

UPCOMING MEETING: LARVAL 2008

Lisbon, Portugal

July 6-11, 2008

<http://larval2008.fc.ul.pt>

The symposium programme was planned to cover a wide range of research areas on larval biology, however six more specific symposia were chosen. They are:

- Larval behaviour, dispersal and mortality (organised by J.I. Gonzalez-Gordillo and H. Queiroga). Invited speakers: Alvaro T. Palma and Alejandro Gallego.
- Molecular and geochemical markers for assessing larval dispersal (organized by L. Levin and R.C. Vrijenhoek). Invited speakers: Stephen Sweater and Matt Hare.
- Larval feeding strategies (organised by R. Calado and K. Anger). Plenary talk by R. Calado.
- Eggs, embryogenesis and early larval life (organised by B.W. Hansen). Invited speaker Richard Emlet.
- Ontogenetic strategies in extreme aquatic environments (organised by A. Hilario). Invited speakers: Anna Metaxas and Sven Thatje.
- Larval settlement: cues, behaviour response, and possible mechanism (organised by P.-Y. Qian and J.T. Hoeg). Plenary talks by th session organisers.

For more information, contact Antonina dos Santos at antonina@ipimar.pt, larval2008@ipimar.pt or visit the website.

FRESHWATER PRAWN FARMING IN BANGLADESH: HISTORY, PRESENT STATUS AND FUTURE PROSPECTS

Nesar Ahmed, Harvey Demaine, James F. Muir-2008

Aquaculture Research 39 (8): 806–819

Abstract:

Within the overall agro-based economy in Bangladesh, freshwater prawn (*Macrobrachium rosenbergii*) farming is currently one of the most important sectors of the national economy. During the last two decades, its development has attracted considerable attention for its export potential. Freshwater prawn farming offers diverse livelihood opportunities for a large number of rural poor. Although the prospects for prawn farming are positive, it requires some research and development activities for long-term sustainability. This paper provides an overview of freshwater prawn farming in Bangladesh.

(Department of Fisheries Management, Bangladesh Agricultural University, Mymensingh-2202, Bangladesh; email of N. Ahmed: nesar_2000@yahoo.com)

SALINITY-INDUCED QUIESCENCE IN EGGS OF THE CALANOID COPEPOD ACARTIA TONSA (DANA): A SIMPLE METHOD FOR EGG STORAGE

Jonas K. Højgaard, Per M. Jepsen, Benni W. Hansen-2008

Aquaculture Research 39 (8) : 828–836

Abstract:

We report the effect of salinity and temperature on the viability of stored culture-based subitaneous eggs of the calanoid copepod *Acartia tonsa* for use of copepods in fish larvae culture. Quiescence induction was recorded at 17 and 25 °C, in salinities from 0 to 30. Quiescence was strongly induced at 0 salinity and partially at 5 in both temperatures. Eggs incubated at 0 salinity for up to 12 days at both temperatures showed a decline in the fraction able to be induced into quiescence by abrupt salinity changes. The hatching success of eggs that were able to enter quiescence stabilized after a 1-day incubation and remained 25% viable for 12 days in 17 °C. On the contrary, the 25 °C trial showed a gradual decline in viability until stabilizing 10% at day 7 and onwards. Longterm 17 °C incubation for

35 days showed that eggs remained quiescent with a viability of 14%. Hence, we recommend salinity storage of *A. tonsa* subitaneous eggs as a relevant short-term technique, and a suitable alternative to the recently proposed cold storage of eggs when eggs are to be shipped from the copepod producer to a given fish larvae hatchery.

(Department of Environment, Social and Spatial Change, Roskilde University, Universitetsvej 1, PO Box 260, DK-4000 Roskilde, Denmark; email of B. W. Hansen: bhansen@ruc.dk)

CHITOSAN AS A WALL MATERIAL FOR A MICROENCAPSULATED DELIVERY SYSTEM FOR MACROBRACHIUM ROSENBERGII (DE MAN) LARVAE

Abdulaziz Anas, Rosamma Philip, Isaac Sarojeni Bright Singh-2008

Aquaculture Research 39(8): 885–890

Abstract:

Chitosan has been widely accepted as a wall material for preparing microcapsules of various purposes in human medicine. The possibility of using chitosan as a wall material for microencapsulating nutrients and drugs for aquaculture purposes, specifically to *Macrobrachium rosenbergii* larvae was evaluated in this study. Two types of chitosan-coated microcapsules were prepared using either acetone (MEC-A) or NaOH (MEC-N) as the cross-linking agents. They were compared with a microbound diet relative to total leaching of nutrients and free amino acids (FAA). Among the microcapsules, MEC-N showed the lowest level of total leaching of nutrients (23.3%) during 5 h of immersion in seawater and released 65% FAA after 60 min. During laboratory trials, 75% larvae had accepted the MEC-N capsule. The results of the study suggest that chitosan can be used as a wall material for preparing microcapsules to deliver drugs and nutrients to *M. rosenbergii* larvae.

(National Centre for Aquatic Animal Health, Cochin University of Science and Technology, Kochi 682 016, Kerala, India; email of I. S. Bright Singh: bsingh@md3.vsnl.net.in)

EFFECT OF DIETARY PROTEIN AND LIPID LEVELS AND PROTEIN-ENERGY RATIO ON GROWTH INDICES, FEED UTILIZATION AND BODY COMPOSITION OF FRESHWATER PRAWN, MACROBRACHIUM ROSENBERGII (DE MAN 1879) POST LARVAE

Ashraf M A-S Goda-2008

Aquaculture Research 39(8): 891–901

Abstract:

A grow-out experiment was designed to determine the effect of different dietary protein, lipid levels and protein–energy (P:E) ratio on growth performance and feed utilization of the freshwater prawn, *Macrobrachium rosenbergii* post larvae (PL) culture in pond net enclosures (hapa, 3.75 m³ each) for 12 weeks (84 days). The experimental treatments were assigned in triplicate. Six test diets were formulated to contain three different protein levels (300, 350 and 400 g kg⁻¹ diet) and two lipid levels (100 and 140 g kg⁻¹ diet) in a factorial manner (3 × 2) to provide six different dietary P:E ratio: 16, 17, 18, 19, 20 and 21 mg CP kJ⁻¹ g⁻¹. The result showed that the highest significant (P ≤ 0.05) survival rate, growth indices and feed utilization were observed for *M. rosenbergii* PL fed a diet with a P:E ratio of 17 mg CP kJ⁻¹ g⁻¹, whereas, the lowest value was recorded for prawns fed a diet with a P:E ratio of 20 mg CP kJ⁻¹ g⁻¹. Whole body contents of protein and lipid were highest (P ≤ 0.05) when fed diets with 21 and 17 mg CP kJ⁻¹ g⁻¹ respectively. Concerning dietary protein levels, the highest (P ≤ 0.05) values for survival and growth indices were observed for PL fed a diet containing 300 g kg⁻¹ diet protein. The same trend was observed for PL fed a diet with 100 g kg⁻¹ diet lipid level, irrespective of dietary protein levels. A diet containing 300 g kg⁻¹ protein and 100 g kg⁻¹ lipid with a dietary P:E ratio of 17 mg CP kJ g⁻¹ is recommended to stimulate growth performance and nutrients utilization efficiency of *M. rosenbergii* PL.

(28 Niseem Asaad Street, Medan El-Afdal–Shobra, Post No. 11231, Cairo, Egypt; goda_ashraf@yahoo.com)

IS GONADAL INVESTMENT IN WALLEYE (SANDER VITREUS) DEPENDENT ON BODY LIPID RESERVES? A MULTIPULATION COMPARATIVE ANALYSIS

Matthew D. Moles, Thomas A. Johnston, Beren W. Robinson, William C. Leggett, and John M. Casselman-2008

Can. J. Fish. Aquat. Sci. 65(4): 600–614

Abstract:

A key requirement of effective fisheries management is a better understanding of the mechanisms driving recruitment variability. Recent research suggests that the quantity and quality of gametes produced by fish is closely linked to the availability of surplus energy, usually stored as lipid. We sampled mature walleye (*Sander vitreus*) from seven populations across Canada to determine if indices of reproductive effort were positively related to indices of adult nutrient reserves, primarily body lipid concentration. Populations varied greatly in growth rates, body lipid contents, and reproductive traits. Within-population trends between indices of reproductive effort and parental body traits were highly variable. Body lipid concentration was most closely related to gonad lipid concentration, but not in all populations. Among populations, relative fecundity and ovary lipid concentrations were positively related, and egg size was negatively related to whole-body lipid concentrations; no trends were evident for males. Our results suggest that relationships between walleye reproductive effort and body lipid reserves may be more complex than previously thought.

BODY CONDITION INFLUENCES SPERM ENERGETICS IN LAKE WHITEFISH
(*COREGONUS CLUPEAFORMIS*)

Gary Burness, Albrecht I. Schulte-Hostedde, Robert Montgomerie-2008

Can. J. Fish. Aquat. Sci. 65(4): 615–620

Abstract:

Theoretical models predict that individual males will increase their investment in ejaculates when there is a risk of sperm competition. Because the production of ejaculates is assumed to be energetically costly, only those males in good physical condition should be capable of producing ejaculates of high quality. We studied ejaculate investment (relative testis size, controlling for body size) as well as the size, behaviour, and energetics of spermatozoa in lake whitefish (*Coregonus clupeaformis*), a species in which males provide nothing but sperm to females during reproduction. Ejaculate investment was condition dependent, with males in better body condition having relatively larger testes. Sperm adenosine triphosphate (ATP) levels were unaffected by male condition alone, but increased with testis size when controlling statistically for both male size or body condition. Thus, males investing in relatively larger testes produced spermatozoa with higher energetic capacity. We also discovered testis asymmetry in this species, a phenomenon not previously reported in fishes, though widespread in other taxa. The mass of the (larger) left testis was a better predictor of sperm ATP stores than the mass of the (smaller) right testis (controlling for body size), suggesting that testis size asymmetry might be related to the production of high-quality sperm.

ENVIRONMENTAL ENRICHMENT IN STEELHEAD (*ONCORHYNCHUS MYKISS*)
HATCHERIES: FIELD EVALUATION OF AGGRESSION, FORAGING, AND
TERRITORIALITY IN NATURAL AND HATCHERY FRY

Christopher P. Tatara, Stephen C. Riley, Julie A. Scheurer-2008

Can. J. Fish. Aquat. Sci. 65(4): 744–753

Abstract:

Reforms for salmonid hatcheries include production of hatchery fish with behavioral characteristics similar to wild conspecifics. Enrichment of the hatchery environment has been proposed to achieve this goal. Field experiments of steelhead (i.e., sea-run rainbow trout, *Oncorhynchus mykiss*) fry from a common stock reared under natural (i.e., stream), enriched hatchery, and conventional hatchery conditions indicated no significant differences in the rates of foraging or aggression between rearing treatments. However, the rates of foraging and aggression of natural fry were significantly affected by the type of hatchery fry stocked with them. Natural steelhead fry fed at lower rates and exhibited higher rates of aggression when stocked with steelhead fry raised in enriched hatchery environments. Territory sizes of steelhead fry ranged from 0.015 to 0.801 m²; were significantly, positively related to body length; and were not significantly different between rearing treatments. We conclude that

hatchery steelhead fry released into streams establish territories that are proportional to their body length and similar in size to territories of natural steelhead fry. Our results indicate that both conventional and enriched hatchery environments produce natural social behaviors in steelhead released as fry and that fry from enriched hatchery environments may alter the foraging and aggressive behavior of natural, resident steelhead fry.

INCREASES IN STEELHEAD (*ONCORHYNCHUS MYKISS*) REDD ABUNDANCE RESULTING FROM TWO CONSERVATION HATCHERY STRATEGIES IN THE HAMMA HAMMA RIVER, WASHINGTON

Barry A. Berejikian, Thom Johnson, Richard S. Endicott, Joy Lee-Waltermire-2008

Can. J. Fish. Aquat. Sci. 65(4): 754–764

Abstract:

Conservation hatcheries for anadromous salmonids that aim to increase production and minimizing genetic, ecological, and demographic risks have not been experimentally tested for their ability to increase number of adults spawning in the natural environment. The conservation hatchery program for steelhead (i.e., sea-run rainbow trout, *Oncorhynchus mykiss*) evaluated in this study caused an increase in the number of redds in the supplemented Hamma Hamma River compared with the presupplementation period. Three control populations (nonsupplemented) either remained stable or declined over the same period. The increase in redds from hatchery-produced spawners did not reduce the redd production from natural-origin spawners. The strategy of rearing and releasing adult steelhead accounted for the greatest proportion of redd abundance increases. Environmentally induced differences in spawn timing between the adult release group and anadromous adults of hatchery and natural origin may explain why the adult release group and anadromous adults assortatively formed pairing combinations on the spawning grounds. Although captive reared adults produced the majority of redds in years they were released in substantial numbers, uncertainty regarding the relative reproductive success of this strategy suggests caution in recommending one strategy over the other. A demographic boost to the naturally spawning population was effected while managing to minimize negative ecological consequences.

THE ONTOGENY OF PHYSIOLOGICAL RESPONSE TO LIGHT INTENSITY IN EARLY STAGE SPINY LOBSTER (*JASUS EDWARDSII*) LARVAE

Michel Bermudes, Arthur J. Ritar, Chris G. Carter-2008

Comparative Biochemistry and Physiology - Part A: Molecular & Integrative Physiology 150(1): 40-45

Abstract:

Early stage phyllosoma larvae of the spiny rock lobster *Jasus edwardsii* were examined for swimming speed, feeding, oxygen consumption and nitrogen excretion as instantaneous performance indicators when exposed to different irradiance levels. Swimming speed was measured in recently hatched Stage I larvae while all other parameters were measured in larvae from hatch to mid-Stage V. The swimming speed of recently hatched Stage I phyllosoma increased logarithmically between light intensities of 2.9×10^{14} and 1.8×10^{16} quanta $s^{-1} cm^{-2}$ indicating that, within this range, swimming activity was only suppressed at the lowest irradiance level. Larvae examined under dark (no light) conditions showed lower feed intake, oxygen consumption and nitrogen excretion than larvae under low (7.7×10^{12} q $s^{-1} cm^{-2}$) and high (3.9×10^{14} q $s^{-1} cm^{-2}$) light intensities, and this was a consistent pattern observed throughout development from hatch to Stage V. There was no difference in feeding, oxygen consumption and nitrogen excretion between larvae exposed to low and high light intensities. However, from mid-Stage I to mid-Stage V, the metabolic feeding efficiency (feed intake:oxygen consumption ratio) was consistently higher in larvae exposed to low light intensity than in phyllosoma assessed in the dark and under high irradiance. A light intensity of about 7.7×10^{12} quanta $s^{-1} cm^{-2}$ and no higher than 3.9×10^{14} quanta $s^{-1} cm^{-2}$ is recommended to stimulate feeding and optimise metabolic feeding efficiency in early larval stages of *J. edwardsii*.

(Shellfish Culture Ltd, 290 Clifton Beach Road, Clifton Beach, Tasmania 7020, Australia; email of A. Ritar: Arthur.Ritar@utas.edu.au)

ONTOGENESIS OF CATABOLIC AND ENERGY METABOLISM CAPACITIES DURING THE EMBRYONIC DEVELOPMENT OF SPOTTED WOLFFISH (ANARHICHAS MINOR)

Véronique Desrosiers, Nathalie R. Le François, Helge Tveiten, Inger Andreassen, Pierre U. Blier-2008

Comparative Biochemistry and Physiology Part B: Biochemistry and Molecular Biology 150(2): 200-206

Abstract:

The catabolic and energy metabolism capacities during spotted wolffish (*Anarhichas minor*) embryogenesis were investigated. We assessed the embryo's ability to catabolize proteins (trypsin-like proteases) and lipids (triglyceride lipase) and examined the development of metabolic capacities using enzymatic assays: ability to use carbohydrates (pyruvate kinase), amino acids (aspartate aminotransferase) and fatty acids (hydroxyacyl-CoA dehydrogenase) for energy production, and aerobic (citrate synthase) and anaerobic (lactate dehydrogenase) energy production. Functional enzymatic systems were detected from the eyed stage (350 degree-days), except for fatty acids, which was detected from 540 degree-days. To compare the development of 1) aerobic and anaerobic pathways and 2) the capacity to mobilize the different energy substrates, enzymatic ratios were calculated. Anaerobic capacity appeared to increase at a significantly higher rate than the aerobic capacity. Ratios revealing the relative capacity to use specific energy substrates showed a significantly slower increase during development in the capacity to use carbohydrates than amino acids and fatty acids. The end of embryogenesis was characterized by a significant decrease in the use of carbohydrates for aerobic energy production but an increasing capacity to use amino acids. Egg survival as affected by the variability in metabolic parameters is discussed.

(Laboratoire de Biologie Intégrative, Université du Québec à Rimouski, Rimouski, Québec, Canada ; email of P. Blier : pierre_blier@uqar.qc.ca)

SELECTION OF SUITABLE REFERENCE GENES FOR REAL-TIME PCR STUDIES OF ATLANTIC HALIBUT DEVELOPMENT

Jorge M.O. Fernandes, Maren Mommens, Ørjan Hagen, Igor Babiak, Christel Solberg-2008

Comparative Biochemistry and Physiology Part B: Biochemistry and Molecular Biology 150(1):23-32

Abstract:

Gene expression studies are fundamental to understand the molecular basis of severe malformations in fish development, particularly under aquaculture conditions. Real-time PCR (qPCR) is the most accurate method of quantifying gene expression, provided that suitable endogenous controls are used to normalize the data. To date, no reference genes have been validated for developmental gene expression studies in Atlantic halibut (*Hippoglossus hippoglossus*). We have determined the expression profiles of 6 candidate reference genes (*Actb*, *Eef2*, *Fau*, *Gapdh*, *Tubb2* and 18S rRNA) in 6 embryonic and 5 larval stages of Atlantic halibut development. There were significant changes in expression levels throughout development, which stress the importance and complexity of finding appropriate reference genes. The three software applications (BestKeeper, geNorm and NormFinder) used to evaluate the stability of potential reference genes produced comparable results. *Tubb2* and *Actb* were the most stable genes across the different developmental stages, whereas 18S rRNA and *Gapdh* were the most variable genes and thus inappropriate to use as reference genes. According to geNorm and NormFinder, the best two-gene normalization factors corresponded to the geometric average of *Tubb2/Actb* and *Tbb2/Fau*, respectively. We believe that either of these normalization factors can be used for future developmental gene expression studies in Atlantic halibut.

(Department of Fisheries and Natural Sciences, Bodø Regional University, N-8049 Bodø, Norway; email of J. Fernandes: Jorge.fernandes@hibo.no)

DYNAMIC EXPRESSION PATTERN OF THE GROWTH HORMONE RECEPTOR DURING EARLY DEVELOPMENT OF THE CHILEAN FLOUNDER

Eduardo Fuentes, Erika Poblete, Ariel E. Reyes, María Inés Vera, Marco Álvarez, Alfredo Molina-2008

Comparative Biochemistry and Physiology Part B: Biochemistry and Molecular Biology 150(1): 93-102

Abstract:

The entire cDNA sequence of the growth hormone receptor (GHR) of the Chilean flounder (*Paralichthys adspersus*) was cloned by RT-PCR and RNA ligase rapid amplification of 5' and 3'ends. The deduced amino acid sequence contains 641 residues and codes for the GHR1 form. The receptor includes all the structural domains and motifs responsible for its interaction with the growth hormone and growth signal transduction. Sequence comparison revealed 95 and 88% identity with other flat fish such as the Japanese flounder and Atlantic halibut respectively, but decreased to 41% with the GHR of other teleosts such as salmon. In addition we performed a phylogenetic analysis of this receptor in teleosts. RT-PCR experiments were performed to study the expression of GHR1 mRNA in different tissues of juvenile fish, detecting the transcripts in all tissues investigated with higher expressions in the liver, brain and gonads. Additionally, using whole-mount in situ hybridization in larvae stages, we observed an on and off GHR1 mRNA expression pattern. This novel finding evidences that during early development of a teleost, GHR1 is transiently expressed in somites, a source of muscle, bone and spinal chord precursors cells, suggesting a relevant role of GH in fish development. GHR1 was also temporally detected in the notochord, intestines, brain and retinal layers, before its ubiquitous establishment.

(Laboratorio de Biotecnología Molecular, Universidad Andrés Bello, Av. República 217, Piso 3, Santiago, Chile; email of A. Molina: amolina@unab.cl)

THE ROLE OF THYROID HORMONES DURING THE DEVELOPMENT OF EYE PIGMENTATION IN THE PACIFIC BLUEFIN TUNA (*THUNNUS ORIENTALIS*)

Yutaka Kawakami, Kenichi Yokoi, Hidemi Kumai, Hiromi Ohta-2008

Comparative Biochemistry and Physiology Part B: Biochemistry and Molecular Biology 150(1): 112-116

Abstract:

Thyroid hormones (THs) are essential for the embryonic and post-embryonic development of fish. We studied the role of THs during the early, post-embryonic, development of Pacific bluefin tuna. Embryos were treated with L-thyroxine (T4) or the anti-thyroid drug methimazole (MMI), and reared in microtitre plates for 3 days. Immersion in MMI, but not T4, led to retardation of retinal pigment epithelium (RPE) pigmentation 3 days post-hatching (dph). Concurrent immersion in T4 and MMI had no effect of RPE pigmentation. We also measured the expression of TRA, TRB, and TR β mRNA using real-time RT-PCR. Treatment with MMI significantly reduced TR β mRNA expression. Taken together these results suggest that the development of RPE pigmentation is mediated by TH, most likely via TR β .

(Department of Fisheries, Graduate School of Agriculture, Kinki University, Nara 631-8505, Japan; email of Yutaka Kawakami: yutakakjp@yahoo.co.jp)

EXPRESSION OF THE OLIGOPEPTIDE TRANSPORTER, PEPT1, IN LARVAL ATLANTIC COD (*GADUS MORHUA*)

J.J. Amberg, , 1, , C. Myr, 1, Y. Kamisaka, A.-E.O. Jordal, M.B. Rust, R.W. Hardy, R. Koedijk, I. Rønnestad-2008

Comparative Biochemistry and Physiology Part B: Biochemistry and Molecular Biology 150(2): 177-182

Abstract:

The intestinal absorption of di- and tri-peptides generally occurs via the oligopeptide transporter, PepT1. This study evaluates the expression of PepT1 in larval Atlantic cod (*Gadus morhua*) during the three weeks following the onset of exogenous feeding. Larval Atlantic cod were fed either wild captured zooplankton or enriched rotifers. cDNA was prepared from whole cod larvae preceding first feeding and at 1000 each Tuesday and Thursday for the following three weeks. Spatial and temporal

expression patterns of PepT1 mRNA were compared between fish consuming the two prey types using in situ hybridization and quantitative real-time PCR. Results indicated that PepT1 mRNA was expressed prior to the onset of exogenous feeding. In addition, PepT1 was expressed throughout the digestive system except the esophagus and sphincter regions. Expression slightly increased following first-feeding and continued to increase throughout the study for larvae feeding on both prey types. When comparing PepT1 expression in larvae larger than 0.15-mg dry mass with expression levels in larvae prior to feeding, no differences were detected for larvae fed rotifers, but the larvae fed zooplankton had significantly greater PepT1 expression at the larger size. In addition, PepT1 expression in the zooplankton fed larvae larger than 0.15-mg dry mass had significantly greater expression than rotifer fed larvae of a similar weight. Switching prey types did not affect PepT1 expression. These results indicate that Atlantic cod PepT1 expression was slightly different relative to dietary treatment during the three weeks following first-feeding. In addition, PepT1 may play an important role in the larval nutrition since it is widely expressed in the digestive tract.

(University of Idaho, Hagerman Fish Culture Experiment Station, 3059-F National Fish Hatchery Road, Hagerman, ID 83332, USA; email of J. Amberg: jamberg@vandals.uidaho.edu)

TEMPERATURE INFLUENCE ON THE SPAWNING PERFORMANCE OF ARTIFICIALLY-MATURED JAPANESE EEL, ANGUILLA JAPONICA, IN CAPTIVITY

Shuo-Zeng Dou, Yoshiaki Yamada, Akihiro Okamura, Akira Shinoda, Satoru Tanaka, Katsumi Tsukamoto-2008

Environmental Biology of Fishes 82(2): 151-164

Abstract :

We studied the influence of temperature on the spawning performance of artificially matured Japanese eels, *Anguilla japonica*, in captivity. We used routine hormone injections to bring females and males to maturity in separate aquaria. We recorded the behavior of three pairs of such hormone-treated matured eels in an aquarium (2 replicates) at four temperatures: 14, 18, 22, and 27°C, respectively. They became active and frequently left the bottom swimming in the water column, and spawning events occurred. Females released eggs in the water column around the activity peaks. Males preceded females in reaching activity peaks (presumably the timing of sperm ejection and egg release), possibly resulting in the low fertilization we observed in this experiment. Males and females returned back to the aquarium bottoms and became quiet after spawning. On several occasions, male-female or female-female pairs were observed to ‘cruise together’ in the water column for several to tens of seconds prior to egg releasing, but no courtship behavior indicative of spawning such as pairing and chasing was observed in the eels in our study. Our results suggest that 18–22°C might be the thermal preference for spawning for Japanese eels, which approximates the temperature range of the 500 m deep water layer around the Mariana Islands seamount area, the presumed spawning site for the Japanese eel.

(Institute of Oceanology, Chinese Academy of Sciences, 7 Nan-hai Lu Road, Qingdao, 266701, P.R. China; email of Shuo-Zeng Dou: szdou@ms.qdio.ac.cn)

REGULATION OF GROWTH, FATTY ACID COMPOSITION AND DELTA 6 DESATURASE EXPRESSION BY DIETARY LIPIDS IN GILTHEAD SEABREAM LARVAE (SPARUS AURATA)

M. S. Izquierdo, Lidia Robaina, Eduardo Juárez-Carrillo, V. Oliva, Carmen María Hernández-Cruz, Juan Manuel Afonso-2008

Fish Physiology and Biochemistry 34(2): 117-127

Abstract: The $\Delta 6$ and $\Delta 5$ desaturases and elongases show only very limited activity in marine fish, and little is known of the possibility of enhancing $\Delta 6$ desaturase gene expression in these fish. The use of plant oils in marine fish diets is limited by their lack of n-3 highly unsaturated fatty acids (HUFA) despite an abundant content of the 18C fatty acid precursor linoleic and α -linolenic acids. The objective of the present study was to determine the ability of larval gilthead seabream to utilize vegetable oils and assess the nutritional regulation of $\Delta 6$ desaturase gene expression. Seventeen-day-old gilthead seabream larvae were fed during a 17-day period with one of four different microdiets

formulated with either sardine fish oil (FO), soybean, rapeseed or linseed oils, respectively, or a fifth diet containing defatted squid meal and linseed oil. Good larval survival and growth, both in terms of total length and body weight, were obtained by feeding the larvae either rapeseed, soybean or linseed oils. The presence of vegetable oils in the diet increased the levels of 20:2n-9 and 20:2n-6, 18:2n-9, 18:3n-6, 20:3n-6 and 20:4n-6, in larvae fed rapeseed and soybean oils in comparison to those fed FO. In addition, a sixfold increase in the relative expression of $\Delta 6$ desaturase-like gene was found in larvae fed rapeseed and soybean oils, denoting the nutritional regulation of desaturase activity through its gene expression in this fish species. However, feeding linseed oil did not increase the expression of the $\Delta 6$ desaturase gene to such a high extent.

(Grupo de Investigación en Acuicultura, ICCM & IUSA, C/. Trasmontaña s/n, 35413 Arucas, Las Palmas, Spain; email of Lidia Robaina: lidia@iccm.rcanaria.es)

ANTI-OXIDANT STATUS IN EMBRYONIC, POST-HATCH AND LARVAL STAGES OF ASIAN SEABASS (LATES CALCARIFER)

N. Kalaimani, N. Chakravarthy, R. Shanmugham, A. R. Thirunavukkarasu, S. V. Alavandi, T. C. Santiago-2008

Fish Physiology and Biochemistry 34(2): 151-158

Abstract :

The concentrations of anti-oxidant enzymes such as superoxide dismutase (SOD), catalase (CAT) and selenium-dependent glutathione peroxidase (SeGPx), and low molecular weight free-radical scavengers such as reduced glutathione (GSH) and ascorbic acid (vitamin C) were evaluated during the period from gastrulation (GS) to 25 days post-hatch (dph) in the larvae of Asian Seabass, *Lates calcarifer*. Oxidative damage due to lipid peroxidation (LPO) was also assessed, by evaluation of the formation of malondialdehyde (MDA). All the three anti-oxidant enzymes, SOD, CAT and GPx, showed high activities during gastrulation, suggesting an increased metabolic rate during the period of embryonic development. Though the SOD activity apparently decreased progressively during 3–20 dph of larval development, the difference was not significant. CAT showed high activity during gastrulation and remained constant up to 3 dph, suggesting an increased need to metabolise hydrogen peroxide (H₂O₂) and organic peroxides. In contrast, SeGPx activity increased progressively from 5 dph to 25 dph during larval development, indicating an increased need to detoxify lipid peroxides. This is evident from the observation of increased lipid peroxidation from 10 dph to 25 dph during larval development. GSH levels were low at gastrulation, indicating increased metabolic rate and formation of lipid radicals during this period, corresponding to the decrease in the level of ascorbic acid, which is consumed for regeneration of GSH.

(Central Institute of Brackishwater Aquaculture, 75, Santhome High Road, R.A. Puram, Chennai, Tamil Nadu, 600028, India; email of N. Kalaimani: nkalaimani77@yahoo.com)

BIOCHEMICAL COMPOSITION OF CAVIAR AS A TOOL TO DISCRIMINATE BETWEEN AQUACULTURE AND WILD ORIGIN

J. Gessner, S. Würtz, F. Kirschbaum, M. Wirth-2008

Summary:

The over-exploitation of sturgeons for caviar production has led to drastic decreases of the commercially harvested sturgeon stocks. As a consequence, all sturgeon species were world-wide listed in Annex II or I of the CITES regulations. Since caviar trade needs to be controlled precise source (farmed vs wild) and species identification of the caviar are essential. Species discrimination is successfully performed by molecular genetic techniques. Whereas the origin of caviar either from wild stocks or from aquaculture cannot yet be differentiated using these techniques. As a consequence, the lack of an applicable technique for source identification complicates the control of black marketing of illegally produced sturgeon products. The determination of the chemical and biochemical composition of caviar, both of wild caught and farmed animals was attempted in this study to explore the potential of biochemical techniques for source identification. The results on size, protein and fat content, fatty acid (FA) composition of triglycerides (TG) and phospholipids (PL), as well as the concentrations of relevant heavy metals and chlorinated hydrocarbons from 38 samples of

wild caught and 12 samples of farmed sturgeon were investigated. Significant differences with respect to the origin of the caviar were revealed in FA composition only. TG and PL contained more n-3 FAs, especially eicosapentaenoic (20:5 n-3) and docosahexaenoic acid (22:6 n-3) than n-6 FAs. Specific differences in the TG profile of wild caught and intensively farmed fish, depended on the feed sources utilized. It is therefore suggested to use specific FAs as additives to the formulated diets in order to provide the opportunity to ease the verification of the farm origin in traded sturgeon commodities.

(Leibniz-Institute of Freshwater Ecology and Inland Fisheries, Müggelseedamm 310, D-12587 Berlin, Germany; email of Jörn Gessner: sturgeon@igb-berlin.de)

CELL WALL DEFICIENT SACCHAROMYCES CEREVISIAE STRAINS AS MICROBIAL DIET FOR ARTEMIA LARVAE: PROTECTIVE EFFECTS AGAINST VIBRIOSIS AND PARTICIPATION OF PHENOLOXIDASE

C.R. Rojas-García, A.F.M. Hasanuzzaman, P. Sorgeloos, P. Bossier-2008

Journal of Experimental Marine Biology and Ecology 360(1): 1-8

Abstract:

Thousands of *Artemia* larvae (1000 to 4800 ind bottles⁻¹) were reared axenically with live and cooked cell wall deficient *Saccharomyces cerevisiae* (SC) strains as microbial diet to examine the protective effects against vibriosis and the participation of phenoloxidase. Firstly, six different cell wall deficient SC strains (*fks1*, *knr4*, *kre6*, *chs3*, *gas1* and *mnn9*) were compared for best larval growth and phenoloxidase-like (PO-L) responses after infection with *Vibrio proteolyticus*. Live SC-*mnn9* and SC-*gas1* provided the best ($P < 0.05$) dietary support for *Artemia* growth and induced higher PO-L ($P < 0.05$). Secondly, SC-*mnn9*, SC-*gas1* and the SC-wild type (WT) were prepared as cooked microbial diet and were offered to germfree (GF) larvae. Growth, PO-L responses and survival after infection with *Vibrio campbellii* were higher ($P < 0.05$) in larvae fed with cooked SC-*mnn9* and SC-*gas1* compared to SC-WT. Cooked SC-WT was a poor diet for GF *Artemia*, nevertheless, a rapid diet swap to cooked SC-*gas1* or SC *mnn9* improved the PO-L and survival against *V. campbellii* which suggested that the protective effect of SC-*mnn9* and SC-*gas1* could also be effective in larvae that have been undernourished. *Artemia*'s PO-L seemed to vary in accordance to growth status, health or disease caused by vibriosis. This apparent capacity of *Artemia* to express PO-L under health and disease offers an interesting tool to explore its participation in the innate defense system of crustacean larval stages.

(Laboratory of Aquaculture and *Artemia* Reference Centre, Faculty of Bioscience Engineering, Ghent University, Rozier 44, 9000 Ghent, Belgium; email of C. Rojas: carlos.rojas@inbox.com)

ONTOGENETIC CHANGES IN THE CRITICAL SWIMMING SPEED OF GADUS MORHUA (ATLANTIC COD) AND MYOXOCEPHALUS SCORPIUS (SHORTHORN SCULPIN) LARVAE AND THE ROLE OF TEMPERATURE

Lu Guan, Paul V.R. Snelgrove, A.K. Gamperl-2008

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Abstract:

Most studies on behavioural contributions to dispersal and recruitment during early life history stages of fishes have focused on coral reef species. For cold ocean environments, high variation in seasonal temperature and development times suggest that parallel studies on active behaviour are needed for cold-water species. Thus, we examined the critical swimming speed (U_{crit}) of marine fish larvae from 2 contrasting species: *Gadus morhua* (Atlantic cod) and *Myoxocephalus scorpius* (shorthorn sculpin), a pelagic and bottom spawner respectively. Within-species comparisons showed that sculpin reared at 6 °C had lower initial U_{crit} values, but a faster U_{crit} increase through development compared with 3 °C conspecifics, ultimately resulting in faster critical swimming speeds at metamorphosis (10.5 vs. 9.1 cm·s⁻¹). In contrast, although cod larvae reared at 10 °C were faster swimmers at first feeding than 6 °C fish, temperature differences were absent after the first week. These results show that temperature influences the trajectory of larval critical swimming speed development, but that the relationship is species-specific. Although 6 °C sculpin and cod of similar length had equivalent U_{crit} values, the smaller size of cod at hatch (5.3 vs. 10.8 mm for sculpin) resulted in much lower age-

specific Ucrit values for cod. These data have significant implications for how swimming activity of the two species might affect dispersal, particularly in the first few weeks post-hatch. Overall, our data suggest that temperature during larval development influences the swimming capacity of cold-water marine fishes, and has important ramifications for biophysical models of dispersal.

(Ocean Sciences Centre Memorial University of Newfoundland, St John's, Newfoundland, Canada A1C 5S7;; email of P. Snelgrove: psnelgro@mun.ca)

HYPOXIA, LOW SALINITY AND LOWERED TEMPERATURE REDUCE EMBRYO SURVIVAL AND HATCH RATES IN BLACK BREAM ACANTHOPAGRUS BUTCHERI (MUNRO, 1949)

K. L. Hassell, P. C. Coutin, D. Nuggeoda-2008

Journal of Fish Biology 72(7): 1623–1636

Abstract:

Embryo survival and hatch rates were measured in black bream *Acanthopagrus butcheri* exposed to different treatments of dissolved oxygen: hypoxic and normoxic, three salinities: 15, 23 and 35 and two temperatures: 16 and 20° C. Hypoxic conditions (50% saturation) reduced 1 day embryo survival by up to 15% ($P < 0.05$) compared to embryos held in normoxic (>80% saturation) conditions. Temperature had no effect on the survival of embryos in these treatments, however, lowered salinity significantly reduced embryo survival at 20° C, but not at 16° C. Mean hatch rates were reduced by 10–28% in hypoxic treatments ($P < 0.05$) and lowered salinity treatments ($P < 0.05$). Hatching was delayed by up to 24 h at 16° C and very low (or zero) hatching occurred in hypoxic treatments at salinities of 15 and 23. These results confirm that environmental conditions in estuaries are important factors in determining spawning success of black bream and are discussed in relation to global warming and climate change that are likely to alter the physical conditions in southern Australian estuaries.

(Biotechnology and Environmental Biology, School of Applied Sciences, RMIT University, P. O. Box 71, Bundoora, Victoria 3083, Australia; email of K. L. Hassell: kathryn.hassell@rmit.edu.au)

ALLOMETRIC GROWTH AND FUNCTIONAL DEVELOPMENT OF THE GUT IN DEVELOPING COD GADUS MORHUA L. LARVAE

P.-A. Wold, K. Hoehne-Reitan, J. Rainuzzo, E. Kjørsvik-2008

Journal of Fish Biology 72(7): 1637–1658

Abstract:

The development of the gut epithelium in cod *Gadus morhua* was studied during the larval period in intensive rearing systems. Cod larvae were fed enriched rotifers from mouth opening. On 17 days post-hatch (dph) one group of larvae were fed *Artemia* sp. nauplii while another group were fed both rotifers and a formulated diet (co-fed). At the end of the experiment (30 dph) larvae receiving live feed were almost three times larger than the co-fed larvae, although no clear signs of pathological effects due to feeding regime were found in any larvae sampled for morphological studies. The midgut volume in larvae fed live feed increased by a factor of 38 during the experiment, and in particular volume increased rapidly between 24 and 30 dph. The enterocyte size increased between 12 and 24 dph from 652 ± 64 to $1479 \pm 144 \mu\text{m}^3$ (mean \pm s.e.). When enterocytes reached their maximum size, several morphological changes in the gut epithelium were initiated, such as increased number of mitochondria per enterocyte, increased size of the nuclei and a considerable increase in microvilli surface area. The mitochondrial membrane structures changed during the experiment, suggesting a maturation process of the mitochondria. The midgut development was strongly related to larval size rather than age. On 30 dph co-fed larvae were equal in size to *Artemia* sp. fed larvae on 24 dph. This was reflected by equal values of estimated midgut volume, midgut length and total number of enterocytes and the number of mitochondria per enterocyte. The microvilli surface area, however, was significantly larger in co-fed larvae on 24 dph compared to live-feed larvae on 30 dph. This increase in absorptive surface was probably a response to suboptimal feeding conditions. The strong correlation between gut development and larval size and the lack of clear pathological effects, suggested that the gut tissue is flexible and can withstand periods of suboptimal nutrition at this stage.

(The Norwegian University of Science and Technology, Department of Biology, N-7491 Trondheim, Norway; email of P.-A. Wold: per-arvid.wold@bio.ntnu.no)

SUCCESS OF EMBRYONIC DEVELOPMENT OF RECIPROCAL HYBRIDS OF BREAM
ABRAMIS BRAMA (L.) AND WHITE BREAM BLICCA BJOERKNA (L.)

M. Vetemaa, R. Kalda, M. Tambets-2008

Journal of Fish Biology 72 (7): 1787–1791

Abstract:

Success of embryonic development of reciprocal hybrids of bream *Abramis brama* and white bream *Blicca bjoerkna* was tested under laboratory conditions. Fertilization and embryonic development success of hybrids until hatching was high and comparable to that of pure species.

(Estonian Marine Institute, University of Tartu, Vanemuise 46, 51014 Tartu, Estonia; email of M. Vetemaa: markus.vetemaa@ut.ee)
