

INFORMATION OF INTEREST

Marine Functional Foods: [book](#) by Joop Lutén, 2009 (for content tables click [here](#))

Seafood Research from Fish to Dish : quality, safety and processing of wild and farmed seafood [book](#) by Joop Lutén et al., 2006 (for content tables click [here](#))

A review on culture, production and use of Spirulina as food: [book](#) by Habib et al., 2008

The State of the World Fisheries and Aquaculture 2008, FAO Rome, 192 pp. [Website](#) to order, [pdf](#) of English version

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A COMPARISON OF LARVAL PRODUCTION OF THE NORTHERN SCALLOP, ARGOPecten PURPURATUS, IN CLOSED AND RECIRCULATING CULTURE SYSTEMS

Germán Merino, Eduardo Uribe, Gaspar Soria, Elisabeth von Brand-2009

Aquacultural Engineering 40(2): 95-103

Abstract:

Northern scallop *Argopecten purpuratus* aquaculture relies on an efficient all year-round larval supply. Larvae are generally produced in closed aquaculture systems (CAS) using the batch techniques with periodical water changes. For instance, survival rates are greatly variable and can range from 0 to 80% making production of scallop larvae uncertain. The main goal of this study was to determine the feasibility of rearing scallop larvae in a recirculating aquacultural system (RAS), and secondarily to compare scallop larval growth rate and time length to reach the settling stage when reared with a traditional Chilean CAS technique and in a novel RAS technique in an industrial-like approach.

Several batches of larvae were cultured in CAS and RAS. Larvae were fed on *Isochrysis galbana* cultured in 35-L tubular photobioreactors. Growth rates were significantly different ($F_{11,2840} = 274.66$; $p < 0.001$). All scallop larvae cultured in CAS showed lower growth rates ranging within 4.49 and 7.30 $\mu\text{m day}^{-1}$ and protracted period of culture until settlement (at least 10 more culture days) than those reared in RAS (growth rates between 9.56 and 13.15 $\mu\text{m day}^{-1}$). However, final survival (from D-larvae until settlement) of larvae reared in CAS showed higher values than those values recorded for larvae cultured on RAS. Higher growth rates observed in RAS could be attributed to a reduction in daily manipulation of the animals and/or more feed availability as well as higher temperatures and a steady state conditions in water quality. Even though, the reduction in time for rearing larvae until settlement in RAS was high, the comparison between systems is more significant in view of the reduction in make up seawater from 100% of system volume (CAS) to less than 10% of system volume (RAS). Therefore, RAS was independent from daily water quality variation from natural seawater by increasing water retention time, and with that improve water quality steady state conditions. Results of this research show that a more efficient use of water and heating systems than generally used in the Chilean hatchery industry is achievable. This is an important result since it could lead to significant reductions in the cost of operating a scallop hatchery, however further work is required to accurately compare the two systems (CAS and RAS). The main result from this research is that scallop larvae can be cultivated using recirculating aquaculture systems (RAS) as a method to increase production. The information reported in this paper will be useful for the improvement of scallop larvae culture techniques under controlled conditions.

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EFFECTS ON GROWTH AND SURVIVAL OF LOACH (*MISGURNUS ANGUILLICAUDATUS*)
LARVAE WHEN CO-FED ON LIVE AND MICROPARTICLE DIETS

Youji Wang, Menghong Hu, Weimin Wang, Ling Cao-2009

Aquaculture Research 40(4):385 – 394

Abstract:

The effectiveness of co-feeding loach (*Misgurnus anguillicaudatus*) larvae with live and microparticle diets on weaning performance was described here. Dry weight, total length, length and weight-specific growth rate (SGR) and survivals were monitored at 23–25 °C from the 4th day post hatching (dph) in different diet regimes, which included: microparticle diets (A), live cladocerans (B), enriched cladocerans (C), half microparticle diets plus half live cladocerans (D) and half microparticle diets plus half enriched cladocerans (E). The SGR (L and W) were significantly lower in treatment A than in other treatments after completing metamorphosis (day 4–20, $P < 0.05$). On 30 dph, dry weight (mg) and total length (mm) were significantly lower in treatment A than in other treatments ($P < 0.05$). There were no significant differences in growth in treatments B, C, D and E before 30 dph. However, when live feed was withdrawn from 31–60 dph, in metamorphosed fish, there were significant differences ($P < 0.05$) among the treatments in survival and growth. Metamorphosed fish in treatment E had higher survival than the fish in other treatments at the end of the experiment. The SGR (L and W) of weaned fish in treatments B and C were similar but lower than in treatments A, D and E respectively. However, dry weight and total length in treatment A were significantly lower than in treatments D and E. It is suggested that weaning of *M. anguillicaudatus* from early development would appear to be feasible and that larval co-feeding improves the growth and the survival.

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SHORT COMMUNICATION

EFFECTS OF A PEROXIDE-BASED COMMERCIAL PRODUCT ON BACTERIAL LOAD OF
LARVAL REARING WATER AND ON LARVAL SURVIVAL OF TWO SPECIES OF
SPARIDAE UNDER INTENSIVE CULTURE: PRELIMINARY STUDY

Gemma Giménez-Papiol, Francesc Padrós, Ana Roque, Alicia Estévez, Dolores Furones-2009

Aquaculture Research 40(4): 504 – 508

Abstract:

Larvae of two Mediterranean Sparidae species, *Sparus aurata* and *Dentex dentex*, were used to test the efficacy of a peroxide-based product (Ox-Aquaculture©) on the reduction in bacterial load in larval rearing water and its effects on larval survival. Eleven-day-old *S. aurata* larvae and 15-day-old *D. dentex* larvae were exposed to different concentrations of Ox-Aquaculture© (50, 100 and 200 mg L⁻¹, and 20 and 50 mg L⁻¹ respectively) for 1 h. Results indicated that 50 and 20 mg L⁻¹ were the most effective concentrations for the reduction in bacterial load (at least one order of magnitude) after 1 h treatment, without affecting larval survival and/or vitality in 11 dph *S. aurata* and 15 dph *D. dentex* larvae respectively. Ox-Aquaculture© concentrations of 200 and 50 mg L⁻¹ during 1 h affected negatively final survival rate of the larvae of *S. aurata* and *D. dentex* respectively.

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EARLY OSTEOLOGICAL DEVELOPMENT OF THE FINS IN THE HATCHERY-REARED RED
PORGY, *PAGRUS PAGRUS* (L. 1758)

D. Çoban, C. Suzer, H. O. Kamacı, Ş. Saka, K. Firat-2009

Journal of Applied Ichthyology 25(1):26 – 32

Abstract:

The present study was undertaken to establish the normal, healthy features of morphological structures at various developmental stages as achieved under well-defined environmental culture

conditions (temperature between 16 and 21°C, salinity 36 ppt, pH around 7.6, and oxygen saturation over 95%) common in aquaculture of the species. The pectoral fin supports began to develop at 2.90 mm total length (TL), followed by those of dorsal fins at 5.5 mm TL, caudal fins at 5.6 mm TL, pelvic fins at 5.9 mm TL and anal fins at 6.0 mm TL. The pelvic fins appeared fully at 7.4 mm TL. Development of dorsal lepidotrichia was first observed at 6.9 mm TL, attaining their final number at 7.6 mm TL. The dorsal spines first appeared at 6.5 mm TL and were complete at 7.4 mm TL. The anal lepidotrichia appeared during the development phase from 6.8 to 8.6 mm TL. At 5.6 mm TL, the upward flexion of the urostyle was initiated. The caudal lepidotrichia formed within the primordial fin at 5.6 mm TL and reached the final count at 7.4 mm TL. The caudal dermatotrichia first appeared at 7.3 mm TL and all forms were observed by 15.5 mm TL. The development pattern of fin supports found in *Pagrus pagrus* is quite similar to that described for other Sparid species.

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HABITAT SELECTIVITY OF MEGALOPAE AND JUVENILE MUD CRABS (*SCYLLA SERRATA*): IMPLICATIONS FOR RECRUITMENT MECHANISM

James A. C. Webley, Rod M. Connolly, Ruth A. Young-2009

Journal Marine Biology 156(5): 891-899

Abstract:

Megalopae of several crab species exhibit active habitat selection when settling. These megalopae usually select structurally complex habitats which can provide refuge and food. The portunid mud crab, *Scylla serrata*, is commonly found within the muddy estuaries of the Indo-West Pacific after attaining a carapace width >40 mm. Despite substantial efforts, the recruitment mechanism of juvenile mud crabs to estuaries is not understood because their megalopae and early stage crablets (carapace width <30 mm) are rarely found. We used laboratory experiments to determine whether megalopae and early stage crablets are selective among three estuarine habitats which commonly occur in Queensland, Australia. These animals were placed in arenas where they had a choice of habitats: seagrass, mud or sand, and arenas where they had no choice. Contrary to the associations exhibited by other portunid crab megalopae, *S. serrata* megalopae were not selective among these estuarine habitats, suggesting that they tend not to encounter these habitats, or, gain no advantage by selecting one over the others. The crablets, however, strongly selected seagrass, suggesting that residing within seagrass is beneficial to the crablets and likely increases survival. This supports the model that for *S. serrata*, crablets and not megalopae tend to colonise estuaries, since a selective behaviour has evolved within crablets but not megalopae.

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GROWTH AND SURVIVAL OF LARVAL AND JUVENILE GILA CHUB AT DIFFERENT TEMPERATURES

Andrew A. Schultz, Scott A. Bonar-2009

North American Journal of Aquaculture 71:1-5

Abstract:

The information needed to effectively culture imperiled native fishes for recovery efforts is lacking for certain species, yet it is critical for proper management and conservation. Culture techniques and requirements are virtually unknown for Gila chub *Gila intermedia*, a species federally listed as endangered. We tested the effect of four different water temperatures on the growth, survival, and overt health and appearance of larval (20, 24, 28, and 32°C) and two sizes of juvenile Gila chub (20, 23, 26, and 29°C). Growth of larvae was highest at 28°C and lowest at 32°C, whereas survival of larvae was highest at 24°C and lowest at 20°C. Spinal deformities were common for larvae reared at 32°C but generally uncommon for those reared at lower temperatures. Although growth of small (32–49 mm total length) and large (52–72 mm) juveniles generally increased with temperature, the differences were not statistically significant. In any experiment testing small and large juveniles, survival was 100% and no external abnormalities were noted. Water temperatures from 20°C to 28°C

appear suitable for rearing larval Gila chub, temperatures from 24°C to 28°C being optimal. Water temperatures from 20°C to 29°C appear suitable for rearing juvenile Gila chub.
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APPROPRIATE FOOD TYPE, FEEDING SCHEDULE AND ARTEMIA DENSITY FOR THE ZOEAL LARVAE OF THE MUD CRAB, SCYLLA TRANQUEBARICA (CRUSTACEA: DECAPODA:PORTUNIDAE)

Juliana C. Baylon-2009

Aquaculture 288(3-4): 190-195

Abstract:

Scylla tranquebarica is an edible portunid crab with high commercial value. To develop hatchery techniques for juvenile production, the feeding requirements of the larvae were investigated. Experiments were carried out to identify food preferences, feeding schedule and optimum prey density. Larval diets of rotifer *Brachionus* sp, brine shrimp *Artemia* sp nauplii, and a combination of both were provided and survival, development, and metamorphosis to megalopa monitored. The timing for the withdrawal of rotifers from the larval diet and the timing of the introduction of brine shrimp nauplii, were also examined. The effect of varying densities of *Artemia* nauplii in the larval diet was also tested. Results showed that the best survival, most rapid development and highest metamorphosis to megalopa were found for larvae fed with a combination diet of rotifers and *Artemia* nauplii from Z1 to Z3, and *Artemia* nauplii only from Z4 onwards. Continued co-feeding with rotifers up to the last zoeal stage did not provide added benefit to the larvae. Larvae fed exclusively with rotifers all died at Z5 stage while those fed purely with *Artemia* nauplii had low survival to the megalopa stage. It was found that on *Artemia* density of 4.0 nauplii mL⁻¹ given at Z1–Z2 stages, reduced to 2.0 nauplii mL⁻¹ at Z3–Z4 stages, and further decreased to 1.0 nauplii mL⁻¹ at Z5 stage, resulted in the best survival to the megalopa stage. These results advance the development of hatchery techniques for the mud crab, *S. tranquebarica*.

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FEEDING HABITS OF HATCHERY-REARED LARVAE OF GREATER AMBERJACK *SERIOLA DUMERILI*

Katsuyuki Hamasakia, Koya Tsuruokaa, Kazuhisa Teruyab, Hiroshi Hashimotoc, Kazuhisa Hamadad, Takuro Hottae, Keiichi Mushiake-2009

Aquaculture 288(3-4): 216-225

Abstract:

To obtain basic knowledge on the feeding habits of greater amberjack *Seriola dumerili* larvae during the early phase of seed production, larvae were reared until 15–20 days post hatching. Larvae were fed on rotifers *Brachionus plicatilis* sp. complex with different body sizes, i.e., super small type, small type, and large type rotifers, and the survival rate, standard body length (SBL) and gut contents of the larvae were examined. There were no significant effects of rotifer size on survival and growth of greater amberjack larvae, except for the smallest SBL of larvae fed with super small type rotifers. The body sizes (lorica length and lorica width) of rotifers ingested by larvae did not change in accordance with the growth in larval body size and mouth size from the onset of feeding to ~ 7.6 mm SBL, despite the larvae having a chance to prey on larger body size rotifers in the tanks. Counting the number of rotifer eggs in the guts revealed that larvae ≥ 4.5 mm SBL appeared to selectively prey on egg-bearing rotifers, whose body sizes are relatively large among the rotifer populations in the tanks, indicating an ontogenic change in the feeding habit of greater amberjack larvae.

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IN VIVO EFFECTS OF SINGLE OR COMBINED N-ACYL HOMOSERINE LACTONE QUORUM SENSING SIGNALS ON THE PERFORMANCE OF MACROBRACHIUM ROSENBERGII LARVAE

Kartik Baruah, Dang T.V. Cam, Kristof Dierckens, Mathieu Wille, Tom Defoirdt, Patrick Sorgeloos, Peter Bossier-2009

Aquaculture 288(3-4): 233-238

Abstract:

Three experiments, each of 8-days, were conducted to evaluate the effects of (5) N-acyl homoserine lactone (AHL) either alone or in combination on the development and survival of *Macrobrachium rosenbergii* larvae. Experiment 1 was carried out as preliminary trial to confirm whether AHL mixture added daily at 1 mg/L concentration could have any negative effect on the larval performance. In experiment 2, it was verified whether the negative effect on the larvae was due to individual AHL or their interactions and experiment 3 was carried out to determine the critical threshold dose of AHL mixture. Results revealed that AHL mixture added daily at 1 mg/L concentration significantly ($P < 0.01$) reduced the development and survival of the larvae. Except for C4-HST, there was no significant effect ($P > 0.05$) of any of the AHL molecules added individually at 1 mg/L concentration on the development and survival of the prawn larvae. The AHL molecule C4-HST significantly ($P < 0.01$) reduced the larval stage index (LSI) and survival of prawn larvae by about 9.1 and 8.7%, respectively. In contrast, the AHL mixture added daily at 1 mg/L concentration significantly ($P < 0.01$) reduced the LSI and survival of the larvae by 12 and 41%, respectively. Thus the poor development and low survival of the larvae is probably due to the interaction of different AHL molecules which could have instigated the production of various virulence factors in micro-organisms associated with the larvae. Using the AHL mixture, the dose response relationship with respect to the performance of the larvae showed that the development of the larvae was already negatively affected by adding the mixture to a final concentration of 0.125 mg/L while at that concentration, the survival was still unaffected. This indicates that the standing microbial communities associated with the prawn larvae can become virulent when a quorum or critical threshold level is reached through the daily addition of the AHL mixture at a concentration of 0.125 mg/L.

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CO-FEEDING IN SENEGALESE SOLE LARVAE WITH INERT DIET FROM MOUTH OPENING PROMOTES GROWTH AT WEANING

Sofia Engrola, Luís Figueira, Luís E.C. Conceição, Paulo J. Gavaia, Laura Ribeiro, Maria Teresa Dinis-2009

Aquaculture 288(3-4): 264-272

Abstract:

The aim of this study was to determine if sole larvae co-fed with inert diet at mouth opening would perform better than larvae fed with live prey and if such a feeding regime would produce better quality juveniles. The experiment was separated into two phases: pelagic and benthic. In the pelagic phase, treatments consisted of the standard feeding regime (rotifer and *Artemia* feeding), the standard feeding regime and inert diet, and rotifer for a longer period than the standard feeding regime until larvae reached 9 days after hatching (DAH). By the end of the pelagic phase, when the postlarvae were 20 DAH, sole that were co-fed with inert diet from mouth opening, were significantly smaller in weight than postlarvae fed exclusively with live prey. Sole digestive maturation was improved by co-feeding the inert diet. Survival rates, skeletal deformities and quality evaluation were not affected by the feeding regimes. In the benthic phase, the postlarvae from standard feeding regime (pelagic phase) were separated into two treatments: standard live *Artemia metanauplii* until weaning and standard frozen *Artemia metanauplii* until weaning. Remaining treatments were the follow up of treatments from the pelagic phase. At the end of the experiment i.e. 68 DAH, the postlarvae co-fed with inert diet from mouth opening were significantly larger than all the postlarvae from remaining feeding regimes.

The results of the present study demonstrate that it is possible to offer inert diet to sole at mouth opening in a co-feeding regime and to produce better quality postlarvae. Co-fed sole were larger and had a better tail condition at the end of the weaning.

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DETERMINATION OF APPARENT PROTEIN DIGESTIBILITY OF LIVE ARTEMIA AND A MICROPARTICULATE DIET IN 8-WEEK-OLD ATLANTIC COD GADUS MORHUA LARVAE

Ronald B. Johnson, Matthew A. Cook, Peter M. Nicklason, Michael B. Rust-2009

Aquaculture 288(3-4): 290-298

Abstract:

A technique was developed to determine apparent digestibility coefficients (ADCs) of protein in microparticulate and live feeds for marine fish larvae. The technique is analogous to methods used for larger fish and allows for an in vivo measurement of protein digestibility by employing a spectrophotometric protein assay for protein determination and rare earth oxides as inert digestibility markers. Either a microbound microparticulate diet developed in our laboratory or Artemia nauplii were fed to 8-week-old Atlantic cod as a single 30-min feeding and fecal solids collected 6 h later. Protein ADCs for the two diets were significantly different ($P = 0.016$) with determined ranges of 47 to 58% and 76 to 86%, (Artemia and microparticulate diets, respectively). Measured ADCs are presented as a range to account for the possibility of leaching of protein from the microparticulate diet, and the evacuation (loss) of marker from the live prey during the 30-min feeding. It is suggested that this new technique will assist researchers in selecting experimental larval feeds with the most nutritive potential for extended feeding studies. Detection limits for this technique were determined to be 8.6 μg for protein and 0.020 and 0.038 μg for yttrium (Y_2O_3) and dysprosium (Dy_2O_3) markers, respectively, in collected fecal solids.

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EFFECTS OF NITROGEN GAS SUPERSATURATION ON GROWTH AND SURVIVAL IN LARVAL COD (GADUS MORHUA L.)

Katrine Skajaa Gunnarsli, Hilde Toften, Atle Mortensen-2009

Aquaculture 288(3-4): 344-348

Abstract:

Gas supersaturation is one suggested cause of the extensive mortality that is often found during intensive production of Atlantic cod larvae (*Gadus morhua* L.). In the present study, cod larvae (32 to 64 days post-hatch (dph)) were exposed to nitrogen supersaturated water with levels of total dissolved gas (TDG) of 103 and 106%. A control group was given vacuum-degassed water (TDG < 100%). Larvae were sampled weekly and standard length and dry weight were measured. Larval mortality was estimated regularly and at the termination of the experiment, the numbers of survivors were counted. As regards larval mortality, no effect of exposure to supersaturated water was evident. Towards the end of the experiment some larvae were found floating on the surface most likely as an effect of gas supersaturation. Growth rate was not affected during the first three weeks of treatment. By the time the larvae reached metamorphosis, a chronic effect of gas bubble trauma (GBT) was expressed as a reduction in growth. Even though not significant, the effect seemed to appear even at the lowest saturation level used (103%). Thus, even a low level of gas supersaturation should be avoided in intensive culture of cod larvae.

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SHORT COMMUNICATION

VIRAL ENCEPHALOPATHY AND RETINOPATHY IN HATCHERY-REARED JUVENILE THREAD-SAIL FILEFISH (STEPHANOLEPIS CIRRHIFER)

N. Pirarat, T. Katagiri, M. Maita, T. Nakai, M. Endo-2009
Aquaculture 288(3-4): 349-352

Abstract:

The present study characterizes the clinical picture of viral encephalopathy and retinopathy associated with betanodavirus infection in hatchery-reared juvenile thread-sail filefish. Necrotic encephalomyelitis was clearly evident in the spinal cord, the medulla oblongata, and the cerebellum. Necrotic retinitis and gastroenteritis were also noted. Immunohistochemistry using an anti-betanodavirus rabbit serum revealed that the viral antigens were present in the gastrointestinal tract, the spinal cord, the brain and the retina correlating with the histopathological changes. Strong positive immunohistochemical reactions in the stomach and intestine suggest that the gastrointestinal tract was a possible portal of entry into fish.

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NO INCREASE IN DEVELOPMENTAL DEFORMITIES OR FLUCTUATING ASYMMETRY IN RAINBOW TROUT (*ONCORHYNCHUS MYKISS*) PRODUCED WITH CRYOPRESERVED SPERM

William P. Young, Kathryn Frenye, Paul A. Wheeler, Gary H. Thorgaard-2009

Aquaculture 289(1-2): 13-18

Abstract:

Although cryopreservation is a widely accepted tool in animal breeding and human reproduction, questions have arisen regarding the health and viability of fish sired by cryopreserved sperm. We examined rainbow trout families produced using fresh and cryopreserved milt to determine if sperm cryopreservation negatively influenced early development. Fresh and cryopreserved milt from 3 males were used to fertilize eggs from 6 females in a 3 × 6 factorial design. Survival to eye, survival to fry, proportion of fry deformities and developmental stability were compared for fresh vs. cryopreserved milt. Results revealed a significant reduction in survival to eye ($P < 0.001$) and survival to fry ($P < 0.001$) for families sired using cryopreserved milt. Survival during the interval from eye to fry did not differ among the groups ($P = 0.127$), indicating that survival differences occurred prior to the eye stage. These results could be explained by reduced fertilization success of cryopreserved sperm. We examined developmental differences by analyzing the proportion of haploid embryos at the eyed stage, the proportion of fry deformities at hatch and fluctuating asymmetry (FA) of pectoral fin rays. Results revealed no significant difference between the groups. Our observations that surviving fry produced using cryopreserved sperm showed no differences in early development suggest that sperm cryopreservation is a viable option for use in breeding programs and in conservation and recovery of imperiled salmonid populations.

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CAN UMBRELLA-STAGE ARTEMIA FRANCISCANA SUBSTITUTE ENRICHED ROTIFERS FOR COBIA (*RACHYCENTRON CANADUM*) FISH LARVAE?

Van Can Nhu, Kristof Dierckens, Thu Huong Nguyen, Mai Thien Tran, Patrick Sorgeloos-2009

Aquaculture 289(1-2): 64-69

Abstract:

Appropriate food of suitable nutritional value is crucial for first-feeding stages of the larvae of cobia *Rachycentron canadum*, a very fast growing marine fish species. Best survival and growth results in cobia larviculture have been reported with a starter diet of HUFA-enriched rotifers and –as mouth size permits – followed by freshly-hatched and eventually HUFA-enriched *Artemia nauplii*. Using the smaller-sized Vietnam *Artemia franciscana* (AF) strain instead of the Great Salt Lake *A. franciscana* strain, it has been shown that the rotifer-feeding period could be shortened with 3 days, resulting in significant improvements in larval survival and growth. This study verified the possibility to feed umbrella-stage *Artemia* for further shortening and eventually completely substituting rotifer start feeding.

The experiment was conducted in 200-L tanks and lasted 18 days. AF umbrella Artemia was used as sole feed during the whole rotifer feeding period (UAF), compared to the use of enriched rotifers for the first 2 days followed by AF-umbrella (ER + UAF) and the use of enriched rotifers as control (ER). The feeding incidence of UAF treatments was significantly lower ($P < 0.05$) in the 1st feeding day, however, the ingestion and digestion of AF were evident. Growth and survival as well as deformities at day 18 post-hatching were not significantly different for all treatments ($P > 0.05$). The viability of cobia larvae after exposure to high salinity stress was lower in the ER treatment at day 8 post-hatching, but higher at day 18 post-hatching ($P < 0.05$). The ability of cobia larvae to ingest and digest AF umbrella at first feeding as well as the nutritional suitability of AF umbrella is discussed. The possibility to use umbrella-stage Artemia opens an opportunity to simplify the rearing protocol and to reduce production costs of cobia larviculture.

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RESPONSE OF NEWLY HATCHED OCTOPUS BIMACULOIDES FED ENRICHED ARTEMIA SALINA: GROWTH PERFORMANCE, ONTOGENY OF THE DIGESTIVE ENZYME AND TISSUE AMINO ACID CONTENT

Yesika Solorzano, María Teresa Viana, Lus M. López, Juan Gabriel Correa, Conal C. True, Carlos Rosas-2009

Aquaculture 289(1-2): 84-90

Abstract:

The performance of *Octopus bimaculoides* juveniles from coastal areas of Baja California (Mexico) and reared in captivity was evaluated using *Artemia salina* as food source in three different treatments: *Artemia* enriched with either AlgaMac or *Spirulina maxima* and without enrichment. After 20 days, significant differences were found among treatments in terms of growth, which was significantly higher for juvenile fed AlgaMac-enriched *Artemia*, followed by those fed unenriched *Artemia*. Moreover, far higher growth rates (0.74–0.88 mg day⁻¹) were obtained than those reported for other octopus species of the same size. Digestive enzyme activity during the experimental period (20 days) showed an oscillatory behavior, with a tendency to stabilize after day 15. Trypsin was the most important protease, though lipases and amylases were also present. The whole-body lipid content of the juvenile was apparently influenced by the lipid content in the food. The amino acid profile remained unaffected after juvenile were fed the different treatments; however, differences were found between the initial and final whole-body content of the juvenile, with relatively lower amounts of isoleucine, leucine and tyrosine, and relatively higher amounts of threonine, alanine and glycine after 20 days of feeding. The *Artemia* amino acid content of phenylalanine, isoleucine, leucine and valine was limited, and growth would likely be further promoted with a more suitable diet. Thus, *O. bimaculoides* is a promising species for commercial culture, and even though good results were obtained when fed *Artemia*, a more appropriate food source should be sought to obtain an amino acid profile that will maximize growth.

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EFFECT OF MICROALGAE CONCENTRATION ON LARVAL SURVIVAL, DEVELOPMENT AND GROWTH OF AN AUSTRALIAN STRAIN OF GIANT FRESHWATER PRAWN MACROBRACHIUM ROSENBERGII

Malwine Lober, Chaoshu Zeng-2009

Aquaculture 289(1-2): 95-100

Abstract:

The present study investigated the effects of microalgae *Nannochloropsis* sp. addition and concentration on larval survival, development and growth of an Australian strain of *M. rosenbergii* (lineage II). Newly hatched larvae were reared to postlarval (PL) stage under the condition of no algae

addition ('clear water') and four *Nannochloropsis* concentrations of 2.5, 6.25, 12.5 and 25×10^5 cells/ml. All treatments were in quadruplicate and each replicate had 30 larvae stocked in a 5L vessel. Larvae were fed 3 *Artemia*/ml throughout with 100% water exchange daily. The results showed that larval survival to PL at the two higher algae concentrations of 12.5 and 25×10^5 cells/ml (70.8 and 63.3%, respectively) were significantly higher ($P < 0.05$) than those of lower algae concentrations of 2.5 and 6.25×10^5 cells/ml and the 'clear water' treatments (26.7, 35.0 and 30.0%, respectively). Meanwhile, the fastest mean development to PL (30.6 days) registered at the highest algal density was 14 days shorter than that of the 'clear water' treatment (44.3 days). Larval development at the two higher algal densities were significantly shorter than that of the 'clear water' treatment and larval development of the highest algal density was further significantly faster than those of the two lower algal densities (40.1 and 40.0 days) ($P < 0.05$). The mean dry weights of newly settled PL of the two high algal density treatments were also significantly heavier ($P < 0.05$) than those of the lowest algal density and the 'clear water' treatments. The results have shown that the addition of *Nannochloropsis* sp. at appropriate levels substantially improved performance of larval culture of the Australian strain of *M. rosenbergii*, suggesting that the Australian native strain has a promising potential for aquacultural development.

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A LACK OF CONSISTENT RELATIONSHIP BETWEEN DISTRIBUTION OF LIPID DROPLETS AND EGG QUALITY IN HATCHERY-RAISED RAINBOW TROUT, *ONCORHYNCHUS MYKISS*

Andrzej Ciereszko, Mariola Wojtczak, Grzegorz J. Dietrich, Henryk Kuźmiński, Stefan Dobosz-2009
Aquaculture 289(1-2):150-153

Abstract:

The usefulness of lipid droplet distribution patterns for grading eggs of hatchery-raised rainbow trout, *Oncorhynchus mykiss*, was evaluated. Eggs from females of autumn ($n = 29$) and spring ($n = 30$) spawning were evaluated for distribution of lipid droplets and tested with a water turbidity test as well. Fertilization rates were measured in eyed-stage embryos, hatched-stage embryos and swim-up stage larvae. For both spawnings high fertilization rates were recorded, and lipid droplet distribution patterns were characteristic for good quality eggs. In the autumn spawning, the lipid droplet distribution pattern was significantly related to fertilization rates. Moreover, the differences in egg quality recorded at the eyed stage were more pronounced at hatching and swim-up stages. However, distribution of lipid droplets was not a useful parameter for the evaluation of egg quality in the spring spawning. The water turbidity test was not related to lipid droplet distribution. At present due to inconsistent results and the lack of understanding of this inconsistency, lipid droplet distribution for the evaluation of the quality of rainbow trout eggs must be used with caution. Our results suggest that breeding and maintenance conditions influence lipid droplet distribution in salmonid eggs.

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EFFECTS OF PURE MICROCYSTIN-LR ON THE TRANSCRIPTION OF IMMUNE RELATED GENES AND HEAT SHOCK PROTEINS IN LARVAL STAGE OF ZEBRAFISH (*DANIO RERIO*)

Yuan Li, Baojian Sun, Hongjuan Wu, Pin Nie-2009

Aquaculture 289(1-2): 154-160

Abstract:

Microcystins (MCs) are cyanobacterial toxins in water blooms that have received increasing attention as a public biohazard for human and animal health. Previous studies were mainly focused on the toxic effects on adult fish, rather than juvenile or larvae, and the response of fish immune system were usually neglected. This paper presents the first data of the effects of microcystin-LR (MC-LR) on transcription of several genes essential for early lymphoid development (*Rag1*, *Rag2*, *Ikaros*, *GATA1*, *Lck*, *TCR α*) and heat shock proteins (*HSP90*, *HSP70*, *HSP60*, *HSP27*) in zebrafish larvae. Relative

changes of mRNA transcription were analyzed by real time PCR. The transcription of Rag1, Rag2, Ikaros, GATA1, Lck and TCR α were up-regulated when following exposure to 800 μ g/L MC-LR, which may indicate that specific lymphocytes differentiation and TCR/Ig arrangement are induced to counteract the toxic effects of MC-LR. It was also interesting to note the dramatically increased transcription of HSP90, HSP70, HSP60 and HSP27, which may indicate their important roles as molecular chaperones under oxidative stress.

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CAPRELLID AMPHIPODS: AN OVERLOOKED MARINE FINFISH AQUACULTURE RESOURCE?

Chris M.C. Woods-2009

Aquaculture 289(3-4): 199-211

Abstract:

The present review examines aspects of the known biology and ecology of caprellid amphipods and their potential suitability as a novel marine finfish feed. Caprellids are widely distributed globally and are an important secondary trophic link in many marine ecosystems. They form an important natural dietary component in a variety of coastal marine finfish and appear to contain relatively high levels of beneficial polyunsaturated fatty acids, particularly docosahexaenoic acid (DHA), 22:6n-3 and eicosapentaenoic acid (EPA), 20:5n-3, although their overall nutritional value is poorly known. Relatively sedentary, caprellids are common members of epibiotic communities on a variety of natural substrata. They readily colonize artificial structures, and under appropriate conditions can attain high biomass, particularly in environments with a higher organic loading, such as around fish farms. Caprellids can exhibit fast growth with relatively quick time to reproductive maturity, short interbrood periods and release of juveniles at parturition. They are opportunistic feeders capable of using a variety of feeding techniques, and environmental tolerances in some species can be quite broad. There is a paucity of information available on culture techniques for caprellids, with most accounts relating to small-scale experimental or laboratory culture, although many of these do indicate the potential suitability of caprellids to larger scale culture. Overall, these characteristics indicate that caprellids are worthy of consideration for application in marine finfish aquaculture.

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THE RELATIONSHIP OF EMBRYONIC DEVELOPMENT, MORTALITY, HATCHING SUCCESS, AND LARVAL QUALITY TO NORMAL OR ABNORMAL EARLY EMBRYONIC CLEAVAGE IN ATLANTIC COD, GADUS MORHUA

Trevor S. Avery, Shaun S. Killen, Tamara R. Hollinger-2009

Aquaculture 289(3-4): 265-273

Abstract:

A reliable method for assessing the viability of fertilized eggs early in development would be beneficial for the aquaculture industry, allowing egg batches with a high probability of low hatching success to be discarded before costly resources are devoted to their culture, and for recruitment models where egg viability is used predictively. During the last decade, the observation of cellular morphology during embryogenesis has received increased attention as a potential early indicator of embryo quality. However, most often, abnormally cleaving eggs are assessed en masse even though noticeable differences in cleavage patterns are generally present between individual eggs. We separated six egg batches of Atlantic cod, *Gadus morhua* Linnaeus, 1758, into normal and abnormal cleavage patterns, reared eggs individually in a temperature-controlled room, and recorded daily egg mortality until hatch, hatching success, larval deformation, and larval mortality. Seven abnormal cleavage patterns were readily distinguishable and all showed moderate variability in egg mortality. Both normal and abnormal eggs had similar mortality-rate trends, consisting of an initial high mortality that became asymptotic at about day 8 of development at 6.5 °C. Specific cleavage patterns showed variable mortality-rate trends. No significant differences in cumulative egg mortality were

found between any abnormal cleavage patterns, but overall, abnormal eggs had significantly greater egg mortality than normal eggs. Hatching success was high in all groups and not significantly different between normal and abnormal eggs. Few larvae were deformed within any egg batch or pattern and no consistent trends were noted. A severity index was calculated and a suggested severity order determined as asymmetry < adhesions < margins ≤ inclusions < blastomere size.

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JAW MALFORMATION IN STRIPED TRUMPETER *LATRIS LINEATA* LARVAE LINKED TO WALLING BEHAVIOUR AND TANK COLOUR

Jennifer M. Cobcroft, Stephen C. Battaglene-2009

Aquaculture 289(3-4): 274-282

Abstract:

Jaw malformations are a recurrent obstacle in the hatchery production of high quality juveniles of many marine finfish species. Whilst nutrition and temperature are often cited as the most likely causes, this study investigated manipulation of the physical culture environment and larval behaviour to reduce jaw malformations. The onset of jaw malformation after metamorphosis in striped trumpeter, *Latris lineata*, follows changes in larval behaviour from an even distribution throughout the water column to close association with the tank walls, often with vigorous swimming into the walls known as 'walling' behaviour. Larvae were reared through metamorphosis, 16 to 44 days post-hatching (dph), in twenty four 300-l hemispherical tanks with six different wall colours, black, blue, green, marble (a black, grey and white mottled pattern), red and white. Walling behaviour and jaw malformation were assessed. The highest proportion of severely malformed jaws at 44 dph occurred in red tanks, followed by green, white, blue, black and marble. More fish walled in coloured tanks (25–44%) than in black and marble tanks (9.6 and 3.4%, respectively). The proportion of fish with jaw malformations at 44 dph was positively correlated with fish walling behaviour. Both black and marble tanks had more than 50% of fish with normal jaws at 44 dph, and close to 80% with no or very minor malformations. Growth and survival to 44 dph were highest in the black (15.7 ± 1.3 mm fork length, 7.9 ± 0.9 mg dry weight, $71 \pm 6\%$) and marble (15.6 ± 1.2 mm, 7.6 ± 0.5 mg, $58 \pm 17\%$) tanks, compared with the lowest values in red tanks (14.2 ± 1.1 mm, 6.4 ± 0.4 mg, $11 \pm 6\%$). Potential mechanisms for the influence of walling behaviour on jaw malformation are mechanical damage and poor nutrition, via reduced feed intake and increased energy expenditure. The study highlights the often overlooked importance of hard-surface interactions in the growth and survival of some cultured marine fish and demonstrates a cheap and effective technique for assessing tank background colour as a means of reducing malformations in cultured fish.

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FEEDING PREFERENCES OF THE DUSKY GROUPER (*EPINEPHELUS MARGINATUS*, LOWE 1834) LARVAE REARED IN SEMI-INTENSIVE CONDITIONS: A CONTRIBUTION ADDRESSING THE DOMESTICATION OF THIS SPECIES

Tommaso Russo, Clara Boglione, Paolo De Marzi, Stefano Cataudella-2009

Aquaculture 289(3-4): 289-296

Abstract:

Despite research efforts addressing artificial propagation, dusky grouper aquaculture still relies on experimental trials owing to the low survival rates of larvae and juveniles, thus rendering mass rearing difficult to attain. Although some authors suggested that the preys offered to the early larval stages represent the major problem facing the rearing of all grouper species, very little information is available in literature on larval development and the behaviour of dusky grouper. The objective of this study was to investigate the trophic preferences of larval stages of the dusky grouper by rearing using a semi-intensive technology. Larvae were reared in pilot scale mesocosms (60 m³) from 3 to 35 days post hatching. The rearing system was supplied with wild zooplankton collected in a natural coastal

lagoon in order to augment the chances of satisfying the larvae's feeding requirements; the feeding preferences were analyzed during ontogenesis. The relationship between mouth gape and dimensions of preys, considered as 3-D objects, was investigated to identify possible critical factor.

The results of this study suggested a sequence of suitable food items from the beginning of exogenous feeding until day 35 post hatching. In particular, dusky grouper larvae actively select copepod nauplii in the size range between 2 and 12 mm in TL, and *Artemia salina* nauplii for TL larger than 9 mm. The rearing approach applied seemed to be promising. Indeed, while previous rearing trials of dusky grouper failed within ten days or finished at 30 days post hatching with a lower percent of survivors, this paper reports the best survival rate reported for this species ($10\% \pm 7.0$ survivors at 35 days post hatching). Finally, mouth width was observed to be the limiting factor in the selection of prey, while the smallest prey size plays a critical role in determining ingestion. Our results contribute to clarifying some aspects of the larval ecology of this species, furnishing some suggestions for its cultivation.

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IMPROVEMENT OF REARING CONDITIONS FOR JUVENILE LOBSTERS (*HOMARUS GAMMARUS*) BY CO-CULTURING WITH JUVENILE ISOPODS (*IDOTEA EMARGINATA*)

Isabel Schmalenbach, Friedrich Buchholz, Heinz-Dieter Franke, Reinhard Saborowski-2009
Aquaculture 289(3-4): 297-303

Abstract:

Growth conditions of the juvenile lobsters, *Homarus gammarus*, were optimized in view of a restocking project of the lobster population at Helgoland (German Bight, North Sea) aimed to produce more than ten thousand juvenile lobsters per year. Growth and survival rates of juvenile lobsters depend on diet, temperature and water quality. In the present study, diet at optimum temperature was considered, but special emphasis was placed on the optimization of cleaning and feeding methods from both an economical and ecological point of view. Six dietary treatments of juvenile lobsters (each $n = 99$) were tested in individual compartments in a semi-closed re-circulation system at around 20 °C. Lobsters were fed with combinations of two diets, newly hatched *Artemia* sp. nauplii and minced crabs *Cancer pagurus* (whole carcasses), every 2 or 4 days until a carapace length of 10 mm was reached. During the experiment (max. 105 d), juvenile isopods, *Idotea emarginata*, were constantly present in the lobster boxes. More frequent feeding significantly increased growth rates of the juvenile lobsters while different feeding combinations had no effect. The highest growth rate (0.091 ± 0.02 mm CL day⁻¹) was at a feeding frequency of every 2 days for each diet. At this rate the carapace length of 10 mm was reached in 68–71 days. The survival rate of the juvenile lobsters ranged from 90–97%. The diet consisting of *C. pagurus* was most cost-efficient and was obtained as discards from the crab fishery at Helgoland. The co-culture of juvenile lobsters with juvenile isopods *I. emarginata* as "cleaning organisms" was ideally suited for the rearing of lobsters and reduced the maintenance time by 50%. The isopods also served as supplementary diet.

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THE EFFECT OF DISPENSABLE AMINO ACIDS ON NITROGEN AND AMINO ACID LOSSES IN ATLANTIC SALMON (*SALMO SALAR*) FRY FED A PROTEIN-FREE DIET

Tarik Abboudi, Muriel Mambrini, Yvan Larondelle, Xavier Rollin-2009
Aquaculture 289(3-4): 327-333

Abstract:

The nutritional role of dispensable amino acids (DAAs) has been seldom studied in fish, while the metabolism of these species is orientated toward the oxidation of amino acids (AAs) for energetic purpose. The objective of this study was to characterize the role of DAAs in the absence of indispensable (I) AA supply in Atlantic salmon and to verify if, as in mammals they play a nutritional role under near maintenance conditions. Therefore we measured the effect of adding DAAs on

nitrogen and AA losses in Atlantic salmon fry fed a protein-free (PF) diet. Fry were either starved or fed a PF diet or a DAA-supplemented (DAA-PF) diet for 30 days. The maintenance protein requirement estimated from the endogenous losses were 1.11, 1.58 and 0.65 g/kg BW/day for starved fish, fish fed PF or DAA-PF diets, respectively. The daily IAA and DAA losses of fish fed the DAA-PF diet were greatly reduced (– 55 and – 63%, respectively) compared to fish fed the PF diet ($P < 0.05$), except for proline and serine for which the reduction was not significant. Among the DAAs, alanine and glycine losses were particularly reduced when fish were fed the DAA-PF diet compared to the PF-diet (– 74 and – 82% for alanine and glycine, respectively). Among the IAAs, methionine loss was the most reduced by the supplementation of the PF-diet with DAAs (– 72%). These results showed the indispensable role of DAAs under near maintenance conditions and their sparing effect on the use of alanine and glycine specifically.

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VITAMIN CONTENT AND QUALITY OF EGGS PRODUCED BY BROODSTOCK INJECTED WITH VITAMINS C AND E DURING ARTIFICIAL MATURATION IN JAPANESE EEL *ANGUILLA JAPONICA*

H. Furuita, T. Ishida, T. Suzuki, T. Unuma, T. Kurokawa, T. Sugita, T. Yamamoto-2009

Aquaculture 289(3-4): 334-339

Abstract:

This study was conducted to investigate the effects of injection of vitamins C (VC) and E (VE) into broodstock on the vitamin levels of broodstock and eggs and subsequent egg and larval quality in the Japanese eel. Broodstock were allotted to one of three groups; control group, injected with physiological saline; early group, injected with vitamins during the early part of maturation (1st–3rd weeks after initiation of maturation induction); later group, injected with vitamins during the later part of maturation (4th–6th weeks after initiation of maturation induction). Broodstock were injected with an emulsion of VC and VE at the same time as an injection of salmon pituitary extract during the induction of maturation. The emulsion was prepared by mixing α -tocopherol, sodium ascorbate, an emulsifier, and water just before injection. The levels of both vitamins in eggs and broodstock increased following vitamin injection. However, the accumulation of vitamins in broodstock and eggs was higher for VE than for VC. Hatching rate, survival and normality of larvae increased with vitamin treatments. The results of this study showed that VC and VE injection into broodstock during artificial maturation increases the vitamin content of eggs and can improve egg quality in Japanese eel

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CORRELATION BETWEEN ENVIRONMENTAL IODIDE CONCENTRATIONS AND LARVAL GROWTH, SURVIVAL, AND WHOLE BODY CONCENTRATIONS OF THYROID HORMONES AND CORTISOL IN PACIFIC THREADFIN (*POLYDACTYLUS SEXFILIS*)

Elisha M. Witt, Charles W. Laidley, Kenneth K.M. Liu, Tetsuya Hirano, E. Gordon Grau-2009

Aquaculture 289(3-4): 357-364

Abstract:

Pacific threadfin (*Polydactylus sexfilis*), known locally by its Polynesian name “moi”, is rapidly becoming a premier aquaculture species in Hawaii and throughout the Indo-Pacific. Nevertheless, threadfin culture is suffering from extraordinary loss of seed stock during the pre-metamorphic and metamorphic periods, and from dramatic size variation between animals after metamorphosis that leads to cannibalism. The objective of the present study was to examine effects of iodide concentration of rearing tanks on larval growth, survival, metamorphosis, and whole body concentrations of thyroid hormones and cortisol. Threadfin larvae raised in ocean water grew significantly larger, and showed increased survival compared with larvae raised in water from a seawater-injected well that had lower iodide concentrations. Larvae raised in ocean water developed more rapidly than in well seawater. At 14 days post-hatch, 50% of the larvae raised in ocean water

reached flexion-stage, compared to 15% in well seawater. In ocean water-raised larvae, whole body thyroxine (T4) concentrations increased sharply from 0.4–0.5 ng/g at hatching through day 13 post-hatch to 1.9 ng/g on day 15, and decreased gradually to 0.5 ng/g by day 23. Larvae raised in well seawater did not show a peak in T4, as levels increased gradually from 0.2 ng/g on day 1 to 2.4 ng/g by day 25. Profiles of triiodothyronine (T3) were similar between the two groups, decreasing from 0.17 ng/g at 8 h before hatching to 0.02–0.04 ng/g by day 7 post-hatch, and then gradually increasing to 0.45 ng/g by day 23. Whole body concentration of cortisol was 0.5 ng/g prior to hatching for both groups, increasing to 27–30 ng/g by day 5. Cortisol levels fluctuated during days 7 to 25 post-hatch between 12 and 26 ng/g for ocean water-raised larvae, and between 14 and 32 ng/g for larvae raised in well seawater. Absence of a peak in the T4 profile in well seawater-raised larvae may indicate incomplete synchronization of development or metamorphosis. These results suggest the importance of environmental iodide in larval metamorphosis, and subsequent survival and growth, possibly through the synthesis of thyroid hormones.

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