

REVIEW

STATUS AND RECOMMENDATIONS ON MARINE COPEPOD CULTIVATION FOR USE AS LIVE FEED

Guillaume Drillet, Stéphane Frouël, Mie H. Sichlau, Per M. Jepsen, Jonas K. Højgaard, Almagir K. Joarder, Benni W. Hansen-2011

Aquaculture 315(3-4): 155-166

Abstract:

Copepods are important crustaceans studied because of their key role in ecology, trophic biology, fisheries management, in modeling the flow of energy and matter, ecotoxicology, aquaculture and aquarium trade. This paper discusses various aspects of the state of knowledge of copepod culture at large scales and provides the scientific community with ideas and concepts that could improve and quicken the development of copepod mass cultures. As a framework for discussion, we use a conceptual scheme from Teece (1988) and adapted it to our goal: 'how to capture value from a copepod product'. The suggestions include: 1) optimize cultures by automation and implement recirculation technology for improving water quality; 2) use harpacticoid and cyclopoid copepods in industries that can produce large amounts of these prey on site at any given time; but use calanoid copepods for industries limited in production time and those that export copepod products (e.g. eggs); 3) select preferentially local copepod species and if possible species with lipid conversion capabilities; 4) optimize sex ratio and selection/cross-breeding to develop suitable copepod strains for aquaculture; 5) explore the use of probiotics for improving the fitness of copepod cultures; and 6) encourage copepod producers/retailers to use/develop an efficient sales and marketing strategy.

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A PROTOCOL AND CULTIVATION SYSTEM FOR GNOTOBIOTIC ATLANTIC COD LARVAE (*GADUS MORHUA* L.) AS A TOOL TO STUDY HOST MICROBE INTERACTIONS

Torunn Forberg, Augustine Arukwe, Olav Vadstein-2011

Aquaculture 315(3-4): 222-227

Abstract:

Commensal bacteria in the gut of all vertebrates play essential roles in the development and functionality of the host. Studying the host raised in the absence of bacteria, or under gnotobiotic conditions (with a known composition of bacteria) has become an important tool to unravel the complex host-microbe interactions. In this study we describe a protocol to generate bacteria-free Atlantic cod (*Gadus morhua* L.) larvae, independent on the continued addition of antibiotics. An experimental system allowing for feeding of the larvae was also developed, and used successfully during a gnotobiotic start feeding experiment.

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EFFECTS OF STORAGE TIME, SEX STEROIDS AND MEDIA COMPOSITION ON EGG VIABILITY OF RAINBOW TROUT (*ONCORHYNCHUS MYKISS*)

Mahmoud Nafisi Bahabadi, Alireza Shoaie, P. Mark Lokman-2011

Aquaculture 315(3-4): 306-311

Abstract:

The effects of storage time and media composition with or without steroids on the viability of unfertilized eggs from rainbow trout (*Oncorhynchus mykiss*) were studied. In this study, the percentages of eyed and hatched eggs were used as proxies for egg viability. Unfertilized eggs were stored in coelomic fluid (CF), steroid-free coelomic fluid (SFCF), SFCF + 17,20 β -dihydroxy-4-pregnen-3-one (17,20 β -P), SFCF + estradiol-17 β (E₂), SFCF + 11-ketotestosterone (11-KT), artificial media (Cortland), Cortland + SFCF, Cortland + 17,20 β -P, Cortland + E₂ or Cortland + 11-KT at 4 °C for 0, 4,

7, 10 or 15 days prior to fertilization. Accordingly, viability of eggs tended to decrease during storage for 7 days in all media, as hatching rates decreased from $57 \pm 16.8\%$ to $46 \pm 16.9\%$. By 10 days of storage, only eggs in CF were fertilizable, yielding rates of eying and hatching of $38 \pm 22.0\%$ and $16 \pm 9.3\%$, respectively. None of the eggs reached the eyed stage when stored for 15 days. The osmolality of media increased and the pH decreased during storage. Water uptake during hardening decreased with storage time. We conclude that natural fluids bathing the eggs of trout are superior in maintaining egg viability than a suite of other media, and that key bioactive steroids do not affect storage. However, storage is impaired in steroid-free CF, suggesting that some unidentified charcoal-adsorbable components in CF are important for maintenance of viability.

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EFFECTS OF TEMPERATURE AND SALINITY DURING INCUBATION ON HATCHING AND YOLK UTILIZATION OF GULF KILLIFISH *FUNDULUS GRANDIS* EMBRYOS

Charles A. Brown, Craig T. Gothreaux, Christopher C. Green-2011

Aquaculture 315(3-4): 335-339

Abstract:

This study serves to determine the influence of incubation temperature and salinity on egg-yolk utilization and size at hatch in Gulf killifish *Fundulus grandis*. Variables such as body length, body depth at vent and yolk area at hatch have been viewed as critical aspects for larval survival at first feeding and beyond. Incubation temperatures were maintained at 20, 21.6, 23 and 29 °C using incubation chambers. Incubation trays were filled with 50 mL of water at salinity concentrations of 10 g/L and 20 g/L. Newly fertilized eggs were placed in the incubation trays and checked daily for the presence of newly hatched larvae. The larvae were collected and analyzed by image analysis software to determine the length, body depth and yolk area of each larva. Larvae incubated in lower temperatures had the longest incubation time but were more developed with the least amount of yolk. Conversely, larvae incubated in the highest temperature had the shortest incubation time but were less developed with the greater relative amounts of yolk. Larvae from the 20 g/L salinity trial had a longer mean time to hatch and total length compared to the 10 g/L trial. The results of this study may be used in estimating developmental responses to temperature and salinity. Coordination of hatch times and morphometric traits can be managed through the manipulation of temperature and salinity to achieve desired parameters.

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APPLICATION OF THE MINUTE MONOGONONT ROTIFER *PROALES SIMILIS* DE BEAUCHAMP IN LARVAL REARING OF SEVEN-BAND GROUPER *EPINEPHELUS SEPTEMFASCIATUS*

Stenly Wullur, Yoshitaka Sakakura, Atsushi Hagiwara-2011

Aquaculture 315(3-4): 355-360

Abstract:

In comparison to the rotifer *Brachionus rotundiformis*, the euryhaline rotifer *Proales similis* has a much smaller body size (83 µm in length and 40 µm in width), and it may be applicable as live food for rearing marine fish larvae with a very small mouth size. A mass culture technique of *P. similis* was recently established, and it has already been confirmed that marine fish larvae could ingest *P. similis*. In the present study, we further investigated the use of *P. similis* as an initial food by observing larval ingestion and digestion and analyzing the nutritional profile, as well as through a 10-day larval rearing trial to investigate survival and growth. Seven-band grouper *Epinephelus septemfasciatus* larvae showed higher selectivity against *P. similis* than *B. rotundiformis* 4 days after hatching. The larvae digested and utilized *P. similis* as an energy resource as they grew, and survived until the end of the experiment. The fatty acid profile of *P. similis* changed according to the type of microalgae; *Nannochloropsis oculata* NIES-2146 strain and “super fresh” *Chlorella vulgaris* V-12® (Chlorella Industry, Fukuoka, Japan) were used as food sources. Higher growth and survival during the initial

10 days were observed when *P. similis* and *B. rotundiformis* were co-fed to the seven-band grouper larvae.

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USE OF ENTEROCOCCUS FAECIUM TO IMPROVE COMMON SOLE (SOLEA SOLEA) LARVICULTURE

Matteo A. Avella, Ike Olivotto, Stefania Silvi, Cataldo Ribecco, Alberto Cresci, Francesco Palermo, Alberta Polzonetti, Oliana Carnevali-2011

Aquaculture 315(3-4): 384-393

Abstract:

The potential of common sole *Solea solea* (Linnaeus, 1758) for consistent production in recirculating systems is limited by the huge losses usually observed during the early stages of larval development, mainly due to pathogen infections and insufficient nutritional balance. In the hope that use of a suitable probiotic strain may counter these difficulties, in this study we isolated *Enterococcus faecium* IMC 511 from common sole brood stock and utilized it as probiotic candidate during fish feeding. After a daily administration (twice a day) to sole larvae through live feeds, the intestinal presence of *E. faecium* IMC 511 was estimated on days 10, 30, and 50 post hatch, and the effects on intestinal microbial load, fish survival, welfare, and growth were evaluated by morphometric and molecular approaches by examining relative body weight, total length, and gene expression of myostatin. In particular, the effect on animal welfare was assessed through analyses of cortisol levels and 70 kDa Heat Shock Protein gene expression.

The results showed that while the *Vibrio* populations of the intestine of *S. solea* larvae were reduced in a significant way by the probiotic *E. faecium* IMC 511, survival was not affected. 70 kDa Heat Shock Protein and myostatin gene expression were significantly reduced in probiotic fed larvae with respect to the control group. It is of note that *E. faecium* IMC 511 seemed to be predominant at day 50 post hatching, probably due to stabilization of the intestinal microbiota, a factor that, together with the lower levels of HSP70, could improve animal well-being and growth.

Cortisol levels significantly increased after 10 days of treatment in probiotic fed larvae, while on days 30 and 50 no significant differences were observed among all experimental groups. Considered together, the microbiological data and the molecular and morphometric results suggest that 50 days of probiotic treatment can improve common sole larval growth.

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SHORT COMMUNICATION

GAMETE COLLECTION METHOD AND EGG QUALITY COMPARISON IN ATLANTIC COD, *GADUS MORHUA* L. MATING PAIRS AND ITS IMPORTANCE IN SELECTIVE BREEDING

L. Lush, D. Hamoutene^a, D. Drover, A. Walsh, V. Puvanendran-2011

Aquaculture 315(3-4): 407-409

Abstract:

Studies on gamete collection methods and their relationship to the selective breeding of Atlantic cod are limited. Communal spawning in this species prevents parental identification of offspring, therefore other methods need to be investigated for the generation of parent-identified families. To determine the effects of alternative methods of gamete collection from communal spawning, broodstock cod pairs were paired mated and also stripped spawned, in successive batches, and egg quality was assessed. Paired t-tests showed that fertilization success and blastomere symmetry were significantly higher in eggs generated by paired mating. In contrast, hatch success did not differ significantly between the two methods. Therefore, both methods are suited to obtain familial information. Cellular repair is hypothesized as the mechanism by which early egg abnormalities are corrected, resulting in equal hatching success between the two artificial spawning methods.

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EFFECT OF IODINE ENRICHMENT OF *ARTEMIA* SP. ON THEIR NUTRITIONAL VALUE FOR LARVAL ZEBRAFISH (*DANIO RERIO*)

M. Hawkyard, Ø. Sæle, A. Nordgreen, C. Langdon, K. Hamre-2011

Aquaculture 316(1-4): 37-43

Abstract:

Dietary iodine may play an important role in the nutritional health of freshwater fish larvae. *Artemia*, commonly used for the culture of larval zebrafish (*Danio rerio*), contain low concentrations of iodine when compared with wild-caught zooplankton. Iodine concentrations of *Artemia* can be increased using wax spray beads (WSB) containing potassium iodide (KI; KI WSB); however, the availability of iodine in enriched *Artemia* for fish larvae is currently unknown. The objectives of this study were to: 1) evaluate the use of KI WSB for enrichment of *Artemia* with iodine; 2) determine if zebrafish larvae were able to obtain iodine from KI WSB-enriched *Artemia*; 3) investigate the effects of KI WSB-enriched *Artemia* on the growth, survival and thyroid status of larval zebrafish; 4) determine if *Artemia* were a potential source of exogenous thyroid hormones (TH) for larval fish; and 5) determine if KI WSB had an effect on bacterial concentrations associated with *Artemia*. A 24-day feeding trial was conducted to compare the effects of iodine-enriched *Artemia* with unenriched *Artemia* on the survival and growth of larval zebrafish. Zebrafish fed *Artemia* enriched with KI WSB showed a ten-fold increase in total iodine levels and increased survival when compared with larvae fed unenriched *Artemia*. Thirty-eight days-post-fertilization (dpf) zebrafish larvae fed iodine-enriched *Artemia* had lower epithelium to colloid (v:v) ratios when compared to those fed unenriched *Artemia*. *Artemia* were found to contain significant levels of outer-ring deiodinase and THs. KI WSB had no effect on the levels of marine bacteria associated with *Artemia*. The results of this study indicate that iodine contained in KI WSB enriched *Artemia* is available to larval fish. There was also evidence to suggest that early-stage zebrafish benefit from increased levels of dietary iodine. In addition, *Artemia* may provide larval fish with significant levels of exogenous THs and deiodinase.

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EFFECTS OF 12 FACTORS ON BURBOT *LOTA LOTA* (L., 1758) WEANING PERFORMANCES USING FRACTIONAL FACTORIAL DESIGN EXPERIMENT

Awatef Trabelsi, Jean-Noël Gardeur, Fabrice Teletchea, Pascal Fontaine-2011

Aquaculture 316(1-4) : 104-110

Abstract:

Sixteen weaning protocols for burbot were tested by using a fractional factorial design experiment taking into account 12 factors (feeding, environmental and stocking density factors) with two modalities. A high survival rate (76%), associated with the lowest cannibalism rate (7%) was recorded for a combination that groups: a long photophase (18 h), low light intensity (70 lx), white tank colour, slightly salty water (5 ppm), high larval density (150 individuals/L), a dry commercial food (AgloNorse) distributed every hour without a co-feeding period, a long weaning duration (10 days) and feeding rate decrease (30% daily). In this combination, however, specific growth rate was weak ($1.3\%.d^{-1}$) compared to other combinations where growth rate was high but associated with both high cannibalism and final weight heterogeneity. Statistical analyses of factor effects showed that low salinity associated with dry food distribution as well as a long weaning period (10 days) increased significantly the survival rate ($p < 0.05$). Total mortality was associated with no salinity, a short weaning duration and feeding at daylight with INVE food (Lansy). Different combinations of treatment modalities can lead to similar performances implying that significant effects were modified by others within the rearing system and that all interactions had not been highlighted.

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WATER QUALITY AND MICROBIAL COMMUNITY STRUCTURE IN JUVENILE ATLANTIC COD (*GADUS MORHUA* L.) CULTURES

Terje van der Meeren, Laila Brunvold, Ruth-Anne Sandaa, Øivind Bergh, Tonje Castberg, Runar Thyraug, Anders Mangor-Jensen-2011

Aquaculture 316(1-4): 111-120

Abstract:

The effect of water treatment and flow rate on young Atlantic cod juveniles was investigated in a 36-days experiment. Four different flow rates (10, 20, 40, and 70 times the effective tank volume per day) were set up in triplicate tanks within each of three rigs with recirculated, UV-radiated, and untreated water, respectively. Each of the 36 tanks was stocked with 200 weaned cod juveniles at a mean weight of 0.048 g. Fish mortality was recorded daily in all tanks, and growth (wet weight) was determined at the end of the experiment. The microflora in the rearing water was investigated by means of PCR-DGGE and flow cytometry. Observed mortality was significantly higher at low flow rates while otherwise unexplained mortality (presumed to be due to cannibalism) was lowest in the recirculation system. No correlation was found between survival and growth. Growth was significantly affected by both water exchange rate and treatment, as the juveniles from high flow rates and the UV-treatment showed elevated growth rates. Both growth and survival scaled in accordance with metabolic factors like oxygen saturation and unionized ammonia. Bacterial concentrations increased in all tanks and treatment from the beginning of the experiment to the end. The UV-treated and untreated water started at typical seawater concentrations ($0.5-1 \times 10^6 \text{ mL}^{-1}$) and increased five to tenfold during the experiment. The recycled water tanks started with bacterial concentrations 2–5 times higher than the UV- and untreated experiments at the time of fish transfer, and ended up with 10 times higher concentrations in the end. Cluster analysis of the DGGE profiles separated the recirculation tanks, including the respective inlet water, from the flow-through systems, with one exception (the highest flow rate). Eighty-five% of the sequences clustered within the Gammaproteobacteria, further divided into four distinct clusters. One of the clusters was only detected in the recirculation system, and showed highest affiliation to bacteria belonging to the *Alteromonas/Pseudoalteromonas* genera. In contrast, bacteria belonging to the family *Vibrionaceae* were detected in the flow-through systems.

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COMPARATIVE EFFECTS OF HUMAN CHORIONIC GONADOTROPIN (HCG) AND GONADOTROPIN-RELEASING HORMONE AGONIST (GNRHA) TREATMENTS ON THE STIMULATION OF MALE SENEGALESE SOLE (*SOLEA SENEGALENSIS*) REPRODUCTION

José M. Guzmán, Jesús Ramos, Constantinos C. Mylonas, Evaristo L. Mañanós-2011

Aquaculture 316(1-4): 121-128

Abstract:

The aquaculture of Senegalese sole (*Solea senegalensis*) is limited by the failure of cultured breeders (F1 generation) to produce fertilized spawning. Critical reproductive dysfunctions have been observed in both female and male Senegalese sole cultured breeders, including reduced fecundity and diminished sperm production. The present work aimed to study the effectiveness of different hormonal treatments on the stimulation of male reproduction. Male Senegalese sole cultured breeders were treated with 1) saline injections (controls), 2) gonadotropin-releasing hormone agonist (GnRHa) injections ($25 \mu\text{g kg}^{-1}$), 3) GnRHa slow release implants ($40 \mu\text{g kg}^{-1}$) or 4) human chorionic gonadotropin (hCG) injections (1000 IU kg^{-1}). Each group of males was placed in separated spawning tanks together with females treated with GnRHa implants.

All three hormonal treatments increased plasma testosterone (T) and 11-ketotestosterone (11-KT) levels and the gonadosomatic index (GSI), with highest effects exerted by the hCG treatment. Histological examination of the testes showed no effect of the GnRHa injection, but a clear stimulation of germ cell proliferation and testicular maturation by GnRHa implants and hCG injections. As expected, GnRHa implantation of females induced egg release in all experimental tanks and interestingly, female fecundity increased in tanks containing GnRHa- or hCG-treated males. A fertilized spawning was

obtained only from the group containing hCG-treated males. In conclusion, hormonal treatments stimulated steroidogenesis and spermatogenesis in male Senegalese sole, with highest efficiency of the hCG multiple injection treatment. Female fecundity was affected by the hormonal treatment applied over the accompanying males, suggesting a pheromone communication between fish. However, none of the treatments seemed to be adequate in solving the problem of lack of fertilized spawning in cultured Senegalese sole broodstocks.

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EDITORIAL

INTERNATIONAL SYMPOSIUM ON AQUACULTURE, BIOLOGY AND MANAGEMENT OF COMMERCIALY IMPORTANT CRABS, SHANGHAI (CHINA), 8–11 NOVEMBER 2009 (ISABMC-2009)

Lewis Le Vay, Colin Shelley, Chaoshu Zeng, Patrick Sorgeloos-2011

Aquaculture International 19(2)

Over recent decades, crab aquaculture has emerged as a new industry, driven by increasing market demand and collapses of crab stocks and fisheries worldwide. Building on symposia previously held in Australia, the Philippines and Vietnam, the ISABMC-2009 meeting brought together international crab scientists and industry to share insights into crab aquaculture, biology and resource management and to highlight future research needs for the sustainable development of crab aquaculture. The symposium was hosted at the new campus of Shanghai Ocean University. Over the last 20 years, Chinese mitten crab farm production in China has grown from just over 3,000 tonnes to over 500,000 tonnes per annum. In addition, China is now the largest producer of farmed mud crabs, *Scylla* spp., and the swimming crab, *Portunus trituberculatus*, at over 106,000 tonnes and 100,000 tonnes per annum, respectively. Vietnam has also reported impressive growth in mud crab aquaculture production from just 3,000 tonnes in 1995 to an estimated 30,000 tonnes per annum, with one-third of this production based on crablets produced in hatcheries. In the Philippines also, hatchery production of mud crabs is increasing, with private hatcheries now using technology developed by the South East Asian Fisheries Development Centre and the University of the Philippines Visayas. The symposium highlighted—in addition to the rapid growth in production of the major farmed crab species—the increasing number of species of crab currently being cultured. Another exciting revelation from the meeting was that a number of successful stock enhancement trials of various crab species have now taken place around the world (USA, Japan, Philippines, Vietnam), demonstrating the potential for hatchery-produced crab stock to successfully support the recovery of wild stocks. A concluding workshop identified the following important themes for further consideration and action: sustainability of both crab fisheries and farming systems; domestication of stocks for farming; hatchery technology; development of specialised crab feeds; techniques to reduce cannibalism of crabs during grow-out; disease management; and economic analysis to drive future research. The ISABMC also highlighted the need for concerted international collaboration in research, farming technology and fisheries management to optimise the benefits of the world's crab resources within an ecologically sustainable development framework. Mitten crab farming in China is mostly conducted at low stocking densities, often integrated with other land use, over very large areas of coastal and inland wetlands. In the case of mud crabs, growth in production has largely been made using low-density farming systems, often in small-scale farms using integrated systems involving polyculture and mangrove silviculture and has so far avoided the widespread disease problems typically associated with intensification. The symposium's scientific committee urged that the sustainable expansion of crab culture should include responsible approaches to integrated management of coastal ecosystems to prevent the environmental problems that have developed with intensive and widespread culture of other species.

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A REVIEW OF SEED PRODUCTION AND STOCK ENHANCEMENT FOR COMMERCIALY IMPORTANT PORTUNID CRABS IN JAPAN

Katsuyuki Hamasaki, Yasuhiro Obata, Shigeki Dan, Shuichi Kitada-2011

Abstract:

We reviewed the present status of seed production for stock enhancement and evaluated the impact of stocking on commercial catches in Japan, of portunid crabs particularly *Portunus trituberculatus* and *Scylla paramamosain*. The mean survival rate from hatching to first-stage crabs was around 10%, and 20–30% of the larval culture trials conducted in recent years could not harvest juveniles during seed production. To achieve reliable mass seed production technologies, measures for controlling disease and the nutritional condition of larvae in seed production tanks are required to be developed. The main spawning season extends from April/May to July. Reflecting their life cycle characteristics such as high growth rates, crabs recruit to the fishery after September and largely contribute to the commercial landings until December in the hatching year. The main release season of juveniles is from June to July. Consequently, released juveniles are expected to contribute to commercial landings in the release year. Analyses of catch and release statistics in two small bays estimated the yield from released individuals (YPR, yield per release) at 2.4 g for *P. trituberculatus* and 3.3–7.7 g for *S. paramamosain*, which were similar to values reported from tagging surveys. On a major regional basis, catch and release histories of *P. trituberculatus* highlighted the impact of hatchery releases on commercial landings as 33.6 g YPR in the Seto Inland Sea, where catches and releases have been greatest. Although the YPR estimates were different between small bays and major regional seas, Japanese stock enhancement programmes should have had an impact on portunid crab production, dependent on the magnitude of the releases.

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DOMESTICATION OF THE MUD CRAB SCYLLA SERRATA

Emilia T. Quinitio, Joana Joy de la Cruz, Maria Rowena R. Eguia, Fe Dolores Parado-Esteba, Gaudioso Pates, Celia R. Lavilla-Pitogo-2011

Aquaculture International 19(2): 237-250

Abstract:

The significant decrease in wild mud crab population highlights the need to manage the resources and domesticate crabs. This paper presents the initial results of the domestication of mud crab *Scylla serrata* aimed at producing good-quality captive broodstock. The analysis of the genetic structure of the base population was done as a prerequisite for domestication. Adult *S. serrata* from the northern to southern parts of the Philippines (Cagayan, Camarines, Samar, and Surigao) were obtained for genetic diversity analysis and domestication. Analysis of molecular variance showed that differences in the genetic variability between the four populations were not significant. Moreover, no significant deviation from Hardy–Weinberg Equilibrium was observed in each sample population and even in pooled populations. Body weight was positively correlated with the carapace width. Second spawning occurred 41–46 days after the first spawning and 34 days from second to third spawning. However, there was a decrease in the number of zoea in repeat spawnings. Twenty-four first-generation (F1) families were produced from the four sites. The duration from spawning of the base population (P0) to attainment of broodstock size F1 was 10–14 months. Four second-generation (F2) families were produced after 11–12 months. Up to the F2, crabs tested negative for six viruses: white spot syndrome virus, infectious hypodermal and hematopoietic necrosis virus, gill-associated virus, yellow head virus, Taura syndrome virus, and infectious myonecrosis virus. The reproductive performance of P0 was comparable to the succeeding generations. Several families were obtained from one population in a year. However, due to the cannibalistic behavior of crabs, more space is required for the nursery and grow-out phase. The domestication of *S. serrata* is the first study done on any mud crab species in the Indo-west Pacific region. The initial results would serve as guide to understand and eliminate the barriers to mud crab domestication. The breeding technology developed from this study will support the production of good-quality seedstock for farming.

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ADVANCES IN PRECOCITY RESEARCH OF THE CHINESE MITTEN CRAB *ERIOCHEIR SINENSIS*

X. Li, Z. Li, J. Liu, Sena S. De Silva-2011

Aquaculture International 19(2):, 251-267

Abstract:

Precocity has been observed in fishes and crustaceans. However, mechanisms underlying precocity have not been well documented in crustaceans and are thought to be influenced by both genetic and environmental factors. Also, precocity is generally considered to have negative effects on crustaceans. The Chinese mitten crab *Eriocheir sinensis*, a catadromous species endemic to China, is a high valued commodity and in the recent past is being extensively cultured to meet the growing demand by the restaurant trade. The mitten crab is an ideal candidate for precocity studies because of their large size, distinct secondary sex characters, wide distribution and abundant availability from commercial farms. In this article, progress in several aspects of precocity of *E. sinensis* is reviewed, including the phenomena of precocity and its effect, identification of precocious crabs, factors related to precocity (temperature, salinity, light, nutrition, stocking density, and germplasm), relationships between precocity and neuro-endocrine system, steroid hormones or hepatopancreas, prevention and control methods of precocity. In addition, possible future directions for the study of precocity are suggested.

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EFFECT OF DIETARY HUFA ON TISSUE FATTY ACID COMPOSITION AND REPRODUCTIVE PERFORMANCE OF CHINESE MITTEN CRAB *ERIOCHEIR SINENSIS* (H. MILNE-EDWARDS) BROODSTOCK

L. Y. Sui, H. X. Sun, X. G. Wu, M. Wille, Y. X. Cheng, P. Sorgeloos-2011

Aquaculture International 19(2): 269-282

Abstract:

This study was conducted to determine the optimum highly unsaturated fatty acid (HUFA) level in semi-purified diets for female Chinese mitten crab *Eriocheir sinensis* broodstock. Five isolipidic and isonitrogenous diets were formulated to contain different HUFA levels (0.14, 0.65, 1.15, 1.64, and 2.07%, respectively) by the supplementation of HUFA-rich fish oil. Diets were fed to triplicate groups of 25 female crabs (75 animals per treatment) stocked in concrete tanks for 8 months. The hepatopancreas, ovary, and muscle of the crabs were sampled after 3-month culturing, and the eggs were sampled after 8-month culturing. The reproductive performance of *E. sinensis* broodstock was evaluated in relation to the different dietary HUFA levels. Moreover, the fatty acid composition of the hepatopancreas, ovary, muscle, and eggs was determined in crabs fed various levels of HUFA. The results showed that a significant positive correlation was observed between the dietary HUFA level and the HUFA content in hepatopancreas, ovary, and egg, respectively. However, no significant difference in gonadosomatic index, hepatosomatic index, and total ovarian and hepatopancreatic lipid content among the treatments was observed after 3-month culturing. Also, the reproductive performance was similar for all treatments after 8-month culturing. The fact of lacking significant correlation between reproductive parameters and dietary HUFA level was discussed in respect of the catadromous life cycle of *E. sinensis* and warranted further research with more comprehensive approaches.

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EFFECT OF HYPOXIA ON IMMUNOLOGICAL, PHYSIOLOGICAL RESPONSE, AND HEPATOPANCREATIC METABOLISM OF JUVENILE CHINESE MITTEN CRAB *ERIOCHEIR SINENSIS*

Renjie Qiu, Yongxu Cheng, Xuxiong Huang, Xugan Wu, Xiaozhen Yang, Rui Tong-2011

Aquaculture International 19(2) : 283-299

Abstract:

The juvenile Chinese mitten crabs *Eriocheir sinensis* (1.40 ± 0.43 g) were cultured in water of 5.34 ± 0.43 (hypoxia, treatment group) and 21.02 ± 0.06 kPa (high dissolved oxygen (DO), control group) DO for 24 h, respectively. The total hemocyte counts (THC), the hyaline hemocyte counts were measured at 0 and 24 h in the treatment group, and superoxide dismutase (SOD) activity, concentrations of lactic acid and hemocyanin (Hc) in hemolymph and the metabolism of hepatopancreas (concentrations of glucose, total cholesterol, uric acid, total protein, urea, triglyceride in hepatopancreas) were assayed at 0, 2, 8, and 24 h in both treatment and control groups. The hyaline hemocyte counts and THC decreased significantly by 66 and 49% after exposure to hypoxic water for 24 h, respectively. SOD activity, Hc and lactic acid content were significantly affected in treatment group, and there were significant differences between treatment and control groups. In the treatment group, the concentration of glucose, cholesterol and uric acid in hepatopancreas had a significant variation for 24 h. The concentration of total protein, urea and triglyceride between treatment and control groups was not significantly different after 0, 2, 8, 24 h. However, there were significant differences between treatment and control groups in terms of total protein, glucose, and uric acid concentration. Taken together, the effect of hypoxia is comprehensive in juvenile Chinese mitten crab *Eriocheir sinensis*.

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EFFECTS OF LIGHT INTENSITY ON MOLTING, GROWTH, PRECOCITY, DIGESTIVE ENZYME ACTIVITY, AND CHEMICAL COMPOSITION OF JUVENILE CHINESE MITTEN CRAB *ERIOCHEIR SINENSIS*

Xiaowu Li, Zhongjie Li, Jiashou Liu, Tanglin Zhang, Chaowen Zhang-2011

Aquaculture International 19(2): 301-311

Abstract:

A 74-day growth trial was carried out to investigate the effects of light intensity on the juvenile Chinese mitten crab, *Eriocheir sinensis*, under semi-natural conditions. The experiment had three light intensity treatment groups, natural light (NL), middle light (ML), and low light (LL), as light intensity became weaker. The results indicated that light intensity had no significant effect on molting interval and molting frequency but did have a significant effect on the molting weight gain of the crab. Molting weight gain in group NL was significantly higher than that in group LL ($P < 0.05$). Specific growth rate in weight (SGR_w) and in carapace width (SGR_{cw}), weight gain, and final body weight were significantly affected by light intensity ($P < 0.05$). No significant difference was detected in survival between groups ($P > 0.05$). The precocious rate in groups NL, ML, and LL was 26.14, 15.48, and 17.14%, respectively. The precocious rate in group NL was significantly higher than that in groups ML and LL ($P < 0.05$). Chemical composition of the crab body was significantly affected by light intensity, but the activity of alkaline phosphatase, trypsin, and pancreatic lipase was not significantly affected by light intensity. The results indicated that the submitted light intensity was useful in reducing the precocious rate without affecting the normal growth of juvenile *E. sinensis*.

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EXPERIMENTAL NURSERY CULTURE OF THE MUD CRAB *SCYLLA PARAMAMOSAIN* (ESTAMPADOR) IN CHINA

Haihui Ye, Yong Tao, Guizhong Wang, Qiongwu Lin, Xuelei Chen, Shaojing Li-2011

Aquaculture International 19(2): 313-321

Abstract:

For the improvement of nursery culture of the mud crab *Scylla paramamosain*, a special nursery facility was purposely designed and built. This facility consists of nursery ponds (areas of 20, 50, and 120 m², respectively) and a seed collecting pond connected to each nursery pond. There were 140 nursery facility units in operation for large-scale juvenile crab production. A series of experiments were carried out using the facility to investigate the effects of the age of megalopae, stocking density, and culture

duration of both megalopae and first-stage crabs on the survival of megalopae and early juveniles of *S. paramamosain*. The results showed that when megalopae were stocked at a density between 3,000 and 5,000 ind m⁻² and reared to reach the first-stage crabs, a survival rate of up to 50% could be achieved. When the first-stage juvenile crabs were stocked at a density between 2,000 and 3,000 ind m⁻², their survival was more than 50% after 14 days of culture.

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EFFECTS OF SALINITY AND DIETARY N-3 HIGHLY UNSATURATED FATTY ACIDS ON THE SURVIVAL, DEVELOPMENT, AND MORPHOGENESIS OF THE LARVAE OF LABORATORY-REARED MUD CRAB *SCYLLA SERRATA* (DECAPODA, PORTUNIDAE)

Shigeki Dan, Katsuyuki Hamasaki-2011

Aquaculture International 19(2): 323-338

Abstract:

We investigated the effects of feeding rotifers containing various levels of n-3 highly unsaturated fatty acids (n-3HUFA) to *Scylla serrata* larvae at different developmental stages on their survival, development, and morphogenesis when they were cultured at six salinity levels. The first-, third-, and fifth (last)-stage zoeae and megalopae were reared to first-stage crabs at salinities of 10, 15, 20, 25, 30, and 35‰, with three different feeding regimes of rotifers containing different levels of n-3HUFA. The larvae successfully developed to the subsequent stages at 20–35‰ salinity. The highest survival rates to first-stage crabs were recorded at 20–25‰ salinity. The morphological features of the megalopa observed in the last-stage zoeae, represented by the ratio of the chela length to carapace length, tended to advance with increasing salinity, indicating higher assimilation efficiency at higher salinities. The megalopal features of the last-stage zoeae were enhanced when the larvae were fed rotifers containing higher amounts of docosahexaenoic acid (DHA). As reported previously, final-stage zoeal larvae with advanced megalopal features often experienced moult death syndrome (MDS). These results show that when larvae are fed rotifers with high DHA under high-salinity conditions, morphogenesis is accelerated, resulting in MDS. Therefore, to evaluate the effects of salinity on larval survival, it is necessary to examine larval morphogenesis in terms of MDS. In conclusion, we recommend that not only survival but also larval morphogenesis should be examined when evaluating the results of rearing experiments with *S. serrata* larvae.

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EFFECT OF AMMONIA AND NITRITE ON VIGOUR, SURVIVAL RATE, MOULTING RATE OF THE BLUE SWIMMING CRAB *PORTUNUS PELAGICUS* ZOEAE

Yong Yang Liao, Hong Hu Wang, Zhi Gan Lin-2011

Aquaculture International 19(2): 339-350

Abstract:

The effects of ammonia and nitrite on vigour, survival rate, moulting rate of zoea of blue swimming crab, *Portunus pelagicus*, were studied. A total of five nitrite-N treatments (26.67, 53.34, 106.68, 213.36, 426.72 mg/l) and a control (no nitrite-N added) were set up for the acute nitrite-N toxicity experiment; a total of five ammonia-N treatments (8.43, 16.86, 33.72, 67.44, 134.88 mg/l) and a control (no ammonia-N added) were set up for the acute ammonia-N toxicity experiment. The results showed that the vigour, survival rate and moulting rate of zoea of the blue swimming crabs exposed to over 53.34 mg/l were significantly different ($P < 0.05$) from the control group. The zoea LC50 values (mg/l) of nitrite-N were 179.47, 76.56, 66.70, 37.49, 25.01, 25.35, 25.34 mg/l for 24, 36, 48, 60, 72, 84, 96 h, respectively. The vigour, survival rate and moulting rate of zoea of the blue swimming crabs exposed to over 16.86 mg/l were significantly different ($P < 0.05$) from the control group. The zoea LC50 values (mg/l) of ammonia-N were 51.04, 39.62, 38.72, 24.43, 16.90, 13.42, 11.16 mg/l for 24, 36, 48, 60, 72, 84, 96 h, respectively. The zoeae are highly sensitive to ammonia and nitrite, and the toxicity of ammonia and nitrite on *Portunus pelagicus* decrease with development of this crab.

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ISOLATION AND CHARACTERIZATION OF VIBRIO METSCHNIKOVII CAUSING INFECTION IN FARMED PORTUNUS TRITUBERCULATUS IN CHINA

Xihe Wan, Hui Shen, Libao Wang, Yongxu Cheng-2011

Aquaculture International 19(2): 351-359

Abstract:

In August 2008, a massive epizootic occurred among *Portunus trituberculatus* reared together with *Palaemon carinicauda* Holthuis and *Sinonovacula constricta* in the seawater pond of Ningang farm, Rudong district, Jiangsu province, China. The disease occurred in crabs from juveniles to adults, and the mortality rate reached 30–40%. The diseased crabs exhibited lethargy, hepatopancreas turgidity, and elevated levels of turbid hemolymph. A gram-negative, rod-shaped bacterium (designated as strain LGS-1) was isolated from the ascitic fluid of the diseased and moribund crabs and was confirmed as the causative agent by our infectivity study. We conducted morphological and biochemical characterization of LGS-1, and sequenced the 16S rRNA gene, which led us to identify the bacterium as *Vibrio metschnikovii*. Drug sensitivity tests showed that this pathogenic bacterium is sensitive to florfenicol, orfloxacin, and SXT, but completely resistant to antibacterial drugs like gentamicin, erythrocine, and aceomycin. This is the first report on *Vibrio metschnikovii* as a virulent pathogen for *Portunus trituberculatus*.

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PHENOTYPIC DIFFERENCES BETWEEN HATCHERY-REARED AND WILD MUD CRABS, SCYLLA SERRATA, AND THE EFFECTS OF CONDITIONING

Lee Parkes, Emilia T. Quintio, Lewis Le Vay-2011

Aquaculture International 19(2) : 361-380

Abstract:

Hatchery-reared animals for stock enhancement should be competent to survive and grow at rates equivalent to those of wild conspecifics. However, morphological differences are often observed, and pre-conditioning steps may be required to improve the fitness of hatchery-reared juveniles prior to release. In the present study, hatchery-reared *Scylla serrata* juveniles were reared either individually (HR-solitary) or groups in tanks (HR-communal), the latter group being exposed to intraspecific competition and foraging for food. After 21 days, both groups were compared to similar size wild-caught juveniles in terms of morphometric measurements of carapace spination, abnormalities and carapace colouration. There were some limited significant differences between HR-communal crabs and HR-solitary crabs in terms of length of 8th and 9th lateral spines and in body-weight-carapace width ratio, but both treatments differed from wild crabs, which were heavier and had longer carapace spines for their size. In contrast, both HR treatments exhibited common abnormalities including deformities in the shape of the abdomen, in particular occurrence of an asymmetrical telson or a deeply folded telson. In all cases, abnormalities persisted through moulting. Initially, carapace colour differed in all measures of colour between HR and wild crabs. However, these differences reduced after a period of 4–8 days of conditioning on coloured tank backgrounds or dark sand or mud backgrounds, without moulting. Similarly, hatchery-reared crabs exhibited very limited burying behaviour on first exposure to sediment, but this increased to levels observed in wild crabs within 2–4 days. Thus, short-term conditioning of hatchery-reared crabs on dark sediments may be effective in increasing predator avoidance and survivorship in released animals, and present results suggest that this can be achieved after relatively short periods of 1 week or less.

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DEVELOPMENT OF LARVAL CULTURE TECHNIQUES FOR THE SHORE CRAB, *CARCINUS MAENAS* (L)

Thomas H. Galley, Benjamin C. Green, Lloyd Watkins, Lewis Le Vay-2011

Aquaculture International 19(2): 381-394

Abstract:

The shore crab *Carcinus maenas* is a commercially important species, utilised as sea angling bait as well as supporting a European-wide fishery. Hatchery production could provide an alternative source of bait crabs, alleviating potential competition between these sectors and environmental concerns regarding bait collection practices. A series of experiments were carried to investigate the potential for hatchery production, focusing on effects of dietary regimes and stocking densities through the zoeal stages and the influence of tank substrates and stocking density during the megalopa stage. Inclusion of the rotifer *Brachionus plicatilis* as live food for early larval stages conveyed no advantage in terms of survival or rate of development compared to a diet of *Artemia* nauplii. Increasing zoea stocking densities (from 94 to 557 l⁻¹) had a significantly negative effect upon survival to the megalopa stage (from 75% down to 47%), although this was off-set by a significant increase in production, with 260 megalopae⁻¹ produced from an initial density of 557 zoeae l⁻¹. The inclusion of substrates for megalopa stages had no impact on production or development rate, compared to tanks with no substrate. The completely benthic behaviour of megalopae indicates that tank floor area will be a limiting factor for crab production. Increasing stocking density of megalopae was found to significantly and negatively influence survival, although above 10,000 megalopae m⁻² the rate of decline in survival stabilised and maximum production (3,114 juveniles m⁻²) of juvenile crabs could be achieved at the highest stocking densities tested (40,000 m⁻²).

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