

INFORMATION OF INTEREST

- Aquaculture Planning Workshop “Plan Internacionalizacion de Acuicultura Marina 2006” Madrid, Spain November 28, 2006: [presentations](#)
 - 3rd International Symposium on Stock Enhancement and Sea Ranching, Seattle (WA-USA), Sept 18-21, 2006: Abstracts of [Oral](#) and of [Poster Presentations](#)
 - European Science Foundation – Marine Board. [Position Paper 8. Navigating the Future III. November 2006](#)
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FATTY ACID COMPOSITION OF ARTEMIA (BRANCHIOPODA, ANOSTRACA) CYSTS FROM TROPICAL SALTERNES OF SOUTHERN MEXICO AND CUBA

Rafael Tizol-Correa, Laura Carreón-Palau, Bertha O. Arredondo-Vega, Gopal Murugan, Laura Torrentera, Teresita DNJ Maldonado-Montiel, Alejandro M. Maeda-Martínez-2006

Journal of Crustacean Biology 26(4): 503-509

Abstract:

The growing demands and high costs of commercial Artemia cysts and the establishment of new shrimp hatcheries and farms have caused people to search for local sources of Artemia, putting special attention on their nutritional characteristics. As an essential step to determine the biochemical composition of Artemia, the fatty acid profiles of decapsulated cysts from six tropical salterns of southern Mexico (Campeche (1), Oaxaca (1), and Yucatán (4)), two of Cuba (Camagüey and Guantánamo), and from a temperate site (San Francisco Bay, USA) (SFB) were analysed using direct transesterification and gas chromatography-mass spectrometry. Of 51 fatty acids identified, C16:0 (hexadecanoic), C16:1n5 (hexadecenoic), C18:1n9 (octadecenoic), C18:1n7 (octadecenoic), and C18:2n6 (octadecadienoic) were the major compounds found. The SFB strain from a temperate area showed significant differences from the rest of the samples of tropical origin, having a greater concentration in the fatty acids 18:2n5 (10,13-octadecadienoic), 18:3n3 (octadecatrienoic), and 18:4n3 (6, 9, 12, 15-octadecatetraenoic). The SFB strain showed the lowest proportion of mono-unsaturated fatty acids. Based on the fatty acid composition, the Artemia strains studied can be assessed as “freshwater” type, except for the one from Oaxaca, that had a “marine” type profile characterized by 3% to 4% of the fatty acid C20:5n3 (eicosapentaenoic).

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NON-LETHAL HEAT SHOCK PROTECTS GNOTOBIOTIC ARTEMIA FRANCISCANA LARVAE AGAINST VIRULENT VIBRIOS

Yeong Yik Sung, Els J.M. Van Damme, Patrick Sorgeloos, Peter Bossier-2006

Fish & Shellfish Immunology 22(4): 318-326

Abstract:

Brine shrimp Artemia were exposed under gnotobiotic conditions to a non-lethal heat shock (NLHS) from 28 to 32, 37 and 40 °C. Different recovery periods (2, 6, 12 and 24 h) and different heat-exposure times (15, 30, 45 and 60 min) were tested. After these NLHS, Artemia was subsequently challenged with Vibrio. Challenge tests were performed in stressed and unstressed nauplii at concentrations of 10⁷ cells ml⁻¹ of pathogenic bacteria, Vibrio campbellii and Vibrio proteolyticus. A NLHS with an optimal treatment of 37 °C for 30 min and a subsequent 6 h recovery period resulted in a cross-protection against pathogenic Vibrio. A 100% increase in the larval survival (P < 0.05) was observed. We have also demonstrated by Western blot that a NLHS increases the expression of HSP-70 in heat-shocked (HS) treated animals. This report is the first to reveal a cross protection of a NLHS

against deleterious bacterial challenges in living crustaceans. The putative role of heat shock proteins (HSPs) in this process is discussed.

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THE RECENT SPREAD OF ARTEMIA PARTHENOGENETICA IN WESTERN AUSTRALIA

Kellie McMaster, Alan Savage, Terrie Finston, Michael S. Johnson, Brenton Knott-2007

Hydrobiologia 576: 39-48

Abstract:

In Western Australia, populations of *Artemia parthenogenetica* in coastal salt lakes at Rottnest Island and Lake Hayward, and in salterns at Port Hedland and Shark Bay, are widely accepted to have been introduced by humans. Further, within the past 10 years, populations of *A. parthenogenetica* have been found in inland playa salt lakes in the wheatbelt of south-west Western Australia, where none had been recorded in previous salt lake studies. Here we hypothesise that birds act as transport vectors for *Artemia* cysts both within Australia and between the Asian and Australian continents. Allozyme analysis was used to identify clonal types (multi-locus genotypes), clonal frequencies, genotypic diversities and genotypic identity of six populations (three coastal, three inland).

Overall, the inland populations displayed almost identical genotypic structure to the coastal population from Lake Hayward, indicating that Lake Hayward could be the major source for dispersal and colonisation of inland populations. Results support the hypothesis of dispersal inland by nomadic bird species. Furthermore, evidence suggests that the inland and Lake Hayward populations may be an example of a metapopulation.

The greater variety of genotypes present in the Rottnest population indicates that this population has received a large number of small immigrations, or that it received one large introduction. The former may indicate a long period of suitable salinities, providing a greater time-span over which migration and succession of clonal types could occur in comparison to other populations. While we cannot rule out the possibility of human introduction of *A. parthenogenetica* to Rottnest, the hypothesis of cyst dispersal along the Austral-Asian flyway remains possible.

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SALINITY OF WATER AS A FACTOR TO DETERMINE THE DEVELOPMENT OF THE BRINE SHRIMP ARTEMIA POPULATIONS IN SIBERIAN LAKES

L. I. Litvinenko, A. V. Kozlov, A. I. Kovalenko, D. S. Bauer-2007

Hydrobiologia 576: 95-101

Abstract:

The influence of salinity on 27 *Artemia parthenogenetica* populations in Siberia was investigated. Salinity in the lakes sampled ranged from 50 g l⁻¹ to 265 g l⁻¹. *Artemia* were characterized on the basis of biomass, number of cysts, weight and the length of females, number of cysts in brood and several biometric parameters. Average values of shrimp biomass, number of planktonic and benthic cysts and number of cysts in broods were largest in locales with salinity 77–144 g l⁻¹. Increased salinity reduced the number of setae on the furcal branch and the length of the cephalothorax.

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HORMONALLY INDUCED SPAWNING, EMBRYONIC DEVELOPMENT, AND LARVAL REARING OF THE SOUTHERN TEMPERATE BANDED MORWONG, CHEILODOCTYLUS SPECTABILIS

Arthur J. Ritar, Tyas A. Pribadi-2006

Journal of the World Aquaculture Society 37(4): 397-406

Abstract:

Banded morwong (*Cheilodactylus spectabilis*) are of interest for marine finfish aquaculture in temperate southern Australia. To improve their ovulatory response, adult females were implanted during the autumn spawning season with slow-release pellets containing 0–400 µg luteinizing-hormone-releasing hormone analogue (LHRHa)/kg body weight within 24 h of capture from the wild. Compared to the sham control group, animals treated with LHRHa produced significantly more eggs on each day after implantation for the following 7 d (91 ± 39 and 290 ± 38 mL) and a higher proportion ovulated (8/12 and 27/27). Of fish treated with LHRHa, 93% ovulated 2 d after implantation and 79% ovulated three times at 2-d intervals, whereas control animals showed no cyclicity of ovulation and few ovulated more than once. Egg production was highest at the first ovulation after LHRHa treatment and declined at subsequent ovulations. In a second experiment investigating the range 100–400 µg LHRHa, there was no effect of dose rate on ovulation parameters, which additionally examined implantation either immediately after capture or after a 5-d delay. Compared to immediate implantation, a delay resulted in a lower proportion of animals that could be stripped after implantation (100 and 50%, respectively) and the volume of eggs was lower (135 ± 15 and 107 ± 10 mL). The egg quality was poor following delayed implantation, resulting in no fertilization after artificial insemination compared with immediate implantation in which fertilization and hatch rates were higher for eggs collected on Day 2 after implantation ($79 \pm 8\%$ and $58 \pm 9\%$) than on Day 4 ($23 \pm 7\%$ and $15 \pm 6\%$). Thus, it is important to implant animals as soon as possible after capture to ensure optimum egg quality. Good-quality eggs were buoyant and spherical and had a diameter of 1050 ± 25 µm with a single pigmented oil droplet of 190 ± 9 µm. When a separate large batch of eggs collected 2 d after implantation with 100 µg LHRHa was inseminated and cultured at 18 C, larvae hatched after 63 ± 2 h at a standard length of 2.6 ± 0.4 mm. Newly hatched larvae were buoyant and transparent with only a few melanophores, eyes were nonpigmented and jaws were nonfunctional. By the fourth day, jaws were functional and eyes were fully pigmented. Utilization of the endogenous yolk and oil was completed by Day 6, and swimming commenced with exogenous feeding. Larvae, initially fed lipid-enriched rotifers followed by *Artemia*, reached 8.9 ± 0.7 mm length on Day 55, after which they metamorphosed to the postlarval paperfish stage of development, 22 ± 0.9 mm on Day 100, and 43 ± 1.0 mm at 6 mo of age. The results show that treatment of wild-caught females with slow-release pellets containing LHRHa is effective for the production of eggs for hatchery rearing.

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COMBINED EFFECTS OF TURBULENCE AND SALINITY ON GROWTH, SURVIVAL, AND WHOLE-BODY OSMOLALITY OF LARVAL SOUTHERN FLOUNDER

Adam Mangino Jr, Wade O. Watanabe-2006

Journal of the World Aquaculture Society 37 (4): 407–420

Abstract:

The southern flounder (*Paralichthys lethostigma*) is a commercially important marine flatfish from the southeastern Atlantic and Gulf Coasts of the USA and an attractive candidate for aquaculture. Hatchery methods are relatively well developed for southern flounder; however, knowledge of the optimum environmental conditions for culturing the larval stages is needed to make these technologies more cost effective. The objectives of this study were to determine the effects of water turbulence (as controlled by varying rates of diffused aeration) on growth, survival, and whole-body osmolality of larval southern flounder from hatching through day 16 posthatching (d16ph). Embryos were stocked into black 15-L cylindrical tanks under four turbulence levels (20, 90, 170, and 250 mL/min of diffused aeration) and two salinities (24 and 35 ppt) in a 4×2 factorial design. Larvae were provided with enriched s-type rotifers from d2ph at a density of 10 individuals/mL. Temperature was 19 C, light intensity was 390 lx, and photoperiod was 18 L:6 D. Significant ($P < 0.05$) effects of turbulence on growth (notochord length [NL], wet weight, and dry weight) were observed. On d16ph, NL (µm) increased with decreasing turbulence level and was significantly greater at 20 mL/min (64.2) and 90 mL/min (58.2) than at 170 mL/min (56.3) and 250 mL/min (57.2). Survival declined primarily during the prefeeding and first-feeding stages from d0 to d8ph, then stabilized from d8 to d16ph. In

contrast to growth trends, survival (%) on d16ph increased with increasing turbulence levels and was significantly greater at 170 mL/min (57.9) and 250 mL/min (54.0) than at 20 and 90 mL/min (21.4 and 26.2, respectively). Mean rotifer concentrations (individuals/mL) at 24 h postfeeding were significantly higher ($P < 0.05$) in the low-turbulence treatments of 20 mL/min (4.48) and 90 mL/min (4.23) than in the high-turbulence treatments of 170 and 250 mL/min (2.28 and 2.45, respectively). Under both salinities, larval whole-body osmolality (mOsm/kg) increased with increasing turbulence levels and was significantly higher at 250 mL/min (427) than at 20 mL/min (381), indicating osmoregulatory stress at the higher turbulence levels. On d14ph, larvae in all treatments were positively buoyant in 35 ppt and negatively buoyant in 24 ppt. Results showed that growth of southern flounder larvae in 15-L tanks was maximized under low turbulence levels of 20 and 90 mL/min, while survival was maximized at high turbulence levels of 170 and 250 mL/min. The data suggested that, in prefeeding- and early-feeding-stage larvae (which have weak swimming ability), higher turbulence levels improved buoyancy and prevented sinking. In feeding-stage larvae (which are relatively strong swimmers), higher turbulence levels caused excessive swimming, osmoregulatory stress, and slower growth. Based on these results, we recommend that turbulence levels be maintained relatively high during prefeeding (yolk sac) and first-feeding stages to maintain buoyancy and survival and then decreased for mid- to late-feeding- and premetamorphic stage larvae to optimize prey encounters and feeding efficiency.

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THE EFFECTS OF SUPPLEMENTAL DIETARY CHOLESTEROL ON GROWTH, DEVELOPMENT AND SURVIVAL OF MUD CRAB, SCYLLA SERRATA, MEGALOPA FED SEMI-PURIFIED DIETS

May-Helen Holme, Chaoshu Zeng, Paul C. Southgate-2006

Aquaculture 261(4): 1328-1334

Abstract:

The effects of varying levels of dietary cholesterol on growth, development time and survival of mud crab, *Scylla serrata* megalopa were investigated using semi-purified microbound diets (MBD). Five iso-energetic diets containing different level of cholesterol ranging from 0.14% to 1% of dry weight of the diet were tested. Fifteen megalopa were reared individually for each dietary treatment, and development time and survival were recorded on a daily basis. More than 25% of megalopa from all treatments were able to metamorphose into the first crab stage, suggesting that the endogenous level of cholesterol in the basal diet (0.14%) was sufficient to support development of the megalopa stage of this species. Widest mean carapace width (3.53 ± 0.08 mm) and highest mean dry weight (2.11 ± 0.22 mg) were recorded for juveniles that molted from megalopa fed live *Artemia*, whereas no megalopa in the unfed control treatment metamorphosed into crabs. The average development time from megalopa to the juvenile crab stage varied between the treatments, where megalopa fed live *Artemia* or MBD containing 0.2%, 0.4% or 0.8% total cholesterol showed the most synchronized molting (between 8.0 and 9.9 days). Longest development time was recorded for the megalopa fed diets containing 0.14% or 1% total cholesterol (both 11 days). Highest survival (74.3%) was recorded for the megalopa fed a diet containing 0.8% cholesterol. The results of this study are valuable in research to develop formulated diets for mud crab larvae as a replacement for live food in hatchery culture.

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SUCCESSFUL CULTURE OF LARVAE OF LITOPENAEUS VANNAMEI FED A MICROBOUND FORMULATED DIET EXCLUSIVELY FROM EITHER STAGE PZ2 OR M1 TO PL1

Louis R. D'Abramo, Elifonso Isiordia Perez, Ravi Sangha, Ana Puello-Cruz-2006

Aquaculture 261(4): 1356-1362

Abstract:

In three separate experiments, harpacticoid copepods *Tisbe monozota* (alive and dead) and a microparticulate microbound diet were evaluated as alternatives to live *Artemia nauplii* as food, beginning at either stage PZ2 or M1, in the larval culture of *Litopenaeus vannamei*. Larvae were cultured in 2 L round bottom flasks at a density of 150 L⁻¹ (Experiment 1) and 100 L⁻¹ (Sections 3.2 and 3.3) at 28 °C, 35‰ salinity and 12:12 LD photoperiod, and fed 4×/day⁻¹. Larvae were initially fed a mixture of phytoplankton to stages PZ2 or M1 and then fed either live *Artemia*, live or dead copepods, or a microparticulate microbound diet. The experiments were terminated and all larvae were harvested when more than 80% of larvae had molted to postlarvae 1 (PL1) within any flask representing any of the treatments. The comparative value of the different diets and feeding regimes was determined by mean survival, mean dry weight and total length of individual larva, and percentage of surviving larvae that were PL1. Trypsin activity of samples of larvae from each treatment was also determined. The microparticulate microbound diet effectively served as a complete substitute for *Artemia nauplii* when fed beginning at stage M1. When fed at the beginning of the PZ2 stage, survival was comparable to that of larvae fed *Artemia*, but mean dry weight, mean total length, and percent of surviving larvae that were PL1 generally were significantly less. Responses to the feeding of copepods, whether fed dead or live, as a substitute were generally significantly less than those of larvae fed either the *Artemia nauplii* or the microparticulate diet. Values of trypsin activity (10– 5 IU/μg⁻¹ dry weight) corresponded to the relative proportions of the different larval stages within a treatment, with higher activity being characteristic of early stages. Previously demonstrated successful results with another species of crustacean suggest that the microparticulate microbound diet has characteristics that should be effective in the culture of the carnivorous stages of other crustacean and fish larvae that are currently fed live *Artemia nauplii*.

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EFFECTS OF Na⁺/K⁺ AND Mg²⁺/Ca²⁺ RATIOS IN SALINE GROUNDWATERS ON Na⁺-K⁺-ATPASE ACTIVITY, SURVIVAL AND GROWTH OF MARSUPENAEUS JAPONICUS POSTLARVAE

Lu-Qing Pan, Zhi-Hua Luan, Cai-Xia Jin-2007

Aquaculture 261(4): 1396-1402

Abstract:

The effects of the Na⁺/K⁺ and Mg²⁺/Ca²⁺ ratios in saline groundwaters on Na⁺-K⁺-ATPase activity, survival and growth of *Marsupenaeus japonicus* postlarvae were investigated. The results indicate that the Na⁺-K⁺-ATPase activity, survival rate and weight gain of postlarvae were significantly affected by the Na⁺/K⁺ and Mg²⁺/Ca²⁺ ratios (P < 0.05). The Na⁺-K⁺-ATPase activity of postlarvae, in every treatment, changed corresponding to Na⁺/K⁺ and Mg²⁺/Ca²⁺ ratios, and came to a stable level after 24 h. There was a negative relation between Na⁺-K⁺-ATPase activity and Na⁺/K⁺ ratio, while there was a positive relation between Na⁺-K⁺-ATPase activity and Mg²⁺/Ca²⁺ ratio. Compared with seawater (the Na⁺/K⁺ and Mg²⁺/Ca²⁺ ratios are 27.8 and 4.64 respectively), the Na⁺-K⁺-ATPase activity of the Na⁺/K⁺ ratio 30 treatment showed no significant difference, while the Mg²⁺/Ca²⁺ ratio 4.5 treatment showed distinct difference. The survival rates and weight gain of postlarvae increased markedly when the suitable amount of K⁺ and Ca²⁺ was added to test water, and arrived at their maximum in the Na⁺/K⁺ ratio 20–30 or Mg²⁺/Ca²⁺ ratio 4.5 treatment, having no significant difference compared with normal seawater. Therefore, considering the Na⁺/K⁺, Mg²⁺/Ca²⁺ ratios and the absolute concentration of Mg²⁺, Ca²⁺ in the experimental saline groundwaters applied to *Marsupenaeus japonicus* farming, it should be modulated to around 30, 4.5 and 1312 mg/l, 291 mg/l, respectively.

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DEVELOPMENTAL REGULATION OF GASTRIC PEPSIN AND PANCREATIC SERINE
PROTEASE IN LARVAE OF THE EURYHALINE TELEOST, OREOCHROMIS MOSSAMBICUS

Ming-Ji Lo, Ching-Feng Weng-2006

Aquaculture 261(4): 1403-1412

Abstract:

Most recent research on teleost digestive enzymes has focused on the immunohistochemistry of flounder and catfish, fewer studies have been done of gene expression. The present study is made an attempt to clarify the expression of digestive enzymes in tilapia (*Oreochromis mossambicus*) during larval development. This work was done by cloning the digestive enzymes, semi-quantifying the expression of genes by RT-PCR-Southern blot, detecting the expression of proteins (western blot) and investigating enzymatic activity. Under microscopic observation, the mouths of tilapia larvae were seen to open on the third day after hatching and on the fifth day after hatching, the actinotrichia were reabsorbed and the larvae began feeding. The partial nucleotide sequences of pepsinogen, trypsinogen and chymotrypsinogen were obtained. After RT-PCR and southern blotting analysis, the expressing pattern of pepsinogen mRNA appeared on day 2 after hatching, while mRNAs of trypsinogen and chymotrypsinogen were both detected 1 day after hatching. The proteins of larval pepsin, trypsin and chymotrypsin appeared 1 day after hatching, and specific activities of these enzymes were detectable on day 3 (for pepsin) and day 5 (for trypsin and chymotrypsin) after hatching. The transcription of the genes for these three digestive enzymes gradually increased after hatching and that all protein detected on day 1, suggesting that all proteins may result from maternal sources.

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SUSPENSION OF ANNUAL GAMETOGENESIS IN NORTH AMERICAN GREEN SEA
URCHINS (*STRONGYLOCENTROTUS DROEBACHIENSIS*) EXPERIENCING INVARIANT
PHOTOPERIOD—APPLICATIONS FOR LAND-BASED AQUACULTURE

S. Anne Böttger, Michael G. Devin, Charles W. Walker-2006

Aquaculture 261(4): 1422-1431

Abstract:

Sea urchin fisheries are valuable commercial resources in the United States with processed gonads sold in Japanese and American markets and maximum US sales of \$150M US dollars in 1996. Wild populations of sea urchins on all coasts of the US have been dramatically over-fished. Aquaculture of sea urchins in land-based facilities can help restore commercial populations and preserve this ecologically important herbivore. In this study, we used invariant summer photoperiod to prevent gametogenesis in the North American green sea urchin (*Strongylocentrotus droebachiensis*) maintained in a land-based aquaculture system and provided a commercially available formulated feed that promotes maximum growth of intra-gonadal somatic nutrient storage cells called nutritive phagocytes. Results were compared with individuals fed the same formulated feed under ambient photoperiod in cages in the ocean. Monthly samples of gonads from both treatments were evaluated for gonad index, volume fractions of cellular constituents of the germinal epithelium, oocyte diameters and taste. Over the 5 months of this study, gonad indices increased significantly ($p < 0.001$) in both treatments from $4.8\% \pm 0.9$ (all values \pm SE) initially to $20.5\% \pm 2.1$ under invariant and $23.2\% \pm 1.4$ under ambient photoperiod with no significant difference between treatments ($p = 0.55$). Volume fractions of nutritive phagocytes increased to $80.3\% \pm 5.9$ (initial $37.9\% \pm 7.1$) in males and $71.0\% \pm 6.7$ (initial $10.3\% \pm 4.0$) in females ($p < 0.001$) only under invariant photoperiod. Nutritive phagocyte lengths increased under both photoperiod treatments, but the volume fraction containing nutrients was higher under invariant photoperiod. Volume fractions of gonial/gametogenic cells increased significantly ($p < 0.001$) only under ambient photoperiod from $20.4\% \pm 5.5$ to $37.8\% \pm 1.8$ in males and 0% to $22.6\% \pm 3.6$ in females. The volume fraction of residual oocytes from last year's oogenesis increased under invariant photoperiod while that of both residual and new oocytes increased under ambient photoperiod. Residual oocyte diameters increased from $56.2 \mu\text{m} \pm 2.2$ initially to $93.5 \mu\text{m} \pm 3.7$ under invariant and those of residual and new oocytes to $126.0 \mu\text{m} \pm 7.3$ under ambient photoperiod. Invariant photoperiod yields gonads in both sexes of *S. droebachiensis* that do not initiate fall gametogenesis but attain large size as their nutritive phagocytes grow

substantially in size. A Canadian study of wild-collected *S. droebachiensis* indicated that gonads taste best when they contain pre-dominantly nutritive phagocytes and not copious gametes, however gonad taste in our study was unsatisfactory suggesting that the only commercially available sea urchin diet requires modification to support commercial development of land-based aquaculture.

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EARLY DEVELOPMENT OF THE SHORTFIN SILVERSIDE *CHIROSTOMA HUMBOLDTIANUM* (VALENCIENNES, 1835) (ATHERINIFORMES: ATHERINOPSIDAE)

Ma. Cecilia Hernández-Rubio, Gerardo Figueroa-Lucero, Irene de los A. Barriga-Sosa, José Luis Arredondo-Figueroa, Thalía Castro-Barrera-2006

Aquaculture 261(4): 1440-1446

Abstract:

The shortfin silverside *Chirostoma humboldtianum* has been considered for culture in Mexico, but success has been limited by a poor knowledge of its early development. First synthesis of the early development of the shortfin silverside is presented to determine conditions suitable for rearing. Brooder maturation was induced through photothermal cycles. *C. humboldtianum* ova were fertilized in vitro. The eggs were incubated in reconstituted water (160–180 mg/L CaCO₃) at 18 °C and 5 gm of NaCl per litre. During the hatching day, 300 shortfin silversides were stocked and followed up until metamorphosis in order to establish the timing of exogenous feeding, changes in food type, growth and development during critical periods for survival, according to the theory of saltatory ontogeny. Free embryos hatched 12 days after fertilization at 18 °C. First critical point for survival is the beginning of exogenous feeding. Free embryos started mixed feeding on day four of post-hatching (dph), point of no-return was presented towards the end of mixed feeding on 6 dph, larval period began at six (dph) when the anus is opened, and metamorphosis to juvenile was presented at 65 dph with a SL of 19.34 ± 2.28 mm, when scales and fins were well developed. Differences in growth between periods were detected: free embryos growth slower than larvae but mouth size depicted a larger growth rate in the former. Cephalic length and mouth size were negatively related to standard length in embryos and larvae. Mouth size was positively related to cephalic length in free embryos but negative in larvae. Results suggest that during the free embryo phase, growth priorities are directed to the development of apparatuses and systems; whereas, during the larval period, energy is directed to growth in length, mouth size and development of fins, which allows them to increase their swimming velocity, grants them a greater capacity to obtain exogenous food and, in consequence, increases fitness for survival.

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SEROTONIN STIMULATES OVARIAN MATURATION AND SPAWNING IN THE BLACK TIGER SHRIMP *PENAEUS MONODON*

Kanokpan Wongprasert, Somluk Asuvapongpatan, Pisit Poltana, Montip Tiensuwan, Boonsirm Withyachumnarnkul-2006

Aquaculture 261(4): 1447-1454

Abstract:

Serotonin (5-hydroxytryptamine, 5HT) has been reported to induce ovarian maturation and spawning in the crayfish *Procambarus clarkii* and white Pacific shrimp *Litopenaeus vannamei*. The aim of this study was to explore the role of exogenous 5HT on the reproductive performance of the black tiger shrimp *Penaeus monodon*. 5HT solution was injected into domesticated *P. monodon* broodstock at 50 µg/g body weight and ovarian maturation and spawning were recorded. The presence of 5HT in the ovary and oviduct of *P. monodon* was also studied by immunohistochemistry and its levels in the

ovary by enzyme link immunoabsorbance assay (ELISA). The 5HT-injected *P. monodon* developed ovarian maturation and spawning rate at the level comparable to that of unilateral eyestalk-ablated shrimp. Hatching rate and the amount of nauplii produced per spawner were also significantly higher in the 5HT-injected shrimp, compared to the eyestalk-ablated shrimp. 5HT-positive reactions were found in the follicular cells of pre-vitellogenic oocytes, in the cytoplasm of early vitellogenic oocytes and on the cell membrane and cytoplasm of late vitellogenic oocytes. 5HT in the ovary was present at 3.53 ± 0.26 ng/mg protein level in previtellogenic stage and increased to 17.03 ± 0.57 ng/mg protein level in the mature stage of the ovary. The results suggest a significant role of 5HT, possibly directly on the ovary and oviduct, on the reproductive function of female *P. monodon*.

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EFFECT OF MICROENCAPSULATED DIETS SUPPLEMENTED WITH GENETICALLY MODIFIED BACTERIA ON THE GROWTH AND SURVIVAL OF *FENNEROPENAEUS INDICUS* POSTLARVAE

S. Sirvas-Cornejo, J.W. Latchford, D.A. Jones-2007

Aquaculture Nutrition 13(1): 10-16

Abstract :

Microencapsulated diets were prepared and supplemented with two genetically modified bacteria that produced digestive enzymes. One produced a protease (strain *Escherichia coli* XL1Bluep635), and the other a lipase and a protease (strain *E. coli* XL1Bluep7). *Fenneropenaeus indicus* at the postlarval 1 stage (PL1) were fed these diets for 16 days, and their total length and survival were recorded every 2 days. The results were analyzed by anova and sequential Turkey-Kramer analysis. Shrimp fed on the diet supplemented with strain *E. coli* XL1Bluep635 (diet 635) exhibited the fastest growth rate of 0.26 mm day⁻¹, followed by shrimp fed on the control commercial unsupplemented diet CD2 – 0.21 mm day⁻¹, and shrimp fed on diet supplemented with strain *E. coli* XL1Bluep7 (diet 7) – 0.20 mm day⁻¹. The growth rates of shrimp fed on diet supplemented with control strain *E. coli* XL1BluepUC19 (diet XL1), and those fed on unsupplemented diet prepared in our laboratory (D2), were 0.15 and 0.14 mm day⁻¹, respectively. The survival of shrimp fed on diets CD2 and 635 showed the same level of survival of 83.3%, followed by those fed on diet D2.

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EFFECT OF TWO CHOLINE SOURCES ON THE PERFORMANCE OF POSTLARVAL *MARSUPENAEUS JAPONICUS* BATE

F.R. Michael, S. Teshima, S. Koshio, M. Ishikawa, O. Uyan, T. Ren-2007

Aquaculture Nutrition 13(1): 59-

Abstract :

The present study was conducted to clarify the effect and the interaction between two choline sources [choline chloride (CC) and soybean phosphatidylcholine (SPC)] on the performances of postlarval shrimp, *Marsupenaeus japonicus*. A 30-day feeding experiment was conducted as a 2 × 2 factorial design. The postlarval shrimp were fed with four κ-carrageenan micro-bound diets that contained two levels of CC (0.6 and 1.2 g kg⁻¹) and two levels of SPC (20 and 40 g kg⁻¹). A significant (P < 0.05) interaction was also detected between both choline sources in terms of the weight gain, apparent feed efficiency ratio, apparent protein efficiency ratio and total lipid, free choline and phosphatidylcholine contents of the shrimp whole body except for survival, moisture, and protein contents of the whole body. At the lower dietary SPC (20 g kg⁻¹) level, increasing of CC level from 0.6 to 1.2 g kg⁻¹ significantly enhanced the above parameters, whereas such positive effect of dietary CC was diminished at the higher dietary SPC (40 g kg⁻¹) level. Standing on the different viewpoint, the effect of supplemental SPC was also affected with the dietary levels of CC.

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PIGMENTATION AND EYE MIGRATION IN ATLANTIC HALIBUT (*HIPPOGLOSSUS HIPPOGLOSSUS* L.) LARVAE: NEW FINDINGS AND HYPOTHESES

K. Hamre, E. Holen, M. Moren-2007

Aquaculture Nutrition 13(1): 65-80

Abstract:

Atlantic halibut juveniles, which have been fed *Artemia* during larval development, frequently demonstrate malpigmentation and impaired eye migration. This is in contrast to the high percentage of normally developed larvae fed copepods, reared under similar conditions. Nutrition is therefore an important component influencing larval development. Analyses of the nutrient composition of *Artemia* and copepods show that Atlantic halibut larvae fed *Artemia* probably receive sufficient amounts of vitamin A by converting canthaxanthin, while iodine may be deficient, possibly leading to interrupted thyroid hormone synthesis. An unbalanced fatty acid composition, such as high levels of arachidonic acid and low levels of docosahexaenoic acid, can be another limiting factor in *Artemia*. Vitamin A, fatty acids and thyroid hormones have all been shown to affect pigmentation in flatfish. They are ligands to nuclear receptors, thyroid hormone receptors, retinoic acid receptors, retinoic X receptors and peroxisomal proliferator-activated receptors, which are members of the superfamily of steroid hormone receptors. The receptors interact with each other to promote gene expression that modulates proliferation and differentiation of cells. Our hypothesis is that these interactions are important for development during flatfish metamorphosis. Very little data exist on the topic of impaired eye migration. However, energy limitation, iodine deficiency and an unbalanced fatty acid composition have been proposed as possible explanations. Here, we review the literature on development of pigment cells and the possible mechanisms behind the effects of vitamin A, fatty acids and thyroid hormone on pigmentation and eye migration during development of Atlantic halibut larvae.

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THE NUTRITIONAL IMPORTANCE OF POLYUNSATURATED FATTY ACIDS AND THEIR USE AS TROPHIC MARKERS FOR HERBIVOROUS ZOOPLANKTON: DOES IT CONTRADICT?

Müller-Navarra, Dörthe C.-2006

Archiv für Hydrobiologie, 167(1-4): 501-513

Abstract:

Fatty acids of field caught *Daphnia* spp. (Phyllopoda) and *Eudiaptomus* spp. (Copepoda) representing a non-selective and a selective grazer were analyzed and compared to the respective fatty acids of their potential food, i.e. seston <30 µm. In addition, values in daphniids from the field were compared to *D. galeata* fed cultured algae (*Scenedesmus obliquus*, *Cryptomonas erosa*, *Nitzschia palea*). In *Daphnia* spp. from the field their EPA content varied least among all ω3-polyunsaturated fatty acids (ω3-PUFA) and less than in their food. Hence, it can be considered to be more homeostatic than in the food. This becomes especially evident when comparing fatty acid profiles of *D. galeata* feeding on the cultured algae which had very different fatty acid compositions. However, the variation in daphniids' EPA and ω3-PUFA content is much greater than what is observed for phosphorus (P) content in daphniids, owing the fact that PUFA and P are under different physiological constraints. Although the fatty acid pattern of *D. galeata* was greatly influenced when feeding on the algal cultures in the laboratory, no significant correlations were found between seston and *Daphnia* spp. and *Eudiaptomus* spp. for most PUFA and fatty acid ratios used as trophic markers. Thus, different to the laboratory situation when food was superfluous, a more homeostatic ω3-PUFA profile occurred under limiting conditions in the field.

MORPHOLOGICAL AND MOLECULAR DATA REVEAL THE PRESENCE OF THE INVASIVE ARTEMIA FRANCISCANA IN MARGHERITA DI SAVOIA SALTERNS (ITALY)

Graziella Mura, Ilias Kappas, Athanasios D. Baxevanis, Salvatore Moscatello, Quirico D'Amico, German M. Lopez, Francisco Hontoria, Francisco Amat, Theodore J. Abatzopoulos-2006

International Review of Hydrobiology 91(6): 539 – 554

Abstract:

Introduced populations of the American invasive *Artemia franciscana* have been reported in Mediterranean countries except for Italy. A recent sampling at Margherita di Savoia revealed the presence of mating pairs in a saltwork known to host only parthenogens. An integrated approach, based on scanning electron microscopy of four morphological traits, discriminant analysis of 13 morphometric characters and 16S rRNA PCR-RFLP profiles of eight endonucleases was implemented for the identification of the invader. Patterns of variability in all assayed markers provided congruent and solid evidence that the allochthonous species is *A. franciscana*. Native parthenogens are still predominant (98.4%) in this Italian site but they can be rapidly outcompeted by *A. franciscana*, as it occurred in similar cases throughout Europe and elsewhere.

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LOSS OF GENETIC VARIATION IN HATCHERY-REARED INDIAN MAJOR CARP, CATLA CATLA

M. M. Hansen, V. Simonsen, K.-L. D. Mensberg, Md. R. I. Sarder, Md. S. Alam-2006

Journal of Fish Biology 69: 229-241

Abstract:

The hypothesis that effective population sizes are low in hatchery-reared catla (*Catla catla*) from Bangladesh, possibly leading to inbreeding and loss of variation, was tested. The study was based on analysis of seven microsatellite loci in three samples of hatchery-reared catla and four samples representing wild populations. Pair-wise estimates of genetic differentiation between samples were low between wild samples (θ ranging from 0.012 to 0.034), but high between hatchery samples (θ ranging from 0.153 to 0.185), suggesting strong genetic drift in hatcheries. Genetic variation, both in terms of expected heterozygosity and allelic richness, was significantly lower in hatchery samples than in samples of wild catla. Application of a method for reconstructing families among offspring without parental genetic data showed that the hatchery samples consisted of very few half- and full-sib families, whereas the wild samples consisted of a high number of families, suggesting that most individuals were unrelated. Finally, estimation of the effective number of parents (N_b) in the largest sample of hatchery fish confirmed that effective population size was low ($N_b = 14.9$ for multiallelic loci and $N_b = 10.6$ if alleles were pooled into two composite alleles). The results show that low effective population sizes leading to loss of variation and possibly inbreeding depression should be a matter of serious concern in aquaculture production of catla.

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THE INFLUENCE OF TEMPERATURE DURING EARLY LIFE ON PHENOTYPIC EXPRESSION AT LATER ONTOGENETIC STAGES IN SEA BASS

E. Georgakopoulou, D. G. Sfakianakis, S. Kouttouki, P. Divanach, M. Kentouri, G. Koumoundouros-2007

Journal of Fish Biology 70(1): 278-291

Abstract:

To exam whether the temperature experienced by fishes at early developmental stages can influence their phenotype at subsequent stages, the model species used, European sea bass *Dicentrarchus labrax* was subjected to water temperatures of 15 or 20° C during the half-epiboly stage until the metamorphosis. Meristic and morphometric characters at three different stages, well after the end of the thermal treatments, were explored. Body shape and most of the meristic characters were

significantly affected by the environmental temperature during their early life stages. Fish body shape at 15° C tended to be more slender than at 20° C. The dorsal spines and soft rays, the pectoral lepidotrichia and caudal dermatotrichia were significantly affected. Phenotypic differences due to the two thermal regimes are discussed in terms of their functional meaning during the transition from the planktonic to the littoral niche.

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HOW DOES SALINITY TOLERANCE INFLUENCE THE DISTRIBUTIONS OF BRACHIONUS PLICATILIS SIBLING SPECIES?

C. D. Lowe, S. J. Kemp, C. Díaz-Avalos, D. J. S. Montagnes-2007

Journal Marine Biology 150(3): 377-386

Research Article

Abstract:

Environmental salinity is important in defining *Brachionus plicatilis* sibling species distributions. However, while salinity influences distributions, sibling species often co-exist. Three different mechanisms potentially account for the partial co-occurrence of sibling species: (1) siblings have differing salinity tolerances that partially overlap; (2) siblings physiological tolerances may be commonly broad, but relatively small differences in tolerances differentiate distributions via interactions e.g. competition; or (3) siblings distributions may be influenced by physical factors other than salinity. Here, we assess the extent of salinity tolerance in three *B. plicatilis* sibling species (*B. plicatilis* 6TUR, *B. plicatilis* IOM and *B. rotundiformis* 6TOS) by measuring population growth rate (μ , day⁻¹) and egg development time in response to salinity (5–60‰) and salinity fluctuations ($\leq \Delta 40\%$). Sibling species were identified by analysis of the mitochondrial COI gene, and salinity responses were compared by regression analysis. Responses differed significantly between siblings, although the broad trends were similar. Positive growth occurred at all salinities, and highest growth rates ranged between 0.93 and 1.08 day⁻¹ at 16–18‰. Rapid changes in salinity reduced growth rates, but net mortality occurred only in one treatment (100% mortality on transfer from 10 to 40‰). Egg development time was largely invariant with salinity except for *B. plicatilis* IOM and where rotifers were transferred from 30 to 60‰. We indicate that several siblings are similarly euryhaline and tolerate salinity fluctuations. Undoubtedly, wide tolerances in *B. plicatilis* are adaptations to ephemeral and seasonally variable habitats. Given common broad salinity tolerances, it is unlikely that the differential distributions of sibling species are a direct result of physiological constraints. Instead, we illustrate using a simple model that subtle differences in physiological tolerances may have important impacts on interactions between sibling species, which may in turn influence distributions.

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LARVAL SETTLEMENT AND METAMORPHOSIS OF THE MUSSEL MYTILUS GALLOPROVINCIALIS IN RESPONSE TO BIOFILMS

Wei-Yang Bao, Cyril Glenn Satuito, Jin-Long Yang, Hitoshi Kitamura-2007

Journal Marine Biology 150(4): 565-574

Abstract:

Biofilms were allowed to develop on glass slips immersed 1.0–1.5 m below the sea surface in Tachibana Bay, Nagasaki, Japan, for different periods of time from November 2003 to January 2005. The effects of age, immersion month, dry weight, bacterial and diatom densities of these biofilms on the settlement and metamorphosis of pediveliger larvae of the mussel *Mytilus galloprovincialis* were investigated in the laboratory. Furthermore, biofilms were subjected to various treatments to investigate the nature of the settlement and metamorphosis cue in the biofilm. Pediveliger larvae of the mussel settled and metamorphosed in response to biofilms. Settlement and metamorphosis to the post-larval stage significantly increased with the biofilm age. In addition, the biofilm activity varied

depending on the immersion month (season), e.g., for biofilms with the same age, those immersed between June and August had higher activities than those immersed between November and March. The activity of the biofilm also positively correlated with the dry weight, bacterial and diatom densities. These three quantitative parameters of the biofilm were significantly affected by the film age but were not affected by the immersion month, suggesting that other parameters (e.g., community structures, extracellular products) also affected the inductive activity of the biofilm. The fixative agents (formalin and glutaraldehyde), heat, ethanol, ultraviolet irradiation and antibiotics treatments of the biofilm resulted in significant reduction or loss of its inductive activity. The survival of bacterial cells in the treated films where activities were either reduced or lost also decreased significantly. No settlement and metamorphosis were obtained when larvae were exposed to the conditioned water of the biofilm. Thus, larvae of *M. galloprovincialis* settled and metamorphosed in response to a cue produced by living bacteria in the biofilm. The cue may be a bacterial extracellular product which was susceptible to the above treatments.

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STOCKING EFFECTIVENESS OF HATCHERY-PRODUCED JUVENILES OF OCELLATE PUFFER TAKIFUGU RUBRIPES IN NATAL SPAWNING GROUND OF ARIAKE SOUND

Yasuharu Matsumura-2006

Nippon Suisan Gakkaishi 72(6): 1029-1038

Abstract:

This study evaluated the stock effectiveness of hatchery-produced ocellate puffer by sampling survey in Ariake Sound where mature puffer are landed. In 1,584 samples, 85 marked puffer were observed, and were judged to be from age 2 to 8 years old (mainly 3 years old) from marked otolith by alizarin complexone and/or tetracycline. The recapture rate of released seeds (3-100 mm in total length) was estimated to be 0-0.41%, and corresponded to release size. The von Bertalanffy growth equations were fitted as $L_t = 63.3 \{1 - \exp[-0.245(t - 0.192)]\}$ for male, and $L_t = 75.0 \{1 - \exp[-0.130(t - 2.13)]\}$ for female, where t is age (year) and L_t is total length (cm) at the age. All recaptured puffers had matured similar to wild puffer judged from GSI. These results suggest that hatchery-produced ocellate puffer returned to Ariake Sound by homing ability to the same natal spawning ground.

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DEVELOPING METHODS FOR HARVESTING ROSY RED FATHEAD MINNOW EGGS

North American Journal of Aquaculture

Ignacio Masson, Nathan Stone, Yong-Woo Lee-2006

North American Journal of Aquaculture 68:296-305

Abstract.: We evaluated the effectiveness of different types of spawning substrates in retaining the eggs of rosy red fathead minnow *Pimephales promelas*, the potential substrate preference of the fish, and the effectiveness of different concentrations of sodium sulfite for detaching eggs from substrates without affecting egg survival. Egg adherence was determined by placing replicate sections of four types of conveyor belt material of varying roughness into a pool stocked with fathead minnow. A screened tray was suspended below each substrate to catch the eggs that did not adhere. Substrate preference was evaluated by following a similar protocol, but only three males were stocked (equal to the number of replicates of each substrate). To test the efficacy of sodium sulfite in removing eggs, substrates with eggs were placed in 0.0, 1.5, and 3.0% solutions and uniformly agitated. The effect of exposure time and egg age was tested by exposing eggs to a 1.5% solution of sodium sulfite for 0 (control), 5, 10, 15, 20, 25, and 30 min. The two rougher substrates retained a significantly greater percentage of eggs than the two smoother ones (72-77% versus 34-39%). Nest locations near the water inlet and air stones were preferred regardless of substrate type. The 1.5% sodium sulfite solution was as effective as the 3.0% solution in removing eggs from substrates. There were no significant differences in hatching rate or percentage of atypical fry resulting from exposure of eggs to 1.5% sodium sulfite for up to 30 min. An egg harvesting system consisting of placing a rough or

textured substrate in well-aerated locations and subsequent egg removal with sodium sulfite appears to be feasible, although economic questions remain.
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EVALUATION OF FORMALIN AND HYDROGEN PEROXIDE TREATMENT REGIMES ON RAINBOW TROUT EYED EGGS

Michael E. Barnes, Craig A. Soupir-2007

North American Journal of Aquaculture 69: 5–10

Abstract:

This study examined the use of antifungal chemicals at nonstandard treatment concentrations or treatment intervals during the incubation of eyed eggs of rainbow trout *Oncorhynchus mykiss* until hatch in vertically stacked incubation trays. Daily chemical treatments of 500, 1,000, and 1,667 mg of commercial formalin (containing 37% formaldehyde)/L for 15 min and a nonchemical, dead-egg-removal control were included in three trials. The second and third trials added a true control (no antifungal measures) and the third trial also incorporated a treatment of formalin at 1,667 mg/L for 15 min every other day. In these three trials, formalin at 1,000 or 1,667 mg/L daily or 1,667 mg/L every other day significantly improved egg survival to hatch relative to the other treatments and completely controlled fungal growth. A fourth trial evaluated treatments of formalin at 750 mg/L for 15 min daily or every other day, hydrogen peroxide at 500 mg/L for 15 min daily or every other day, and control groups for both treatments. Egg survival to hatch was significantly different among the treatments; the daily 750-mg/L formalin treatment produced the greatest number of hatched fry, followed by the treatment with 750 mg/L formalin every other day, the dead-egg-removal control, and daily hydrogen peroxide treatment. Survival in the every-other-day hydrogen peroxide treatment and the true control could only be estimated because of extreme fungal growth, and was substantially less than the other treatments. Only daily 750 mg/L formalin treatments and dead egg removal completely controlled fungal growth. To adequately control fungus and maximize egg survival, either daily 15-min treatments of formalin at concentrations of at least 750 mg/L or every-other-day treatments of formalin at 1,667 mg/L are recommended.

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COMPARATIVE FATTY ACID COMPOSITION OF EGGS FROM WHITE BASS FED LIVE FOOD OR COMMERCIAL FEED

Ryan L. Lane, Christopher C. Kohler-2007

North American Journal of Aquaculture 69:11–15

Abstract.: We evaluated the influence of two broodstock feeding practices on fatty acid composition and viability of eggs in white bass *Morone chrysops*. The two dietary groups tested were (1) white bass females fed a commercially formulated feed (crude protein, 45%; crude fat, 16%) and (2) white bass females maintained on live food (fathead minnow *Pimephales promelas* and golden shiners *Notemigonus crysoleucas*). Significant differences existed between the dietary treatments in egg fatty acid levels. Eggs of white bass fed live food contained more 11-octadecenoic acid (18:1[n-7]), α -linolenic acid (18:3[n-3]), arachidonic acid (20:4[n-6]), docosahexaenoic acid (22:6[n-3]), and total n-3 fatty acids than eggs of fish fed formulated feed. Conversely, eggs of fish fed the formulated feed contained more oleic acid (18:1[n-9]), linoleic acid (18:2[n-6]), and total monoenoic acids. Female white bass fed live food produced significantly more viable eggs ($68.0 \pm 2.0\%$) at 48 ± 2 h posthatch than did females fed the commercial feed ($57.0 \pm 2.0\%$ [mean \pm SD]). We found that the egg fatty acids of white bass are significantly affected by the diet of the female and suggest that the fatty acid composition of eggs contribute to overall reproductive success and viability of progeny. More information on the nutrient requirements of piscivorous broodstock is needed to allow feeds to be formulated to enhance the viability of eggs and fry.

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SEPTIC TANK TREATMENT OF THE EFFLUENT FROM A SMALL-SCALE COMMERCIAL RECYCLE AQUACULTURE SYSTEM

Robert C. Summerfelt, Christopher R. Penne-2007

North American Journal of Aquaculture 69: 59–68

Abstract:

The efficiency of a conventional domestic septic tank for primary treatment of the wastewater effluent from a small-scale commercial recycle aquaculture system (RAS) was evaluated. The aquaculture facility had five 39.2-m³ dual-drain culture tanks and a total system volume of 249.9 m³. The mean standing stock of fish during the study was 4,837 kg (25.6 kg/m³) consisting of 9.6% largemouth bass *Micropterus salmoides*, 32.1% walleye *Sander vitreus*, 17.8% hybrid striped bass (white bass *Morone chrysops* × striped bass *M. saxatilis*), and 40.5% rainbow trout *Oncorhynchus mykiss*. The entire RAS volume was exchanged with makeup water only once every 62 d. Inflow to the septic tank contained 25.3% total nitrogen (TN) and 55.1% total phosphorus (TP) added to the culture system as fish feed. Relative to inflow, outflow from the septic tank reduced biochemical oxygen demand by 5.1%, TN by 59.5%, TP by 35.3%, settleable solids by 92.6%, total dissolved solids by 9.6%, and total suspended solids by 69.8%. Septic tank effluent was discharged to a subsurface drain tile that passed below a row crop field to a pond; the pond did not discharge from the operator's property during the study (i.e., zero discharge). Of the nutrients fed, 9.6% of TN and 34.5% of TP were present in the septic tank effluent. Septic tank sludge was pumped out monthly and dewatered to 14.9% moisture by air-drying. It contained 3.6% TN and 2.6% TP (percent dry weight) and was test-marketed as a soil amendment for greenhouse use.

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