

**PROBIOTICS IN AQUACULTURE: THE NEED, PRINCIPLES AND MECHANISMS OF ACTION AND SCREENING PROCESSES**

Aditya Kesarcodi-Watson, Heinrich Kaspar, M. Josie Lategan, Lewis Gibson-2008  
*Aquaculture* 274(1): 1-14

**Abstract:**

Aquaculture production of molluscs is worth US\$11 billion per year and represents 65% of World mollusc product. A significant limitation to the industry is loss of stock through bacterial disease. Traditional methods to combat disease with antibiotics have been questioned and alternatives have been sought. The field of probiotics as well as the screening methods used to acquire probiotic strains for the alternative management of disease in aquaculture is discussed. This review provides a comprehensive summary of probiotics in aquaculture with special reference to mollusc culture.

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**DIETARY MANNAN OLIGOSACCHARIDE ENHANCES SALINITY TOLERANCE AND GUT DEVELOPMENT OF LARVAL COBIA**

G. Salze, E. McLean, M.H. Schwarz, S.R. Craig-2008  
*Aquaculture* 274(1): 148-152

**Abstract:**

The potential beneficial effects of supplementing live feeds with mannan oligosaccharide (MOS; BioMos®) upon cobia *Rachycentron canadum* larval performance were examined. Characteristics of fish examined included survival to weaning, growth, ability to withstand osmotic stress and the degree of development of the brush border of the intestine. Live feeds included rotifers (*Brachionus plicatilis*) and *Artemia* which were enriched for 24 h with a commercial enrichment media alone or in combination with 0.2% (dry weight basis) MOS. Salinity challenges were performed at 6 days post-hatch (dph) and at 7, 13, and 14 dph (0 and 65 g L<sup>-1</sup> for 6 dph; 0 and 55<sup>-1</sup> 7+ dph) corresponding to transitions in feeding, to examine the ability of larval cobia to survive stress. Differences ( $P < 0.05$ ) in survival, favoring cobia receiving MOS-supplemented feeds were discerned at 6 and 7 days post-hatch (dph) when fish were challenged at 0 g L<sup>-1</sup> and at 13 dph when challenged with 55 g L<sup>-1</sup> salinity water. Electron microscopy of the mid-intestine of developing larvae revealed that MOS-supplemented diets enhanced ( $P < 0.05$ ) the height of microvilli while reducing ( $P < 0.05$ ) the occurrence and size of supranuclear vacuoles. Supplementation of diets with MOS could assist cobia larvae in maintaining allostasis especially when reared at sub-optimal salinities.

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**SHORT COMMUNICATION****EFFECT OF STARVATION DURING LATE MEGALOPA STAGE OF *MITHRACULUS FORCEPS* (BRACHYURA: MAJIDAE) ON LARVAL DURATION, SYNCHRONISM OF METAMORPHOSIS, SURVIVAL TO JUVENILE, AND NEWLY METAMORPHOSED JUVENILE SIZE**

Joana Figueiredo, Gil Penha-Lopes, Luís Narciso, Junda Lin-2008  
*Aquaculture* 274(1): 175-180

**Abstract:**

Larval resistance to temporary starvation is considered a key factor for successful development in the wild. Subjecting larvae to temporary starvation during early and/or late development is occasionally used in larviculture to reduce production costs.

*Mithraculus forceps* is a popular species in the marine aquarium industry for their ability to control nuisance algae in aquarium tanks; a larval culture methodology was previously proposed in order to avoid collection from the wild. In an attempt to reduce production/feeding costs of *M. forceps* larval culture (two zoea stages and a megalopa), larvae (megalopa stage) were starved after 7 and 8 days post-hatch (DPH); starvation treatments were compared with those of the control treatment where larvae were fed continuously. No differences were found in survival to juvenile, metamorphosis synchronism or larval duration between the treatments, which suggest that at least by day 7 DPH, megalopae have already achieved the point-of-reserve-saturation (PRS) and are able to successfully metamorphose to crab stage without feeding (facultative lecithotrophic); newly metamorphosed juveniles are slightly smaller (particularly the ones starved after 7DPH). This flexible way of development might be very advantageous in the wild and might allow the reduction of costs of larval culture in captivity.

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#### COMPARISONS OF THE GROWTH OF SIX DIATOM SPECIES BETWEEN TWO CONFIGURATIONS OF PHOTOBIOREACTORS

Fernando R. Silva-Aciares, Carlos E. Riquelme-2008

Aquacultural Engineering 38(1): 26-35

Abstract:

The present study reports on the mass culture of six benthic diatom species in two systems termed “ photobioreactors”. One system called “bristles photobioreactor” (PBB) contained polyvinyl chloride (PVC) bristles which provided attachment surface for adhesive diatoms, and an airlift system to provide constant water movement. Results obtained using this apparatus are compared with parallel results obtained when inoculating the same diatom species into a “bubble column photobioreactor” without support bristles (PBC), and a strong column of air bubbles to provide constant agitation. The results showed high efficiency of the PBB in terms of concentration and biomass of the adhesive diatoms *Amphora* spp., *Amphora* spp2, *Navicula* spp. and *Nitzschia ovalis*, on the support filaments. The lesser adhesive diatoms *Nitzschia* sp. and *Cylindrotheca closterium* grew better in suspension in the PBC system. The relation existing between the growth of the microalgae and their accompanying bacterial flora were strongly correlated, indicating simultaneous growth of the two populations. It was also shown that higher bacterial counts were found in the systems having the highest microalgal populations. The present results suggested positive feasibility of growing benthic diatoms of commercial importance, particularly for aquaculture, based on the high degree of adhesiveness of the diatoms produced in the PBB systems. Greater efficiency was obtained in the PBC systems for producing high concentrations and biomass of the lesser adhesive diatom species. This new technology may permit optimizing yields for the mass production of microalgae of commercial importance. Data in the literature suggest that biofilms of benthic diatoms the same as or similar to those presently cultured can aid the settlement and growth of larvae of certain benthic marine invertebrates, some of which are important species in aquaculture.

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A COMPARISON AMONG DIFFERENTLY ENRICHED ROTIFERS (BRACHIONUS PLICATILIS) AND THEIR EFFECT ON ATLANTIC COD (GADUS MORHUA) LARVAE EARLY GROWTH, SURVIVAL AND LIPID COMPOSITION

A.S. Garcia, C.C. Parrish, J.A. Brown-2008

Aquaculture Nutrition 14(1): 14-30

Abstract:

We evaluated the effect of differently enriched rotifers on the early growth, survival and lipid composition of Atlantic cod larvae (*Gadus morhua*). The enrichments tested were: (i) AlgaMac 2000®; (ii) AquaGrow® Advantage; and (iii) a combination of Pavlova sp. paste and AlgaMac 2000®. Larvae from treatment 3 [ $1.50 \pm 0.11$  mg dry weight (dw) and  $7.10 \pm 0.14$  dw specific growth rate (SGR)] were heavier ( $P = 0.006$ ) and grew faster ( $P = 0.004$ ) than larvae from treatment 2 ( $1.03 \pm 0.04$  mg dw and  $6.29 \pm 0.04$  dw SGR). No significant differences were found in the final weight and SGR among larvae from treatment 1 ( $1.21 \pm 0.07$  mg dw and  $6.58 \pm 0.20$  dw SGR) and larvae from treatments 2 and 3. The treatment 3 also resulted in the best survival at the end of the experimental period, estimated to be 3 on a scale from 1 to 5, whereas the survival estimates for the two other groups were 1–2. Larvae from the treatment 3 reached 37 days posthatch with levels of  $\omega$ 6DPA 32-fold higher than newly hatched larvae. Differences in the larval enrichment of  $\omega$ 6DPA may explain the differences in growth and survival of the Atlantic cod larvae.

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SEVERAL MICRONUTRIENTS IN THE ROTIFER BRACHIONUS SP. MAY NOT FULFIL THE NUTRITIONAL REQUIREMENTS OF MARINE FISH LARVAE

K. Hamre, A. Srivastava, I. Ronnestad, A. Mangor-Jensen, J. Stoss-2008

Aquaculture Nutrition 14 (1): 51–60

Abstract:

The current best practice intensive culture of larval Atlantic cod includes feeding rotifers from onset of exogenous feeding until 25–30 days after hatching. These larvae grow considerably slower and develop higher frequencies of deformities than larvae reared in semi-extensive systems, using copepods as feed. The present study compares the micronutrient concentrations in rotifers with those of copepods, with the aim of identifying nutrients that may be limiting for normal growth and development of cod larvae. An additional criterion used is the nutrient requirements given for fish in general, by NRC (1993), as nutrient requirements of cod remains to be determined. Rotifers were fed on four different diets, consisting of baker's yeast with cod liver oil (3.3 : 1 dry weight (DW)/v), baker's yeast with Algamac 2000TM (3.5 : 1 DW), baker's yeast with live algae *Chlorella* (4.1 : 1 DW), and Culture Selco 3000TM (CS). CS was a complete commercial diet for rotifers while the other diets are considered as based on raw ingredients. Compared with copepod nutrient levels, rotifers grown on yeast-based diets supplemented with either cod liver oil, Algamac 2000 or *Chlorella* were apparently sufficient for covering the requirements in cod larvae for all the B-vitamins, except thiamine. Rotifers cultured on the CS diet also had sufficient amounts of thiamine. Of the minerals, only calcium and magnesium were sufficient, using this criterion while iron was on the borderline. However, with reference to the requirements given for larger fish (NRC 1993), only thiamine, vitamin A, manganese, selenium and perhaps copper, appear too low in the rotifers cultured without extra micronutrient supplementation. The other nutrients were present at levels intermediate between copepod and fish requirement levels. This study suggests that it is necessary to develop enrichment techniques to produce rotifers with sufficient amounts of all micronutrients. Such techniques will also be important tools for determining which nutrients are present at levels below the actual requirements in cod larvae. (National Institute of Nutrition and Seafood Research (NIFES), P.O. Box 2029, Nordnes, 5817 Bergen, Norway; email of Kristin Hamre: [kristin.hamre@nifes.no](mailto:kristin.hamre@nifes.no))

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TISSUE CONTENT, FECUNDITY AND QUALITY OF EGGS AND PHYLLOSOMA LARVAE AFTER SUPPLEMENTING THE DIET OF SPINY LOBSTER *JASUS EDWARDSII* BROODSTOCK WITH ASCORBIC ACID-ENRICHED ARTEMIA BIOMASS

G.G. Smith, A.J. Ritar, M.R. Brown-2008

Aquaculture Nutrition 14 (1): 67–76.

Abstract:

Ascorbic acid (AA)-enriched Artemia in alginate pellets and unenriched pellets were fed to *Jasus edwardsii* broodstock to supplement AA intake of the basal diet (mussels, squid and compound prawn pellets) during ovarian development before egg extrusion. Pellet AA content ranged from 150  $\mu\text{g g}^{-1}$  (unenriched) to 9153  $\mu\text{g g}^{-1}$  (enriched). The basal diet (150  $\mu\text{g AA g}^{-1}$ ) was compared with low (150  $\mu\text{g AA g}^{-1}$ ), medium (450  $\mu\text{g AA g}^{-1}$ ) and high (1350  $\mu\text{g AA g}^{-1}$ ) AA supplementation. Dietary AA content was obtained using combinations of unenriched and AA-enriched Artemia in combination with the basal diet. Supplementation resulted in ovarian AA saturation at 240  $\mu\text{g g}^{-1}$ , a significant increase over 152  $\mu\text{g g}^{-1}$  at time 0. Digestive gland concentrations were 76–92  $\mu\text{g AA g}^{-1}$  for diets containing  $\leq 450 \mu\text{g AA g}^{-1}$ , but reached 270  $\mu\text{g AA g}^{-1}$  for the high supplement. The considerable AA store in tail muscle appeared to be translocated to the ovary during maturation. There was no significant AA depletion in eggs during embryogenesis suggesting minimal AA utilization during this phase. *Jasus edwardsii* spawns once annually, unlike other multiple spawning crustaceans. Therefore, AA supplementation did not alter fecundity or phyllosoma quality, but resulted in a dose-dependent increase (up to 33%) in AA content of eggs and phyllosoma.

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DIGESTIVE ENZYME ACTIVITY OF THE RED PORGY (*PAGRUS PAGRUS*, L.) DURING LARVAL DEVELOPMENT UNDER CULTURE CONDITIONS

Cüneyt Suzer, H Okan Kamaci, Deniz Çoban, Şahin Saka, Kürşat Firat, Banu Özkara, Alaattin Özkara-2007

Aquaculture Research 38(16): 1778-1785

Abstract:

The ontogenic development of the main digestive enzymes (proteases, amylase and lipase) in the red porgy, *Pagrus pagrus*, larvae was assayed during the larval development. The green water technique was carried out for larval rearing and whole-body homogenates were used for enzymatic assays in triplicate. Significant alterations in specific activities of all digestive enzymes measured during the period of this study were mostly related to metamorphosis and weaning. Trypsin- and chymotrypsin-specific activities were first detected on day 3, together with opening of the mouth, and slightly increased until 25 days after hatching (DAH). After this period, the specific activities of these enzymes slightly decreased. Pepsin was first detected on day 28, concurrent with stomach formation, and a sharp increase was observed until 30 DAH. A slight decrease was measured from this date until the end of the experiment. Both amylase and lipase were measured for the first time on days 2 and 4 respectively, and the specific activities of these enzymes showed similar patterns during the first week of the study. Then, slight variations were observed until 30 DAH and while lipase-specific activity declined, an increase in the specific activity of amylase was found until the end of the experiment. It is concluded that the variations observed in the specific activity of digestive enzymes were related to either metamorphosis, such as the formation of the stomach (28 DAH), or to changes in food composition. The profile of the developmental pattern of the main digestive enzymes detected in *P. pagrus* is similar to that described for other Sparid species.

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NUTRITIONAL VALUE OF PAVLOVA SPP. (PRYMNESIOPHYCEAE) FOR SPAT OF THE CORTEZ OYSTER CRASSOSTREA CORTEZIENSIS DURING LATE-NURSERY CULTURING AT THE HATCHERY

Josafat J Ojeda-Ramírez, Jorge Iván Cáceres-Puig, José M Mazón-Suástegui, Pedro E Saucedo-2008

Aquaculture Research 39 (1): 18–23

Abstract:

Three Pavlova species were evaluated for their nutritional value as diets for growth and survival of the Cortez oyster *Crassostrea corteziensis* spat during late-nursery cultivation at a hatchery. Microalgae were provided as monospecific diets (*Pavlova salina*, P. sp. C50 and P. sp. C53) and in binary combinations of diets 1+2, 1+3 and 2+3 at  $80\text{--}90 \times 10^3$  cells mL<sup>-1</sup> for 21 days. Juveniles experienced high survival rates and grew well with all dietary treatments, but binary diets yielded greater survival and growth of spat. From the three binary treatments, Diet 6 (P. sp. C50 and P. sp. C53) promoted significantly ( $P < 0.001$ ) fastest growth of juveniles in shell height (0.19 mm day<sup>-1</sup>), shell length (0.14 mm day<sup>-1</sup>), total wet weight (0.04 g day<sup>-1</sup>) and dry weight of meat biomass (0.024 g day<sup>-1</sup>). For all shell dimensions, the lowest growth rates occurred with Diets 2 (P. sp. C56 alone) and 3 (P. sp. C50 alone). These results highlight the importance of testing microalgal diets for bivalve spat rather than just relying on published nutritional values.

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DETERMINATION OF APPROPRIATE AGE AND STOCKING DENSITY OF VUNDU LARVAE, HETEROBRANCHUS LONGIFILIS (VALENCIENNES 1840), AT THE WEANING TIME

Ibrahim Imorou Toko, Emile D Fiogbé, Patrick Kestemont-2008

Aquaculture Research 39 (1): 24–32

Abstract:

Two experiments were conducted in order to determine the appropriate age and stocking density of vundu catfish *Heterobranchus longifilis* at the weaning time. In the first experiment, five triplicate groups of 100 larvae (initial mean weight=3.4 mg) per aquaria were stocked from first feeding [day 3 post-hatch (p.h.)] to day 30 p.h., and then weaned, on days 3 (W3), 5 (W5), 8 (W8) and 14 (W14), and an unweaned group (An). Significant differences were observed in growth, survival, cannibalism, coefficient of weight variation and body composition among larvae weaned at different ages and the control group. The later the larvae were weaned, the better were the growth performances [final mean weight: from 65.1 to 201.1 mg and specific growth rate (SGR): from 11.0 to 15.2% day<sup>-1</sup>] and the survival (from 36.5% to 74.3%). The experiment with stocking densities of 5, 10, 25 and 50 larvae L<sup>-1</sup> showed that increasing the stocking density decreased growth performances and weight variation but improved the survival rate of larvae. The best growth performances (SGR=13.4 and 11.4% day<sup>-1</sup>) with the lowest survival rates (70.3% and 77.3%) were observed in larvae stocked at densities of 5 and 10 larvae L<sup>-1</sup> respectively.

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EFFECTS OF LIVE PREY AVAILABILITY ON GROWTH AND SURVIVAL IN THE EARLY STAGES OF CUTTLEFISH SEPIA OFFICINALIS (LINNAEUS, 1758) LIFE CYCLE

Miguel Correia, Jorge Palma, José Pedro Andrade-2008

Aquaculture Research 39(1): 33-40

Abstract:

This investigation examined the effects of live prey availability on growth and survival of *Sepia officinalis*. Two independent experiments, comprising two feed rations each, were performed, using adequate prey size. In the first experiment, cuttlefish hatchlings were fed live mysids, *Paramysis novelli* [(feed ratio I (fr I)], at 15% body weight per day (bw day<sup>-1</sup>) (fr II5) and 30% bw day<sup>-1</sup> (fr I30). In the second experiment, juvenile cuttlefish were fed live Atlantic ditch shrimp, *Palaemonetes varians* (fr II), under the same experimental design. In both experiments, the final mean weight, feeding rate and instantaneous growth rate were higher when animals were fed feed ratio fr II5 and fr II30 (30% bw day<sup>-1</sup>). The results indicate that prey availability influenced weight gain, irrespective of the prey used, during the first 2 months of cuttlefish life cycle. This effect seems to be more noticeable when a certain limit of prey is achieved. For cuttlefish fed fr II, the optimal prey density is thought to be under 2.5 g prey L<sup>-1</sup> (i.e. 14 shrimp L<sup>-1</sup>). Results indicate that cuttlefish can withstand prey densities up to 120 mysids L<sup>-1</sup> for cuttlefish up to 3 weeks old and 19 shrimps L<sup>-1</sup> for cuttlefish up to 6 weeks old.

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#### OVARIAN HISTOLOGY OF STUNTED POND-REARED MACROBRACHIUM ROSENBERGII FEMALES

A. Paulraj, S. Peixoto, C. Vasumathi, K. Altaff-2008

Aquaculture Research 39 (1): 64–69

Abstract:

The present study describes the ovarian histology of stunted freshwater prawn *Macrobrachium rosenbergii*. The ovarian maturation of stunted animals was examined and compared with similar-aged normal females. Ten animals of the stunted group and each maturation stage of the normal group were sampled from the same pond and had their ovaries removed for histological analysis. Body weight, body length, ovarian weight and gonadosomatic index (GSI) were recorded for each female. The diameters of the different oocyte types were compared among groups through histological assessments. The ovarian histology of stunted *M. rosenbergii* females indicated that although the somatic growth is severely affected (7.6 g), some energy has been placed on the vitellogenesis. Stunted females showed the simultaneous occurrence of previtellogenic, vitellogenic and mature oocytes in their ovarian tissue, but overall oocyte diameter and GSI (1.02%) were significantly affected when compared with normal females.

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#### EFFECT OF LARVAL AND PREY DENSITY, PREY DOSE AND LIGHT CONDITIONS ON FIRST FEEDING COMMON DENTEX (*DENTEX DENTEX L.*) LARVAE

Gemma Giménez, Alicia Estévez-2008

Aquaculture Research 39 (1): 77–84

Abstract:

Initial larval stocking density, prey density, daily prey ration and light conditions (light intensity and photoperiod) were tested for common dentex larval rearing under experimental conditions. Experiments continued until the first peak of larval mortality. The best results in larval survival were obtained with an initial stocking density of between 10 and 40 larvae L<sup>-1</sup>, fed with at least 10 rotifers mL<sup>-1</sup>, maintaining ratios of 500–1000 rotifers larva<sup>-1</sup>, with one or two adjustments of prey density per day. The use of more than 2000 rotifers larva<sup>-1</sup> or three daily adjustments of live prey density had negative effects on larval survival. The best

light conditions for common dentex larval rearing were found using a photoperiod of 24 h L:0 h D and an intensity of at least 3.4  $\mu\text{mol m}^{-2} \text{s}^{-1}$ .

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ARTIFICIAL SPAWNING OF AFRICAN CATFISH HETEROBRANCHUS LONGIFILIS: DIFFERENCES BETWEEN THE EFFECTS ON REPRODUCTION IN FEMALES TREATED WITH CARP PITUITARY HOMOGENATE OR OVOPEL

Elżbieta Brzuska, Jerzy Adamek-2008

Aquaculture Research 39(1): 96–102

Abstract:

The effects of the controlled reproduction of African catfish *Heterobranchus longifilis* after ovulation stimulation with carp pituitary homogenate (CPH; 4 mg kg<sup>-1</sup>; group I) or Ovopel (1/5+1 pellet kg<sup>-1</sup>; group II) were investigated. After the application of Ovopel, eggs were obtained from a higher percentage of females than after a CPH treatment (87.5% and 75.0% respectively). The statistically significant ( $P \leq 0.05$ ) effect of ovulation stimulator was specified only in the case of the weight of eggs (expressed in grams and in percentage of female body weight), being higher in fish treated with Ovopel compared with CPH-treated fish (176.02 g, 8.43% and 109.51 g, 5.48%). The quality of eggs expressed in percentage of live embryos after 24 h incubation was higher by 7.5% in fish treated with Ovopel. Latency period did not significantly affect the weight of eggs, fertilization percentage or percentage of living embryos after 24 h of egg incubation. However, the weight of eggs and percentage of living embryos after 24 h incubation were higher in fish spawning after 12 h latency (159.38 g and 85.30%) compared with the weight and quality of eggs obtained from females spawning after 14 h latency (126.15 g and 76.04%).

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SHORT COMMUNICATION

POSITIVE EFFECTS OF EXPOSURE TO INCREASED WATER VELOCITY ON GROWTH OF NEWLY HATCHED ARCTIC CHARR, *SALVELINUS ALPINUS* L.

Thomas Grünbaum, Richard Cloutier, Nathalie R Le François-2008

Aquaculture Research 39 (1): 106–110

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EFFECTS OF WATER TEMPERATURE ON EARLY DEVELOPMENT OF JAPANESE EEL *ANGUILLA JAPONICA*

Akihiro Okamura, Yoshiaki Yamada, Noriyuki Horie, Tomoko Utoh, Naomi Mikawa, Satoru Tanaka, Katsumi Tsukamoto-2007

Fisheries Science 73 (6): 1241–1248

Abstract:

To determine an optimal temperature range for efficient production of healthy eel larvae *Anguilla japonica*, the effect of water temperature on hatching, survival, and deformity rates was examined. The early ontogeny of morphological features in this species by incubating eggs at five different temperatures (19, 22, 25, 28 and 31°C) was examined. Hatching occurred at 24, 28, 46 and 58 h after fertilization when incubated at 28, 25, 22 and 19°C, respectively; no eggs hatched at 31°C. The growth rate of prefeeding larvae increased as water temperature was elevated and acquisition of feeding ability was also accelerated at higher temperature. Significantly high hatching rates (76–86%,  $P < 0.05$ ) and survival rates

(61–86%,  $P < 0.05$ ) were observed at relatively high temperatures (22–28°C). The deformities were ‘open lower jaw’, ‘pericardial edema’, and ‘notochordal bending’, in which the mouth was deformed with a downward projecting lower jaw, the pericardial cavity was swollen, and the notochord was bent or twisted to various degrees, respectively. Open lower jaw and pericardial edema were especially predominant at 19°C, with rates of 68 and 92%, respectively, compared with 31 and 10% at 25 and 28°C, respectively. The occurrence of notochordal bending was not affected by temperature. The optimal temperature for incubation and rearing *A. japonica* eggs and prefeeding larvae is approximately 25–28°C.

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#### SOMATIC GROWTH AND OTOLITH MICROSTRUCTURE OF LARVAL AND JUVENILE PACIFIC COD *GADUS MACROCEPHALUS*

Yoji Narimatsu, Tsutomu Hattori, Yuji Ueda, Hiroshi Matsuzaka, Masaru Shiogaki-2007

Fisheries Science 73 (6): 1257–1264

Abstract:

Microstructures of sagittae and lapilli were examined in relation to somatic growth for reared larvae and juveniles of Pacific cod. The Laird–Gompertz model was fitted to the daily age and somatic growth relationship. Growth increments were deposited on a daily basis in both kinds of otoliths, with a check formed at hatching. Two subsequent checks and an accessory primordia (AP) occurred in the sagittae. The lapillus was adequate for increment width measurement through the early life stages. Sagittal and frontal plane of sagitta was adequate for measurement in the pre-AP and post-AP formation stages, respectively. The shift of desirable plane was caused by changes in otolith and increment shapes with AP formation. Back-calculated total lengths using the biological intercept method did not significantly differ with certain body lengths ( $P > 0.05$ ), suggesting validity of back-calculation in this species. Using the back-calculated total length, morphological and ecologic changes that seemed to affect checks and AP formations are discussed.

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#### REPRODUCTION OF SEA URCHIN *LOXECHINUS ALBUS* IN CHILOÉ ISLAND, CHILE

Sohei Kino, Yukio Agatsuma-2007

Fisheries Science 73 (6): 1265–1273

Abstract:

During 1986–1989, the seasonal maturation and gonad index (gonad weight/body weight  $\times$  100) of adult *Loxechinus albus* were examined at nine sites, and the appearance of four-armed echinopluteus larvae was investigated at three sites off the eastern coast of Chiloé Island, Chile. Spawning occurred during November–January when the gonad indices fell to a minimum, the number of mature specimens decreased and four-armed larvae appeared, corresponding to the rise in water temperature. The number of four-armed larvae appearing at the northern site was markedly less than that at the southern site. The sea urchins matured in January and February immediately after spawning at many sites and a high percentage of maturation lasted for a long period at some sites. These findings are considered to be associated with high food availability and annual narrow ranges of water temperature.

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#### COMPARISON OF OZONE, HYDROGEN PEROXIDE AND REMOVAL OF INFECTED EGGS FOR PREVENTION OF FUNGAL INFECTION IN STURGEON HATCHERY



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Abstract:

The objective of this study was to evaluate the effects of ozone, hydrogen peroxide and removal of infected eggs (five times per day) on prevention of fungal infection on Iranian sturgeon *Acipenser persicus*. The effects of 0.05, 0.1 and 0.15 p.p.m. of ozone, and 500 and 1000 p.p.m. of hydrogen peroxide in two different egg disinfection procedures (with and without removal of infected eggs) were examined on hatching ratio. Egg disinfection by 1000 p.p.m. hydrogen peroxide (with removal of infected eggs) resulted in the greatest hatching ratio (78%) among all treatments. Among ozone treatments, 0.15 p.p.m. (with removal of infected eggs) showed the highest hatching ratio (76.4%). The hatching ratio of the control group (without disinfectant and removal of infected eggs) was 34.4%. Removal of infected eggs increased the hatching ratio by 16.1% compared to treatments without infected egg removal, and there was a significant difference ( $P < 0.01$ ). Ozone is preferred to hydrogen peroxide because a lower concentration of ozone is required to disinfect the culture medium; consequently, environmental pollution will be decreased. A low correlation ( $r = -0.35$ ) was observed between hatchery water temperature and fungal infection percentage in the control.

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