INFORMATION OF INTEREST

Research Methodology Communication Oswald van Cleemput 2008 [PDF]
FUTURE PROSPECTS FOR FISH AND FISHERY PRODUCTS - Fish consumption in the European Union in 2015 and 2030 - European overview FAO Fisheries Circular 2007 No. 972/4, Part 1 European overview and Part 2 Country projections
African aquaculture: realizing the potential: article by Brummett et al. in Food Policy 2008
Summary Document of Aquaculture Europe 2008 conference in Cracow, Poland
The aquaculture of groupers: new book published by the Asian Fisheries Society
FAO Aquaculture Gateway Page
Critical success factors for fish larval production in European Aquaculture: a multidisciplinary network (LARVANET) - new COST action - see website for details

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RACEWAY DESIGN AND SIMULATION SYSTEM (RDSS): AN EVENT-BASED PROGRAM TO SIMULATE THE DAY-TO-DAY OPERATIONS OF MULTIPLE-TANK RACEWAYS
Yin-Han Wang, Richard Turton, Ken Semmens, Tatiana Borisova-2008
Aquacultural Engineering 39(2-3): 59-71
Abstract:
A software program, called Raceway Design and Simulation System (RDSS), has been built using Visual Basic for Applications in Microsoft® Excel. The purpose of the software is to allow users to manage their raceways more efficiently by providing a tool to simulate the operation of an existing raceway or to predict conditions in a raceway under a wide variety of operating conditions. The program simulates the conditions in a system of multiple tanks that may be arranged in sets of parallel raceways with serial water flow. The user may specify the use of overflow weirs or customized oxygen injection points in order to reoxygenate the water flow from succeeding tanks in each raceway. During the course of the simulation, the user may specify the size, number, location, and price of any new fish introduced into any raceway tank. Subsequent movement of fish between tanks or removal of part or all of a cohort is tracked by the program.

Input data required include properties of the influent water such as temperature, flowrate, dissolved oxygen, pH, total ammonia nitrogen, and salinity. Fish growth is predicted using these input data and stocking information that is provided by the user. Fish mortality may be specified for each tank in a raceway. In addition, the costs of food, the purchase cost of fish, and the revenue from the sale of fish are also tracked.

A comprehensive user manual is included with the software that provides information on the basic operation of the program, all the programming features, troubleshooting and, the various error messages that the user may encounter when using the program.
(Department of Chemical Engineering, West Virginia University, P.O. Box 6102, Morgantown, WV 26506, United States; email of Richard Turton: richard.turton@mail.wvu.edu)

A NOVEL APPROACH TO DENITRIFICATION PROCESSES IN A ZERO-DISCHARGE RECIRCULATING SYSTEM FOR SMALL-SCALE URBAN AQUACULTURE
Alon Singer, Shmuel Parnes, Amit Gross, Amir Sagi, Asher Brenner-2008

Aquacultural Engineering 39(2-3): 72-77
Abstract:
This paper presents an innovative process to solve the nitrate build-up problem in recirculating aquaculture systems (RAS). The novel aspects of the process lie in a denitrification bioreactor system that uses solid cotton wool as the primary carbon source and a unique degassing chamber. In the latter, the water is physically stripped of dissolved gaseous O2 (by means of a Venturi vacuum tube), and the subsequent denitrification becomes more efficient due to elimination of the problems of oxygen inhibition of denitrification and aerobic consumption of cotton wool. The cotton wool medium also serves as a physical barrier that traps organic particles, which, in turn, act as an additional carbon source for denitrification. Operation in the proposed system gives an extremely low C/N ratio of 0.82 g of cotton wool/g of nitrate N, which contributes to a significant reduction of biofilter volume. The additional advantage of using solid cotton wool as the carbon source is that it does not release organic residuals into the liquid to be recycled. Operation of the system over a long period consistently produced effluents with low nitrate levels (below 10 mg N/l), and there was only a very small need to replace system water. The overall treatment scheme, also incorporating an aerobic nitrification biofilter and a granular filtration device, produced water of excellent quality, i.e., with near-zero levels of nitrite and ammonia, a sufficiently high pH for aquaculture, and low turbidity. The proposed system thus provides a solution for sustainable small-scale, urban aquaculture operation with a very high recovery of water (over 99%) and minimal waste disposal.
(Department of Biotechnology Engineering and Unit of Environmental Engineering, Ben-Gurion University of the Negev, P.O. Box 653, Beer-Sheva 84105, Israel; email of A. Brenner: brenner@bgu.ac.il

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EFFICACY OF A PILOT-SCALE WASTEWATER TREATMENT PLANT UPON A COMMERCIAL AQUACULTURE EFFLUENT: I. SOLIDS AND CARBONACEOUS COMPOUNDS
Simonel Sandu, Brian Brazil, Eric Hallerman-2008
Aquacultural Engineering 39(2-3): 78-90
Abstract:
A pilot-scale wastewater treatment station was built and operated at a commercial recirculating aquaculture facility in order to initiate, characterize and optimize the operation of a treatment strategy for effluent recovery and reuse. The treatment train consisted of sedimentation, denitrification, ozonation, trickling filter treatment, and chemical flocculation. The study consisted of four different sets of treatment conditions, differentiated by alternative use of 6 or 4 lpm flow and recycling rates, ozone doses between 36.6 and 82.5 mg O3/l water, and 6- or 9-min ozonation time. The effects of treatment on solids and dissolved organic compounds are reported here. Over 70% of solids were removed by sedimentation under all experimental conditions. At the end of treatment, up to 99% of TSS was removed due to the combined action of ozonation and chemical flocculation. COD removal was not significantly different among experimental conditions by sedimentation (59.2–62.7%, $p > 0.05$), but was positively correlated with ozone dose (slope = 0.452, r2 = 0.99), yielding total COD removal η(CODt) of 19.8–40.7%. Of these amounts, 60.4–66.5% of COD was removed with foam, while the balance was mineralized. The ozone reactivity was 83.7% at a dose of 82.5 mg O3/l water. The ozone consumption coefficient Y(O3/CODox) for COD oxidized was 1.92–2.23 g/g O3 COD and 0.70–0.78 g O3/g COD when total COD removed was considered. Overall, 87.9–92.4% of COD was removed by the treatment train, to an average of 44 mg/l at the highest ozone dose, a value 3.3–3.9 times less than in fish tanks. Under the same conditions, cBOD5 was reduced by 88%, 3.8–4.1 times less than in fish tanks. The water's biodegradability was increased by over 20%. DOC did not change significantly through the treatment train, and fluctuated through the system due to methanol addition to support denitrification. Work with the pilot station showed that the treatment strategy employed could support effective recovery and recycling of aquaculture effluent, although salts and refractory organics may accumulate in the system.
(Department of Fisheries and Wildlife Sciences, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061, USA; email of Eric Hallerman: ehallerm@vt.edu)

ENGINEERING INVESTIGATION OF DESIGN PROCEDURES FOR CLOSED CONTAINMENT MARINE AQUACULTURE SYSTEMS
David W. Fredriksson, Igor Tsukrov, Patrick Hudson-2008
Aquacultural Engineering 39(2-3): 91-102
Abstract:
The objective of this paper is to investigate potential design procedures for rigid, closed containment aquaculture systems deployed in the marine environment. In this context, closed containment is a term used to describe a range of aquaculture technologies that attempt to restrict and control interactions between farmed fish and the external aquatic environment, with the goal of minimizing impacts. The containment units are often closely spaced and moored to the seafloor bottom. The geographical area of interest is the Straits of Georgia, British Columbia in Canada.

In this study, the design configurations of multiple closed containment systems are investigated. The design procedures include examining: (1) local environmental conditions, (2) drag forces on multiple containment units, (3) wave loading, (4) undamped heave motions, (5) mooring gear components and (6) material stresses on a rigid containment structure. Operational and other design considerations are also discussed. Preliminary findings indicate that wave forces could be substantial. In addition, little is known about how containment units, which are closely spaced, will respond individually or as a farm when subjected to surface waves.
(Department of Naval Architecture and Ocean Engineering, United States Naval Academy, 590 Holloway Road, 11D, Annapolis, MD 21108, USA; email of David W. Fredriksson: fredriks@usna.edu)

OPTIMAL STOCKING IN INTENSIVE AQUACULTURE UNDER SINUSOIDAL TEMPERATURE, PRICE AND MARKETING CONDITIONS
Ido Seginer, Ilan Halachmi-2008
Aquacultural Engineering 39(2-3): 103-112
Abstract:
When the environmental and/or market conditions of an intensive aquacultural operation vary with time, maximization of profit may require a time dependent fish stocking rate. A simplified stocking problem is formulated where temperature, market price and/or market demand change sinusoidally over the annual cycle. The fish biomass sustaining-capacity is limited by the water treatment equipment, and is expressed in terms of maximum feeding rate per unit volume of culture tanks.

It is demonstrated that under such conditions, sinusoidal stocking rates produce good sub-optimal solutions. A critical element of the solution is the time delay (phase-shift) between the constraining (restricting) conditions (temperature and market), and the stocking cycle. Furthermore, if the solutions for two individual conditions have very different time delays, a combination of the two conflicting restrictions is likely to produce poor returns.
(Civil and Environmental Engineering, Technion, IIT, Haifa 32000, Israel; email of I. Seginer: segineri@tx.technion.ac.il)

MUTUALISM BETWEEN EURYHALINE TILAPIA SAROTHERODON MELANOTHERON HEUDELOTII AND CHLORELLA SP.—IMPLICATIONS FOR NANO-ALGAL PRODUCTION IN WARMWATER PHYTOPLANKTON-BASED RECIRCULATING SYSTEMS
Sylvain Gillesa, Gérard Lacroix, Daniel Corbin, Ngansoumana Bâ, Carla Ibañez Luna, Jacob Nandjui, Allassane Ouattara, Ousséni Ouédraogo, Xavier Lazzaro-2008
Aquacultural Engineering 39(2-3): 113-121
Abstract:
The West-African euryhaline tilapia, Sarotherodon melanotheron heudelotii shift from visually feeding on zooplankton when juveniles to mostly filter feeding on phytoplankton when adults. When reared using an appropriate ration in intensive aquaculture systems, S. m. heudelotii also consume

algal-based detritus, and contribute to sediment mineralization, clean up their environment, and ultimately stimulate and sustain algal growth. We analysed such practical advantages for phytoplankton-based recirculating systems, using S. m. heudelotii and Chlorella sp. as biological material originating from the prototype of such a system operated in Senegal. We performed a 24-h factorial design experiment in 36 tubs, cross-classifying three levels of S. m. heudelotii (fishless control, unfed fish, and fed fish) with four levels of Chlorella initial density.

Chlorella overall mean density increased significantly from fishless, to unfed fish, and fed fish treatments, and with Chlorella initial density. S. m. heudelotii did not alter nitrogen nor phosphorus concentrations, only affected by algal initial densities. Most ammonia excreted by fish was probably uptaken by Chlorella. Bacteria-mediated diurnal nitrification was possibly an alternative ammonium loss mechanism at highest oxygen concentrations. Algae were not limited by nitrogen or phosphorus but most likely by low dissolved organic carbon availability. Chlorella differential responses with fed vs. unfed Sarotherodon suggest that CO2 supplied by heterotrophic S. m. heudelotii respiration played a key role. Observed Chlorella growth rates were similar to the highest rates obtained in algal mass cultures, enriched with CO2, nitrate and phosphate, under artificial lighting.

Our results suggest the existence of a Sarotherodon-Chlorella mutualism in our systems, where S. m. heudelotii provide CO2, the major limiting factor of Chlorella growth, whereas Chlorella oxygenate and detoxify the water media from ammonia, promoting S. m. heudelotii production. This mutualism could be used to optimize photosynthetic suspended-growth aquaculture systems, particularly in the Tropics where light is abundant and temperature is continuously high.
(IRD, UR 167 CYROCO, Campus ISRA-IRD, BP 1386, Bel-Air, Dakar CP 18524, Senegal; email of X. Lazzaro: xavier.lazzaro@ird.fr)

IS SPERMATOPHORE MELANISATION IN CAPTIVE SHRIMP (LITOPENAEUS VANNAMEI) A RESULT OF AN AUTO-IMMUNE RESPONSE?
Sian Diamond, Adam Powell, Robin J. Shields, Andrew F. Rowley-2008
Aquaculture 285(1-4): 14-18
Abstract:
Male reproductive tract degenerative syndrome in shrimp is a condition associated with the melanisation and degradation of sperm housed in the spermatophores. While it has been suggested that this condition is associated with a number of external factors including temperature, diet and microbial infection, the cause of this condition is still unclear. This current study examines if the melanisation of the spermatophores may be a result of an auto-immune condition during which the spermatozoa are recognised as ‘foreign’ by the shrimp's immune system. Initial studies examined the morphology of spermatozoa extracted from normal and heavily melanised spermatophores. A larger percentage of abnormal sperm were found in the melanised compared with the normal spermatophores. There was no indication of any bacterial infection associated with the melanised spermatophores ruling this out as a potential trigger for the syndrome. Incubation of apparently healthy sperm from non-melanised spermatophores with blood cells (haemocytes) showed little interaction while incubation of abnormal sperm from animals with the syndrome with haemocytes resulted in their phagocytosis. Histological analysis of melanised spermatophores revealed the presence of abnormal sperm together with melanised and non-melanised amorphous debris but there was no indication of any haemocyte infiltration or general host reaction to the presence of these abnormal cells in vivo. Overall, although in vitro experiments indicated that damaged sperm together with attendant amorphous debris is apparently recognised as foreign leading to its engulfment by phagocytic haemocytes, such interaction was not observed in vivo. The possible reasons for this disparity are discussed.
(Centre for Sustainable Aquaculture Research, Department of Environmental & Molecular Biosciences, Swansea University, Singleton Park, Swansea SA2 8PP, UK; email of Andrew F. Rowley: a.f.rowley@swansea.ac.uk)

AN ACYL HOMOSERINE LACTONE-DEGRADING MICROBIAL COMMUNITY IMPROVES THE SURVIVAL OF FIRST-FEEDING TURBOT LARVAE (SCOPHTHALMUS MAXIMUS L.)
Nguyen Thi Ngoc Tinh, b, Vu Hong Nhu Yen, Kristof Dierckens, Patrick Sorgeloos, Peter Bossier-2008
Aquaculture 285(1-4): 56-62
Abstract:
Two N-acyl homoserine lactone (AHL) degrading enrichment cultures (EC3 and EC5), originating from the microbial community of the Penaeus vannamei shrimp gut, were incorporated into first-feeding turbot larvae through addition to the rearing water and/or bio-encapsulation in rotifers, prior to their feeding to the turbot larvae. Both ECs were able to colonize the larval gut and to persist up to five days after their addition was discontinued. However, only EC5 was effective in improving turbot larvae survival under the experimental conditions, i.e. when the survival of turbot larvae was compromised through the daily addition of AHL molecules (1 mg l− 1). The latter treatment reduced the survival to 5.9% or 10.4% dependent on the experiment (while in the control treatment, the survival was 35% and 92.1%, respectively). Through the addition of EC5, the effect of AHL could be nullified. There was a strong negative correlation between the residual AHL concentration in the water and the larval survival on the last day. The negative effect on turbot larval survival might be caused by AHL-induced in situ production of virulence factors by uncharacterised opportunistic bacteria, while EC5 can counteract this effect. These results suggest that quorum sensing interference might become part of novel non-antibiotic based strategies to overcome high mortalities in the industrial larval production of marine fish.
(Laboratory of Aquaculture & Artemia Reference Center, Ghent University, Rozier 44, 9000 Gent, Belgium; email of Peter Bossier: Peter.Bossier@ugent.be)

THE EFFECTS OF SEASON, TEMPERATURE AND PHOTOPERIOD ON THE GONAD DEVELOPMENT OF EVECHINUS CHLOROTICUS
Philip J. James, Philip L. Heath-2008
Aquaculture 285(1-4): 67-77
Abstract:
A series of experiments testing the effects of seasonality, temperature and photoperiod were carried out to investigate the effects of biotic (gametogenesis) and abiotic factors (temperature and photoperiod) on roe enhancement of Evechinus chloroticus. Urchins were collected and held at 10, 14 and 18 °C and in 6, 12 and 18 h light in three 10-week experiments during spring, summer and winter. Groups of 20 urchins (mean test diameter = 85.9 ± 0.2 mm; mean wet weight = 264.4 ± 1.5 g) were held in baskets and fed ad libitum a formulated moist feed.

Seasonal effects on the final urchin gonad index (GI) of each experiment reflected the initial GI of the urchins at the beginning of each experiment. There were seasonal effects observed for the increase in GI values in the experimental urchins but these were restricted to a slightly higher increase in GI in summer. Urchins held at 18 °C had significantly higher GI values and larger increases in GI than those held at 14 °C, except in summer when there was no significant difference between the final GI values of these two temperature treatments. Urchins held at 14 °C had significantly greater gonad growth and increase in GI than those held at 10 °C in each of the three experiments. In terms of the economics of roe enhancement, the benefits of increases in GI must be weighed against any increase in holding temperatures in land-based holding systems, or in transporting urchins to sites with warmer ambient temperatures in sea-based holding systems. Photoperiod appeared to have no effect on gonad growth except in summer when the short day treatment (6 h L) had significantly lower GI and increase in GI than the other treatments (12 or 18 h L). Season had an effect on gonad colour, temperature had a limited effect on gonad yellowness and photoperiod had no effect. None of the experimental factors had a significant effect on urchin survival. The reproductive stage of the experimental urchins advanced with increasing temperature. Seasonal changes in the reproductive cycle of E. chloroticus do not appear to have a significant effect on gonad growth other than during periods when there is a high percentage of urchins in the “spent” stage (summer).

(National Institute of Water and Atmospheric Research, Wellington, New Zealand; email of Philip J. James: p.james@niwa.co.nz)

REPRODUCTIVE CYCLE AND CONDITIONING OF TRANSLOCATED SCALLOPS (PECTEN MAXIMUS) FROM FIVE BROODSTOCK POPULATIONS IN NORWAY

Thorolf Magnesen, Gyda Christophersen-2008
Aquaculture 285(1-4): 109-116

Abstract:
In Norway sea ranching depends on deployment of animals of local origin, and growers demand large spat outside the natural production season. To develop stock-specific production of juveniles, knowledge on local scallop reproductive cycle and performance in hatchery was needed. Broodstock sized scallops (Pecten maximus) were collected from 5 locations along the coast of Norway from 59°N to 65°N during 2004 and 2005, and translocated to natural sea location at 61°N. The reproductive cycles were characterised and the possibility of performing successful hatchery conditioning and spawning outside the natural reproduction cycle was investigated.

Results showed that scallops from south-western Norway (3 locations) all had distinct season summer peaks in the reproductive cycles. Scallops from the northern part (2 locations) quickly rebuilt the gonad after spawning and seemed to have full gonads through most of the year. Gonad indices in the southern group varied between 5 and 15%, while in the northern group it was 10 to 25% of total tissue weight. Both in December and March most individuals (> 75%) in the southern group had empty gonads, while most individuals in the northern group were characterised as being in gonad maturation stages 3–6. There was no complete synchronous gonad development through the year, and most developmental stages were present at all times. Scallops from the southern locations showed small changes in gonad maturation after translocation to the new environment. Scallops from northern locations kept the original cycle, but seemed to spawn later in summer. Scallops from the 3 southern locations responded to conditioning methods in the hatchery from late autumn to spring, as did one of the northern populations, while the other northern population could not be conditioned in winter. Based on reproductive cycle and hatchery performance we suggest that scallops from the 5 locations belonged to 3 distinct different populations. The differences in timing of gametogenesis and response to conditioning environment have implications for spat production in the hatchery and must be accounted for in order to fulfil the requirements of site-specific spat for scallop sea ranching in Norway.

(University of Bergen, Department of Biology, PO Box 7800, N-5020 Bergen, Norway; email of Thorolf Magnesen: thorolf.magnesen@bio.uib.no)

CRYOPRESERVATION OF SPERM FROM MURRAY COD, MACCULLOCHELLA PEELII PEELII

Jonathan Daly, David Galloway, William Bravington, Michael Holland, Brett Ingram-2008
Aquaculture 285(1-4): 117-122

Abstract:
Freshwater fish sperm are inactive in the male reproductive tract and seminal plasma. They are activated under hypotonic conditions, with a brief period of motility at the time of fertilization. The aims were to find a dilution medium that would maintain sperm inactivity, to assess the cytotoxicity of a range of cryoprotectants, and test the effectiveness of selected diluents for cryopreservation of Murray cod sperm. Sperm remained immotile in ionic and non-ionic solutions above 300 mOsm kg− 1. Sperm motility after centrifugation and re-suspension in fresh water was better for solutions of 300 and 600 mOsm kg− 1 than 900 mOsm kg− 1. In the presence of cryoprotectants, dimethylsulfoxide, dimethylacetamide, and methanol, recovery was better at 300 mOsm kg− 1 compared to 600 mOsm kg− 1. Sperm diluted in all media containing glycerol remained inactive after centrifugation and re-suspension in water. A cryopreservation diluent composed of 300 mOsm kg− 1 d-Sorbitol (DS) solution with 10% methanol produced the best post-thaw motility (51.4 ± 3.4%), followed by Tris–Sucrose–Potassium (TSK) solution with 10% methanol (32.9 ± 4.7%), and Modified Kurokuras

medium with 10% methanol (27.5 ± 4.8%). Fluorescent staining for membrane integrity (SYBR-14 and Propidium Iodide) reflected the post-thaw motility results. Fertilization trials using sperm frozen in DS solution with 10% methanol produced a hatch rate of 11.0% (63.1 ± 18.23% of a control fresh sperm hatch rate) and 6.4% (58.5 ± 32.50% of fresh sperm hatch rate) using sperm frozen with TSK with 10% methanol. This represents the first successful cryopreservation of sperm from Murray cod. Sperm cryopreservation will facilitate both conservation and aquaculture of the Murray cod and related endangered Maccullochella species.
(Centre for Reproduction and Development, Monash Institute of Medical, Research, Clayton, Victoria 3168, Australia; email of Jonathan Daly: Jonathan.Daly@med.monash.edu.au)

EVALUATION OF CHANGES IN NUTRIENT COMPOSITION DURING PRODUCTION OF CROSS-LINKED PROTEIN MICROENCAPSULATED DIETS FOR MARINE FISH LARVAE AND SUSPENSION FEEDERS
Andreas Nordgreen, Manuel Yúfera, Kristin Hamre-2008
Aquaculture 285(1-4): 159-166
Abstract:
Cross-linked protein capsules as a vehicle for delivery of nutrients to marine fish larvae and marine suspension feeders were investigated. The effects of the production process on both qualitative and quantitative changes in protein, lipid and micronutrient concentrations were evaluated. There were no changes in lipid concentration and only minor (but significant) differences in crude protein concentrations as a result of the encapsulation process. However, there was nearly a complete loss of water-soluble nitrogen during capsule production — almost 100% of the water-soluble protein was cross-linked and made insoluble and 79% of the TCA-soluble N was lost. Peptides and free amino acids were lost during the capsule washing stages, but except for a 100% loss of taurine, small changes in the amino acid profile were observed. There was more than 90% loss of water-soluble micronutrients such as thiamin, vitamin C and zinc during capsule production, and only minor increase in concentration of thiamin and zinc in the diet by increasing the levels of these minerals and vitamins were possible. The fat-soluble vitamin E was not affected by the production process and can be delivered at controlled concentrations, but vitamin A had loss ranging from 4–57% with increased inclusion of vitamin A. With the existing production protocol, the results suggest that cross-linked protein capsules are not suitable for the delivery of water-soluble nutrients to fish larvae and marine suspension feeders.
(National Institute of Nutrition and Seafood Research (NIFES), Post-box 2029 Nordnes, 5017 Bergen, Norway; email of Andreas Nordgreen: Andreas.Nordgreen@nifes.no)

FATTY ACID COMPOSITION OF LARVAE OF THE SAND DOLLAR DENDRASTER EXCENTRICUS (ECHINODERMATA) MIGHT REFLECT FA COMPOSITION OF THE DIETS
Sophie B. George, Colleen Fox, Stuart Wakeham-2008
Aquaculture 285(1-4): 167-173
Abstract:
Fatty acid (FA) requirements of echinoderm larvae were examined by a study of the FA composition, growth, and development of Dendraster excentricus larvae fed a microencapsulated diet, and two algal diets. Larvae were assigned to three treatments with three replicates per treatment, a microencapsulated diet, a single algal diet of Dunaliella tertiolecta and a mixed algal diet of Isochrysis galbana and Dunaliella tertiolecta. The percentage of saturated fatty acids (SAFA), short and long chain polyunsaturated fatty acids (PUFA) differed significantly among the algal diets and the microencapsulated diet. Differences in dietary FA composition influenced larval tissue FA composition. Eight day-old sand dollar larvae fed the single and mixed algal diets had a significantly higher percentage of the SAFA myristic acid (14:0), while eight day-old larvae fed the microencapsulated diet had a significantly higher percentage of the SAFA palmitic acid (16:0). Sixteen day-old competent larvae fed all three diets did not differ significantly in the percentage of myristic or palmitic acid. The algal diets had a higher percentage of the short chain PUFAs linolenic (LNA, 18:3n-3) and stearidonic acid (SDA, 18:4n-3) while the microencapsulated diet had the highest

percentage of the long chain PUFAs eicosapentanoic acid (EPA, 20:5n-3) docosahexanoic acid (DHA, 22:6n-3) and arachidonic acid (AA, 20:4n-6). The percentage of short chain PUFAs, though high in the algal diets, was low in the larval tissues, while the percentage of long chain PUFAs, though low in the algal diets, was high in the larval tissues. Competent larvae fed the two algal diets had up to ten times the percentage of EPA and AA than those fed the microencapsulated diet. Unexpectedly, despite a high percentage of DHA and EPA in the microencapsulated diet, the percentage of these long chain PUFAs in the tissues of larvae fed this diet was extremely low. Eight day-old larvae fed the three diets did not differ significantly in total larval length. Competent larvae fed algal diets had significantly longer larval arms, bigger stomachs and larger rudiments than those fed the microencapsulated diet. This study indicates that early larval growth and development of Dendraster excentricus were not discernibly affected by differences in dietary FA composition of microencapsulated and algal diets but the competent larval stages were. Similar growth and development of competent echinoderm larvae fed microencapsulated or algal diets might be obtained by enriching the microencapsulated diets with the short chain PUFAs LNA and SDA, and the long chain PUFAs EPA and AA. This is an important research tool as microencapsulated feeds can be used to establish nutritional requirements of fatty acids for echinoderm larval development.
(Georgia Southern University, Statesboro, Georgia, United States; email of Sophie B. George: georges@georgiasouthern.edu)

UPTAKE OF IODIDE FROM WATER IN ATLANTIC HALIBUT LARVAE (HIPPOGLOSSUS HIPPOGLOSSUS L.)
Mari Moren, Jens J. Sloth, Kristin Hamre-2008
Aquaculture 285(1-4): 174-178
Abstract:
The natural diet of marine fish larvae, copepods, contain 60–350 mg I kg− 1, while live feed used in commercial hatcheries have iodine concentrations in the range of 1 mg kg− 1. Seawater is also considered to be an important source of iodine for marine fish. The question asked in this study is whether Atlantic halibut larvae are capable of absorbing iodide from the water and if so, can the seawater sustain the iodine requirement during larval development and metamorphosis.

Levels of iodide and iodate in seawater samples from four different rearing facilities were analysed. All samples contained relative low levels of iodide (0–22 nM) and except for samples from one site; the levels of iodide and iodate were in agreement with previously published data. The uptake of iodide from seawater was measured by incubating Atlantic halibut larvae in water with a constant level of radioactive iodide (125I−) and increasing levels of cold iodide (127I−). To evaluate whether the uptake of iodide would change during metamorphosis, three different developmental stages (pre metamorphic, metamorphic and post metamorphic) were examined. The uptake was similar for all three stages, increasing with increasing concentration of iodide in the water. The highest level of iodide used was 2000 nM, 100 times higher than what was measured in the seawater samples. The uptake curves did not seem to reach equilibrium. This may be due to a constant non-specific uptake or that the equilibrium level is higher than 2000 nM. The uptake was partly blocked by perchlorate (ClO3−) which is a known inhibitor of the sodium iodide symporter. This indicates that the Atlantic halibut larvae accumulate iodide through both specific and non-specific uptake pathways.
(National Institute of Nutrition and Seafood Research (NIFES), P.O. Box 2029 Nordnes, N-5006 Bergen, Norway; email of Mari Moren: mari.moren@nifes.no)

BIOCHEMICAL STUDIES ON THE INTERACTIVE EFFECTS OF DIETARY CHOLINE AND INOSITOL IN JUVENILE KURUMA SHRIMP, MARSUPENAEUS JAPONICUS BATE
Fady Raafat Michael, Shunsuke Koshio-2008
Aquaculture 285(1-4): 179-183
Abstract:
A 42-day feeding trial was conducted using a 2 × 3 factorial design to evaluate the effect and interaction of choline chloride (CC) and myo-inositol (MI) on juvenile Kuruma shrimp Marsupenaeus

japonicus (initial size 0.93 ± 0.01 g; mean ± S.D.). Six test diets were formulated to contain 3 levels of CC (0, 0.06 and 0.12%) and 2 levels of MI (0 and 0.4%). A significant ($P < 0.05$) interaction was determined between CC and MI on the survival percentage, percent weight gain, specific growth rate, feed efficiency ratio, protein efficiency ratio and both phospholipids and phosphatidylinositol content of the whole body of the juvenile M. japonicus. Control shrimp fed no supplemental CC or MI showed lower ($P < 0.05$) values of the above-mentioned parameters than shrimps fed 0.06 and 0.12% supplemented CC with or without MI supplementation. The present study showed that supplementation of 0.12% dietary CC could compensate Kuruma-shrimp juveniles with the needed phospholipids when fed MI-deficient diets. Also, the supplementation of MI was needed in the case of feeding Kuruma-shrimp juveniles CC-deficient diets to compensate phospholipid deficiency.
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EFFECT OF ZINC AND MANGANESE SUPPLEMENTATION IN ARTEMIA ON GROWTH AND VERTEBRAL DEFORMITY IN RED SEA BREAM (PAGRUS MAJOR) LARVAE

Van Tien Nguyen, Shuichi Satoh, Yutaka Haga, Hiroshi Fushimi, Tomonari Kotani-2008

Aquaculture 285(1-4): 184-192

Abstract:
Feeding trials were carried out to determine the effects of zinc (Zn) and manganese (Mn) supplementation in Artemia on growth, survival, body composition and skeletal deformity of red sea bream larvae. Triplicate groups of red sea bream larvae from 15–30 day post-hatching (dph) were fed four types of Artemia enriched with Zn (Z), Mn (M), both Zn and Mn (ZM) and without Zn or Mn (control). At 30 dph, significantly higher ($P < 0.05$) growth performance of the fish was recorded in M group (TL = 15.60 ± 0.45 mm) compared to that of the control (TL = 14.90 ± 0.41 mm). Fish fed Artemia supplemented with only Zn and with both Zn and Mn showed similar growth performance compared to that of the control. Survival of the fish was not affected either by Zn or Mn supplementation. Increased Mn or both Zn and Mn in Artemia nauplii significantly elevated ($P < 0.05$) crude lipid content in 30dph juvenile compared to that in the Z group. At 30 dph, Mn content in juvenile of M and ZM groups was significantly higher ($P < 0.05$) compared to that in the other groups. Similarly, Zn content in the Z group was significantly higher ($P < 0.05$) compared to that in the M and control groups. Skeletal deformities in the experimental fish at 30 dph were highest ($P < 0.05$) in the control group and were significantly improved by supplementation with Zn and Mn. The major skeletal deformities were observed in the vertebral column, neural and hemal spines. In the vertebral column, occurrence of deformities in the neck, hemal and preural were higher than in other regions. The results of the present study demonstrated that maintenance of Mn level in Artemia nauplii from 12 to 42.8 μg g− 1 (dry-matter basis) improved growth performance of red sea bream larvae. Zn and Mn supplementation in Artemia promoted normal skeletal development of red sea bream larvae.
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COMPARISON OF REPRODUCTIVE OUTPUT, OFFSPRING QUALITY, OVARIAN HISTOLOGY AND FATTY ACID COMPOSITION BETWEEN SIMILARLY-SIZED WILD AND DOMESTICATED FARFANTEPENAEUS PAULENSIS

Silvio Peixoto, Wilson Wasielesky Jr., Ricardo C. Martino, Ângela Milach, Roberta Soares, Ronaldo O. Cavalli-2008

Aquaculture 285(1-4): 201-206

Abstract:
The reproductive performance of similarly-sized wild-caught (W) and domesticated (D) Farfantepenaeus paulensis broodstock (mean weight of 46 g for females and 29 g for males) was assessed over 30 days under standardized conditions. Wild broodstock were collected from a population off the coast of Santa Catarina, Brazil. The domesticated shrimp were first generation lines originated from the same population as the wild broodstock and were reared to 16 months of age in covered raceway tanks. Reproductive performance (e.g. data from successive spawnings) and

offspring quality (egg diameter, length and survival of nauplii and protozoea stages) were recorded. Mature ovaries were sampled for the evaluation of gonadosomatic index (GSI), histological characteristics and fatty acid content. The GSI and ovarian histology indicated that full maturation was attained by both groups, but domesticated females showed a higher percentage of mature oocytes (mean ± standard deviation) (W = 25.9 ± 7.4%; D = 35.5 ± 14.2%). Spawning performance and offspring quality were similar between wild and domesticated broodstock. Although a significantly higher number of eggs per spawning event (W = 184,371 ± 89,011; D = 147,426 ± 79,348) were observed for wild females, the total number of eggs per female (W = 529,065 ± 324,412; D = 421,587 ± 257,677), egg fertilization (W = 75.8 ± 28.8%; D = 69.8 ± 27.9%) and hatching rates (W = 52.3 ± 35.0%; D = 64.1 ± 15.7%) were similar between the two broodstock sources. Ovaries of wild females contained significantly higher levels of n−3 highly unsaturated fatty acids and, as these females produced comparatively more eggs per spawning event, it suggests that these fatty acids may have a role on ovarian development and fecundity. Overall results suggest that the reproductive performance, offspring quality, and ovarian maturation of 16-month-old domesticated F. paulensis broodstock were equivalent to that of similarly-sized wild-caught broodstock from deep-sea waters.
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PERSISTENT ORGANIC POLLUTANTS IN AQUAFEED AND PACIFIC SALMON SMOLTS FROM FISH HATCHERIES IN BRITISH COLUMBIA, CANADA
Barry C. Kelly, Marc P. Fernandez, Michael G. Ikonomou, Wayne Knapp-2008
Aquaculture 285(1-4): 224-233
Abstract:
Recent studies have reported the occurrence of persistent organic pollutants (POPs) in commercial feeds used by fish hatcheries and aquaculture facilities. We measured levels of polychlorinated biphenyls (PCBs), polychlorinated dibenzo-p-dioxins (PCDDs), polychlorinated dibenzo furans (PCDFs), as well as several organochlorine pesticides (OCPs) in several aquafeeds as well as fry and smolts collected from four federal salmonid hatcheries from coastal British Columbia. ΣPCBs in aquafeed samples (n = 22) averaged 270 ± 136 ng/g lipid. ΣDDTs, ΣToxaphene, ΣChlordanes, ΣChlorobenzenes, ΣHexachlorocyclohexanes, dieldrin, endrin and pentachloroanisole in feeds ranged between 0.6 and 200 ng/g lipid. ΣPCDD/F levels in feed samples were relatively low (77 ± 50 pg/g lipid). In some cases, contaminant levels and patterns varied between different feed brands (i.e., Moore–Clarke, EWOS and OMP). ∑PCB concentrations (ng/g lipid) in Moore–Clarke (154.3 ± 88.9) were significantly lower ($p < 0.05$) than ∑PCBs in OMP (319.8 ± 101) and EWOS (376.3 ± 88.2) feeds, which is likely due to different constituent composition in the Moore–Clarke feed. As young hatchery salmon smolts are sequentially introduced to increasingly lipid-rich starter feeds (which contain higher contaminant burdens), dietary exposure of POPs generally increases during the rearing process. However, tissue residue concentrations of POPs in smolts remained relatively low compared to feed, as denoted by the relatively low biomagnification factors of the various POPs (BMFs between 0.2 and 3). 2,3,7,8 TCCD toxic equivalent concentrations (TEQs) in smolts (0.21 ± 0.19 pg/g wet wt.) were generally below levels associated with dioxin-like toxic effects. The highest TEQ was observed in Robertson Creek smolts (0.38 ± 0.11 pg/g wet wt). Biochemical response measurements (EROD activity and CYPIA levels) in liver tissue of those smolts did not show any indication of negative impacts associated with aryl hydrocarbon (Ah) receptor inducers such as dioxins/furans and dioxin-like PCBs.
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DEVELOPMENT OF MODELS OF THRESHOLD AND EFFICIENT ALGAL DENSITIES FOR LARVAL AND JUVENILE TILAPIA OREOCHROMIS NILOTICUS ON RAW SPIRULINA
Jun Lu, Hiroo Satoh, Toshio Takeuchi-2008
Abstract:

Different densities of 14Carbon (14C) labeled Spirulina platensis were fed to larval and juvenile tilapia Oreochromis niloticus with a body weight of 10 mg, 20 mg, 200 mg, 700 mg, 1000 mg, and 1800 mg at a constant temperature of 25 °C during 1-h feeding period. Ingestion rate (IR, μgC/fish/h), assimilation rate (AR, μgC/fish/h), and clearance rate (CR, mL/fish/hour, an indicator exhibiting the fish water filtration effort) of Spirulina were investigated by monitoring the fate of the 14C labeled food. Quadratic regression models were developed for evaluation of ingestion and assimilation of raw Spirulina by larval and juvenile tilapia of different sizes under various algal densities. We estimated the threshold density (TD, mg/L) of Spirulina for tilapia of each size to sustain the basic metabolism when AR calculated from the models initially matched their respective values of resting carbon consumption requirement for respiration. The relationship between TD and body weight (BW, mg) could be expressed as TD = 26.937 W− 0.248 (R2 = 0.936). We estimated the efficient density (ED, mg/L) for the fish of each size to assimilate Spirulina without 'surplus' feeding of suspended raw Spirulina when AR calculated from the models reached their respective maxima. The relationship between ED and body weight (BW, mg) could be expressed as ED = 220.03 BW− 0.203 (R2 = 0.901). Larval and juvenile tilapia seem to utilize Spirulina in a feeding strategy of controlling the net intake and requirement of energy by conditioning the clearance rate on algal suspension at various densities of Spirulina. This feeding strategy becomes more effective with the development of the buccopharyngeal filter feeding apparatus. Only in an artificial ecological system, e.g. CERAS may provide sufficient densities of Spirulina for early larval tilapia without the soundly developed buccopharyngeal filter feeding apparatus to sustain the basic metabolism.
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TECHNICAL IMPROVEMENTS OF A REARING SYSTEM FOR THE CULTURE OF DECAPOD CRUSTACEAN LARVAE, WITH EMPHASIS ON MARINE ORNAMENTAL SPECIES
Ricardo Calado, Tânia Pimentel, António Vitorino, Gisela Dionísio, Maria Teresa Dinis-2008
Aquaculture 285(1-4): 264-269
Abstract:
The present study compares the efficiency of cylindrico-spherical (CST) and cylindrico-conical tanks (CCT) to culture the larvae of decapod crustaceans, with emphasis to marine ornamental species, and describes a new filter system to flush uneaten preys. The ornamental shrimps Lysmata debelius, Lysmata seticaudata and Stenopus hispidus, the ornamental crab Stenorhynchus seticornis and the ornamental hermit crab Clibanarius erythropus were used as case studies. The two types of tanks displayed different water circulation patterns, with the inflowing water in CST being pushed towards the spherical bottom and vertical tank walls, in a gentle upwelling motion, while in CCT the inflowing water was abruptly pushed towards the surface at the center of the tank. In comparison to the "traditional" system, the average time required to replace the mesh screens to flush uneaten preys was inferior when employing the new filter system (30 and 5 s per tank, respectively). The average survival to metamorphosis (± standard error) recorded for L. seticaudata was higher in CST (97.25 ± 0.50%) than in CCT (94.25 ± 0.96%), with a higher percentage of L. debelius larvae in CST also being able to metamorphose (33.75 ± 4.77%), when compared to those in CCT (6.50 ± 3.79%). S. hispidus larvae displayed higher survival to the fifth zoeal stage when raised in CST (93.25 ± 2.99%) than when cultured in CCT (66.50 ± 4.20%). A higher number of C. erythropus were able to successfully occupy gastropod shells and metamorphose in CST (80.25 ± 5.12%) than in CCT (4.25 ± 2.22%). S. seticornis cultured in CST displayed higher survival to metamorphosis than those cultured in CCT (76.25 ± 3.40% and 16.00 ± 2.58%, respectively). A higher percentage of L. seticaudata and L. debelius larvae at the last zoeal stage displayed intact fifth pereiopods in CST (96.02 ± 3.40% and 88.15 ± 8.70%, respectively), when compared to those raised in CCT (83.95 ± 3.86% and 36.54 ± 3.10%, respectively). The percentage of S. hispidus larvae displaying an undamaged rostrum and dorsal abdominal spine was higher in CST than in CCT (95.71 ± 4.19% and 61.84 ± 2.50%, respectively). Along with the new filter system, CST appear as a feasible option for the larviculture of decapods, namely marine ornamental species (shrimps, crabs and hermit crabs), allowing a better use of inert diets and minimizing the risks of larval mortality due to tangling damage, cannibalism and the action of opportunistic pathogens over damaged larvae.

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TOLERANCE OF JUVENILE POMPANO TRACHINOTUS MARGINATUS TO ACUTE AMMONIA AND NITRITE EXPOSURE AT DIFFERENT SALINITY LEVELS

Luiza Dy F. Costa, Kleber C. Miranda-Filho, Marlon P. Severo, Luis A. Sampaio-2008
Aquaculture 285(1-4): 270-272

Abstract:
The present study was conducted to estimate the acute toxicity of unionized ammonia–nitrogen (NH3–N) and nitrite–nitrogen (NO2–N) to juvenile pompano Trachinotus marginatus (0.86 ± 0.21 g) at different salinity levels: 5, 10 (equivalent to its isosmotic point), and 30‰. Fish were acclimated to the different salinities for 10 days and fed ad libitum daily. Groups of five fishes were exposed to five concentrations of NH3–N and NO2–N for 96 h plus control groups for each salinity, where no toxicant was added. Test concentrations ranged from 0.28 to 3.53 mg NH3–N/L and 24.8 to 191.1 mg NO2–N/L with three replicates per treatment. Tests were run using a standard semi-static system with 100% daily renewal of water and toxicants. The results were based on mortality data registered in different concentrations tested, using the software Trimmed Spearman Karber method. The median lethal concentrations (LC50) after 96 h of exposure to NH3–N were 0.66 (0.53–0.81), 1.87 (1.65–2.12) and 1.06 (0.94–1.20) mg NH3–N/L for 5, 10, and 30‰. The 96 h LC50 to NO2–N were 39.94 (36.39–43.84), 116.68 (112.52–121.00) and 37.55 (20.91–67.44) mg NO2–N/L for 5, 10, and 30‰. Acute toxicity of NH3–N and NO2–N to pompano was affected by salinity. Results of the present study show that pompano reared at an isosmotic environment are less sensitive to NH3–N and NO2–N. Tolerance to NH3–N is compromised at reduced salinities, while toxicity of NO2–N is similar at 5 and 30‰.

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