fish. Using the zebrafish, *Danio rerio*, as the experimental model species, we tested the hypothesis that individuals with reactive and proactive coping styles have different responses to swimming-induced activity. Zebrafish were screened for personality using two established behavioural tests: Risk taking test in groups and novel environment in isolation. Latencies to exit the shelter in groups and Duration of Appetite Inhibition (DAI) for the individual test were taken and only fish with results consistent for both tests were selected for the swimming performance test. Non-consistent animals were classified as intermediate and a group of 60 non-tested animals were kept as controls (groups of n=12 animals for each category: proactive, reactive, intermediates and naïve control fish). Swimming performance was evaluated in groups of 12-16 fish for each category group using a 30L swimming tunnel (Loligo Systems). 3 control groups were used to validate the swimming tunnel experimental system. Swimming performance was measured by subjecting fish to a step-wise speed increment protocol consisting of increasing the speed by 4.8 cm/s every two minutes. Each individual fish was visually tracked. The variables measured were the critical swimming speed (Ucrit), time to exhaustion and recovery latencies (s). Analysis of the data from the swimming tunnel test showed a significantly better swimming performance of the proactive zebrafish compared to their reactive counterparts. This was highlighted by the higher Ucrit values of proactive compared to reactive zebrafish, adjusted for the fish size. Interestingly, intermediate fish showed similar swimming performance to the proactive zebrafish. Naïve control fish, showed significantly lower swimming performance than intermediate and proactive fish. These results highlight the importance of coping styles for group composition and the swimming performance of a shoaling fish species. Our study contributes to the establishment of a relationship between behaviour and swimming performance and has important implications for fish swimming in the wild (e.g. migrations) as well as in aquaculture systems.

Acknowledgements: This study was performed during a Short-Term Scientific Mission supported by the COST Action FA1304 "Swimming of fish and implications for migration and aquaculture (FITFISH)."

NOTES

DIDSON TRAINING COURSE

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There is still a challenge to observe fish in their natural environment without exerting a significant impact on their behaviour. The usefulness of non-invasive methods, such as optical cameras, are limited in dark and turbid water. However, due to relatively low attenuation and scattering of sound waves comparing to light ones in sea water, the acoustic methods give the possibility of such non-invasive observations. The **D**ual-frequency **ID**entification **SON**ar (DIDSON) and its later version **A**daptive **R**esolution **I**maging **S**onar (ARIS) are at the forefront of all imaging sonars - they can create high-resolution digital images, approaching optical quality, in which biological targets can be positively identified in a given environment, regardless of unfavourable environmental conditions like high turbidity or bad light conditions. Imaging sonars, known as 'acoustic cameras', have a great potential in fish monitoring, especially in quantitative and qualitative observation of riverine fish migration. As there are no specialists in Poland experienced in DIDSON operation and data processing, the intensive training under the supervision of skilled experts from the Institute of Hydrobiology, Biology Centre of the Czech Academy of Sciences (IHB BC CAS) was advisable. The main aim of STSM 'DIDSON training course' was to learn DIDSON operation and data processing with particular attention focused on:

- pre-processing (data conversion, foreground and background filtering),
- target tracking (manual and automatic),
- target classification in regard to various different parameters, such as target size, target speed, direction of swimming,
- determining the detailed characteristics of fish (length, swimming speed, etc.),
- counting the number of upstream migrating fish with respect to daytime and the whole migration period.

The data used as the training set were gathered in the river Vltava (Czech Republic) during mixed-species fish migration in spring 2015. The DIDSON data were processed with the Sonar5-Pro post-processing software (Lindem Data Acquisition, Oslo, Norway). All analyses were carried out under supervision of Dr. Michal Tušer.

Acknowledgements: This study was performed during a Short-Term Scientific Mission supported by the COST Action FA1304 "Swimming of fish and implications for migration and aquaculture (FITFISH)."

NOTES

APPLICATION OF HIGH TECH SONAR TECHNIQUES FOR THE MONITORING OF FISH MIGRATIONS IN THE DANUBE RIVER (SERBIA)

MARIJA SMEDEREVAC-LALIĆ[1], MILAN ŘÍHA[2], JAN KUBEČKA[2], VLADISLAV DRAŠTÍK[2], JIRI PETERKA[2], MILAN MUŠKA[2], MICHAL TUŠER[2], ALEKSANDAR HEGEDIŠ[1], STEFAN SKORIĆ[1], MIROSLAV NIKČEVIĆ[1], BRANISLAV MIĆKOVIĆ[1], MIRJANA LENHARDT[1,3]

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In last decades, applications of high-tech sonar techniques (split-beam echosounder SIMRAD EK60 and multi-beam acoustic camera – DIDSON/ARIS) have been employed as important devices for the monitoring of fish stock, spatio-temporal distribution, migrations and behavior of fish. Endangered migratory fish species live in Serbia, and the Group for Ichthyology and Aquaculture (Department of Natural Resources and Environmental Sciences, Institute for Multidisciplinary Research, University of Belgrade) studies the migration of these species, especially sturgeons and Pontic shads, as well as other local migratory species. To study such endangered species, non-intrusive methods are best to apply because fish welfare and lowest potential harm are highly demanded. The aim of the STSM was to get training and acquire knowledge in hydroacoustic methods application and to establish collaboration with the Institute of Hydrobiology (IH), Biology Center CAS, Czech Republic. Throughout the project, IH provided a training and knowledge how to utilize the sophisticated equipment in the field data collection during August and September, and how to process collected data during October and November. Specifically, some of the acquired outcomes from the acoustic surveys were how to correctly use and deploy such equipment, how to adjust parameters while recording data, differences about fish behaviour, distribution and movements that appear during day and night, how to distinguish different types of signals that are produced during recording and to be able to recognize what is fish. Moreover, basic knowledge in post-processing of the data collected by both types of sonars using Sonar5-Pro program was given. To conclude, this STSM project provided a good basis for potential future collaboration with the hosting institute on various projects connected with fish migrations. Also, the new knowledge and experiences were presented and transferred to my colleagues in the Group of Ichthyology and Aquaculture. Practical exercises with application of new experiences were performed in Lake Sava in Belgrade, planning to continue working on the Danube River as soon as possible.

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NOTES

SWIMMING EXERCISE TO CONTROL EARLY MATURATION IN MALE SEABASS (*DICENTRARCHUS LABRAX*)

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A problem for European sea bass (*D. labrax*) aquaculture is the high incidence (20 to 30%) of precocious sexual maturation in males that become sexually mature during the first year of life. In wild males, puberty is typically accomplished after the second year of life. Precocious maturation of males, already predominant (up to 70%) in sea bass stocks, places a critical restraint on the production parameters due to the fact that a part of the production is not marketable. In the last ten years, efforts to modulate the onset of puberty in sea bass have focused in manipulating the photoperiod (24L: 0D), as previously demonstrated for other species. Sea bass males subjected to this regime for 12 months after hatching showed a decreased incidence of precocious maturation and increased somatic growth. Previous collaborative studies between Wageningen UR and the University of Barcelona, showed that sustained swimming at optimal swimming speeds resulted in a decrease of the gonadosomatic index of juvenile male sea bass. In this study, testicular mRNA expression levels of genes involved in gonadal development and growth were analyzed by qPCR in the exercised males and compared with levels in non-exercised controls. This was performed to establish the effectiveness of swimming in shifting the energy reserves that are at the base of the trade-off between growth and reproduction at the onset of puberty. Hematoxyin-eosin stained histological sections of testicular samples were examined to quantify the relative abundance of germ cells representing the different spermatogenic stages. The main results were that exercised juvenile male sea bass showed a strong decrease in the expression of genes related to steroidogenesis and gametogenesis when compared to the non-exercised controls. Specifically, expression levels of genes involved in the steroidogenic pathway such as *fshR*, *3βhsd* and *11βhsd* were down-regulated in response to swimming. We also found that the testicular expression of *erβ2* and *amh* was significantly reduced in exercised males confirming the putative role of estrogens in triggering puberty. Similarly, expression levels of *smc1β*, *inhba* and *gsdf1*, genes required for cell proliferation and differentiation, were down-regulated in swimmers, strengthening the idea that these genes are candidate targets for puberty manipulation. The performed histological analysis showed a high predominance of cysts, late spermatogonia A and a small fraction of primary spermatocytes in non-exercised males as opposed to the exercised males where no primary spermatocytes and disperse late spermatogonia A were detected thus confirming our molecular findings. Swimming exercise may therefore be an important tool to delay testicular development in this species and prevent precocious male maturation.

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NOTES

ABSTRACTS:
POSTER PRESENTATIONS

MOVEMENTS AND HOME RANGES OF *CAPOETA ANGORAE* IN RIVER CEYHAN, TURKEY

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In the two streams (Fırnız Stream and Tekir Stream) of River Ceyhan, a total of 47 *Capoeta angorae* individuals, ranging in size from 24.5 cm (138.7 g) to 46.4 cm (787.0 g) were implanted with a 26 mm-long and 9.5 mm-wide coded radio transmitters (Model: MST-930; Lotek Wireless Inc; weight 4.5 g in air; battery life 385 days on the programming on 12 hours/off 12 hours) to determine their movements and home ranges. Radio tracking was performed manually by SRX 400 telemetry receiver and yagi antenna, and the position of every tracked individual of *C. angorae* were recorded by a manual GPS and transferred to the map.
In Fırnız Stream, 16 of the 21 tagged individuals of *C. angorae* were relocated from 10 to 27 times (mean of 18 relocations per fish). The mean distance between the most upstream and the most downstream (linear home range) was 2619 m (from 123 to 4900 m). The mean 95 Kernel density home range for 16 individuals was 2260 m and mean core range (50%) was 824 m. In Tekir Stream, 18 of 26 tagged individuals were relocated from 8 to 26 times (means of 17 relocations per fish). Linear home ranges varied from 458 to 10100 m (mean 2853 m). The mean 95% Kernel density home range was estimated as 2172 m and mean core range (50% Kernel density) was 762 m. Tagged individuals of *C. angorae* in Fırnız Stream relocated in the stream and reservoir. However, only 3 individuals from 26 tagged fish remained in Tekir Stream and the other tagged individuals migrated to the reservoirs located on the upstream and downstream. This was due to variation of the hydrological flow regime of the stream within the day. Because, at the time when the electricity is cheaper, hydropower station stored water into the reservoir and they did not discharge enough water to the stream bed. However, at the time when the electricity is expensive, hydropower plant discharged too much water to the stream bed.

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NOTES

SIMULATED MIGRATION OF FEMINISED EELS TO STIMULATE AND PREDICT THE SEXUAL MATURATION RESPONSE

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In nature, European eels (*Anguilla anguilla*) sexually mature during and/or after the ~6000 km semelparous reproductive migration from their freshwater habitats to the spawning grounds in the Sargasso sea. In captivity, eels have been stimulated to mature with the purpose to artificially reproduce by injecting gonadotropins, either through hypophysation or, more recently, with recombinant FSH and LH. As the use of wild migrant silver eels as broodstock for artificial reproduction trials has become difficult due to management protection measures, conditioning methods should be developed to use farmed eels as broodstock. One such method was developed for Japanese eels and concerns the feminisation of glass eels through feeding estradiol-17β for 5-6 months which accelerates the previtellogenic oocyte development. Recently, we showed that early sexual maturation of farmed European eel can be enhanced by a simulated migration under mimicked photothermal conditions (Mes et al., 2016). With this tool to make farmed eels silver we have developed another important tool for the conditioning of farmed broodstock eels. In this study, we have combined both methods: 1) For the first time European eels were feminised; 2) Feminised eels were then subjected to simulated migration to assess the effects on maturation, and 3) Feminised migrant eels were subsequently stimulated to fully mature by hypophysation. Correlations between the individual maturation responses to simulated migration and to hormonal injections were analyzed to identify potential predictors for the selection of farmed broodstock. Results showed that the feminisation procedure for European eels had been successful. All eels were stimulated in their early maturation by simulated migration as indicated by an increase of the eye index. Fourteen out of the eighteen feminised migrants could be fully matured by hypophysation after 11-17 weekly injections. The eye indices after simulated migration correlated positively with the weight increase after injection 11 as a result of the hydration response of the oocytes (0.9-13.6%) and indicating the speed of the maturation response. The eels that ovulated were those that had the higher eye indices after simulated migration. Therefore we can conclude that simulated migration can be applied for both conditioning and selection of feminised broodstock eels.

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NOTES

RESTORATION OF FISH MIGRATION ON THE DANUBE FOCUSING ON THE MAIN MIGRATION BARRIER - THE IRON GATES HYDROPOWER DAMS BETWEEN ROMANIA AND SERBIA

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The construction of the Iron Gate I and Iron Gate II hydropower dams in 1970 at rkm 943 and in 1984 at rkm 863, respectively, without including fish passages had a negative impact on the fish migration of long distance (sturgeons, shads) as well as medium distance migrants (nase, vimba, common bream, barbel etc). The project "Fish behaviour preparatory study at Iron Gate Hydropower dams and reservoirs", financed by the European Investment Bank, was conducted primarily to test and adapt different telemetry techniques (radio – and acoustic) on sturgeon, in order to achieve the detection resolution required for precisely determining the preferred location of fish pass entrances at the Iron Gate hydropower and navigation systems. The conclusion was that the conditions for use of radio tags to record fish movements below the Iron Gate II dam are extremely difficult and radio telemetry is not an option. Specific equipment was used for extensive range testing, including Vemco and Thelma Biotel acoustic tags / transmitters V16 P and Mega 16, as well as submerged acoustic data logging receivers VR2W and novel TBR 700. Sturgeons (beluga and stellate sturgeon) and other medium distance migratory fish species (barbel, asp, European catfish) were captured, tagged and tracked during 2015. The preferred holding / resting site for beluga sturgeon and catfish was recorded as a preliminary location for a fish pass entrance on the left bank downstream of Iron Gate II, in Romania. This preliminary location for the entrance of the future fish passage needs to be positioned with higher precision by detailed hydraulic modelling and by using acoustic telemetry equipment with improved resolution to record fish movement as tested by this project.

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NOTES

DANUBE STERLET MORPHOMETRICS AND GENETIC – GUIDELINES FOR RESTOCKING PROGRAMS

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Despite sterlet (*Acipenser ruthenus* L.) being a less important resource regarding caviar production, their populations have experienced a decline during the 20th century throughout its range, mainly due to poorly regulated fishery, pollution, habitat fragmentation and habitat loss. Stocking programs are implemented throughout Danube River basin, with Upper Danube populations being dependent on continuous stocking efforts, while commercial exploitation of wild stocks in the Middle and Lower Danube has to be compensated with stocking of larvae, fingerlings and juveniles. Selection of proper specimens for stocking programs should be carefully conducted, since it can lead to deleterious impact, such as reduction of effective population size, inbreeding and outbreeding depression, and loss of locally adapted alleles. Therefore, natural populations should be examined genetically both before and after release of hatchery-reared juveniles. Our research on Middle and Lower Danube sterlet, suggests that genetic variability should be attributed almost entirely to individual variability, with a weak population structure and no clear evidence of a bottleneck and inbreeding within populations. Also, specimens used for the supportive stocking in the Tisza River in Hungary originated from the Danube River, so the information about gene flow between these rivers should be carefully considered. Additionally, most of breeding programs are focused on genetic diversity and do not acknowledge complexities of wild populations fitness architecture. Although Middle and Lower Danube dams are recent, in regard to sterlet population time, they create more lentic conditions that do not suit sterlet rheophilous nature. Both our previous and current morphometric research suggests that hatchery-reared sterlet specimens are not necessarily suited for stocking of certain Danube River sections. Lower Danube section have a different water flow regime and suspended sediment discharge than those in Middle Danube and in Lower Tisza River, so the sterlet specimens are differently adapted to their environment, which is in concordance with our findings. We suggest that both shape analysis and genetic analysis should be applied in restocking programs.

NOTES

SWIMMING AT LOW AMMONIA LEVELS: IMPROVED GROWTH AND PERFORMANCE?

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Ammonia is a waste product from endogenous protein metabolism, and continuously excreted by most fish. As elevated levels of endogenous and exogenous ammonia are toxic, it is a constant concern for aquaculture, and optimal removal and conversion is a key factor. However, a few studies suggest that low levels of ammonia alter protein dynamics and can be beneficial and increase growth rates in both freshwater and marine fish. Not much is known about the exact levels at which these increased growth rates might occur, but it is clear that interactions between water ammonia, pH and temperature are critical. If low levels of exogenous ammonia can serve as a growth stimulant without altering food consumption, this challenges the traditional dogma that the effects of ammonia are detrimental to growth. Swimming might also benefit fish in aquaculture systems, however swimming increases the sensitivity of fish to ammonia and might therefore alter the possible beneficial effects of low exogenous ammonia exposure. In the proposed study we will examine the effects of swimming speed on protein metabolism, growth and performance at different ammonia exposure scenario's. Long-term studies will be performed in our newly built 'Mesodrome' which includes 4 large raceways allowing determination of metabolic rates at different swimming speeds during simultaneous chronic ammonia exposure. Ammonia uptake, conversion and excretion, as well as protein turnover and growth will be assessed during a 2 month exposure period.

NOTES

APPLICATION OF AN UNDERWATER POSITIONING SYSTEM FOR LONG-TERM OBSERVATION OF FISH BEHAVIOR AND HABITAT USE

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Underwater positioning system allows for 3D detection of tagged fish positions with high spatiotemporal resolution over long time period. This has provided researchers with unprecedented possibilities to investigate detailed fish behavior such as habitat use or activity pattern in undisturbed environments. In turn, the resulting data can be used to characterize the behavioral ecology of different species and test various hypotheses of fish behavioral or distributional patterns. In the MacFish project, 264 individuals of six species (pike *Esox lucius*, wels *Silurus glanis*, rudd *Scardinius erythrophthalmus*, perch *Perca fluviatilis*, tench *Tinca tinca*, roach *Rutilus rutilus*) were tagged in two man-made lakes and automatically tracked for three to eleven months. Position for every tagged fish was detected twice a minute with 5 m precision in horizontal direction and 0.75 m in vertical direction. During the project, an enormous dataset of approximately 20 million fish positions were collected. Furthermore, biotic and abiotic environmental factors such as macrophyte cover, water temperature and light level within water column were collected (automatically sampled at 5 minute interval). Combination of fish positions with environmental factors will be used to answering various questions pertaining to fish behavior, e.g. diurnal and seasonal changes in habitat use and activity, response to temperature and light changes, interactions of different species with habitat structural complexity formed by macrophytes, species specific movement patterns, predator – prey interactions, niche characteristics and overlap. Based on preliminary results, underwater positioning system is very promising technology for detailed assessment of fish behavior in different water systems. However, application of the system is financially demanding, labor intensive and requires advanced data processing.

NOTES

THE MARINE MIGRATION AND SWIMMING DEPTH OF SEA TROUT (*SALMO TRUTTA* L.) IN SOUTH-ICELANDIC COASTAL WATERS

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Mapping the period of marine migration and swimming depth of adult sea trout (*Salmo trutta* L.) was investigated in the coastal waters of South-Icelandic using information obtained with data storage. The 41 adult fish tagged and tracked were 32-77 cm in fork length and 4-10 years old at tagging; giving up to 3 periods of sea migration recorded for some individual fish. Typical feeding migration in the sea started in May-June and finished in July-September, with one example of a migration period that started in winter. The duration of the total sea migration period varied from 23-183 days (46 roundtrips), with one fish captured at sea after 188 days. When data from the 11 years of observations (1996 – 2011) on the marine migration of the fish was compared, there was a significant similarity in swimming depth: with 72-89% of the time spent in the top 5 meters (0-5 m) and 9-25% of their time at a depth of 5.1 to 10.0 metres. The overall annual mean depth ranged from 2.5 to 3.8 m and the maximum depth was 70 m. Corresponding measurements on temperature and salinity from the observed migration routes, underlined their shoreline-oriented distribution where higher temperature and lower salinity values are found. Some of the depth profiles from frequent measurements indicated this also, showing occasional fast upward swimming from the bottom in shallow areas close to the shore.

NOTES

THE STORY OF EURASIAN SHADS (*ALOSA SP.*): GENOMICS, MORPHOMETRICS, LIFE HISTORY AND ADAPTATION

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Geometric morphometrics (GM) and otolith analysis can provide valuable information about phenotypic and genetic changes associated with the ecological adaptation and life history evolution of species. Eurasian shad (*Alosa sp.*) or "river herring" are usually anadromous fish, but individuals of some species spend their entire life cycle "landlocked" in freshwater lakes. Migrating shads travel both short (50-200 km) and long distances (300-860 km), but their migration routes are often curtailed by dams without fish passes. On the other hand, dam construction results in man-made lakes that in some cases may host landlocked populations. We are studying phenotypic and genetic changes associated with the transition from an anadromous to a landlocked life history in shad using GM and genomic methods. We are also investigating life history traits such as migration distance, parity and size in anadromous populations, which vary considerably within and between species and may have evolved in response to environmental factors. This data will be analysed with the *Alosa alosa* genome, and pooled (by individual) genome resequencing data from 20 populations, currently being generated at CIBIO-INBIO at the University of Porto, Portugal. By comparing genomic, morphological and otolith data within and between species we hope to understand the genetic architecture of adaptation to freshwater habitats and determine the phylogenetic scale at which convergence at adaptive loci associated with anadromous life history adaptations can be observed. GM analyses will provide quantitative data on interpopulation/interspecies differences in phenotypic adaptations to various environments, migration distances, salinity changes during migration, etc. Otolith studies will provide information on spawning locations of individuals and time spent in different water bodies (marine/freshwater) during their life cycle. Future work includes ecotoxicological and haematological studies of shad to explore the genomic basis of physiological adaptations to different life histories and compromised environments. By combining data from multiple disciplines, we hope to gain new insights into how various shad populations have adapted to specific environmental conditions, how similar their adaptive solutions have been, and what we may expect, or provide for them in the future through conservation and management.

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