
THE BRINE SHRIMP ARTEMIA SP. AS ALTERNATIVE PREY FOR REARING THE PREDATORY BUG MACROLOPHUS CALIGINOSUS

Cristina Castañé, Rosa Quero, Jordi Riudavets-2006

Biological Control 38 (3): 405-412

Abstract:

The predatory bug *Macrolophus caliginosus*, which is widely used in greenhouse crops, is limited in its application by its high price. An important factor in the cost is the high price of *Ephestia kuehniella* eggs, the prey used in their mass rearing. In order to reduce their price, alternatives to moth eggs are currently being investigated. The brine shrimp *Artemia* sp. is produced in large quantities in saline lakes and is fed as live food source to the larvae of a variety of marine and freshwater organisms. In this study, we tested *Artemia* sp. as prey for rearing *M. caliginosus* from two strains. We evaluated developmental and reproduction parameters of the predator when fed nauplii, enriched nauplii with a fatty acid, dry cysts and hydrated cysts, and were compared with those obtained when the predator was fed with *E. kuehniella* eggs. Nauplii had a significant reduction in survivorship, a delay in development of nymphs and a low reproduction of adults. Nauplii enriched with docosahexaenoic acid (DHA, 22:6n-3), a common practice for larviculture of some marine fish species, resulted toxic to *M. caliginosus* nymphs and survival was quite low. On the contrary, either dry or hydrated cysts from the two strains tested of the brine shrimp produced the same nymphal survivorship, nymphal development time and weight and fecundity of adults as those obtained with *E. kuehniella* eggs. Demographic parameters of the eighth generation of the predator reared with cysts of the two strains, either dry or hydrated, were as good as those of moth eggs. We concluded that *Artemia* sp. cysts were a good substitution prey for the mass rearing of *M. caliginosus*.

(Departament de Protecció Vegetal, IRTA-Centre de Cabrils, Ctra. de Cabrils s/n, 08348-Cabrils, Barcelona, Spain; email of C. Castañé: cristina.castane@irta.es)

INVESTIGATION OF THE LIGHT DYNAMICS AND THEIR IMPACT ON ALGAL GROWTH RATE IN A HYDRAULICALLY INTEGRATED SERIAL TURBIDOSTAT ALGAL REACTOR (HISTAR)

Barbara C. Benson, Kelly A. Rusch-2006

Aquacultural Engineering 35 (2): 122-134

Abstract:

There is a need for greater understanding of the light dynamics in photoautotrophic microalgal reactors as commercialization efforts move forward. This paper presents results of experiments performed to determine (1) surface irradiance ($I_0(\text{PAR})$) as a function of lamp elevation; (2) depth (z) and biomass (X) dependent scalar irradiance ($I_z(\text{PAR})$) and attenuation $k_0(\text{PAR})$; (3) average scalar irradiance ($I_a(\text{PAR})$) in the reactor as a function of biomass; and (4) specific growth rate as a function of $I_a(\text{PAR})$ and impacted by photoinhibition for the hydraulically integrated serial turbidostat algal reactor (HISTAR) illuminated by metal halide lamps. *Selenastrum capricornutum* was used as the test organism. Lamp elevation studies resulted in a light energy dissipation coefficient (k_a) of $7.46 \mu\text{mol s}^{-1} \text{m}^{-2} \text{cm}^{-1}$. Light attenuation studies yielded a linear partition of the attenuation coefficient between the water and biomass; $k_0(\text{PAR}) = 1.97 + 0.0575X$ and an exponential relationship between $I_a(\text{PAR})$ and X ; $I_{a456} = 277 e^{-0.0118X}$. Finally, net the specific growth rate was found to follow Steele's model for determination, resulting in a $\mu_{\text{max}} = 1.73 \text{ d}^{-1}$ and $I_{\text{opt}}(\text{PAR}) = 391 \mu\text{mol s}^{-1} \text{m}^{-2}$. (Louisiana State University, Department of Civil and Environmental Engineering, 102 ELAB, Baton Rouge, LA 70803, USA; email of B. Benson: barbarabenson@louisiana.edu)

DESIGN OF A COMPUTERIZED, TEMPERATURE-CONTROLLED, RECIRCULATING AQUARIA SYSTEM

Ann M. Widmer, Corissa J. Carveth, John W. Keffler, Scott A. Bonara-2006

Aquacultural Engineering 35 (2): 152-160

Abstract:

We built a recirculating aquaria system with computerized temperature control to maintain static temperatures, increase temperatures 1 °C/day, and maintain diel temperature fluctuations up to 10 °C. A LabVIEW program compared the temperature recorded by thermocouples in fish tanks to a desired set temperature and then calculated the amount of hot or cold water to add to tanks to reach or maintain the desired temperature. Intellifaucet® three-way mixing valves controlled temperature of the input water and ensured that all fish tanks had the same turnover rate. The system was analyzed over a period of 50 days and was fully functional for 96% of that time. Six different temperature treatments were run simultaneously in 18, 72 L fish tanks and temperatures stayed within 0.5 °C of set temperature. We used the system to determine the upper temperature tolerance of fishes, but it could be used in aquaculture, ecological studies, or other aquatic work where temperature control is required.

(Arizona Cooperative Fish and Wildlife Research Unit, U.S. Geological Survey, University of Arizona, 104 Biosciences East, Tucson, AZ 85719, United States; email of Ann M. Widmer: widmer@gmail.com)

THE GROWTH RATE, BIOMASS PRODUCTION AND COMPOSITION OF CHAETOCEROS SP. GROWN WITH DIFFERENT LIGHT SOURCES

María del Pilar Sánchez-Saavedra, Domenico Voltolinab-2006

Aquacultural Engineering 35 (2): 161-165

Abstract:

The diatom *Chaetoceros* sp. was grown with a continuous photon flow rate of 125 $\mu\text{mol m}^{-2} \text{s}^{-1}$, provided by Cool White (CW), or by Gro-Lux and Gro-Lux wide spectrum agricultural lamps (GRO and GRO/WS). At the end of exponential and during stationary growth, these gave higher cell numbers and biomass than CW lamps. There were no differences in cell concentration and growth rates between GRO and GRO/WS-grown cultures, but biomass was significantly higher with GRO lamps. In all treatments, protein concentration was higher and lipids were lower at the end of exponential growth than in the stationary phase, but proteins remained consistently higher than other treatments with GRO lamps in both growth phases, possibly because of their high emission of blue light. CW gave the highest lipid and GRO/WS the best carbohydrate production during both phases of growth. This suggests that these consistent differences are caused by different spectral qualities of light, that could be used to obtain different live diets for aquaculture, varying the time of harvest and the type of light sources.

(Centro de Investigación Científica y de Educación Superior de Ensenada (CICESE), Departamento de Acuicultura, Kilómetro 107 Carretera Tijuana-Ensenada, Apartado Postal 2732, Ensenada, Baja California, C.P. 22860, Mexico; email of María del Pilar Sánchez-Saavedra: psanchez@cicese.mx)

EFFECT OF DIETARY INULIN AND OLIGOSACCHARIDES AS PREBIOTICS FOR WEANING TURBOT, *PSETTA MAXIMA* (LINNAEUS, C. 1758)

A. S. Mahious, F. J. Gatesoupe, M. Hervi, R. Metailler, F. Ollevier-2006

Aquaculture International 14 (3): 219-229

FISH LARVAE – ZOOPLANKTON RELATIONSHIPS IN MICROCOSM SIMULATIONS OF EARTHEN NURSERY PONDS. I. FRESHWATER SYSTEM

Ana Milstein, Arie Valdenberg, Sheenan Harpaz-2006

Aquaculture International 14 (3): 231 - 246

EFFECTS OF TWO COMMERCIAL MICRODIETS ON GROWTH AND SURVIVAL OF BARRAMUNDI (*LATES CALCARIFER* BLOCH) LARVAE WITHIN VARIOUS EARLY WEANING PROTOCOLS

J. Curnow, J. King, G. Partridge, S. Kolkovski-2006

Aquaculture Nutrition 12 (4): 247-255

Abstract:

Because of high costs and labour requirements along with the highly variable nutritional value of live feeds, we investigated the possibility of early weaning for barramundi (*Lates calcarifer* Bloch) larvae aimed at reducing the use of *Artemia*. Two commercial microdiets, Gemma Micro (Skretting, Australia) and Proton (INVE, Belgium) were compared for growth and survival of larvae using three weaning protocols, until 33 days posthatch (dph). Enriched rotifers were fed to larvae in all protocols through mouth opening until 21, 18 and 30 dph (protocols 1, 2 and 3, respectively). At 13 dph, enriched *Artemia metanauplii* were introduced to weaning protocols 1 and 2, and continued until 29 and 24 dph, respectively, whereas protocol 3 did not receive *Artemia*. Microdiet was initiated at 20, 16 and 13 dph in protocols 1, 2 and 3, respectively. Barramundi larvae grew successfully to 33 dph when co-fed rotifers and microdiet, and significantly larger larvae resulted from feeding Gemma Micro rather than Proton, when *Artemia* were not used. However, larvae weaned onto Proton using a longer period of *Artemia* provision were significantly larger than larvae reared according to all other protocols. Survival was significantly higher in all Gemma Micro protocols when compared with Proton protocols. This was in part due to higher cannibalism when using Proton compared with Gemma Micro ($22.8 \pm 0.9\%$ and $9.2 \pm 0.6\%$, respectively). Cannibalism became more noticeable in all protocols when the larvae reached 7–8 mm standard length and further increased after the cessation of live feed. Tank biomass production was the highest when larvae were weaned onto Gemma Micro including a short period of *Artemia* provision as a result of a combination of high growth and survival. However, similar biomass production resulted when larvae were weaned directly from rotifers onto Gemma Micro and/or from a prolonged *Artemia* period onto proton. The success of weaning barramundi larvae directly to microdiet from rotifers, thus eliminating the need for *Artemia*, was influenced by the microdiet. Relatively higher levels of free amino acids and lipids were believed to contribute to increasing larval growth and survival. Larvae that were fed Gemma Micro showed higher growth when *Artemia* were utilized for a shorter period, while Proton-fed larvae benefited from an extended *Artemia* feeding period.

(Research Division, Department of Fisheries, P.O. Box 20, North Beach, Western Australia, Australia; email of Sagiv Kolkovski: skolkovski@fish.wa.gov.au)

THE GROWTH AND GONADAL MATURATION OF THE AFRICAN CATFISH, *CLARIAS GARIEPINUS* (BURCHELL) BROODSTOCK FED DIFFERENTLY HEATED SOYBEAN-BASED DIETS

A.A. Adewumi-2006

Aquaculture Nutrition 12 (4): 267-274

Abstract:

An investigation was carried out to assess the growth and gonadal maturation of *Clarias gariepinus* (Burchell) fed differently heated soybean diets in concrete tanks. Four hundred and eighty male and female *C. gariepinus* (182 ± 10 g for females and 208 ± 5 g for males) were randomly distributed in groups into hapa nets. Iso-nitrogenous (310 g kg⁻¹ crude protein) and iso-caloric diets (355 Kcal kg⁻¹) prepared from raw soybean (D0) and soybean autoclaved for 5, 10, 15, 20, 25 and 30 min labelled D0, D5, D10, D15, D20, D25 and D30, were fed to the fish for 84 days. The fish meal based diet tagged DFM served as control. The male and female broodfish fed the fish-meal-based diet and diet D25 had significantly higher ($P < 0.05$) growth performance, gonad maturation, gonadosomatic index, relative fecundity and percentage egg fertilization and hatchability than the fish fed the other diets. The females had significantly higher ($P < 0.05$) weight increases and healthier condition over their male counterparts fed the same diets. This study showed that diet D25 was found to be the best substitute for fish meal that provided adequate nutrients required for the formation of genital products that produced strong offspring in *C. gariepinus* broodstock culture.

(Department of Zoology, Obafemi Awolowo University, Ile Ife, Nigeria; zoewumi@yahoo.com)

EFFECT OF THE CULTURE SYSTEM AND CULTURE TECHNIQUE ON BIOCHEMICAL CHARACTERISTICS OF PAVLOVA LUTHERI AND ITS NUTRITIONAL VALUE FOR CRASSOSTREA GIGAS LARVAE

E. Ponis, G. Parisi, J.-R. Le Coz, R. Robert, G.C. Zittelli, M.R. Tredici-2006

Aquaculture Nutrition 12 (4): 322-329

Abstract:

Pavlova lutheri was cultivated in carboys using batch technique and in a flat alveolar photobioreactor (FAP), using initially batch and then semi-continuous techniques. Growth and productivity of the cultures were compared and their nutritional quality was assessed by analysing their biochemical composition (gross composition, fatty acids and sterols) and by evaluating their food value for Pacific oyster (*Crassostrea gigas*) larvae as bispecific diet in association with *Chaetoceros calcitrans forma pumilum*. The highest productivity was achieved with the FAP operating in semi-continuous mode. Gross composition of *P. lutheri* was similar in all cultures, while cellular organic matter content of the microalga grown in FAP in semi-continuous mode was lower. Significant differences in fatty acid content were detected with respect to the n-6 polyunsaturated fatty acid fraction, which was lower in cells cultivated in the FAP in semi-continuous mode. As concerns the main individual fatty acids, docosahexaenoic acid (DHA) content was higher in cells cultivated in the photobioreactor in batch mode than in carboys. The neutral lipid fraction contained seven principal sterols and the comparison among the cultures evidenced different proportions and different patterns. No differences were observed among larvae fed diets containing *P. lutheri* grown in carboys or in the FAP.

(Dipartimento di Scienze Zootecniche, Università degli Studi di Firenze, Firenze, Italy; email of René Robert: rene.robert@ifremer.fr)

SHORT- AND LONG-TERM DIFFERENCES IN GROWTH, FEED CONVERSION EFFICIENCY AND DEFORMITIES IN JUVENILE ATLANTIC COD (*GADUS MORHUA*) STARTFED ON ROTIFERS OR ZOOPLANKTON

Albert K Imsland, Atle Foss, Roland Koedijk, Arild Folkvord, Sigurd O. Stefansson, Thor M. Jonassen-2006

Aquaculture Research 37 (10): 1015-1027

Abstract:

Growth, feed conversion efficiency and frequencies of skeletal deformities were studied in juvenile Atlantic cod (*Gadus morhua*) that had been startfed on either rotifers (rotifer group) or zooplankton (zooplankton group). After metamorphosis, the fish were reared at four constant temperatures (7, 10, 13, 16°C) or moved successively from 16 to 13 and 10°C (T-step, average 13.2°C). The zooplankton group had a consistently higher growth rate at all the temperatures studied. Further, the zooplankton group had higher food intake (20%) and higher feed conversion ratio (1.65 vs. 1.31). In addition, a significantly higher incidence of skeletal deformities was found in the rotifer group (14.2%) compared with the zooplankton group (4.1%). After termination of the laboratory study, the fish were reared in sea pens under ambient conditions for 17 months. Final weights of the zooplankton group were consistently larger (between 12% and 14% larger depending on original temperature groups). To verify the growth results, we conducted a follow-up study where a single egg group was divided into two parts and fed either on rotifers or zooplankton. This study indicated similar growth differences as found in the first study. Overall, our data suggest that different startfeeding diets may be important for long-term growth, incidence of deformities and quality of juvenile cod. The use of zooplankton can greatly improve long-term growth and quality of cod juveniles. The study also highlights the advantage of using elevated temperatures in the juvenile phase as this will lead to significantly higher final weights in the adult stage.

(Akvaplan-niva Iceland Office, Akralind 4, 201, Kópavogur, Iceland; email of A.K. Imsland: albert.imsland@akvaplan.niva.no)

IMPROVING LIVE FEEDS: EFFECT OF A MIXED DIET OF COPEPOD NAUPLII (ACARTIA TONSA) AND ROTIFERS ON THE SURVIVAL AND GROWTH OF FIRST-FEEDING LARVAE OF THE SOUTHERN FLOUNDER, PARALICHTHYS LETHOSTIGMA

Wilcox, Jeffrey A., Tracy, Patrick L., Marcus, Nancy H.-2006

Journal of the World Aquaculture Society 37 (1): 113-120

HIGHLY UNSATURATED FATTY ACID COMPOSITION OF ROTIFERS (BRACHIONUS PLICATILIS) AND ARTEMIA FED VARIOUS ENRICHMENTS

Palmtag, Matthew R., Faulk, Cynthia K., Holt-2006

Journal of the World Aquaculture Society 37 (1): 126-131

(Fisheries and Mariculture Laboratory, University of Texas Marine Science Institute, Port Aransas, Texas 78373 USA)

EFFECT OF DIET PROCESSING METHOD AND INGREDIENT SUBSTITUTION ON FEED CHARACTERISTICS AND SURVIVAL OF LARVAL WALLEYE, SANDER VITREUS

Barrows, Frederic T. Lellis, William A.-2006

Journal of the World Aquaculture Society 37 (2): 154-160

Abstract:

Two methods were developed for the production of larval fish diets. The first method, microextrusion marumerization (MEM), has been tested in laboratory feeding trials for many years and produces particles that are palatable and water stable. The second method, particle-assisted rotational agglomeration (PARA), produced diets that have lower density than diets produced by MEM. Each method was used to produce diets in the 250- to 400- and 400- to 700- μ m range and compared with a reference diet (Fry Feed Kyowa * [FFK]) for feeding larval walleye in two experiments. The effect of substituting 4% of the fish meal with freeze-dried artemia fines was also investigated. In the first experiment, 30-d survival was greater ($P < 0.05$) for fish fed a diet produced by PARA without Artemia (49.1.0%) than for fish fed the same diet produced by MEM (27.6%). The addition of Artemia to a diet produced by MEM did not increase survival of larval walleye. Fish fed the reference diet had 24.4% survival. In the second experiment, there was an effect of both processing method and Artemia supplementation, and an interaction of these effects, on survival. Fish fed a diet produced by PARA without Artemia supplementation had 48.4% survival, and fish fed the same diet produced by MEM had only 19.6% survival. Inclusion of 4% freeze-dried Artemia improved ($P < 0.04$) survival of fish fed MEM particles but not those fed PARA particles. Fish fed FFK had greater weight gain than fish fed other diets in both experiments. Data indicate that the PARA method of diet processing produces smaller, lower density particles than the MEM process and that diets produced by the PARA process support higher survival of larval walleye with low capital and operating costs.

(U.S. Geological Survey, Biological Resources Division, Research and Development Laboratory, R.D. No. 4, Box 63, Wellsboro, Pennsylvania 16901 USA)

PROTEOLYTIC ACTIVITY IN CALIFORNIA HALIBUT LARVAE (PARALICHTHYS CALIFORNICUS)

Zacarias-Soto, Magali, Muguet, Jean B., Lazo, Juan P.-2006

Journal of the World Aquaculture Society 37 (2): 175-185

Abstract:

The digestive tract of many marine fish larvae undergoes numerous morphological and functional changes during ontogeny that can substantially influence larval survival under culture conditions. Increasing our knowledge of the digestive capacity and nutritional requirements of the larvae of new candidate species for aquaculture will aid in the development of optimal feeding protocols and greatly improve production under hatchery conditions. In this study, we assess the proteolytic capacity of California halibut (*Paralichthys californicus*) larvae using biochemical and histological analyses. Newly hatched larvae were reared in a semiclosed recirculating system and fed with highly

unsaturated fatty acid (HUFA)-enriched rotifers from hatching until 19 d posthatch (dph) and HUFA-enriched *Artemia nauplii* thereafter. Total and specific activity of trypsin and leucine-aminopeptidase (LAP) and acid and alkaline protease activities were assessed throughout development using spectrophotometric techniques. Trypsin-like activity and LAP and alkaline protease activities were detected shortly after hatching and before the opening of the mouth. Acid protease activity was not detected until 36–40 dph, concomitant with the development of the gastric glands. The specific activity of trypsin and LAP showed two distinct peaks at 8 and 20 dph. The second peak coincided with the shift from rotifers to *Artemia*. Hence, newly hatched California halibut larvae possess alkaline proteolytic activity before first feeding. Based on the digestive capacity evaluated in this study and the timing of the development of the functional stomach, we propose that California halibut can be adequately weaned to formulated microdiets around 36 dph.
(Department of Animal Science, University of California, Davis, California 95616 USA)

LARVICULTURE OF RED FRONT SHRIMP, *CARIDINA GRACILIROSTRIS* (ATYIDAE, DECAPODA)

Heerbrandt Thomas C., Lin Junda-2006

Journal of the World Aquaculture Society 37 (2): 186-190

Abstract:

Aquatic ornamental species trade is a growing multimillion dollar industry. Over the past several years, many freshwater shrimp have been growing in popularity in the aquarium industry. This study evaluated the larval culture of the popular aquarium red front shrimp, *Caridina gracilirostris* (Atyidae). We found that the optimal larval and postlarval rearing conditions were 15 ppt, 27°C, fed with a phytoplankton mixture (Phycopure), and at the stocking density of 25 per L. Under these conditions, the newly hatched larvae developed, through six zoeal stages, into postlarvae in 15 d, with a survivorship of 90±8%. The postlarvae acclimated to freshwater when they reached 69 d posthatch.

(Department of Biological Sciences, Florida Institute of Technology, 150 West University Boulevard, Melbourne, Florida 32901 USA)

THE EFFECT OF REARING DENSITY ON GROWTH AND SURVIVAL OF COBIA, *RACHYCENTRON CANADUM*, LARVAE IN A CLOSED RECIRCULATING AQUACULTURE SYSTEM

Hitzfelder, Holt G. Joan, Fox, McKee-2006

Journal of the World Aquaculture Society 37 (2): 204-209

(Maritech, Research and Development, 805 46th Place, Vero Beach, Florida 32963 USA)

REFINING FEEDING PRACTICES FOR HATCHERY PRODUCTION OF SIBERIAN STURGEON, *ACIPENSER BAERI*

Hamlin Heather J., Michaels James T., Beaulaton Constance M., Main Kevan L.-2006

Journal of the World Aquaculture Society 37 (2): 224-230

(Mote Marine Laboratory, Center for Aquaculture Research and Development, 1600 Ken Thompson Parkway, Sarasota, Florida 34236 USA)

ACUTE TOXICITY OF AMMONIA TO *PENAEUS SEMISULCATUS* POSTLARVAE IN RELATION TO SALINITY

Kir Mehmet, Kumlu Metin-2006

Journal of the World Aquaculture Society 37 (2): 231-235

(Faculty of Fisheries, Cukurova University, 01330 Balcali, Adana, Turkey)

EFFECTS OF DELAYED INITIAL FEEDING ON LARVAL FEEDING, EARLY SURVIVAL,
AND GROWTH OF RED SPOTTED GROUPER EPINEPHELUS AKAARA LARVAE

Kenzo Yoseda, Kazuhisa Teruya, Takuma Sugaya, Sachio Sekiya-2006

Nippon Suisan Gakkaishi 72 (4): 702-709

Abstract:

This study investigated the effects of delayed initial feeding on the growth, feeding, and survival of early stage red spotted grouper *Epinephelus akaara* larvae in relation to the absorption of endogenous reserves at 26°C. Five different feeding regimes were prepared as follows: No. 1: rotifers fed initially at 0 hours after the onset of feeding (HAOF), No. 2: rotifers fed initially from 6 HAOF, No. 3: rotifers fed initially from 12 HAOF, No. 4: rotifers fed initially from 18 HAOF, and No. 5: starved control. The larvae were fed rotifers (a small Thai strain) at a density of 20 ind./mL except for No. 5. Feeding amounts and survival showed a tendency to be lower when the onset of feeding was delayed. Larval growth showed significant differences between No. 1 and No. 2-4 at 66 HAOF ($p < 0.05$ or 0.01). In contrast, starved larvae (No. 5) showed negative growth from 12 to 66 HAOF. The beginning of the negative growth point coincided with the time of complete oil globule absorption. These results indicate that larval growth was closely related with endogenous reserves, and larvae possess a very short period during which they are resistant to food deprivation. We conclude that their growth and survival are affected if they fail to initially feed within 6 HAOF at 26°C.

(Yaeyama Station, National Center for Stock Enhancement, Fisheries Research Agency, Ishigaki, Okinawa 907-0451, Japan)

LARVAL DEVELOPMENT AND OCCURRENCE OF MORPHOLOGICAL ABNORMALITIES
IN HATCHERY-REARED JAPANESE FLOUNDER *PARALICHTHYS OLIVACEUS* LARVAE
FED MARINE ROTIFER *BRACHIONUS PLICATILIS* AT DIFFERENT POPULATION
GROWTH STAGES

Tsutomu Tomoda, Masahiko Koiso, Jau-neng Chen, Toshio Takeuchi-2006

Nippon Suisan Gakkaishi 72 (4): 725-733

Abstract:

We assessed the dietary value of rotifers at different population growth stages for hatchery-reared Japanese flounder, *Paralichthys olivaceus*, in terms of larval development and the occurrence of morphological abnormalities. Rotifer cultures were prepared daily and continued for up to eight days. Rotifers were harvested on day 2 from the start of batch culture (early-exponential growth phase), as well as on day 4 (late-exponential phase) and day 8 (stationary phase), and equally enriched with freshwater *Chlorella* containing n-3 HUFA. The flounder larvae were supplied until 24 days after hatching (DAH) with rotifers at each of these growth phases. During 18-30 DAH, larvae fed rotifers at the late-exponential growth phase showed higher performance in growth and morphological development than those fed stationary-phase rotifers. All groups of larvae were raised until approximately 40 mm total length (55 DAH), at which time the juveniles that had been fed late-exponential-phase rotifers had the lowest incidence of malpigmentation and/or skeletal malformation ($p < 0.0001$). The population growth stage of the rotifers used for enrichment had a large influence on the occurrence of morphological abnormalities in larviculture of Japanese flounder.

(Notojima Station, National Center for Stock Enhancement, Fisheries Research Agency, Notojima, Ishikawa 926-0216, Japan)

THE BRINE SHRIMP'S TALE: A TOPSY TURVY EVOLUTIONARY FABLE

Geoffrey Fryer-2006

Biological Journal of the Linnean Society 88: 377-382

Abstract:

It has been suggested that: (1) the brine shrimp, *Artemia* (Branchiopoda: Anostraca), which habitually swims inverted, has 'only recently turned over'; (2) if this habit were to persist for tens of millions of years, original dorsal-ventral homologies would become obliterated; (3) it would become necessary to

re-define the concept of dorsal and ventral because so many details would have changed over evolutionary time; and (4) if modern brine shrimps were to maintain the habit of swimming upside down for 100 Myr into the future, they might give rise to a whole new sub-kingdom whose descendants would be defined as having a dorsal nerve cord. However, brine shrimps and their allies have not recently turned over. All the nearly 300 extant anostracans swim inverted, and members of the order have clearly done so for more than 400 Myr, yet their anatomical arrangements are the same as in crustaceans that live dorsal side up. Nor do crustaceans that swim inverted and even hang from the surface film depart from the standard arrangement. The claim that inverted swimming became a genetically determined attribute of brine shrimps via the operation of the so-called Baldwin effect is rejected, as is the concept itself.

(Institute of Natural and Environmental Sciences, University of Lancaster, Lancaster LA1 4YQ, United Kingdom)

IMMUNOLOCALISATION OF NERVOUS NECROSIS VIRUS INDICATES VERTICAL TRANSMISSION IN HATCHERY PRODUCED ASIAN SEA BASS (*LATES CALCARIFER BLOCH*)—A CASE STUDY

I.S. Azada, K.P. Jithendrana, M.S. Shekhara, A.R. Thirunavukkarasua, L.D de la Pena-2006
Aquaculture 255 (1-4): 39-47

Abstract:

A probable vertical mode of piscine nodavirus transmission is reported in the present investigation based on a case of nodavirus associated larval mortalities in hatchery produced Asian sea bass. Polyclonal rabbit anti-SJNNV antibodies (SGWak97) detected the viral antigens in the tissue sections from the eggs and the larvae at different time intervals from - 1 to 42 days post hatch (dph). Immunopositive ovarian connective tissue associated with the oocytes along with the progressive localization of the viral antigens in the brain, spinal cord, liver, stomach and dermal musculature during the larval development indicates a probable vertical transmission of nodavirus in the Asian sea bass. The surviving larger larvae, from the batch suffering mass mortalities, produced very intense immunofluorescent positivity in the liver, stomach and dermal musculature. Results of this investigation demonstrating a possibility of vertical transmission of the nodavirus emphasize the need for screening of eggs and larvae for evolving suitable preventive and prophylactic health management strategies.

(Central Institute of Brackishwater Aquaculture, 75-Santhome High Road, R.A.Puram, Chennai-600 028, India; email of I.S. Azada: azadis@rediffmail.com)

EFFECTS OF ENROFLOXACIN AND FLORFENICOL ON SURVIVAL AND BACTERIAL POPULATION IN AN EXPERIMENTAL INFECTION WITH LUMINESCENT *VIBRIO CAMPBELLII* IN SHRIMP LARVAE OF *LITOPENAEUS VANNAMEI*

Sonia Soto-Rodríguez, Mauricio Armenta, Bruno Gomez-Gil-2006

Aquaculture 255 (1-4): 48-54

Abstract:

The survival and bacterial load (vibrios) was evaluated in *Litopenaeus vannamei* shrimp larvae, stages Zoea 1 and 2, exposed for 24 h to the antimicrobial agents enrofloxacin and florfenicol. At concentrations higher than 20 µg ml⁻¹, both antimicrobial agents were toxic for the larvae. LC50 for enrofloxacin and florfenicol was 46.47 µg ml⁻¹ and 32.42 µg ml⁻¹, respectively, for Zoea 1. Both agents reduced significantly the bacterial load in both larval stages and a significant correlation could be established between the concentration of the antibiotics and the bacterial loads of both zoeas. Survival of Zoea 1 larvae was significantly reduced when they were exposed to enrofloxacin and to the strain CAIM 333, but not when exposed only to CAIM 333 as compared to the controls. Larvae exposed to CAIM 333 only had a higher bacterial load than the other treatments. The use of enrofloxacin is of little use for treating infected shrimp larvae since high concentrations (20 µg ml⁻¹) have to be used to eliminate the potential pathogens in situ and those high concentrations are toxic to the larvae.

(Centro de Investigación en Alimentación y Desarrollo, A.C., Unidad Mazatlán en Acuicultura y Manejo Ambiental, AP 711, CP 82010 Mazatlán, Sinaloa, Mexico; email of Sonia Soto-Rodríguez: ssoto@victoria.ciad.mx)

MICROBIAL CONDITIONS AND ANTIMICROBIAL ACTIVITY IN CULTURES OF TWO MICROALGAE SPECIES, TETRASELMIS CHUII AND CHLORELLA MINUTISSIMA, AND EFFECT ON BACTERIAL LOAD OF ENRICHED ARTEMIA METANAUPLII

Pavlos Makridis, Rita Alves Costa, Maria Teresa Dinis-2006

Aquaculture 255 (1-4): 76-81

Abstract:

The microbial conditions and antimicrobial activity were determined in batch cultures of two microalgae species, *Tetraselmis chuii* and *Chlorella minutissima*. The number of bacteria associated with the microalgae cultures showed an exponential growth 2, 10, and 16 days after inoculation, and they were higher in *T. chuii* in all three sampling points compared with *C. minutissima*. No presumptive *Vibrio* strains were observed in any of the samples, as measured by the growth on TCBS agar. A total of 17 and 30 bacterial strains were isolated from *C. minutissima* and *T. chuii*, respectively. A high percentage of Gram-positive strains was detected among the bacterial strains isolated, as Gram-positive strains constituted 82% (14 / 17) and 73% (22 / 30) of the total numbers of isolates in *C. minutissima* and *T. chuii*, respectively. The isolated bacteria were screened in vitro for inhibition against two pathogenic strains, and nine of the 34 strains tested (26%) showed inhibition in vitro against either *Photobacterium damsela*, susp. *piscicida* or *Vibrio anguillarum*. Incubation of enriched *Artemia* in cultures of the two microalgae for 30 min resulted in a significant decrease of the bacterial load in *Artemia* ($P < 0.05$), and a significant decrease of the level of presumptive *Vibrio* in *Artemia* homogenates ($P < 0.05$). The results of this study demonstrate a simple and practical approach to decrease the microbial load and at the same time reduce the percentage of *Vibrio* among the bacteria associated with enriched *Artemia*.

(Center for Marine Sciences, University of Algarve, 8000-118 Faro, Portugal ; email of P. Makridis: makridis@her.hcmr.gr)

ISOLATION OF VIBRIO HARVEYI BACTERIOPHAGE WITH A POTENTIAL FOR BIOCONTROL OF LUMINOUS VIBRIOSIS IN HATCHERY ENVIRONMENTS

M.G. Vinoda, M.M. Shivu, K.R. Umesha, B.C. Rajeeva, G. Krohne, Indrani Karunasagara, Iddya Karunasagara-2006

Aquaculture 255 (1-4): 117-124

Abstract:

A double stranded DNA bacteriophage of *Vibrio harveyi* was isolated from shrimp farm water from the west coast of India. The isolated phage belonged to the family Siphoviridae. Its broad lytic activity against *V. harveyi* isolates both from the west and east coast of India suggested that it had a potential for biocontrol of luminous vibriosis due to *V. harveyi* in aquaculture systems. Microcosm studies with *Penaeus monodon* larvae infected with *V. harveyi* showed that larval survival in the presence of bacteriophage was enhanced (80%) as compared with the control (25%). Field trials were conducted in a commercial hatchery where there was a natural outbreak of luminous bacterial disease. Treatment with bacteriophage improved larval survival and brought about decline in luminescent *V. harveyi* counts in hatchery tanks. It could hence be concluded that the bacteriophage had a potential for biocontrol of *V. harveyi* in hatchery settings.

(Department of Fishery Microbiology, Karnataka Veterinary, Animal and Fisheries Sciences, University, College of Fisheries, Mangalore 575002, India; email of I. Karunasagara: mircen@sancharnet.in)

THE PRESENCE OF ENDOGENOUS L-CARNITINE IN LIVE FOODS USED FOR LARVICULTURE

Dong Ming Zhang, Takao Yoshimatsu, Mitsuhiro Furuse-2006

Aquaculture 255 (1-4): 272-278

Abstract:

The endogenous presence of l-carnitine (free and esterified l-carnitine) in live foods used for larviculture was determined by a method of HPLC assay based on enzymatic reactions. Two strains of marine rotifers (*Brachionus rotundiformis* and *Brachionus plicatilis*), freshwater Cladocera (*Moina macrocopa*), six populations of *Artemia* and two species of microalgae (*Nannochloropsis oculata* and *Chlorella vulgaris*) were cultured and tested.

Results showed that *B. rotundiformis* and *B. plicatilis* have 161–504 $\mu\text{g g}^{-1}$ DW and 338–393 $\mu\text{g g}^{-1}$ DW total l-carnitine under varying culture conditions, respectively. The study further revealed that temperature shifts (24 h, 5–15 °C lower) did not affect l-carnitine content in the two strains, whereas, culture temperature and starvation remarkably influenced l-carnitine content in *B. rotundiformis*. These effects were accounted for by a significantly lower and a significantly higher l-carnitine content ($P < 0.05$) in the groups under low culture temperature (15 °C) without 24 h starvation and high culture temperature (30 °C) with 24 h starvation, respectively. In *M. macrocopa*, 386 $\mu\text{g g}^{-1}$ DW total l-carnitine was detected. The total l-carnitine levels, ranging from 220 to 493 $\mu\text{g g}^{-1}$ DW, had significant ($P < 0.05$) variability in newly hatched *Artemia* nauplii from samples of various populations. The total l-carnitine contents in microalgae *N. oculata* and *C. vulgaris* have no significant ($P > 0.05$) differences between condensed commercial products, but significant ($P < 0.05$) differences were observed in laboratory cultured *N. oculata*, ranging from 91 to 314 $\mu\text{g g}^{-1}$ DW, associated with different light intensities and photoperiods.

These results indicated that endogenous l-carnitine is quite variable in live foods depending on their physiological status, and is significantly influenced by environmental factors, such as culture temperature, starvation and light conditions.

(Laboratory of Advanced Animal and Marine Bioresources, Graduate School of Bioresource and Bioenvironmental Sciences, Kyushu University, Fukuoka 812-8581, Japan; email of Dong Ming Zhang: dmzhang@jlau.edu.cn)

PROBIOTIC EFFECT IN VIVO OF ROSEOBACTER STRAIN 27-4 AGAINST VIBRIO (LISTONELLA) ANGUILLARUM INFECTIONS IN TURBOT (SCOPHTHALMUS MAXIMUS L.) LARVAE

Miquel Planas, María Pérez-Lorenzo, Mette Hjelm, Lone Gram, Ingrid Uglenes Fiksdal, Øivind Bergh, José Pintado-2006

Aquaculture 255 (1-4): 323-333

Abstract:

The purpose of this study was to evaluate the probiotic effect of the marine bacterium *Roseobacter* strain 27-4 in turbot larvae infected with the pathogen *Vibrio* (*Listonella*) *anguillarum*. Initial trials demonstrated that cells of *Roseobacter* were not harmful to larvae whereas, large amounts of bacterial culture supernatant caused rapid mortality (70% at day 10 compared to 20% in the control). A similar high mortality was, however, also seen, when sterile marine broth was added to the larvae. Presumably both types of medium enhanced growth of opportunistic pathogens. In subsequent trials, both a pathogen, *Vibrio anguillarum*, and the probiont, *Roseobacter* strain 27-4, were delivered to the larvae incorporated in rotifers. Accumulated mortality of *Vibrio* infected larvae increased to 80–90% over 10 days, whereas, mortality in non-infected controls was significantly lower (60–70%). Feeding larvae with rotifers enriched with *Roseobacter* 27-4 parallel to *V. anguillarum* infection, brought the accumulated mortality to the level of control indicating a clear in vivo effect. *Roseobacter* 27-4 could be detected in larvae both by agar plating and by immunohistochemistry, being located in the gastrointestinal lumen, and apparently did not colonise the larval gut and intestinal epithelium. Plate counts decreased when enriched feed was no longer added, suggesting that the probiont, *Roseobacter* 27-4, should be supplied repeatedly to exert its positive effect.

(Instituto de Investigaciones Marinas (CSIC), Eduardo Cabello 6, 36208 Vigo, Galicia, Spain; email of M. Planas: mplanas@iim.csic.es)

CAN ATLANTIC COD (GADUS MORHUA) LARVAE BE WEANED FASTER ONTO DRY FEED AT HIGHER TEMPERATURES?

V. Puvanendran, Amanda L. Burt, Joseph A. Brown-2006

Aquaculture 255 (1-4): 334-340

Abstract:

Live feed production is costly, labour intensive, and comprises a large proportion of the hatchery production cost. The cost of live food production required to culture marine finfish larvae such as Atlantic cod (*Gadus morhua*) can be reduced by a shorter and more efficient weaning period. In this study, hatchery reared cod larvae were exposed to different temperatures while being weaned from *Artemia* (brine shrimp) to dry food from 45 days post-hatch (dph). In the first experiment, two temperatures were used: 11.5 and 7.5 °C. During weaning, the amount of *Artemia* fed to the larvae was gradually decreased while the dry feed was increased. Larval foraging behaviour and mortality were monitored. The growth rate and mortality of the larvae were not significantly different between the two treatments. However, the larvae in the 11.5 °C treatment showed a significant increase in the intake of dry feed. Thus, a second experiment was conducted at 11.5 and 14.5 °C to examine if weaning could be further improved. Results showed that the growth rate of larvae between the two temperatures did not differ significantly, however, mortality rate in 14.5 °C treatment was significantly higher than 11.5 °C treatment. Larval orientation towards and ingestion of dry feed were not significantly different in experiment two. Results of our experiments suggest that a possible optimal weaning temperature for larval cod between is 11.5 and 14.5 °C.

(Aquaculture Research and Development Facility, Ocean Sciences Centre, Memorial University, St. John's, Newfoundland and Labrador, Canada A1C 5S7 ; email of V. Puvanendran: puvy@mun.ca)

EFFECTS OF SALINITY, PHOTOPERIOD AND ADULT STOCKING DENSITY ON EGG PRODUCTION AND EGG HATCHING SUCCESS IN ACARTIA TONSA (CALANOIDA: COPEPODA): OPTIMIZING INTENSIVE CULTURES

Myron A. Peck, Linda Holste-2006

Aquaculture 255 (1-4): 341-350

Abstract:

The interest in large-scale culturing of copepods for marine fish aquaculture is growing, however studies quantifying the optimal conditions for intensive copepod production are generally lacking for most species. In the present study, we examined how large ranges in each of three factors (salinity, photoperiod duration, and culture density) influenced the egg production (EP) and 48-h egg hatching success (HS) of *Acartia tonsa* Dana (Copepoda : Calanoida). The effect of anaerobic storage time (2 to 185 d) at 4 °C on HS of eggs was also quantified. In this species, HS was more strongly impacted by differences in salinity and photoperiod than was EP while the opposite was true for the impact of adult stocking density. In terms of salinity, the lowest and highest mean EP (17 and 40 eggs female⁻¹ d⁻¹) was observed at 30 and 14 psu, respectively, and HS was estimated to be > 75% for all salinities > 13 psu. The photoperiod duration (used to rear copepods and incubate eggs) had little effect on total daily EP but significantly influenced HS which was 27, 55, 85 and 78% at photoperiods of 8, 12, 16, and 20 h, respectively. Adult stocking density had no effect on HS but the relative number of eggs harvested (# female⁻¹) was highest at 65 ind l⁻¹ and lowest at 425 ind l⁻¹. For eggs produced using a 12 h photoperiod, HS (%) decreased linearly by 4% every 20 days (i.e., the HS of eggs incubated at 20 psu was predicted to be 82% and 47% after one week and six months of storage, respectively). For maximum egg production and 48-h egg hatching success of *A. tonsa* cultures, results of this study suggest using salinities of 14 to 20 psu, photoperiods between 16 and 20 h, and low (50 ind l⁻¹) adult stocking densities.

(Institute for Hydrobiology and Fisheries Research, University of Hamburg, Olbersweg 24, D-22767 Hamburg, Germany; email of Myron Peck: Myron.peck@uni-hamburg.de)

IMPACTS OF HAB SPECIES HETEROSIGMA AKASHIWO ON EARLY DEVELOPMENT OF THE SCALLOP ARGOPECTEN IRRADIANS LAMARCK

Liping Wang, Tian Yan, Mingjiang Zhou-2006

Aquaculture 255 (1-4): 374-383

Abstract:

The effects of *Heterosigma akashiwo* on the early development of *Argopecten irradians* Lamarck: eggs, D-shaped larvae, eye-spot larvae and juveniles, were investigated under laboratory conditions. Exposing fertilized eggs to various densities of *H. akashiwo* algal culture revealed that the development of the embryos to the gastrula was significantly slowed at densities of more than 1×10^4 cells/ml algal cells, and mostly was arrested when the embryos reached the trochophore larvae stage. At this stage, several trochophore larvae were adhered together by the algal cells, resulting in the inhibition of their swimming activity. Larvae had still not developed into D-shaped larvae after 30 h, and therefore did not finish the hatching process. The attachment and adherence of the algal cells to the larvae might be an important process in the mechanism of the impact on egg hatching success.

The activity of the D-shaped larvae was significantly inhibited after 48 h exposure to *H. akashiwo* at a density of 15×10^4 cells/ml and after 96 h at 10×10^4 cells/ml. The survival rate of the eye-spot larvae was decreased significantly after 48 h exposure to the algal culture at densities of more than 1×10^4 cells/ml. However, all the juveniles could survive and their climbing and attachment activity were not affected after 1 and 5 h exposure to the algal culture at all the various algal cell densities tested from 5 to 20×10^4 cells/ml.

The results indicated that susceptibility of embryos or larvae to the alga *H. akashiwo* differs depending on the developmental stage. The embryos and the eye-spot larvae of *A. irradians* are more sensitive stages to the toxicity of *H. akashiwo*. Observed effects of *H. akashiwo* exposure on early development of *A. irradians* serve to point out to the potential danger of this alga for scallop populations. The possible toxicological mechanisms of *H. akashiwo* on the scallop embryos and larvae are discussed.

(Institute of Oceanology, Chinese Academy of Sciences, Qingdao 266071, PR China; email of Tian Yan: tianyan@ms.qdio.ac.cn)

EVALUATION OF DNA METHODOLOGIES IN IDENTIFYING BRACHIONUS SPECIES USED IN EUROPEAN HATCHERIES

Spiros Papakostas, Stefania Dooms, Alexander Triantafyllidis, Daphne Deloof, Ilias Kappas, Kristof Dierckens, Tania De Wolf, Peter Bossier, Olav Vadstein, Sunniva Kui, Patrick Sorgeloos, Theodore J. Abatzopoulos-2006

Aquaculture 255 (1-4): 557-564

Abstract:

Few efforts have dealt with the genetic make up of the *Brachionus plicatilis* rotifers which are often used as live feed in the larviculture of many marine fish. Recent results have demonstrated that the *B. plicatilis* species is actually a species complex. In this study a number of molecular markers (Restriction Fragment Length Polymorphism (RFLP) analysis of mitochondrial COI gene, Single-Stranded Conformation Polymorphism (SSCP) analysis and Denaturing Gradient Gel Electrophoresis (DGGE) of mitochondrial 16S rRNA gene as well as microsatellite genotyping of nuclear loci) have been developed and applied to identify genetically rotifer strains used in European hatcheries. All methods have proven highly efficient for the reliable diagnosis of the genetic variability within hatchery strains at bulk or individual level. Results point towards an absence of the typical *B. plicatilis* and *Brachionus rotundiformis* species and a predominance of the *Brachionus* sp. Cayman biotype (*Brachionus* SM morphological type). All the other biotypes/species were either rarely found or were coexistent with *B. sp. Cayman*. These biotypes were *B. plicatilis sensu stricto*, *B. sp. Nevada* and *B. sp. Austria*, all belonging to the *Brachionus* L group. Minimal genetic variability was detected within strains. The above results have important implications for rotifer cultures, with respect to the different temperature and salinity optima of each biotype/species. Caution is needed regarding the common practice used by hatcheries around the world of exchanging samples based solely on morphological criteria.

(Department of Genetics, Development and Molecular Biology, School of Biology, Aristotle University of Thessaloniki, 541 24, Greece; email of Theodore J. Abatzopoulos: abatzop@bio.auth.gr)

HUMAN CHORIONIC GONADOTROPIN INDUCES SPERMATOGENESIS AND SPERMATION IN 1-YEAR-OLD EUROPEAN SEA BASS (*DICENTRARCHUS LABRAX*): ASSESSMENT OF SPERM QUALITY

Roberta Schiavone, Loredana Zilli, Sebastiano Vilella, Christian Fauvel-2006

Aquaculture 255 (1-4): 522-531

Abstract:

The aims of the present study were (a) to compare sperm quality (percentage of motile spermatozoa, motility duration, density and fertility after cryopreservation) between precocious and normally maturing male European sea bass *Dicentrarchus labrax*, (b) to examine the potential of human chorionic gonadotropin (hCG) to increase spermiation in precocious males and (c) to examine the potential of hCG to induce spermatogenesis and spermiation in non-precocious 1-year-old males. One hundred precocious and 100 non-precocious fish were each randomly divided in two groups each: control (precocious saline-treated and non precocious saline-treated) and treated (precocious hCG-treated and non precocious hCG-treated). Treated groups were administered weekly with 1000 IU hCG kg⁻¹ body weight while control groups were injected with physiological solution. Milt volume produced, sperm concentration, motility duration and fertilising ability were assessed every week in each group. The effect of the hormonal treatment on gonadal development was examined based on the gonadosomatic index and testicular histology. The results demonstrate that sperm produced by precocious fish has characteristics (mean value of motility class, mean maximum motility duration, concentration and fertility after cryopreservation) similar ($P > 0.05$) to those produced by 2-year-old fish. Human chorionic gonadotropin treatment in precocious fish resulted in a significant increase ($P < 0.05$) of milt volume, without affecting sperm quality. In non-precocious fish, hCG treatment resulted in greater percentage of spermiation ($P < 0.05$) compared to non-precocious saline-treated group. At the end of the trial (three weeks), 29 out of 50 non-precocious hCG-treated fish were spermiating and, within these 23 produced $> 200 \mu\text{l}$ per fish of milt. No differences were observed in terms of sperm concentration, motility class, motility duration and fertilizing capacity due to hCG treatment in either precocious, or non-precocious fish. In addition, analysis of the testicular histology of fish that did not spermiate after hCG treatment, shows a significant ($P < 0.05$) enhancement of testicular development stages. The present study demonstrated that (a) precocious European sea bass males produce milt of comparable sperm characteristics to adult individuals, (b) treatment of non-precocious males with hCG induced spermatogenesis and spermiation and (c) treatment of precocious males with hCG enhanced milt volume without affecting other sperm characteristics, including fertilizing ability.

(Laboratory of Comparative Physiology, Department of Biological and Environmental Sciences and Technologies, University of Lecce, Via Provinciale Lecce-Monteroni, 73100 Lecce, Italy; email of R. Schiavone: roberta.schiavone@unile.it)

INDUCTION OF SEX CHANGE WITHIN TWO FULL MOONS DURING BREEDING SEASON AND SPAWNING IN GROUPER

Mohammad Ashraful Alam, Ramji Kumar Bhandari, Yasuhisa Kobayashi, Kiyoshi Soyano, Masaru Nakamura-2006

Aquaculture 255 (1-4): 532-535

Abstract:

Artificial sex change was induced within two full moons by an aromatase inhibitor (AI; 1 mg/fish) during the breeding season to establish the quickest method of sex change and natural spawning of the honeycomb grouper (*Epinephelus merra*). The sex change from female (ovary) to male (testis) occurred during the time between the two full moons (3 weeks) following AI implantation, and the efferent ducts of sex-changed males were filled with sperm. To examine sperm fertility, sex-changed males were mated with natural, normal females and produced fertilized eggs. Most of the hatched

larvae grew normally without any morphological deformities. Therefore, the use of this method which is the quickest known sex change method using AI, may contribute to quality sperm production for grouper aquaculture.

(Sesoko Station, Tropical Biosphere Research Center, University of the Ryukyus, Sesoko 3422, Motobu, Okinawa 905-0227, Japan; email of Mohammad Ashraful Alam: mohammad.ashraful.alam@gmail.com)

THERMAL DEPENDENCE OF EMBRYONIC DEVELOPMENT AND HATCHING RATE IN LABEO ROHITA (HAMILTON, 1822)

T. Das, , A.K. Pal, , S.K. Chakraborty, S.M. Manush, R.S. Dalvi, K. Sarma, S.C. Mukherjee-2006
Aquaculture 255 (1-4): 536-541

Abstract:

The present study was designed to assess the embryonic development of *Labeo rohita* fertilized eggs incubated at four different temperatures (26, 31, 33 and 36 °C) until hatching. Fertilization was carried out at ambient temperature (26 °C) and was considered as 0 h of embryonic development. Developmental stages were monitored by sampling embryos in different temperatures at particular intervals. Highest hatching percentage and least time for attaining each ontogenic stage were observed at 31 > 33 > 26 > 36 °C and were significantly different ($p < 0.05$). The lowest hatching percentage and maximum time duration for attaining a given ontogenic stage were observed at 36 °C; this treatment also resulted in malformed embryos. Our study demonstrated that incubation temperature significantly ($p < 0.05$) influences hatching duration, hatching rate and survival of *L. rohita* eggs.

(Fish Biochemistry Laboratory, Central Institute of Fisheries Education, Fisheries University Road, 7 Bungalows, Andheri (W), Mumbai, India; email of A.K. Pal: akpal_53@redillmail.com)

THE CLAM, XISHI TONGUE COELOMACTRA ANTIQUATA (SPENGLER), A PROMISING NEW CANDIDATE FOR AQUACULTURE IN CHINA

Hui Liu, Jian Xin Zhu, Hui Ling Sun, Jian Guang Fang, Ru Cheng Gao, Shuang Lin Dong-2006
Aquaculture 255 (1-4): 402-409

Abstract:

Methods and results of recent hatchery studies in rearing the clam, Xishi tongue, *Coelomactra antiquata* (Spengler) are documented in this paper. About 17 million juveniles were produced using hatchery methods, the largest production ever reported. A summary of its biological and ecological characteristics and techniques for hatchery rearing and growout are reported. Because of good growth rate, ease of artificial breeding and growout, this famous Chinese delicacy is a promising new candidate for aquaculture. This indigenous Chinese species has excellent potential for aquaculture; and due to its decline in natural abundance, hatchery rearing and growout may help the conservation of this species in the wild.

(Laboratory of Aquaculture Ecology, Fisheries College, Division of Marine Life Science and Technology, Ocean University of China, 5 Yushan Road Qingdao, 266003, China; email of Shuang Lin Dong: Dongsl@ouc.edu.cn)

INFLUENCE OF PRE-INDUCTIVE PHOTOPERIOD VARIATIONS ON EURASIAN PERCH PERCA FLUVIATILIS BROODSTOCK RESPONSE TO AN INDUCTIVE PHOTOTHERMAL PROGRAM

Pascal Fontaine, Caroline Pereira, Neil Wang, Michel Marie-2006
Aquaculture 255 (1-4): 410-416

Abstract:

The objective of this study was to determine the effect of pre-inductive photoperiod variations on the reproductive response of Eurasian perch *Perca fluviatilis* to an inductive photo-thermal program. Broodstock was reared at constant temperature and photoperiod ($T = 22-24$ °C, 13L : 11D). Then five batches (25 fish per tank, 150–200 g) were transferred into 5 tanks for a 2-week acclimatization

phase. During this phase, water temperature was maintained between 22–24 °C and 3 different photoperiod regimes were applied (8L : 16D, 12L : 12D and 16L : 8D), corresponding to a high photoperiod decrease (HD), a slight photoperiod decrease (SD) and a high photoperiod increase (HI, 3 batches), respectively. At the end of the acclimatization phase (W0), water temperature was progressively decreased in all tanks from 22 to 6 °C over a 6-week period and kept at 6 °C over a 3-week period. For the HI regime, photoperiod was progressively reduced to 8L : 16D in one tank over a 6-week period (HIpD), abruptly reduced to 8L : 16D when temperature was close to 11 °C in another tank (HIaD), or maintained at 16L : 8D (HIc) in the last tank. From W0 and over a 9-week period, five fish were sampled per tank every third week for calculation of gonadosomatic index (GSI) and assessment of plasma testosterone (T), 17 β -estradiol (E2, females only) and 11-keto-testosterone (11-KT, males only) levels. No gametogenesis was observed in males nor females when photoperiod was increased during the acclimatization phase (HI), mean GSI remaining below 1%. A significant GSI increase (to a final value of 5%) was observed in treatments SD and HD in males and females. In these treatments, plasma T and 11-KT in males, and plasma T and E2 in females were significantly higher. Our results demonstrate that a photoperiod increase during the acclimatization phase before the application of a photo-thermal programme (pre-inductive period) inhibits the onset of the gametogenesis in Eurasian perch. Photoperiodic manipulations during the pre-inductive period can highly disturb the planning of reproductive cycle.

(Unité de Recherche Animal et Fonctionnalité des Produits Animaux, INRA - INPL - UHP, Nancy 1, MAN, 34 rue Sainte Catherine, 54000 Nancy, France ; email of P. Fontaine : pascal.fontaine@lsaman.uhp-nancy.fr)

INTENSIVE MASS PRODUCTION OF ARTEMIA IN A RECIRCULATED SYSTEM

Odi Zmora, Muki Shpigel-2006

Aquaculture 255 (1-4): 488-494

Abstract:

An outdoor closed system for intensive Artemia biomass production was evaluated. The system integrates the use of inexpensive agro-techno products and photosynthesis to create an improved diet for culturing adult Artemia. The diet in the initial days of culture consists of microalgae, followed by a mixture of torula yeast and soy protein. No water or solids are discharged from the system during the entire production cycle. Waste products are recycled by bacteria, microalgae and protozoa, which themselves are subsequently ingested by the Artemia in a continuous cycle. The final yield of adult Artemia after 17 to 20 days averaged 40.28 ± 4.84 kg m⁻³ (wet weight) in 600 l and 31 kg m⁻³ in 3000-l tanks. Maximal yield was up to 47.5 kg m⁻³. Food conversion rate (FCR) ranged between 0.17 and 0.25. Survival rates from inoculation date averaged $23.3 \pm 9.24\%$. Systems of this type can productively supply hatcheries of finfish, shrimp and crabs with large quantities of live Artemia.

(National Center for Mariculture (NCM), Israel Oceanographic and Limnological Research Ltd., P.O. Box 1212, Eilat 88112, Israel; email of Odi Zmora: zmorao@umbi.umd.edu)

LARVAL AND JUVENILE REARING OF COMMON SOLE (SOLEA SOLEA L.) IN THE NORTHERN ADRIATIC (ITALY)

Renato Palazzi, Jacopo Richard, Gabriella Bozzato, Lorenzo Zanella-2006

Aquaculture 255 (1-4): 495-506

Abstract:

Research on the rearing cycle of the common sole, Solea solea, was done at an experimental hatchery in the Lagoon of Venice (Italy). The aim was to develop rearing schedules suitable for market production and document any technical problems. Larval metamorphosis studied on 9 groups of larvae reared at 18 °C demonstrated high temporal variability. Caudal metamorphosis and eye migration occurred between 9 days after hatching (DAH) and 24 DAH, and between 13 DAH and 25 DAH, respectively. A larval rearing schedule based on live-food feeding was set at 18–19 °C, which achieved an average survival rate of 40% at 28 DAH.

Three weaning trials comparing two commercial feeds were carried out on larvae about 30 DAH. One of these feeds was sufficient in itself to complete juvenile weaning, reaching average survival rates of 85%, which are comparable to those obtained in the control groups fed with live *Artemia*. Average survival rates of 43% were obtained with the second commercial feed. Both commercial feeds enabled superior juvenile growth on average to that in the control groups.

An on-growing trial in extensive conditions was done in an earthen pond of 370 m², stocking juveniles with an average weight of 3.6 g at a density of 1.5 juveniles/m². The trial started in mid-September and lasted until the following August, when it was stopped because of high mortality due to viral encephalopathy and retinopathy infections. Growth was negligible during winter and began again in spring, reaching the maximum incremental rate between May and June, at temperatures of between 20 and 25 °C. The specific growth rate never exceeded a daily value of 2%, while the average final size reached after 10 months rearing was 12 g.

A double replicate trial of intensive rearing was carried out starting with soles of 7 g, reared at a density of 150 juveniles/m² in circular fibreglass tanks of 10 m² surface. This trial was also stopped during the following summer because of the considerable mortality due to viral infection. The soles had reached an average size of 54 g in August, after 300-day rearing.

Sole can be bred and reared with good efficiency related to its survival rate, but the results of the growth trials, both intensive and extensive, do not allow conclusions to be made on the growth performance in the experimented conditions. The health problems compromised the growth trials towards the middle of the favourable growing season. The trials highlight both the high susceptibility of sole to viral encephalopathy and retinopathy infections, and the scarce tolerance of this species to temperatures of above 25 °C, which caused the onset of frequent bacterial infections.

(Veneto Agricoltura, Impianto Ittico Sperimentale "Pellestrina", Strada dei Murazzi, Pellestrina, Venice, Italy; email of Renato Palazzi: pellestrina@venetoagricoltura.org)
